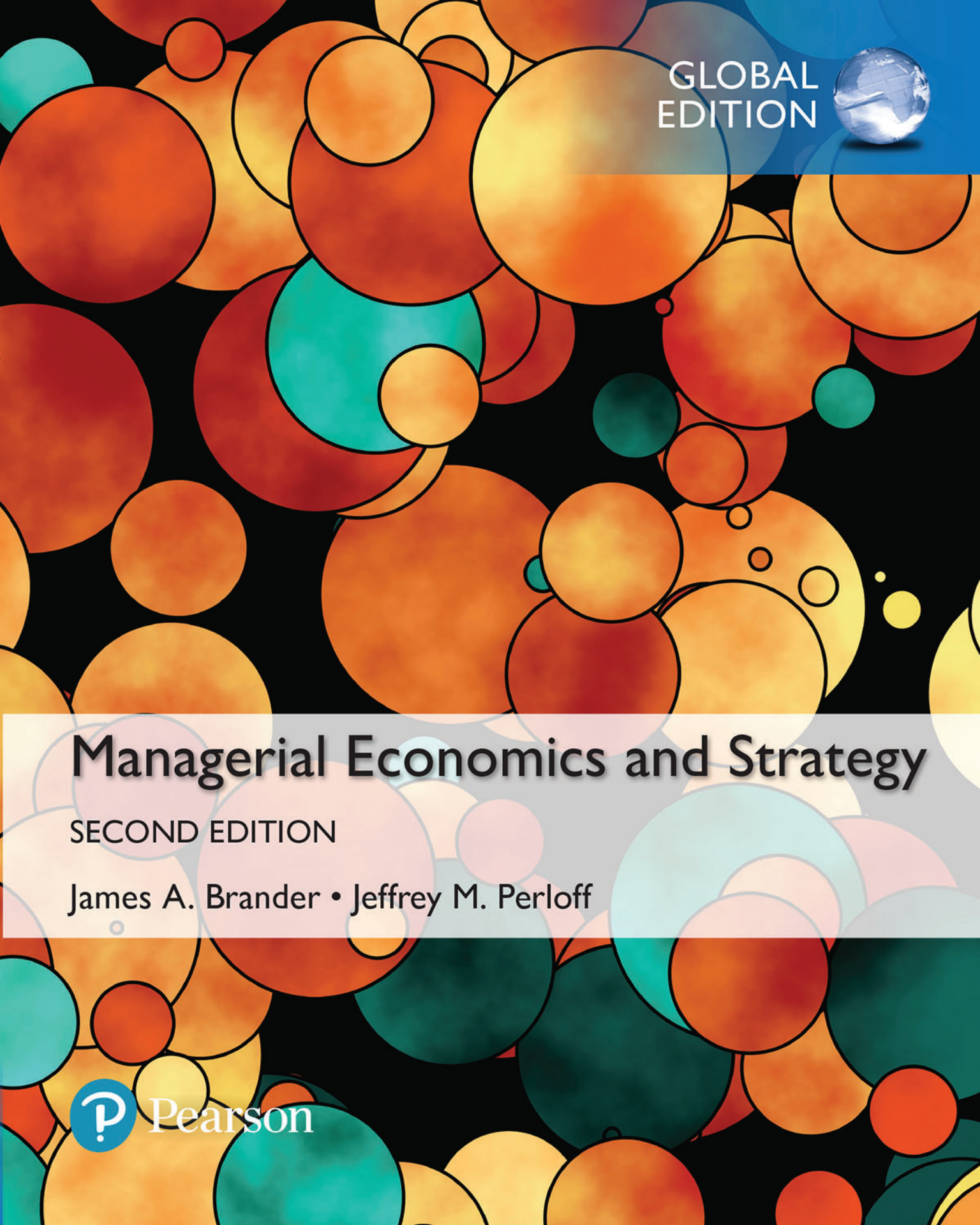

Managerial Economics and Strategy

SECOND EDITION

James A. Brander • Jeffrey M. Perloff

Pearson

Managerial Economics and Strategy

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Brief Contents

Contents

Preface

Successful managers make extensive use of economic tools when making important decisions. They use these tools to produce at minimum cost, to choose a price or an output level to maximize profit, and for many other managerial decisions including:

- How much to advertise.
- What strategies to use to compete with rival firms.
- Whether to sell several goods in a bundle for a single price.
- Whether to offer buy-one-get-one-free deals.
- How to design compensation contracts to provide appropriate incentives for employees.
- How to structure an international supply chain to take advantage of cross-country differences in production costs.

We show how to apply economic theory using actual business examples and real data. Our experience teaching managerial economics at the Wharton School (University of Pennsylvania) and the Sauder School of Business (University of British Columbia) as well as teaching a wide variety of students at the Massachusetts Institute of Technology; Queen's University; and the University of California, Berkeley, has convinced us that students prefer our emphasis on real-world issues and examples from actual markets.

What's New in the Second Edition

We have substantially revised the second edition based in large part on the very helpful suggestions of instructors and students who used the first edition. We have updated and revised every chapter. The vast majority of the Mini-Cases (brief applications of the theory) are updated or new. Each chapter opener now lists learning objectives, and Chapters 2–17 contain new end-of-chapter questions.

New Themes

This edition contains new material on two themes that have become increasingly important in business schools and corporate boardrooms: *corporate social responsibility* (CSR) and *innovation*. A new section on CSR in Chapter 7 discusses the tradeoff that managers face between promoting social objectives and maximizing short-run profit, but also describes how some *strategic* CSR activities increase long-run profits. Chapter 16 examines the possible role of environmental CSR as a response to environmental externalities.

This edition increases our coverage of innovation. The section "Innovation" in Chapter 5 contains an expanded treatment of *process innovation* and *organizational innovation*. The section "Cost and Innovation Strategies" in Chapter 13 examines the role of innovation in dynamic games between rival firms. Many of our Mini-Cases and other examples focus on the knowledge-based economy, in which innovation plays a crucial role. Such examples include genetically modified foods, the use of robots, the efforts of drug companies to maximize the profits earned from drug development, and the Internet.

Other New Content

We have revised and updated the text throughout the book. For example, the international coffee market is now the main example in the supply and demand analysis in Chapter 2. Chapter 3 illustrates econometric forecasting using Nike's revenue and features the Excel Regression tool. Chapter 7 defines and discusses opportunistic behavior in a section on "Transaction Costs and Opportunistic Behavior." Chapter 11 simplifies the treatment of the Cournot model in the main text by moving the algebraic analysis of the n-firm case with general linear demand to an appendix. Chapter 12 adds a discussion of double auctions. A new appendix to Chapter 13 covers the Stackelberg model with general linear demand. Chapter 17 uses newly estimated supply and demand curves to analyze the effect of trade policy in the oil market.

Most importantly, because instructors and students enjoyed the cartoons in the first edition, we have increased the number in this edition to 21. In addition to providing entertainment, these cartoons convey important economic points in a memorable way.

Managerial Problems, Mini-Cases, and Managerial Implications

In the second edition, we have 103 Managerial Problems and Mini-Cases. Of these, 80% are new or updated. The one-third that are new address important current topics including "Capping Oil and Gas Bankruptcies," "Entry and Exit of Solar Power Firms," "Chinese State-Owned Enterprises," and "Mobile Phone Number Portability." Of the 36 Managerial Implications (statements of economic principles that managers can use to make key managerial decisions), 4 are new and 12 are updated.

End-of-Chapter Questions

This edition has 593 end-of-chapter questions, of which 150 are new. We have increased the integration between Mini-Cases and end-of-chapter questions: Half of the Mini-Cases have corresponding end-of-chapter questions.

Spreadsheet Exercises

Many instructors and students appreciated the first edition's spreadsheet exercises (designed by Satyajit Ghosh) and asked for more. This edition has 50% more: three exercises at the end of each chapter (apart from Chapter 1) instead of two.

MyLab Economics Videos

The second edition provides enhanced integration with MyLab Economics (**http://www.myeconlab.com**), a powerful online learning support system. Probably the most striking innovation in this edition is the addition of a set of MyLab Economics Videos that illustrate key points in the text. An icon shows which figures, tables, sections, and Excel applications have MyLab Economics Videos by Tony Lima, a skilled and experienced professor. For 48 of the book's figures, he slowly builds each figure and explains the economics behind each step. Six of his MyLab Economics Videos cover normal-form games. One MyLab Economics Video addresses correlation and diversification, while two MyLab Economics Videos tackle moral hazard. Two other MyLab Economics Videos show students how to use Excel to run regressions.

Experiments

The textbook now advises students about the availability of single-player experiments in MyLab Economics. A student plays against virtual players to see how competitive markets work, how price controls and taxes affect markets, how markets respond to informational problems, and why public goods are underprovided.

Main Innovations

This book differs from other managerial economics texts in three main ways.

- It places greater emphasis than other texts on modern theories that are increasingly useful to managers in areas such as agency and contract theory, behavioral economics, game theory, and pricing.
- It makes more extensive use of real-world business examples to illustrate how to use economic theory in making business decisions.
- It employs a *problem-based* approach to demonstrate how to apply economic theory to specific business decisions.

Modern Theories for Business Decisions

This book covers all the standard economic theory, of course. However, what sets it apart is its emphasis on modern theories that are particularly useful for managers.

Agency and Contract Theory How can a manager induce employees to work hard rather than shirk? How can the owner of a firm make sure a manager, as the owner's *agent*, acts in the owner's best interests rather than in the manager's own interests? How can a manager avoid being exploited by experts and other people with superior information? We use modern contract theory to show how to write contracts to avoid or minimize such problems.

Behavioral Economics. Should a manager allow workers to opt in or opt out of a retirement system? How can the manager of a motion picture firm take advantage of movie reviews? We address questions such as these using behavioral economics—one of the hottest new areas of economic theory—which uses psychological principles to explain why people deviate from rational behavior. These theories are

particularly relevant for managers, but managerial economics textbooks have largely ignored them.

Game Theory. Should the manager of a radio station schedule commercial breaks at the same time as rival firms do? What strategy should a manager use when bidding in an auction for raw materials? Under what circumstances should a manager act to prevent entry by a rival? This book goes well beyond other managerial economics texts by making significant use of game theory to examine such topics as oligopoly quantity and price setting, entry and exit decisions, entry deterrence, and innovation. Game theory provides a way of thinking about business strategies and choosing strategies that maximize profits. Unlike most microeconomics and managerial economics books, our applications of game theory are devoted almost exclusively to actual business problems.

Pricing. How often should a manager put products on sale? Should a manager charge low prices to build a network of users for a product? When should a manager use pricing tools such as volume discounts, off-season discounts, rebates, and package deals? When should a manager charge various customers different prices? This book provides more analysis of these important real-world pricing tools than other managerial economics textbooks.

Real-World Business Examples

We demonstrate that economics is practical and useful to managers by examining real markets and actual business decisions. We do so in two ways. In our presentation of the basic theory, we use real-world data and examples. Second, we examine many real-world problems in our various features.

To illustrate important economic concepts, we use graphs and calculations based on actual markets and real data. Students learn the basic model of supply and demand using estimated supply and demand curves for coffee, and they practice estimating demand curves using real data from sources such as from the Portland Fish Exchange. They study how imported oil limits pricing by U.S. oil producers using real estimated supply and demand curves, derive cost curves from Japanese beer manufacturers using actual estimated production functions, and analyze oligopoly strategies using estimated demand curves and cost and profit data from the real-world rivalries between United Airlines and American Airlines and between Coke and Pepsi.

Problem-Based Learning

Managers have to solve business problems daily. We use a problem-solving approach to demonstrate how economic theory can help managers make good decisions. In each chapter, we solve problems using a step-by-step approach to model good problem-solving techniques. At the end of each chapter, we have an extensive set of questions. Some of these require the student to solve problems similar to those solved in the chapter, while others ask the student to use the tools of the chapter to answer questions about Mini-Cases and Managerial Implications within the chapter or new real-world problems. We also provide exercises asking students to use spreadsheets to apply the theory they have learned to real-world problems.

Features

This book has more features dedicated to showing students how to apply theory to real-world problems than do rival texts.

Managerial Implications. The *Managerial Implications* feature provides bottom-line statements of economic principles that managers can use to make key managerial decisions. For example, we describe how managers can assess whether they are maximizing profit. We also show how they can structure discounts to maximize profits, promote customer loyalty, design auctions, prevent gray markets, and use important insights from game theory to make good managerial decisions.

Mini-Cases. Eighty-seven *Mini-Cases* apply economic theory to interesting and important managerial problems. For example, Mini-Cases demonstrate how price increases on iTunes affect music downloads using actual data, how to estimate Crocs' production function for shoes using real-world data, why top-end designers limit the number of designer bags customers can buy, how "poison pills" at Yahoo! harmed shareholders, how Pfizer used limit pricing to slow the entry of rivals, why advertisers pay so much for Super Bowl commercials, and how managers of auto manufacturing firms react to tariffs and other regulations.

Q&As. After the introductory chapter, each chapter provides three to five *Q&As* (Questions & Answers). Each Q&A poses a qualitative or quantitative problem and then uses a step-by-step approach to solve the problem. The 55 Q&As focus on important managerial issues such as how a cost-minimizing firm would adjust to changing factor prices, how a manager prices bundles of goods to maximize profits, how to determine Intel's and AMD's profit-maximizing quantities and prices using their estimated demand curves and marginal costs, and how to allocate production across plants internationally.

Managerial Problems and Managerial Solutions. After the introductory chapter, each chapter starts with a *Managerial Problem* that motivates the chapter by posing real-world managerial questions. At the end of each chapter, we answer this question in the *Managerial Solution* using the economic principles discussed in that chapter. Thus, each Managerial Problem–Managerial Solution pair combines the essence of a Mini-Case and a Q&A.

End-of-Chapter Questions. Starting with Chapter 2, each chapter ends with an extensive set of questions, including many real-world problems. Each Q&A has at least one associated end-of-chapter question that references that Q&A and allows the student to answer a similar problem. In addition, many of the end-of-chapter questions relate to Mini-Cases. The answers to selected end-of-chapter problems appear at the end of the book, and answers to all of the problems are available online in MyLab Economics.

Spreadsheet Exercises. In addition to the verbal, graphical, and mathematical exercises, each chapter has three end-of-chapter *spreadsheet exercises*. These exercises demonstrate how managers can use a spreadsheet to apply the economic methods described in the chapter. They address important managerial issues such as choosing the profit-maximizing level of advertising or designing compensation contracts to motivate employees. MyLab Economics provides answers for all of the book's spreadsheet exercises, as well as additional spreadsheet exercises.

Using Calculus. *Using Calculus* sections show how to analyze theory with calculus, reinforcing the graphical, verbal, and algebraic treatment of theory. In contrast, most other books relegate calculus to appendices, mix calculus in with other material where it cannot easily be skipped, or avoid calculus entirely. Because of this structure, both courses that use calculus and those that do not can use this book effectively. Some clearly indicated end-of-chapter questions use calculus.

Alternative Organizations

Because instructors differ in the order in which they cover material and in the range of topics they choose to teach, this text allows for flexibility. The most common approach to teaching managerial economics is to follow the sequence of the chapters in order. However, many variations are possible. For example, some instructors choose to address empirical methods (Chapter 3) first.

Instructors may skip consumer theory (Chapter 4) without causing problems in later chapters. Or, they may cover consumer theory after the chapters on production and cost (Chapters 5 and 6).

Chapter 7, "Firm Organization and Market Structure," provides an overview of the key issues that are discussed in later chapters, such as types of firms, profit maximization and its alternatives, conflicts between managers and owners (and other "agency" issues), and the structure of markets. We think that presenting this material early in the course is ideal, but an instructor can cover all of this material except for the section on profit maximization later.

An instructor may teach pricing with market power (Chapter 10) at any point after discussing monopoly (Chapter 9). Because game theory is introduced in two chapters (Chapters 12 and 13), instructors can conveniently choose how much game theory to present. Although Chapter 11 on oligopoly and monopolistic competition precedes the game theory chapters, a course could cover the game theory chapters first.

A common variant is to present Chapter 14 on uncertainty earlier in the course. A course could present asymmetric information (Chapter 15) at any point after Chapter 7 (if it is covered) and the uncertainty chapter. Thus, a course could cover both the uncertainty and information chapters early.

Chapter 16 on government and business discusses market failures, government regulation, externalities, public goods, and intellectual property. A course could cover this material earlier. For example, the regulation and intellectual property material could follow monopoly. The externality and public good treatment could be presented at any point after Chapter 8 on competitive firms and markets.

The final chapter, Global Business (Chapter 17), is valuable in a course that stresses international issues. An instructor could cover this chapter at any point after the competition and monopoly chapters.

MyLab Economics

MyLab Economics is a powerful assessment and tutorial system that works hand-in-hand with *Managerial Economics*. It includes comprehensive homework, quiz, test, and tutorial options, allowing students to test their knowledge and instructors to

manage all assessment needs in one program. Students and instructors can register, create, and access all of their MyLab courses, regardless of discipline, from one convenient online location: **http://www.pearsonmylab.com**.

Key innovations in the MyLab Economics course for *Managerial Economics*, second edition, include the following resources for students and instructors:

- **Pearson eText.** The Pearson eText gives students access to their textbook anytime, anywhere. In addition to notetaking, highlighting, and bookmarking, the Pearson eText offers interactive and sharing features. Instructors can share comments or highlights, and students can add their own, for a tight community of learners in any class.
- **MyLab Economics Videos.** Key figures and concepts from the textbook are presented in step-by-step animations with audio explanations of the action. These new videos are embedded in the eText and are accessible through MyLab Economics.
- **MyLab Economics Q&As.** Key Q&A features from the textbook are available in MyLab Economics. Many students have difficulty applying economics concepts to solving problems. The goal of this digital resource is to help students overcome this hurdle by giving them a model of how to solve an economic problem by breaking it down step by step. In this text, the Q&A features are presented as solved problems. Each Q&A in the printed text has a similar companion problem online so students can practice their problem-solving skills. These interactive tutorials help students apply basic problem-solving skills to homework, quizzes, and exams. The goal is for students to build skills they can use to analyze real-world economic issues they hear and read about in the news. Each Q&A in MyLab Economics and the eText also includes at least one additional graded practice exercise for students.
- **MyLab Economics Spreadsheet Exercises.** MyLab Economics provides Excel spreadsheets that students can work with and worked-out answers for end-of-chapter spreadsheet exercises.
- **NEW: Math Review Exercises in MyLab Economics.** MyLab Economics now offers a rich array of assignable and auto-graded exercises covering fundamental math concepts geared for managerial economics students. Aimed at increasing student confidence and success, the new math skills review Chapter R is accessible from the assignment manager and contains over 150 graphing, algebra, and calculus exercises for homework, quiz, and test use.
- **Practice.** Algorithmically generated homework and study plan exercises with instant feedback ensure varied and productive practice that helps students improve their understanding and prepare for quizzes and tests. Exercises that require drawing figures encourage students to practice the language of economics.
- **Learning Resources.** Personalized learning aids such as Help Me Solve This Problem walkthroughs, Teach Me explanations of the underlying concept, and figure Animations provide on-demand help when students need it most.
- **Study Plan.** Customized study plans show students which sections to study next, give easy access to practice problems, and provide an automatically generated quiz to prove mastery of the course material.
- **Digital Interactives.** Focused on a single core topic and organized in progressive levels, each interactive immerses students in an assignable and auto-graded

activity. Digital Interactives are lecture tools for traditional, online, and hybrid courses, many incorporating real-time data, data displays, and analysis tools for rich classroom discussions.

- **Learning Catalytics.** Learning Catalytics™ is a "bring your own device" student engagement, assessment, and classroom intelligence system that lets learners use their smartphone, tablet, or laptop to participate in and stay engaged in lecture. It allows instructors to generate classroom discussion, guides lectures, and promotes peer-to-peer learning with real-time analytics. Now students can use any device to interact in the classroom, engage with content and even draw and share graphs. Instructors can divide classes into pairs or groups based on learners' response patterns, and learners with greater proficiency help motivate other learners while allowing instructors time to provide individualized and focused attention to learners who will benefit from it.
- **Current News Exercises.** These exercises provide a turnkey approach to assign gradable news-based exercises in MyLab Economics. Every week, Pearson scours the news, finds a current article appropriate for a managerial economics course, creates an exercise based on this news article, and then automatically adds it to MyLab Economics.
- **Reporting Dashboard.** Faculty can view, analyze, and report learning outcomes clearly and easily using the Reporting Dashboard. It is available via the Gradebook and fully mobile-ready. The Reporting Dashboard presents student performance data at the class, section, and program levels in an accessible, visual manner.
- **LMS Integration.** Faculty can link from any LMS platform to access assignments, rosters, and resources, and synchronize MyLab grades with your LMS gradebook. For students, a new direct, single sign-on provides easier access to all the personalized learning MyLab resources.
- **Mobile Ready.** Students and instructors can access multimedia resources and complete assessments from any mobile device.
- **Experiments in MyLab Economics.** Flexible, easy to assign, auto-graded, and available in Single and Multiplayer versions, the Experiments in MyLab Economics make learning fun and engaging.

  For more information, visit **http://www.myeconlab.com**.

Supplements

This book has a full range of supplementary materials that support teaching and learning.

- The *Online Instructor's Manual* by Matt Roelofs of Western Washington University contains many useful and creative teaching ideas. It offers additional discussion questions, and provides solutions for all the end-of-chapter questions in the text.
- The *Online Test Bank* by Todd Fitch of the University of California, Berkeley, features problems of varying levels of complexity, suitable for homework assignments and exams. Many of these multiple-choice questions draw on current events.

- The *Computerized Test Bank* reproduces the Test Bank material in the TestGen software, which is available for both Windows and Macintosh. With TestGen, instructors can easily edit existing questions, add questions, generate tests, and print the tests in a variety of formats.
- The *Online PowerPoint Presentation* by Nelson Altamirano of National University contains text figures and tables, as well as lecture notes. These slides allow instructors to walk through examples from the text during in-class presentations.

These teaching resources are available online for download at the Instructor Resource Center, accessible from **http://www.pearsonglobaleditions.com/brander**.

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J. M. P.
J. A. B.

1 Introduction

An Economist's Theory of Reincarnation: If you're good, you come back on a higher level. Cats come back as dogs, dogs come back as horses, and people—if they've been very good like George Washington—come back as money.

If all the food, clothing, entertainment, and other goods and services we wanted were freely available, no one would study economics, and we would not need managers. However, most of the good things in life are scarce. We cannot have everything we want. Consumers cannot consume everything but must make choices about what to purchase. Similarly, managers of firms cannot produce everything and must make careful choices about what to produce, how much to produce, and how to produce it. Studying such choices is the main subject matter of economics. **Economics** is the study of decision making in the presence of scarcity.[1]

Managerial economics is the application of economic analysis to managerial decision making. It focuses on how managers make economic decisions by allocating the scarce resources at their disposal. To make good decisions, a manager must understand the behavior of other decision makers, such as consumers, workers, other managers, and governments. In this book, we examine decision making by such participants in the economy, and we show how managers can use this understanding to be successful.

Main Topics

In this chapter, we examine two main topics

1. **Managerial Decision Making:** Economic analysis helps managers develop strategies to achieve a firm's objective—such as maximizing profit—in the presence of scarcity.
2. **Economic Models:** Managers use models based on economic theories to help make predictions about consumer and firm behavior, and as an aid to managerial decision making.

1.1 Managerial Decision Making

A firm's managers allocate the limited resources available to them to achieve the firm's objectives. The objectives vary for different managers within a firm. A production manager's objective is normally to achieve a production target at the lowest

[1] Many dictionaries define economics as the study of the production, distribution, and consumption of goods and services. However, professional economists think of economics as applying more broadly, including any decisions made subject to scarcity.

possible cost. A marketing manager must allocate an advertising budget to promote the product most effectively. Human resource managers design compensation systems to encourage employees to work hard. The firm's top manager must coordinate and direct all these activities.

Each of these tasks is constrained by resource scarcity. At any moment in time, a production manager has to use the existing factory and a marketing manager has a limited marketing budget. Such resource limitations can change over time but managers always face constraints.

Profit

The main objective of most private sector firms is to maximize *profit*, which is the difference between revenue and cost. Senior managers of a firm might have other concerns as well, including social responsibility and personal career objectives. However, the primary responsibility of senior managers to the owners of the firm is to focus on the *bottom line*: maximizing profit.

Managers have a variety of roles in the profit maximization process. The production manager seeks to minimize the cost of producing a particular good or service. The market research manager determines how many units of any particular product can be sold at a given price, which helps to determine how much output to produce and what price to charge. The R&D manager promotes the development of new products that will be attractive to consumers. The most senior manager, usually called the *chief executive officer* (CEO), must insure that all managerial functions are coordinated so that the firm makes as much profit as possible.

Trade-Offs

People and firms face trade-offs because they can't have everything. Managers must focus on the trade-offs that directly or indirectly affect profits. Evaluating trade-offs often involves *marginal* reasoning: considering the effect of a small change. Key trade-offs include:

- **How to produce.** To produce a given level of output, a firm trades off inputs, deciding whether to use more of one and less of another. Car manufacturers choose between metal and plastic for many parts, which affects the car's weight, cost, and safety.
- **What prices to charge.** Some firms, such as farms, have little or no control over the prices at which their goods are sold and must sell at the price determined in the market. However, many other firms set their prices. When a manager of such a firm sets the price of a product, the manager must consider whether raising the price by a dollar increases the profit margin on each unit sold by enough to offset the loss from selling fewer units. Consumers, given their limited budgets, buy fewer units of a product when its price rises. Thus, ultimately, the manager's pricing decision is constrained by the scarcity under which consumers make decisions.
- **Whether to innovate.** One of the major trade-offs facing managers is whether to maximize profit in the short run or in the long run. For example, a forward-looking firm may invest substantially in innovation—designing new products and better production methods—which lowers profit in the short run, but may raise profit in the long run.

Other Decision Makers

It is important for managers of a firm to understand how the decisions made by consumers, workers, managers of other firms, and governments constrain their firm. Consumers purchase products subject to their limited budgets. Workers decide on which jobs to take and how much to work given their scarce time and limits on their abilities. Rivals may introduce new, superior products or cut the prices of existing products. Governments around the world may tax, subsidize, or regulate products.

Thus, managers must understand how others make decisions. Most economic analysis is based on the assumption that decision makers are optimizers: they do the best they can with their limited resources. However, we also consider some contexts in which economic decision makers do not successfully optimize when we describe psychological biases and cognitive limits in decision making—a topic referred to as *behavioral economics*.

Interactions between economic decision makers take place primarily in markets. A **market** is an exchange mechanism that allows buyers to trade with sellers. A market may be a town square where people go to trade food and clothing, or it may be an international telecommunications network over which people buy and sell financial securities. When we talk about a single market, we refer to trade in a single good or group of goods that are closely related, such as soft drinks, movies, novels, or automobiles. The primary participants in a market are firms that supply the product and consumers who buy it, but government policies such as taxes also play an important role in the operation of markets.

Strategy

When competing with a small number of rival firms, senior managers consider how their firm's products are positioned relative to those of its rivals. The firm uses a strategy—a battle plan that specifies the *actions* or *moves* that the firm will make to maximize profit. A strategy might involve choosing the level of output, the price, or the type of advertising now and possibly in the future. For example, in setting its production levels and prices, Pepsi's managers must consider what choices Coca-Cola's managers will make. One tool that is helpful in understanding and developing such strategies is *game theory*, which we use in several chapters.

1.2 Economic Models

Economists use economic models to explain how managers and other decision makers make decisions and to interpret the resulting market outcomes. A **model** is a description of the relationship between two or more variables. Models are used in many fields. For example, astronomers use models to describe and predict the movement of comets and meteors, medical researchers use models to describe and predict the effect of medications on diseases, and meteorologists use models to predict weather.

Business economists construct models dealing with economic variables and use such models to describe and predict how a change in one variable will affect another variable. Such models are useful to managers in predicting the effects of their decisions and in understanding the decisions of others. Models allow managers to consider hypothetical situations—to use a *what-if analysis*—such as "What would

Mini-Case

Using an Income Threshold Model in China

According to an *income threshold model*, no one who has an income level below a particular threshold buys a particular consumer durable, such as a refrigerator or car. The theory also holds that almost everyone whose income is above that threshold buys the product.

If this theory is correct, we predict that as most people's incomes rise above the threshold in emergent economies, consumer durable purchases will increase from near zero to large numbers very quickly. This prediction is consistent with evidence from Malaysia, where the income threshold for buying a car is about $4,000.

In China, incomes have risen rapidly and now exceed the threshold levels for many types of durable goods. As a result, many experts correctly predicted that the greatest consumer durable goods sales boom in history would take place there. Anticipating this boom, many companies have greatly increased their investments in durable goods manufacturing plants in China. Annual foreign direct investments (FDI) have gone from $916 million a year in 1983 to $120 billion in 2014, overtaking the United States as the world's largest recipient of FDI. In expectation of this growth potential, even traditional political opponents of the People's Republic—Taiwan, South Korea, and Russia—are investing in China.

One of the most desirable durable goods is a car. Li Rifu, a 46-year-old Chinese farmer and watch repairman, thought that buying a car would improve the odds that his 22- and 24-year-old sons would find girlfriends, marry, and produce grandchildren. Soon after Mr. Li purchased his Geely King Kong for the equivalent of $9,000, both sons met girlfriends, and his older son got married.

Four-fifths of all new cars sold in China are bought by first-time customers. An influx of first-time buyers was responsible for Chinese car sales increasing by a factor of 15 between 2000 and 2015. By 2014, China was producing more than the United States and Japan combined.[2]

happen if we raised our prices by 10%?" or "Would profit rise if we phased out one of our product lines?" Models help managers predict answers to what-if questions and to use those answers to make good decisions.

Simplifying Assumptions

Everything should be made as simple as possible, but not simpler. —Albert Einstein

A model is a simplification of reality. The objective in building a model is to include the essential issues, while leaving aside the many complications that might distract us or disguise those essential elements. For example, the income threshold model focuses on only the relationship between income and purchases of durable goods. Prices, multiple car purchases by a single consumer, and other factors that might affect durable goods purchases are left out of the model. Despite these simplifications, the model—if correct—gives managers a good general idea of how the automobile market is likely to evolve in countries such as China.

[2] The sources for Mini-Cases are available at the back of the book.

We have described the income threshold model in words, but we could have presented it using graphs or mathematics. Representing economic models using mathematical formulas in spreadsheets has become very important in managerial decision making. Regardless of how the model is described, an economic model is a simplification of reality that contains only its most important features. Without simplifications, it is difficult to make predictions because the real world is too complex to analyze fully.

Economists make many *assumptions* to simplify their models. When using the income threshold model to explain car purchasing behavior in China, we *assume* that factors other than income, such as the color of cars, do not have an important effect on the decision to buy cars. Therefore, we ignore the color of cars that are sold in China in describing the relationship between income and the number of cars consumers want. If this assumption is correct, by ignoring color, we make our analysis of the auto market simpler without losing important details. If we're wrong and these ignored issues are important, our predictions may be inaccurate. Part of the skill in using economic models lies in selecting a model that is appropriate for the task at hand.

Testing Theories

Blore's Razor: When given a choice between two theories, take the one that is funnier.

Economic *theory* refers to the development and use of a model to formulate *hypotheses*, which are proposed explanations for some phenomenon. A useful theory or hypothesis is one that leads to clear, testable predictions. A theory that says "If the price of a product rises, the quantity demanded of that product falls" provides a clear prediction. A theory that says "Human behavior depends on tastes, and tastes change randomly at random intervals" is not very useful because it does not lead to testable predictions and provides little explanation of the choices people make.

An alternative theory.

Economists test theories by checking whether the theory's predictions are correct. If a prediction does not come true, they might reject the theory—or at least reduce their confidence in the theory. Economists use a model until it is refuted by evidence or until a better model is developed for a particular use.

A good model makes sharp, clear predictions that are consistent with reality. Some very simple models make sharp or precise predictions that are incorrect. Some more realistic and therefore more complex models make ambiguous predictions, allowing for any possible outcome, so they are untestable. Neither incorrect models nor untestable models are helpful. The skill in model building lies in developing a model that is simple enough to make clear predictions but realistic enough to be accurate. Any model is only an approximation of reality. A good model is one that is a close enough approximation to be useful.

Although economists agree on the methods they use to develop and apply testable models, they often disagree on the specific content of those models. One

model might present a logically consistent argument that prices will go up next quarter. Another, using a different but equally logical theory, may contend that prices will fall next quarter. If the economists are reasonable, they will agree that pure logic alone cannot resolve their dispute. Indeed, they will agree that they'll have to use empirical evidence—facts about the real world—to find out which prediction is correct. One goal of this book is to teach managers how to think like economists so that they can build, apply, and test economic models to deal with important managerial problems.

Positive and Normative Statements

Economic analysis sometimes leads to predictions that seem undesirable or cynical. For instance, an economist doing market research for a producer of soft drinks might predict that "if we double the amount of sugar in this soft drink we will significantly increase sales to children." An economist making such a statement is not seeking to undermine the health of children by inducing them to consume excessive amounts of sugar. The economist is only making a scientific prediction about the relationship between cause and effect: more sugar in soft drinks is appealing to children.

Such a scientific prediction is known as a **positive statement**: a testable hypothesis about matters of fact such as cause-and-effect relationships. *Positive* does not mean that we are certain about the truth of our statement; it indicates only that we can test the truth of the statement.

An economist may test the hypothesis that the quantity of soft drinks demanded decreases as the price increases. Some may conclude from that study that "The government should tax soft drinks so that people will not consume so much sugar." Such a statement is a value judgment. It may be based on the view that people *should* be protected from their own unwise choices, so the government *should* intervene.

This judgment is *not* a scientific prediction. It is a **normative statement**: a belief about whether something is good or bad. A normative statement cannot be tested because a value judgment cannot be refuted by evidence. A normative statement concerns what somebody believes *should* happen; a positive statement concerns what *is* or what *will* happen. Normative statements are sometimes called *prescriptive* statements because they prescribe a course of action, while positive statements are sometimes called *descriptive* statements because they describe reality. Although a normative conclusion can be drawn without first conducting a positive analysis, a policy debate will be better informed if a positive analysis is conducted first.[3]

Good economists and managers emphasize positive analysis. This emphasis has implications for what we study and even for our use of language. For example, many economists stress that they study people's *wants* rather than their *needs*. Although people need certain minimum levels of food, shelter, and clothing to survive, most people in developed economies have enough money to buy goods well in excess of the minimum levels necessary to maintain life. Consequently, in wealthy countries, calling something a "need" is often a value judgment. You almost certainly have

[3] Some argue that, as (social) scientists, we economists should present only positive analyses. Others argue that we shouldn't give up our right to make value judgments just like the next person (who happens to be biased, prejudiced, and pigheaded, unlike us).

been told by someone that "you *need* a college education." That person was probably making a value judgment—"you *should* go to college"—rather than a scientific prediction that you will suffer terrible economic deprivation if you do not go to college. We can't test such value judgments, but we can test a (positive) hypothesis such as "Graduating from college or university increases lifetime income."

SUMMARY

1. **Managerial Decision Making.** Economic analysis helps managers develop strategies to pursue their objectives effectively in the presence of scarcity. Various managers within a firm face different objectives and different constraints, but the overriding objective in most private sector firms is to maximize profits. Making decisions subject to constraints implies making trade-offs. To make good managerial decisions, managers must understand how consumers, workers, other managers, and governments will act. Economic theories normally (but not always) assume that all decision makers attempt to maximize their well-being given the constraints they face.

2. **Economic Models.** Managers use models based on economic theories to help make predictions and decisions, which they use to run their firms. A good model is simple to use and makes clear, testable predictions that are supported by evidence. Economists use models to construct *positive* hypotheses such as causal statements linking changes in one variable, such as income, to its effects, such as purchases of automobiles. These positive propositions can be tested. In contrast, *normative* statements, which are value judgments, cannot be tested.

2 Supply and Demand

Talk is cheap because supply exceeds demand.

Learning Objectives

1. Determine a good's market price and quantity using supply and demand curves.
2. Predict how an event that affects consumers or firms changes the market price and quantity.
3. Analyze the market effects of government policy using the supply-and-demand model.
4. Determine for which markets the supply-and-demand model is appropriate.

Managerial Problem

Carbon Taxes

Burning fossil fuels such as gasoline, coal, and heating oil releases gases containing carbon into the air.[1] These "greenhouse" gases are widely believed to contribute to global warming. To reduce this problem and raise tax revenues, many environmentalists and political leaders have proposed levying a *carbon tax* on the carbon content in fossil fuels.[2]

When governments impose carbon taxes on gasoline, managers of firms that sell gasoline need to think about how much of the tax they have to absorb and how much they can pass through to firms and consumers who buy gasoline. Similarly, managers of firms that purchase gasoline must consider how any pass-through charges will affect their costs of shipping, air travel, heating, and production. This pass-through analysis is critical in making managerial decisions concerning how much to produce, how to set prices, whether to undertake long-run capital investments, and whether to operate or shut down.

[1]Each chapter from Chapter 2 on begins with a Managerial Problem that contains a specific question, which is answered at the end of the chapter using the theories presented in the chapter. Sources for the Managerial Problems, Mini-Cases, and Managerial Implications appear at the back of the book.

[2]Their political opponents object, claiming that fears about global warming are exaggerated and warning of large price increases from such taxes.

Finland and Sweden implemented the first broad-based carbon taxes on fuels containing carbon (such as gasoline) in the early 1990s. Various other European countries soon followed suit. However, strong opposition to carbon taxes has limited adoption in the United States and Canada. The first North American carbon tax was introduced in 2006 in Boulder, Colorado (where it was applied to only electricity generation), and this tax was renewed in 2012. In 2007 and 2008, the Canadian provinces of Quebec and British Columbia became the first provinces or states in North America to impose a broad-based carbon tax. Australia adopted a carbon tax in 2012 but repealed it in 2014. Chile enacted a carbon tax in 2014.

Such carbon taxes harm some industries and help others. The tax hurts owners and managers of gasoline retailing firms, who need to consider whether they can stay in business in the face of a significant carbon tax. Shippers and manufacturers that use substantial amounts of fuel in production, as well as other firms, would also see their operating costs rise.

Although a carbon tax harms some firms and industries, it creates opportunities for others. For example, wind power, which is an alternative to fossil fuels in generating electricity, would become much more attractive. Anticipating greater opportunities in this market in the future, in 2013, Warren Buffett acquired two utility-scale solar plants in Southern California for between $2 and $2.5 billion and, in 2014, announced his intention to increase his company's investment in alternative energy to $30 billion. Google invested over $2 billion in wind and other renewable energy as of 2015. By 2015, Germany was generating over 25% of its electric power supply from renewable sources (primarily wind and solar) and has a target of generating 80% by 2050.

Managers in the motor vehicle industry would need to consider whether to change their product mix in response to a carbon tax, perhaps focusing more on fuel-efficient vehicles. Even without a carbon tax, when gas prices rise, many consumers switch from sports utility vehicles (SUVs) to smaller cars. A carbon tax would favor fuel-efficient vehicles even more.

At the end of this chapter, we will return to this topic and answer a question of critical importance to managers in the motor vehicle industry and in other industries affected by gasoline prices: What would be the effect of imposing a carbon tax on the price of gasoline?

To analyze the effects of carbon taxes on gasoline prices and other variables, managers use an economic tool called the *supply-and-demand model*. Managers who use the supply-and-demand model to anticipate the effects of events make more profitable decisions.

The supply-and-demand model provides a good description of many markets and applies particularly well to markets with many buyers and many sellers, as in most agricultural markets, much of the construction industry, many retail markets (such as gasoline retailing), and several other major sectors of the economy. In markets where this model is applicable, it allows us to make clear, testable predictions about the effects of new taxes or other shocks on prices and other market outcomes.

Main Topics

In this chapter, we examine six main topics

1. **Demand:** The quantity of a good or service that consumers demand depends on price and other factors such as consumer incomes and the prices of related goods.
2. **Supply:** The quantity of a good or service that firms supply depends on price and other factors such as the cost of inputs and the level of technological sophistication used in production.
3. **Market Equilibrium:** The interaction between consumers' demand and producers' supply determines the market price and quantity of a good or service that is bought and sold.
4. **Shocks to the Equilibrium:** Changes in factors that affect demand (such as consumer income) or supply (such as the price of inputs) alter the market price and quantity sold of a good or service.
5. **Effects of Government Interventions:** Government policy may also affect the equilibrium by shifting the demand curve or the supply curve, restricting price or quantity, or using taxes to create a gap between the price consumers pay and the price firms receive.
6. **When to Use the Supply-and-Demand Model:** The supply-and-demand model applies very well to highly competitive markets, which are typically markets with many buyers and sellers.

2.1 Demand

Consumers decide whether to buy a particular good or service and, if so, how much to buy based on its price and on other factors, including their incomes, the prices of other goods, their tastes, and the information they have about the product. Government regulations and other policies also affect buying decisions. Before concentrating on the role of price in determining quantity demanded, let's look briefly at some other factors.

Income plays a major role in determining what and how much to purchase. People who suddenly inherit great wealth might be more likely to purchase expensive Rolex watches or other luxury items and would probably be less likely to buy inexpensive Timex watches and various items targeted toward lower-income consumers. More broadly, when a consumer's income rises, that consumer will often buy more of many goods.

The *price of a related good* might also affect consumers' buying decisions. Related goods can be either *substitutes* or *complements*. **Substitutes** are a pair of goods or services for which an increase in the price of one causes a consumer to demand a larger quantity of the other. Before deciding to go to a movie theater, a consumer considers the price of a substitute such as streaming a movie online. The more expensive it is to go to a movie theater, the more likely that the consumer purchases a streamed movie to watch at home instead. Different brands of a good are often close substitutes. Before buying a pair of Levi's jeans, a customer might check the prices of other brands and substitute one of those brands for Levi's if its price is sufficiently attractive.

Complements are a pair of goods or services for which an increase in the price of one causes a consumer to demand a smaller quantity of the other. Smartphones, such as the iPhone and Samsung Galaxy, and music purchased online and downloaded

to the smartphone are complements. A decline in the price of smartphones increases the demand for online music.

Consumers' *tastes* are important in determining their demand for a good or service. Consumers do not purchase foods they dislike or clothes they view as unfashionable or uncomfortable. The importance of fashion illustrates how changing tastes affect consumer demand. Clothing items that have gone out of fashion often languish in discount sections of clothing stores even though they commanded high prices a couple of years (or even a few weeks) earlier when they were in fashion. Firms devote significant resources to trying to change consumer tastes through advertising.

Similarly, *information* about the effects of a good has an impact on consumer decisions. In recent years, positive health outcomes linked to various food items have created greater demand for these healthy foods (such as soy products and high-fiber breads) when the information became well known.

Government rules and regulations affect demand. If a city government bans the use of skateboards on its streets, demand for skateboards in that city falls. Governments might also restrict sales to particular groups of consumers. For example, many political jurisdictions do not allow children to buy tobacco products, which reduces the quantity of cigarettes consumed.

Other factors might also affect the demand for specific goods. For example, consumers are more likely to use Facebook if most of their friends use Facebook. This *network effect* arises from the benefits of being part of a network and from the potential costs of being outside the network.

Although many factors influence demand, economists focus most on how a good's *own* price affects the quantity demanded. The relationship between price and quantity demanded plays a critical role in determining the market price and quantity in supply-and-demand analysis. To determine how a change in price affects the quantity demanded, economists ask what happens to quantity when price changes and other factors affecting demand such as income and tastes are held constant.

The Demand Curve

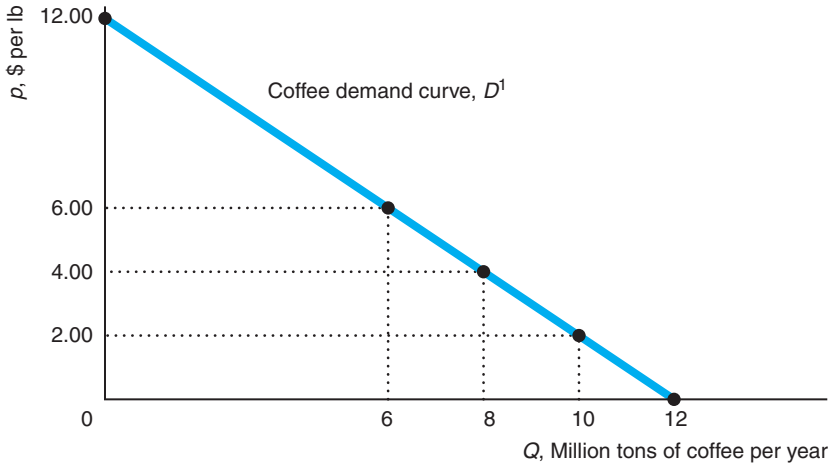
The amount of a good that consumers are *willing* to buy at a given price, holding constant the other factors that influence purchases, is the **quantity demanded**. The quantity demanded of a good or service can exceed the quantity *actually* sold. For example, as a promotion, a local store might sell DVDs for $2 each today only. At that low price, you might want to buy 25 DVDs, but the store might run out of stock before you can select the DVDs you want. Or the store might limit each consumer to a maximum of, for example, 10 DVDs. The quantity you demand is 25; it is the amount you *want*, even though the amount you *actually buy* is 10.

Using a diagram, we can show the relationship between price and the quantity demanded. A **demand curve** shows the quantity demanded at each possible price, holding constant the other factors that influence purchases. Figure 2.1 shows the estimated annual world demand curve, D^1, for coffee, which is one of the world's most valuable traded commodities. The internationally traded commodity is unroasted ("green") coffee beans. These unroasted beans are sold to Starbucks, Folgers, Maxwell House, and other firms that roast and sell coffee to retail consumers.[3] In this section, we

[3]We estimated the demand curve using data from the Food and Agriculture Organization, Commodity Review and Outlook and the International Coffee Organization, **http://www.ico.org/** and World Bank, World Development Indicators. We rounded the numbers for simplicity.

FIGURE 2.1 A Demand Curve

The estimated global demand curve, D^1, for coffee shows the relationship between the quantity demanded per year in millions of tons and the price per lb. The downward slope of the demand curve shows that, holding other factors that influence demand constant, consumers demand a smaller quantity of a good when its price is high and a larger quantity when the price is low. A change in price causes a *movement along the demand curve*. For example, an increase in the price of coffee causes consumers to demand a smaller quantity of coffee.



analyze the market for unroasted coffee beans, which we call *coffee*. Although this demand curve is a straight line, demand curves may also be smooth curves or wavy lines. By convention, the vertical axis of the graph measures the price, p, per unit of the good. We measure the price of coffee in dollars per pound (abbreviated *lb*). The horizontal axis measures the quantity, Q, of the good, which is usually a *physical measure per time period*. This figure measures the quantity of coffee in millions of tons (2,000 lbs) per year.

The demand curve hits the vertical axis at $12, indicating that the quantity demanded is zero when the price is $12 per lb or higher. The demand curve hits the horizontal (quantity) axis at 12 tons, the quantity of coffee buyers would want each year if the price were zero. To find out how much consumers demand at a price between zero and $12, say, $6, we draw a horizontal line from that price on the vertical axis until we hit the demand curve, and then we draw a vertical line down to the horizontal quantity axis. As the figure shows, the quantity demanded at a price of $6 per lb is 6 million tons per year.

One of the most important things to know about a demand curve is what it does *not* show. All relevant economic variables that the demand curve graph does not explicitly show—income, prices of related goods (such as tea or sugar), tastes, information, and so on—are held constant. Thus, the demand curve shows how quantity varies with price but not how quantity varies with income, the prices of related goods, tastes, information, or other variables.

Effects of a Price Change on the Quantity Demanded. One of the most important results in economics is the **Law of Demand**: Consumers demand more of a good if its price is lower, holding constant income, the prices of other goods, tastes, and other factors that influence the amount they want to consume. According to the Law of Demand, *demand curves slope downward*, as in Figure 2.1.

A downward-sloping demand curve illustrates that consumers demand a larger quantity of this good when its price is low and a smaller quantity when its price is high. What happens to the quantity of coffee demanded if the price of coffee drops and all other variables remain constant? If the price of coffee falls from $6 per lb to $4 per lb in Figure 2.1, the annual quantity buyers want to purchase increases from 6 million tons to 8 million tons per year. Similarly, if the price drops from $4 to $2 per lb, the quantity buyers demand increases from 8 to 10 million tons.[4]

These changes in the quantity demanded in response to changes in price are *movements along the demand curve*. Thus, the demand curve is a concise summary of the answer to the question "What happens to the quantity demanded as the price changes, when all other factors are held constant?"

Although we generally expect demand curves to have a clear downward slope, as the coffee demand curve does, a vertical or horizontal demand curve is possible. We can think of horizontal and vertical demand curves as being extreme cases of downward-sloping demand. The Law of Demand rules out demand curves that have an upward slope.

The Law of Demand is an empirical claim—a claim about what actually happens. It is not a claim about general theoretical principles. It is theoretically possible that a demand curve could slope upward. However, the available empirical evidence strongly supports the Law of Demand.

Effects of Other Factors on Demand. If a demand curve shows how a price change affects the quantity demanded, holding all other factors that affect demand constant, how can we use demand curves to show the effects of a change in one of these other factors, such as income? One approach is to draw the demand curve in a three-dimensional diagram with the price of coffee on one axis, income on a second axis, and the quantity of coffee on the third axis. But just thinking about drawing such a diagram probably makes your head hurt.

Economists use a simpler approach to show the effect of factors other than a good's own price on demand. A change in any relevant factor other than the price of the good causes a *shift of the demand curve* rather than a *movement along the demand curve*. We illustrate such a shift in Figure 2.2. This figure shows that the coffee demand curve shifts *to the right* from the original demand curve D^1 to a new demand curve D^2 if average annual household income in high-income countries, which consume most of the world's coffee, increases by $15,000 from $35,000 to $50,000. On the new demand curve, D^2, consumers demand more coffee at any given price than on D^1 because income has risen, encouraging consumers to buy more coffee. At a price of $2 per lb, the quantity of coffee demanded goes from 10 million tons on D^1, before the increase in income, to 11.5 million tons on D^2, after the increase.

The prices of related goods—substitutes and complements—also affect the quantity of coffee demanded. Consumers who view tea and coffee as substitutes demand more coffee at any given price of coffee as the price of tea rises. That is, their demand curve for coffee shifts to the right.

Complements have the opposite effect. Consumers who view sugar and coffee as complements demand less coffee at any given price of coffee as the price of sugar rises. That is, their demand curve for coffee shifts to the left.

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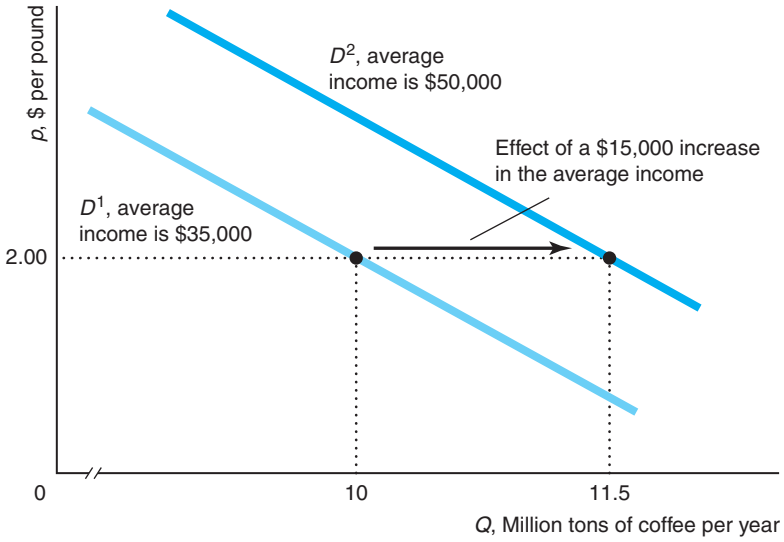
[4]From now on, we will not state the physical and time period measures unless they are particularly relevant. Thus, we say that the price is $2 (with the "per lb" understood) and the quantity is 10 (with the "million tons per year" understood).

FIGURE 2.2 A Shift of the Demand Curve

The global demand curve for coffee shifts to the right from D^1 to D^2 as average annual household income in high-income countries rises by $15,000, from $35,000 to $50,000. As a result of the increase in income, more coffee is demanded at any given price.



In addition, changes in other factors that affect demand, such as information, can shift a demand curve. Reinstein and Snyder (2005) found that movie reviews affect the demand for some types of movies, but not others. Holding price constant, they determined that if a film received "two-thumbs-up" reviews on a popular movie-review television program, the opening weekend demand curve shifted to the right by 25% for a drama, but the demand curve did not significantly shift for an action film or a comedy.

To properly analyze the effects of a change in some variable on the quantity demanded, we must distinguish between a *movement along a demand curve* and a *shift of a demand curve*. A change in the *good's own price* causes a *movement along a demand curve*. A change in *any other relevant factor besides the good's own price* causes a *shift of the demand curve*.

The Demand Function

The demand curve shows the relationship between the quantity demanded and a good's own price, holding other relevant factors constant at some particular levels. We illustrate the effect of a change in one of these other relevant factors by shifting the demand curve. We can also represent the same information—information about how price, income, and other variables affect quantity demanded—using a mathematical relationship called the *demand function*. The demand function shows the effect of a good's own price *and* other relevant factors on the quantity demanded. Any factors not explicitly listed in the demand function are assumed to be irrelevant or held constant. For example, we could specify the demand for coffee as a function of the price of coffee, income, the price of tea, the price of sugar, the prices of other related goods, and possibly other factors as well. However, if we hold all potentially relevant factors except the price of coffee and income constant, the demand function is

$$Q = D(p, Y), \tag{2.1}$$

where Q is the quantity of coffee demanded, D is the demand function, p is the price of coffee, and Y is income. This expression shows how the quantity of coffee demanded varies with the price of coffee and the income of consumers.

Equation 2.1 is a general functional form—it does not specify a particular form for the relationship between quantity, Q, and the explanatory variables, p and Y. The estimated demand function that corresponds to the demand curve D^1 in Figures 2.1 and 2.2 has the specific (linear) form

$$Q = 8.5 - p + 0.1Y, \tag{2.2}$$

where Q is the quantity of coffee in millions of tons per year, p is the price of coffee in dollars per lb, and Y is the average annual household income in high-income countries in thousands of dollars.

When we draw the demand curve D^1 in Figures 2.1 and 2.2, we set Y at a specific value, $Y = 35$ ($35,000) per year. If we substitute this value for Y in Equation 2.2, we can rewrite the quantity demanded as a function of only the price of coffee:

$$\begin{aligned} Q &= 8.5 - p + 0.1Y \\ &= 8.5 - p + (0.1 \times 35) \\ &= 12 - p. \end{aligned} \tag{2.3}$$

The demand function in Equation 2.3 corresponds to the straight-line demand curve D^1 in Figure 2.1 with $Y = 35$. The constant term, 12, in Equation 2.3 is the quantity demanded (in millions of tons per year) if the price is zero. Setting the price equal to zero in Equation 2.3, we find that the quantity demanded is $Q = 12 - 0 = 12$. Figure 2.1 shows that $Q = 12$ where D^1 hits the quantity axis—where price is zero.

Equation 2.3 also shows us how quantity demanded varies with a change in price: a movement *along* the demand curve. If the price falls from p_1 to p_2, the change in price, Δp, equals $p_2 - p_1$. (The Δ symbol, the Greek letter delta, means "change in" the variable following the delta, so Δp is the "change in the price.") If the price of coffee falls from $p_1 = \$4$ to $p_2 = \$2$, then $\Delta p = \$2 - \$4 = -\$2$. Quantity demanded changes from $Q_1 = 8$ at a price of \$4 to $Q_2 = 10$ at a price of \$2, so $\Delta Q = Q_2 - Q_1 = 10 - 8 = 2$ million tons per year, as Figure 2.1 shows.

More generally, the quantity demanded at p_1 is $Q_1 = D(p_1)$, and the quantity demanded at p_2 is $Q_2 = D(p_2)$. The change in the quantity demanded, $\Delta Q = Q_2 - Q_1$, in response to the price change (using Equation 2.3) is

$$\begin{aligned} \Delta Q &= Q_2 - Q_1 \\ &= D(p_2) - D(p_1) \\ &= (12 - p_2) - (12 - p_1) \\ &= -(p_2 - p_1) \\ &= -\Delta p. \end{aligned}$$

Thus, the change in the quantity demanded, ΔQ, is $-\Delta p$ in this case.

For example, if $\Delta p = -\$2$, then $\Delta Q = -1\Delta p = -1(-2) = 2$. That is, a \$2 decrease in price causes the quantity demanded to rise by 2 million tons per year. The change in quantity demanded is positive—the quantity demanded increases—when the price falls. This effect is consistent with the Law of Demand. Similarly, raising the price would cause the quantity demanded to fall.

Using Calculus

Deriving the Slope of a Demand Curve

We can determine how the quantity changes as the price increases using calculus. Given the demand function for coffee of $Q = 12 - p$, the derivative of the demand function with respect to price is $dQ/dp = -1$. Therefore, the slope of the demand curve in Figure 2.1, which is $dp/dQ = 1/(dQ/dp)$, is also -1. More generally, the Law of Demand states that the derivative of the demand function with respect to price is negative, $dQ/dp < 0$.

Summing Demand Curves

The overall demand for coffee is composed of the demand of many individual consumers. If we know the demand curve for each of two consumers, how do we determine the total demand curve for the two consumers combined? The total quantity demanded *at a given price* is the sum of the quantity each consumer demands at that price.

We can use individual demand functions to determine the total demand of several consumers. Suppose that the demand function for Consumer 1 is

$$Q_1 = D^1(p)$$

and the demand function for Consumer 2 is

$$Q_2 = D^2(p).$$

At price p, Consumer 1 demands Q_1 units, Consumer 2 demands Q_2 units, and the total quantity demanded by both consumers is the sum of these two quantities:

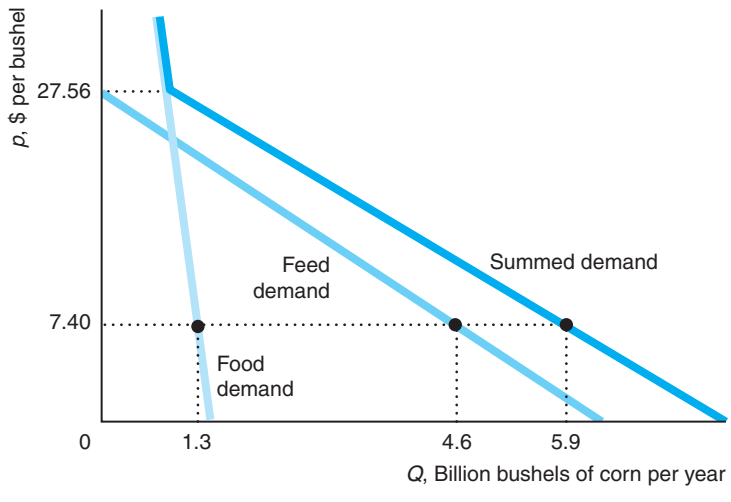
$$Q = Q_1 + Q_2 = D^1(p) + D^2(p).$$

We can generalize this approach to look at the total demand for three, four, or more consumers, or we can apply it to groups of consumers rather than just to individuals. It makes sense to add the quantities demanded only when all consumers face the same price. Adding the quantity Consumer 1 demands at one price to the quantity Consumer 2 demands at another price would not be meaningful for this purpose—the result would not show us a point on the combined demand curve.

Mini-Case

Summing Corn Demand Curves

We illustrate how to sum individual demand curves to get a summed or combined demand curve graphically using estimated demand curves for corn (McPhail & Babcock, 2012). The figure shows the U.S. feed demand (the use of corn to feed animals) curve, the U.S. food demand curve, and the summed demand curve from these two sources.[5]



[5]For graphical simplicity, we do not show the other major sources of U.S. demand for corn: export, storage, and use in biofuels (ethanol). Thus, this summed demand curve is not the total demand curve for corn.

To derive the sum of the quantity demanded for these two uses at a given price, we add the quantities from the individual demand curves at that price. That is, we add the demand curves horizontally. At the 2012 average price for corn, \$7.40, the quantity demanded for food is 1.3 billion bushels per year and the quantity demanded for feed is 4.6 billion bushels. Thus, the summed quantity demanded at that price is $Q = 1.3 + 4.6 = 5.9$ billion bushels.

When the price of corn exceeds \$27.56 per bushel, farmers stop using corn for animal feed, so the quantity demanded for this use equals zero. As a result, the summed demand curve is the same as the food demand curve at prices above \$27.56.

2.2 Supply

Knowing how much consumers want to buy at any given price is not enough by itself to tell us the market price and quantity. We also need to know how much firms want to supply at any given price. Firms determine how much of a good to supply given the price of that good and other factors, including the costs of producing the good. Usually, we expect firms to supply more at a higher price. Before concentrating on the role of price in determining supply, we describe the role of some other factors.

Costs of production (how much the firm pays for factors of production such as labor, fuel, and machinery) affect how much of a product firms want to sell. As a firm's cost falls, it is usually willing to supply more, holding price and other factors constant. Conversely, a cost increase will often reduce a firm's willingness to produce. If the firm's cost exceeds what it can earn from selling the good, the firm will produce nothing. Thus, factors that affect costs also affect supply. If a *technological advance* allows a firm to produce its good at lower cost, the firm supplies more of that good at any given price, holding other factors constant.

Government rules and regulations can also affect supply directly without working through costs. For example, in some parts of the world, retailers may not sell most goods and services on particular days of religious significance. Supply on those days is constrained by government policy to be zero.

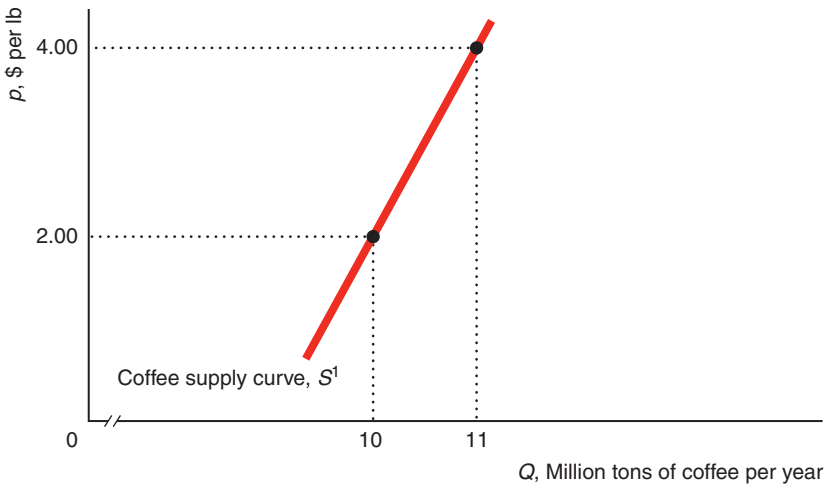
The Supply Curve

The **quantity supplied** is the amount of a good that firms *want* to sell at a given price, holding constant other factors that influence firms' supply decisions, such as costs and government actions. We can show the relationship between price and the quantity supplied graphically. A **supply curve** shows the quantity supplied at each possible price, holding constant the other factors that influence firms' supply decisions. Figure 2.3 shows the estimated supply curve, S^1, for coffee. As with the demand curve, the price on the vertical axis is measured in dollars per physical unit (dollars per lb), and the quantity on the horizontal axis is measured in physical units per period (millions of tons per year). Because we hold fixed other variables that may affect supply, the supply curve concisely answers the question "What happens to the quantity supplied as the price changes, holding all other relevant factors constant?"

Effects of Price on Supply. We illustrate how price affects the quantity supplied using the supply curve for coffee in Figure 2.3. The supply curve is upward sloping. As the price increases, firms supply more. If the price is \$2 per lb, the

FIGURE 2.3 A Supply Curve

The estimated supply curve, S^1, for coffee shows the relationship between the quantity supplied per year and the price per lb, holding constant cost and other factors that influence supply. The upward slope of this supply curve indicates that firms supply more coffee when its price is high and less when the price is low. An increase in the price of coffee causes firms to supply a larger quantity of coffee; any change in price results in a movement *along the supply curve*.



quantity supplied by the market is 10 million tons per year. If the price rises to $4, the quantity supplied rises to 11 million tons. An increase in the price of coffee causes a *movement along the supply curve*: firms supply more coffee.

Although the Law of Demand states that the demand curve slope downward, *no* corresponding "Law of Supply" states that the supply curve must slope in a particular way. We observe supply curves that are vertical, horizontal, or downward sloping in particular situations. However, supply curves are commonly upward sloping. Accordingly, if we lack specific information about the slope, we usually draw upward-sloping supply curves. Along an upward-sloping supply curve, the higher the price, the larger the quantity that firms supply, holding other factors constant.

Effects of Other Variables on Supply. A change in a relevant variable other than the good's own price causes the entire *supply curve to shift*. One such variable is the price of cocoa (which is a major component in chocolate). The land on which coffee is grown can also grow cocoa. When the price of cocoa rises, many coffee farmers switch to producing cocoa. Therefore, when the price of cocoa rises, the amount of coffee produced at any given price for coffee falls.

In Figure 2.4, when the cocoa price increases from $3 per lb to $6 per lb, the supply curve for coffee shifts leftward from S^1 to S^2. At a price of $2 per lb for coffee, the quantity supplied falls from 10 million tons on S^1 to 9.4 million tons on S^2.

It is important to distinguish between a *movement along a supply curve* and a *shift of the supply curve*. When the price of coffee changes, the change in the quantity supplied reflects a *movement along the supply curve*. When the price of cocoa or other variables that affect supply change, the entire *supply curve shifts*.

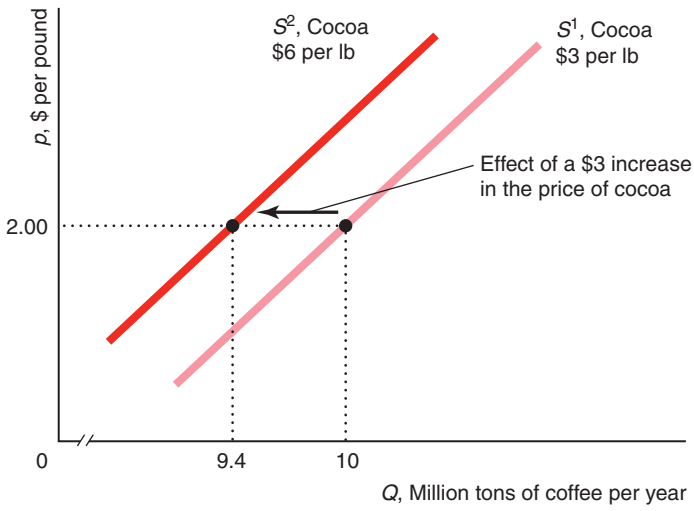
The Supply Function

We can write the relationship between the quantity supplied and price and other factors as a mathematical relationship called the *supply function*. Using a general functional form, we can write the coffee supply function, S, as

$$Q = S(p, p_c), \tag{2.4}$$

FIGURE 2.4 A Shift of a Supply Curve

A $3 per lb increase in the price of cocoa, which farmers can grow instead of coffee, causes the supply curve for coffee to shift leftward from S^1 to S^2. At a coffee price of $2 per lb, the quantity supplied falls from 10 on S^1 to 9.4 on S^2.



where Q is the quantity of coffee supplied, p is the price of coffee, and p_c is the price of cocoa. The supply function, Equation 2.4, might also incorporate other factors such as wages, transportation costs, and the state of technology, but by leaving them out, we are implicitly holding them constant.

Our estimated supply function for coffee is

$$Q = 9.6 + 0.5p - 0.2p_c, \tag{2.5}$$

where Q is the quantity in millions of tons per year, p is the price of coffee in dollars per lb, and p_c is the price of cocoa in dollars per lb. If we hold the cocoa price fixed at $3 per lb, we can rewrite the supply function in Equation 2.5 as solely a function of the coffee price. Substituting $p_c = \$3$ into Equation 2.5, we find that

$$Q = 9.6 + 0.5p - (0.2 \times 3) = 9 + 0.5p. \tag{2.6}$$

What happens to the quantity supplied if the price of coffee increases by $\Delta p = p_2 - p_1$? As the price increases from p_1 to p_2, the quantity supplied goes from Q_1 to Q_2, so the change in quantity supplied is

$$\Delta Q = Q_2 - Q_1 = (9 + 0.5p_2) - (9 + 0.5p_1) = 0.5(p_2 - p_1) = 0.5\Delta p.$$

Thus, a $1 increase in price ($\Delta p = 1$) causes the quantity supplied to increase by $\Delta Q = 0.5$ million tons per year. This change in the quantity of coffee supplied as p increases is a *movement along the supply curve*.

Summing Supply Curves

The total supply curve shows the total quantity produced by all suppliers at each possible price. The overall amount of coffee supplied at any given price is the sum of the quantity supplied by Brazilian, Vietnamese, Colombian, and other producers in various countries.

2.3 Market Equilibrium

The supply and demand curves jointly determine the price and quantity at which a good or service is bought and sold. The demand curve shows the quantities consumers want to buy at various prices, and the supply curve shows the quantities firms want to sell at various prices. Unless firms set the price so that consumers want to buy exactly the same amount that suppliers want to sell, some consumers cannot buy as much as they want or some sellers cannot sell as much as they want.

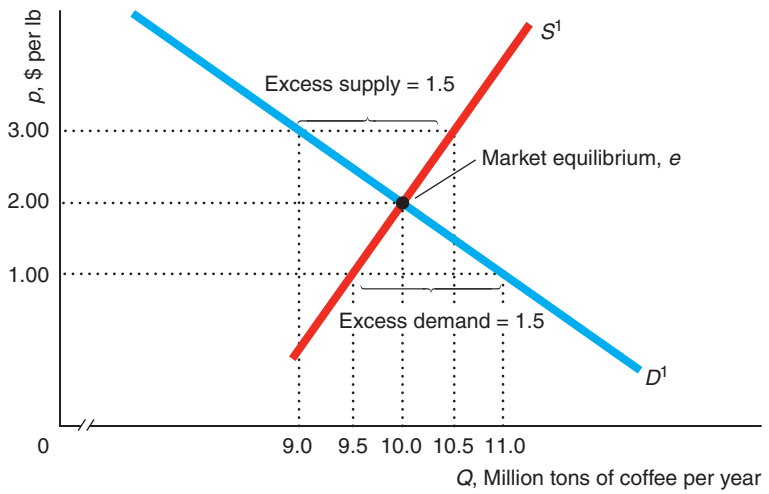
When all market participants are able to buy or sell as much as they want, we say that the market is in **equilibrium**: a situation in which no participant wants to change its behavior. A price at which consumers can buy as much as they want and sellers can sell as much as they want is the *equilibrium price*. At this price, the quantity demanded equals the quantity supplied. This quantity is the *equilibrium quantity*. Thus, if the government does not intervene in the market, the supply-and-demand model is in equilibrium when the *market clears* in the sense that buyers and sellers are both able to buy or sell as much as they want at the market price—no one is frustrated and all goods that are supplied to the market are sold.

Using a Graph to Determine the Equilibrium

To illustrate how supply and demand curves determine the equilibrium price and quantity, we use the coffee example. Figure 2.5 shows the supply curve, S^1, and demand curve, D^1, for coffee. The supply and demand curves intersect at point e, the market equilibrium. The equilibrium price is \$2 per lb, and the equilibrium quantity is 10 million tons per year, which is the quantity firms want to sell *and* the quantity consumers want to buy.

FIGURE 2.5 Market Equilibrium

The intersection of the supply curve, S^1, and the demand curve, D^1, for coffee determines the market equilibrium point, e, where $p = \$2$ per lb and $Q = 10$ million tons per year. At the lower price of $p = \$1$, the quantity demanded is 11, but the quantity supplied is only 9.5, so the excess demand is 1.5. At $p = \$3$, the price exceeds the equilibrium price. As a result, the market has an excess supply of 1.5 because the quantity demanded, 9, is less than the quantity supplied, 10.5. With either excess demand or excess supply, market forces drive the price back to the equilibrium price of \$2.



Using Algebra to Determine the Equilibrium

We can determine the coffee equilibrium mathematically, using supply and demand functions that correspond to the supply and demand curves. We use these two equations to solve for the equilibrium price at which the quantity demanded equals the quantity supplied (the equilibrium quantity). The demand function Equation 2.3 is the relationship between the quantity demanded, Q_d, and the price:[6]

$$Q_d = 12 - p.$$

The supply function Equation 2.6 is the relationship between the quantity supplied, Q_s, and the price:

$$Q_s = 9 + 0.5p.$$

We want to find the equilibrium price, p, at which $Q_d = Q_s = Q$. Thus, we set the right sides of these two equations equal,

$$12 - p = 9 + 0.5p,$$

and solve for the price.

Adding p to both sides of this expression and subtracting 9 from both sides, we find that $3 = 1.5p$. Dividing both sides of this last expression by 1.5, we learn that the equilibrium price is $p = \$2$. We can determine the equilibrium quantity by substituting this p into either the supply function or the demand function. Using the demand function, we find that the equilibrium quantity is

$$Q = 12 - 2 = 10$$

million tons per year. We can obtain the same quantity by using the supply function:

$$Q = 9 + (0.5 \times 2) = 10.$$

Forces That Drive the Market to Equilibrium

A market equilibrium is not just an abstract concept or a theoretical possibility.[7] Economic forces cause markets to adjust to the equilibrium. At the equilibrium, price and quantity remain stable until some new event occurs that shifts the demand or supply curve.

Remarkably, an equilibrium occurs without any explicit coordination between consumers and firms. In a competitive market such as that for most agricultural products, millions of consumers and thousands of firms make their buying and selling decisions independently. Yet each firm can sell the quantity it wants at the market price and each consumer can buy the quantity he or she wants at that price. It is as though an unseen market force like an *invisible hand* (a phrase coined by Adam Smith in 1776) directs people and firms to coordinate their activities to achieve equilibrium.

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[6]Usually, we use Q to represent both the quantity demanded and the quantity supplied. However, for clarity in this discussion, we use Q_d and Q_s.

[7]MyLab Economics has games (called *experiments*) for the Managerial Economics and Strategy course. These online games allow you to play against the computer. The *Market Experiment* illustrates the operation of the supply-and-demand model, allowing you to participate in a simulated market. To play, go to MyLab Economics Multimedia Library, Single Player Experiment, and set the Chapter field to "All Chapters."

What forces cause the market to move to equilibrium? If the price is not at the equilibrium level, consumers or firms have an incentive to change their behavior in a way that will drive the price to the equilibrium level, as we now illustrate.

If the price were initially lower than the equilibrium price, consumers would want to buy more than suppliers want to sell. If the price of coffee is $1 in Figure 2.5, firms are willing to supply 9.5 million tons per year but consumers demand 11 million tons. At this price, the market is in *disequilibrium*: the quantity demanded is not equal to the quantity supplied. This market has **excess demand**—the amount by which the quantity demanded exceeds the quantity supplied at a specified price. If the price is $1 per lb, the market has an excess demand of $11 - 9.5 = 1.5$ million tons per year.

Some consumers are lucky enough to buy the coffee at $1 per lb. Other consumers cannot find anyone who is willing to sell them coffee at that price. What can they do? Some frustrated consumers may offer to pay suppliers more than $1 per lb.

Alternatively, suppliers, noticing these disappointed consumers, might raise their prices. Such actions by consumers and producers cause the market price to rise. As the price rises, the quantity that firms want to supply increases and the quantity that consumers want to buy decreases. This upward pressure on price continues until it reaches the equilibrium price, $2, which eliminates the excess demand.

If, instead, the price is initially above the equilibrium level, suppliers want to sell more than consumers want to buy. For example, at a price of $3, suppliers want to sell 10.5 million tons per year but consumers want to buy only 9 million tons, as Figure 2.5 shows. This market has an **excess supply**—the amount by which the quantity supplied exceeds the quantity demanded at a specified price—of 1.5 ($= 10.5 - 9$) million tons at a price of $3. Not all firms can sell as much as they want. Rather than allow their unsold coffee to get stale, firms lower the price to attract additional customers. As long as the price remains above the equilibrium price, some firms cannot sell as much coffee as they want, so they lower the price further. The price falls until it reaches the equilibrium level, $2, which eliminates the excess supply and hence removes the pressure to lower the price further.

Not all markets reach equilibrium through the independent actions of many buyers or sellers. In institutionalized or formal markets, such as the Chicago Mercantile Exchange—where coffee and other agricultural commodities, financial instruments, energy, and metals are traded—buyers and sellers meet at a single location (or on a single Web site). Often in these markets certain individuals or firms, sometimes referred to as *market makers*, act to adjust the price and bring the market into equilibrium very quickly.

In summary, at any price other than the equilibrium price, either consumers or suppliers are unable to trade as much as they want. These disappointed market participants act to change the price, driving the price to the equilibrium level. The equilibrium price is called the *market clearing price* because no buyers or sellers are frustrated at this price—the market eliminates or clears any excess demand or excess supply.

2.4 Shocks to the Equilibrium

Once a market achieves equilibrium, the equilibrium can persist indefinitely because no one applies pressure to change the price. The equilibrium changes only if a shock occurs that shifts the demand curve or the supply curve. These curves shift if one of the variables we were holding constant changes. If tastes, income, government policies, or costs of production change, the demand curve or the supply curve or both shift, and the equilibrium changes.

Effects of a Shift in the Demand Curve

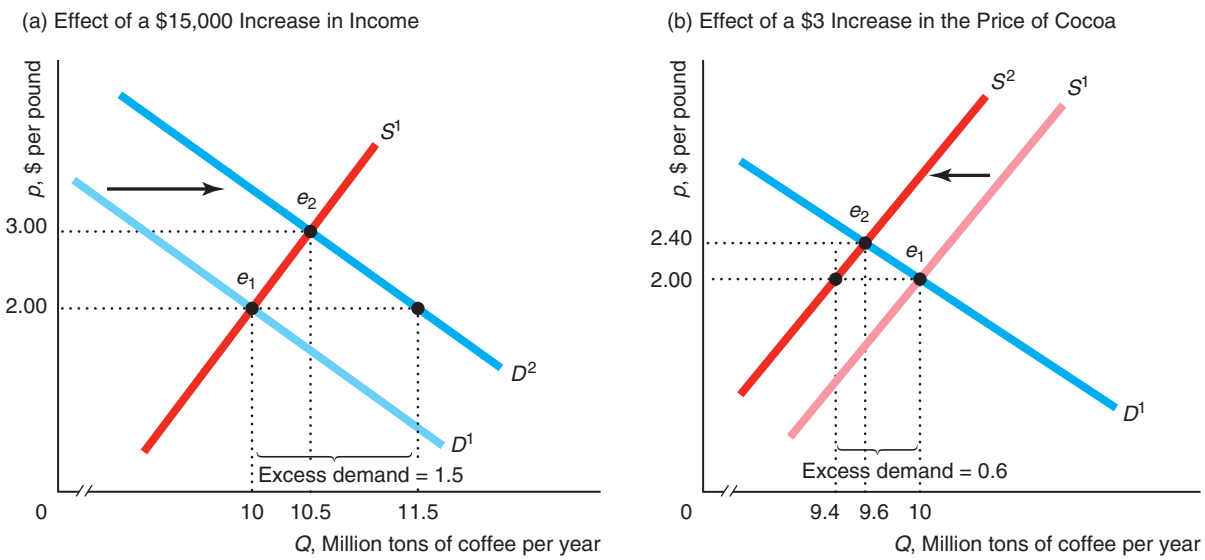
Suppose that the average income in high-income countries increases by $15,000 from $35,000 to $50,000. As a result, consumers purchase more coffee at any given price. Reflecting this change, the demand curve for coffee shifts to the right from D^1 to D^2 in panel a of Figure 2.6. At the initial equilibrium price of $2, consumers now want to purchase 11.5 million tons of coffee per year. However, at that price, suppliers want to sell only 10 million tons, so the market has an excess demand of $11.5 - 10 = 1.5$ million tons.

This excess demand creates market pressure, which drives the price up until it reaches a new equilibrium price of $3. At that price, firms want to sell 10.5 million tons and consumers want to buy 10.5 million tons, the new equilibrium quantity. The increase in income causes a *shift of the demand curve*, which in turn causes a *movement along the supply curve* from e_1 to e_2.

FIGURE 2.6 Equilibrium Effects of a Shift of a Demand or Supply Curve MyLab Economics Video

(a) A $15,000 increase in average annual household income causes the demand curve for coffee to shift to the right from D^1 to D^2. At the original equilibrium (e_1) price of $2, initially the market has excess demand of 1.5 million tons per year. Market pressures drive the price up until it reaches $3 at the new equilibrium, e_2.

(b) A $3 per pound increase in the price of cocoa causes some producers to shift from coffee production to cocoa production, reducing the quantity of coffee supplied at every price. The supply curve shifts to the left from S^1 to S^2, driving the market equilibrium from e_1 to e_2, where the new equilibrium price is $2.40.



Q&A 2.1

The estimated global supply function for coffee is $Q = 9 + 0.5p$. The estimated demand function is $Q = 8.5 - p + 0.1Y$, where Y is the average income in high-income countries in thousands of dollars. The initial income is $Y = 35$ ($35,000). Using algebra, determine the initial equilibrium price and quantity of coffee, and then determine how price and quantity change if the average income increases by 15 to $Y = 50$.

Answer

1. *Substitute the initial value of Y into the demand function to obtain quantity demanded purely as a function of p.* As we derived in Equation 2.3, if $Y = 35$, then

$$Q = 8.5 - p + 0.1Y = 8.5 - p + (0.1 \times 35) = 12 - p.$$

2. *Equate the supply and demand functions to determine the initial equilibrium.* The equilibrium price is determined by equating the right sides of these supply and demand functions:

$$9 + 0.5p = 12 - p.$$

Solving this equation for p, we find that $1.5p = 3$, or $p = \$2$. We calculate the equilibrium quantity by substituting this price into the supply or demand function: $Q = 9 + (0.5 \times 2) = 10$ or $Q = 12 - 2 = 10$ million tons per year.

3. *Repeat steps 1 and 2 using $Y = 50$ instead of $Y = 35$.* The new demand function is

$$Q = 8.5 - p + 0.1Y = 8.5 - p + (0.1 \times 50) = 13.5 - p.$$

Equating this expression to the right hand side of the supply function, we obtain $9 + 0.5p = 13.5 - p$. Solving for p, we find that $1.5p = 4.5$ or $p = \$3$. We calculate the equilibrium quantity by substituting this price into the supply or demand function: $Q = 9 + (0.5 \times 3) = 10.5$ or $Q = 13.5 - (1 \times 3) = 10.5$.

4. *Show how the equilibrium price and quantity of coffee changes by subtracting the original values from the new ones.* The change in the equilibrium price is $\Delta p = \$3 - \$2 = \$1$. The change in the equilibrium quantity is $\Delta Q = 10.5 - 10 = 0.5$ million tons per year. Panel a of Figure 2.6 illustrates these changes in the equilibrium price and quantity.

Well, there goes the price of lobsters!

Effects of a Shift in the Supply Curve

We now consider how a shift in the supply curve affects the coffee market equilibrium. Assume that income remains at its original level of $35,000 but the price of cocoa rises from $3 per lb to $6 per lb. This increase in the price of cocoa causes some coffee producers to switch to cocoa production. As a result, the supply curve for coffee shifts to the left from S^1 to S^2 in panel b of Figure 2.6. At any given price, producers want to supply less coffee than they did before the price of cocoa increased. At the original equilibrium price of coffee of $2 per lb, consumers still want 10 million tons, but producers are now willing to supply only 9.4 million tons, so the market's excess demand is 0.6 million tons. Market pressure forces the price of coffee up until the market reaches a new equilibrium at e_2, where the equilibrium price is $2.40 and the equilibrium quantity is 9.6. Here a *shift of the supply curve* results in a *movement along the demand curve*.

In summary, a change in an underlying factor, such as income, the price of a related good, land use or the cost of production shifts the demand curve or the supply curve. As a result, the equilibrium changes. To describe the effect of this change, we compare the original equilibrium price and quantity to the new equilibrium values.

Managerial Implication

Taking Advantage of Future Shocks

Managers with foresight can use the supply and demand model to anticipate how shocks to supply or demand will affect future business conditions and take advantage of that knowledge. For example, Mars, one of the world's largest producers of chocolate products, is often among the first companies to learn about events that affect cocoa production, most of which occurs in Africa. Using their cocoa supply and demand model, Mars managers (called *Martians*) predict how much prices will change in the near future. If they expect prices to increase substantially, they immediately buy a great deal of cocoa at relatively low prices directly from suppliers in Africa. Alternatively, if they expect prices to fall, they may hold off buying now and then buy later at a lower price from organized markets such as ICE Futures U.S. or the London International Financial Futures and Options Exchange.

Effects of Shifts in both Supply and Demand Curves

Some events cause both the supply curve and the demand curve to shift. If both shift, then the qualitative effect on the equilibrium price and quantity may be difficult to predict, even if we know the direction in which each curve shifts. Changes in the equilibrium price and quantity depend on exactly how much the curves shift, as the following Mini-Case and Q&A illustrate.

Mini-Case

Genetically Modified Foods

A genetically modified (GM) food has had its DNA altered through genetic engineering rather than through conventional breeding. The introduction of GM techniques can affect both the supply and demand curves for a crop.

The first commercial GM food was Calgene's Flavr Savr tomato that resisted rotting, which the company claimed would enable it to stay on the vine longer to ripen to full flavor. It was first marketed in 1994 without any special labeling. Other common GM crops include canola, corn, cotton, rice, soybean, and sugar cane. Using GM seeds, farmers can produce more output at a given cost. At least 29 countries grow GM food crops, which are mostly herbicide-resistant varieties of maize, soy, and oilseed. As of 2015, the largest producers of GM food crops were (in order) the United States, Brazil, Argentina, Canada, and China.

Some scientists and consumer groups have raised safety concerns about GM crops, and these concerns have been particularly influential in Europe. Farmers in the European Union (EU) produce very few GM crops, devoting only 0.1% of their cultivable land to them, due to very restrictive government regulation. In 2015, the EU instituted new rules allowing member states to ban cultivation of particular GM crops even if the EU has approved them.

Sixty-four nations—including those in the EU, Australia, Brazil, China, Japan, and Russia—require the labeling of GM foods. In contrast, the United States does not require labeling.

Prior to 2008 the EU had a de facto ban on imports of GM foods, but in 2008 the World Trade Organization (WTO) forced the EU to end this de facto ban on the basis that it lacked scientific merit and hence violated international trade rules. According to some polls, 70% of consumers in Europe object to GM foods. Fears cause some consumers to refuse to buy a GM crop (or the entire crop if consumers cannot distinguish GM products). Consumers in other countries, such as the United States, are less concerned about GM foods. However, even in the United States, a 2015 poll found that 57% of consumers believe that GM foods are generally unsafe to eat, whereas 88% of scientists believe they are generally safe.

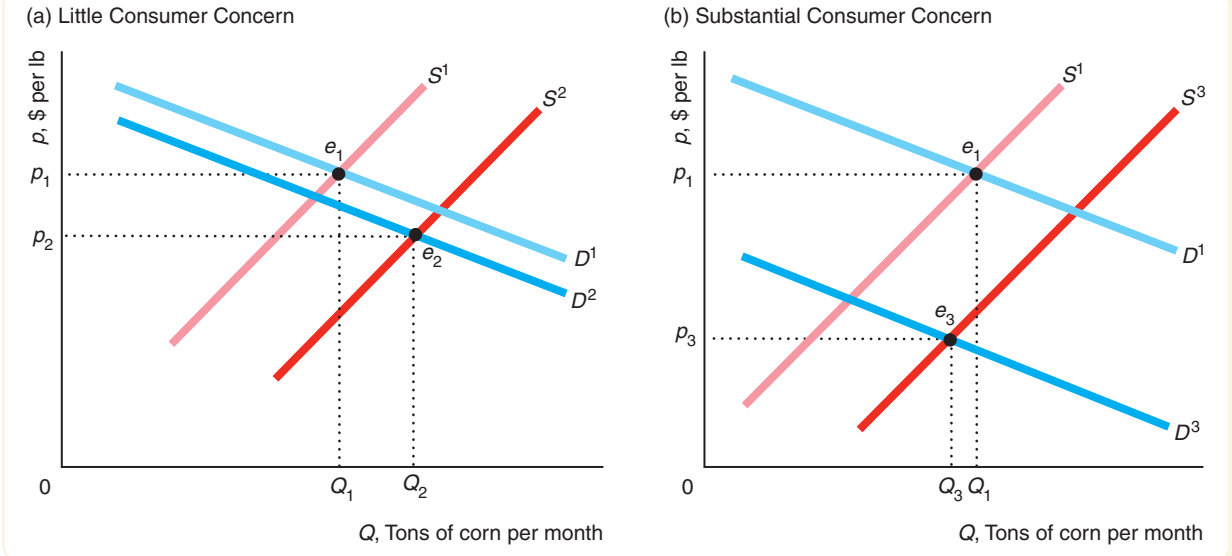
Q&A 2.2

MyLab Economics Q&A

When they became available, StarLink and other GM corn seeds caused the supply curve for the corn used for animal feed to shift to the right. If consumer concerns cause the demand curve for corn to shift to the left, how will the before-GM equilibrium compare to the after-GM equilibrium? Consider the possibility that the demand curve may shift only slightly in some countries but substantially in others.

Answer

1. *Determine the original equilibrium.* The original equilibrium, e_1, occurs where the before-GM supply curve, S^1, intersects the before-GM demand curve, D^1, at price p_1 and quantity Q_1. Both panels a and b of the figure show the same equilibrium.
2. *Determine the new equilibrium*. After the introduction of GM seeds, the new supply curve, S^2, lies to the right of S^1 in both panels. In panel a, the new demand curve, D^2, lies only slightly to the left of D^1, while in panel b, D^3 lies substantially to the left of D^1. In panel a, the new equilibrium e_2 is determined by the intersection of S^2 and D^2. In panel b, the new equilibrium e_3 reflects the intersection of S^3 and D^3.
3. *Compare the before-GM equilibrium to the after-GM equilibrium*. In both panels, the equilibrium price falls from p_1 to either p_2 or p_3.The equilibrium quantity rises from Q_1 to Q_2 in panel a, but falls from Q_1 to Q_3 in panel b.
4. *Comment*. When both curves shift, we cannot predict the direction of change of both the equilibrium price and quantity without knowing how much each curve shifts. Whether a country's growers adopt GM seeds depends crucially on consumer resistance to these new products.



2.5 Effects of Government Interventions

Often governments are responsible for changes in market equilibrium. We examine three types of government policies. First, some government actions shift the supply curve, the demand curve, or both curves, which causes the equilibrium to change. Second, the government may use price controls that cause the quantity demanded to differ from the quantity supplied. Third, the government may tax or subsidize a good, which results in a gap between the price consumers pay and the amount sellers receive.

Policies That Shift Curves

Government policies may cause demand or supply curves to shift. Many governments limit who can buy goods. For example, many governments forbid selling alcohol to young people, which decreases the quantity demanded at each price and thereby shifts the demand curve to the left. Similarly, a government may restrict the amounts of foreign products that can be imported, which decreases the quantity supplied of imported goods at each price and shifts the importing country's supply curve to the left. Or, the government could start buying a good, which increases the quantity demanded at each price for the good and shifts the demand curve to the right.

Mini-Case

Occupational Licensing

In the United States, in many occupations, working without a license is illegal. More than 800 occupations require licensing at the local, state, or federal level, including animal trainers, dietitians and nutritionists, doctors, electricians, embalmers, funeral directors, hairdressers, librarians, nurses, psychologists, real estate brokers, respiratory therapists, and teachers (but not economists).

During the early 1950s, fewer than 5% of U.S. workers were in occupations covered by licensing laws at the state level. Since then, the share of licensed workers has grown, reaching nearly 18% by the 1980s, at least 20% in 2000, and 29% in 2008. During the 2012–2013 legislative sessions, at least seven occupations were newly licensed in at least one state, including scrap metal recyclers in Louisiana and body artists in the District of Columbia (Kleiner, 2015). Licensing is more common in occupations that require extensive education: More than 40% of workers with post-college education are required to have a license compared to only 15% of those with less than a high school education.

A worker must pass a test to get a license in some occupations. Frequently, licensed members of the occupation design these tests. By making the exam difficult, current workers can limit entry. For example, only 46% of people taking the California State Bar Examination in February 2014 passed it, although all of them had law degrees. (The national rate for lawyers passing state bar exams in February 2014 was higher, but still only 57%.)

To the degree that testing is objective, licensing may raise the average quality of the workforce. However, it restricts the number of workers in an occupation, which affects wages. To analyze the wage effect of licensing, we can use a graph similar to panel b of Figure 2.6, where the wage is on the vertical axis and the number of workers per year is on the horizontal axis. Licensing shifts the occupational supply curve to the left, reducing the equilibrium quantity of workers and raising the wage. Kleiner and Krueger (2013) found that licensing raises occupational wages by 18%. Kleiner and Park (2014) reported that licensing electricians raised their wages by 12% and that certain other licensing requirements (such as in education) raised the wage by an additional 6% to 8%.

Price Controls

Government policies that directly control the price of a good may alter the market outcome even though they do not affect the demand or supply curves of the good. Such a policy may lead to excess supply or excess demand if the price the government sets differs from the unregulated equilibrium price. We illustrate this result with two types of price control programs. When the government sets a *price ceiling* at $\overline{p}$, no goods may be sold at a price higher than $\overline{p}$. When the government sets a *price floor* at $\underline{p}$, no goods may be sold at a price below $\underline{p}$.[8]

Price Ceilings. Price ceilings have no effect if they are set above the equilibrium price that would be observed in the absence of the price controls. If the government says that firms may charge no more than $\overline{p} = \$6$ per gallon of gas and firms are actually charging $p = \$4$, the government's price control policy is irrelevant. However, if the unregulated equilibrium price, p, were above the price ceiling $\overline{p}$, the price that is actually observed in the market is the price ceiling. For example, if the equilibrium price of gas were \$4 and a price ceiling of \$3 is imposed, then the ceiling price of \$3 is charged.

[8]MyLab Economics has a *Price Floors Experiment* and a *Price Ceilings Experiment* that illustrate the operation of price controls. To participate go to the MyLab Economics Multimedia Library, Single Player Experiment, and set the Chapter field to "All Chapters."

Currently, Canada and many European countries set price ceilings on pharmaceuticals. The United States used price ceilings during both world wars, the Korean War, and in 1971–1973 during the Nixon administration, among other times. Hawaii limited the price of wholesale gasoline from 2005–2006. New Jersey has a state law that prohibits raising prices by more than 10% within 30 days of a declared state of emergency. In the aftermath of Hurricane Sandy in 2012 many businesses received fines as a result of this law.

The U.S. experience with gasoline illustrates the effects of price controls. In the 1970s, the Organization of Petroleum Exporting Countries (OPEC) reduced supplies of crude oil (which is converted into gasoline) to Western countries. As a result, the total supply curve for gasoline in the United States shifted to the left from S^1 to S^2 in Figure 2.7. Because of this shift, the equilibrium price of gasoline would have risen substantially, from p_1 to p_2. In an attempt to protect consumers by keeping gasoline prices from rising, the U.S. government set price ceilings on gasoline in 1973 and 1979.

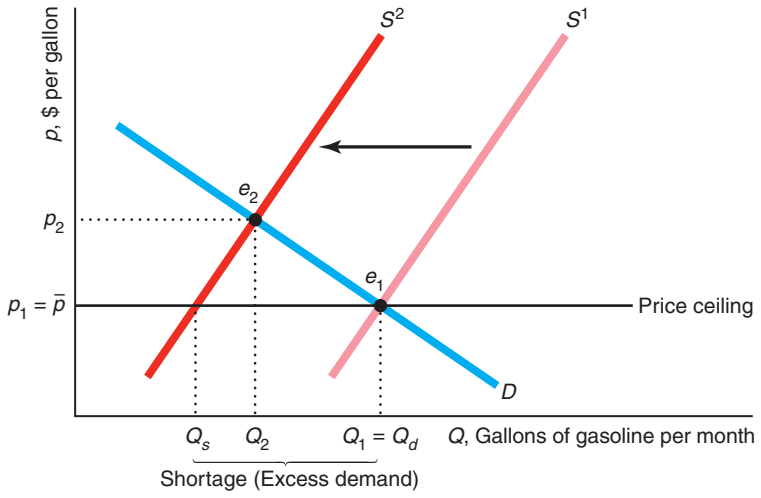
The government told gas stations that they could charge no more than $p_1 = \overline{p}$. Figure 2.7 shows the price ceiling as a solid horizontal line extending from the price axis at $\overline{p}$. The price control is binding because $p_2 > \overline{p}$. The observed price is the price ceiling. At $\overline{p}$, consumers *want* to buy $Q_d = Q_1$ gallons of gasoline, which is the equilibrium quantity they bought before OPEC acted. However, firms supply only Q_s, which is determined by the intersection of the price control line with S^2. The binding price control resulted in excess demand of $Q_d - Q_s$.

Were it not for the price controls, market forces would drive up the market price to p_2, the price at which the excess demand would be eliminated. The government price ceiling prevents this adjustment from occurring. As a result, an enforced price ceiling causes a **shortage**: a persistent excess demand.

At the time of the controls, some government officials argued that the shortages were the result of OPEC's cutting off its supply of oil to the United States, but that's not true. Without the price controls, the new equilibrium would be e_2. In this

FIGURE 2.7 A Price Ceiling on Gasoline MyLab Economics Video

Restrictions on crude oil production (the major input in producing gasoline) cause the supply curve of gasoline to shift from S^1 to S^2. In an unregulated market, the equilibrium price would increase to p_2 and the equilibrium quantity would fall to Q_2. Suppose that the government imposes a price control so that gasoline stations may not charge a price above the price ceiling, $p_1 = \overline{p}$. At this price, producers are willing to supply only Q_s, which is less than the amount $Q_1 = Q_d$ that consumers want to buy. The result is excessive demand, or a shortage of gasoline of $Q_d - Q_s$.



equilibrium, the price, p_2, is much higher than before, p_1, but it eliminates the shortage. Moreover, without controls, the quantity sold, Q_2, is greater than the quantity sold under the control program, Q_s.

With a binding price ceiling, the supply-and-demand model predicts an *equilibrium with a shortage*. In this equilibrium, the quantity demanded does not equal the quantity supplied. The reason that we call this situation an equilibrium, even though a shortage exists, is that buyers and sellers who abide by the law do not change their behavior. Without the price controls, consumers facing a shortage would try to get more output by offering to pay more, or firms would raise prices. With effective government price controls, both firms and consumers know that they can't drive up the price, so they live with the shortage.

What happens? Some lucky consumers get to buy Q_s units at the low price of $\overline{p}$. Other potential customers are disappointed: They would like to buy at that price, but they cannot find anyone willing to sell gas to them. In addition, consumers spend a lot of time waiting in line—a pure waste that adds considerably to the cost of such government interventions.

What determines which consumers are lucky enough to find goods to buy at the low price with price controls? With enforced price controls, sellers use criteria other than price to allocate the scarce commodity. Firms may supply their friends, long-term customers, or people of a certain race, gender, age, or religion. They may sell their goods on a first-come, first-served basis. Or they may limit everyone to only a few gallons.

Another possibility is that firms and customers will try to evade the price controls. A consumer could go to a gas station owner and say, "Let's not tell anyone, but I'll pay you twice the price the government sets if you'll sell me as much gas as I want." If enough customers and gas station owners behaved that way, no shortage would occur. However, in cities such as Chicago, Hartford, New York, Portland, and Tucson, potential customers waited in line at the pump for an hour or more.[9] Deacon and Sonstelie (1989) estimated that for every dollar consumers saved due to the 1979 gasoline price controls, they lost $1.16 in waiting time and other factors.

Mini-Case

Venezuelan Price Ceilings and Shortages

Venezuela is one of the richest countries in Latin America. It is a leading oil producer, and it has many other agricultural and nonagricultural industries.

So why do people start lining up to buy groceries in Venezuela at 4 AM, when shops open at 8 AM? Strict price ceilings on food and other goods create shortages throughout the country.

One survey found that powdered milk, a staple in Venezuela, was unavailable in 42% of the stores visited. Liquid milk was even scarcer. One estimate put the shortage of wheat flour at 60% of the quantity demanded. According to Venezuela's central bank, 28% of products were unavailable in shops in 2014, an all-time high. In 2015, Venezuelans were particularly vexed by condom, birth control pill, and toilet paper shortages.

One would think that Venezuela should be able to supply its citizens with coffee, which it has been producing in abundance for centuries. Indeed, Venezuela exported coffee until 2009. However, since then, it has been importing large amounts of coffee to compensate for a drop in production. Why have farmers and coffee roasters cut production? Due to low retail price ceilings, they would have to produce at a loss.

[9]See MyLab Economics Chapter Resources, Chapter 2, "Gas Lines," for a discussion of the effects of the 1973 and 1979 gasoline price controls.

Because Venezuela regulates the prices of many goods such as gasoline and corn flour while Colombia, its direct neighbor to the west, does not, smuggling occurs. Given that gasoline sells for less than 1¢ a gallon in Venezuela, and the price is $2 a gallon in most of Colombia, the temptation to smuggle is great. Venezuela's Táchira state is adjacent to the Colombian border. Its government says that as much as 40% of the food sent to Táchira is smuggled into Colombia. Why sell corn flour at an artificially low price in Venezuela if you can sell it at a higher, market price in Colombia?

Venezuela's populist President Hugo Chávez and his handpicked successor, Nicolas Maduro, imposed strict price ceilings, purportedly to rein in inflation and make the goods more affordable for the poor. Do the ceilings help the poor?

For many Venezuelans, the answer is "No!" As Nery Reyes, a restaurant worker, said, "Venezuela is too rich a country to have this. I'm wasting my day here standing in line to buy one chicken and some rice."[10]

Recently, demonstrators have taken to the streets to protest persistent economic and social problems, including shortages. Many died in these violent clashes with the National Guard, including a student beauty queen who had been crowned Miss Tourism for the state of Carabobo.

The ultimate irony was that President Nicolas Maduro advised Venezuelans to consume less to alleviate the shortages.

Price Floors. Governments also commonly use price floors. One of the most important examples of a price floor is a minimum wage in a labor market. A minimum wage law forbids employers from paying less than the minimum wage, $\underline{w}$.

Minimum wage laws date from 1894 in New Zealand, 1909 in the United Kingdom, and 1912 in Massachusetts. The Fair Labor Standards Act of 1938 set a federal U.S. minimum wage of 25¢ per hour. The U.S. federal minimum hourly wage rose to $7.25 in 2009 and remained at that level through early 2015, but 29 states and a number of cities set higher minimum wages.[11] The minimum wage in Canada differs across provinces, ranging from C$10.20 to C$11.25 (where C$ stands for Canadian dollars) in 2015. If the minimum wage is *binding*—that is, if it exceeds the equilibrium wage, w^*—it creates *unemployment*: a persistent excess supply of labor.

We illustrate the effect of a minimum wage law in a labor market in which everyone is paid the same wage. Figure 2.8 shows the supply and demand curves for labor services (hours worked). Firms buy hours of labor service by hiring workers. The horizontal axis shows the quantity of hours worked per year, and the vertical axis shows the hourly wage, which is the price of labor hours.

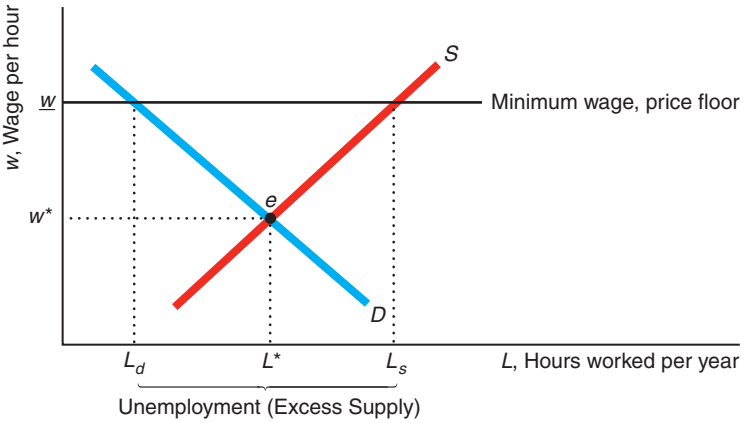
With no government intervention, the market equilibrium is e, where the wage is w^* and the number of hours worked is L^*. The minimum wage creates a price floor, a

[10]William Neuman, "With Venezuelan Food Shortages, Some Blame Price Controls," *New York Times*, April 20, 2012.

[11]See **http://www.dol.gov/** for U.S. state and federal minimum wages. See **http://www.fedee.com/pay-job-evaluation/minimum-wage-rates/** for minimum wages in European countries.

FIGURE 2.8 The Minimum Wage: A Price Floor

In the absence of a minimum wage, the equilibrium wage is w^* and the equilibrium number of hours worked is L^*. A minimum wage, $\underline{w}$, set above w^*, leads to unemployment—persistent excess supply—because the quantity demanded, L_d, is less than the quantity supplied, L_s.



horizontal line, at $\underline{w}$. At that wage, the quantity demanded falls to L_d and the quantity supplied rises to L_s. As a result, the market has an excess supply of labor of $L_s - L_d$. The minimum wage prevents market forces from eliminating this excess supply, so it leads to an equilibrium with unemployment.

The original 1938 U.S. minimum wage law, which was set much higher than the equilibrium wage in Puerto Rico, caused substantial unemployment there. It is ironic that a law designed to help workers by raising their wages may harm some of them by causing them to become unemployed. A minimum wage law benefits only those workers who remain employed.[12]

Why Supply Need Not Equal Demand. The price ceiling and price floor examples show that the quantity supplied does not necessarily equal the quantity demanded in a supply-and-demand model. The quantity supplied need not equal the quantity demanded because of the way we define these two concepts. The quantity supplied is the amount sellers *want to sell* at a given price, holding other factors that affect supply, such as the price of inputs, constant. The quantity demanded is the quantity that buyers *want to buy* at a given price, if other factors that affect demand are held constant. The quantity that sellers want to sell and the quantity that buyers want to buy at a given price need not equal the *actual* quantity that is bought and sold.

When the government imposes a binding price ceiling of $\overline{p}$ on gasoline, the quantity demanded is greater than the quantity supplied. Despite the lack of equality between the quantity supplied and the quantity demanded, the supply-and-demand model is useful in analyzing this market because it predicts the excess demand that is observed.

[12]The minimum wage could raise the wage enough that total wage payments, wL, rise despite the fall in demand for labor services. If the workers could share the unemployment—everybody works fewer hours than he or she wants—all workers could benefit from the minimum wage. Card and Krueger (1995) have argued, based on alternatives to the simple supply-and-demand model, that minimum wage laws raise wages in some markets (such as fast foods) without significantly reducing employment. In contrast, Neumark and Wascher (2008) conclude, based on an extensive review of minimum wage research, that increases in the minimum wage often have negative effects on employment.

We could have defined the quantity supplied and the quantity demanded so that they must be equal. If we were to define the quantity supplied as the amount firms *actually* sell at a given price and the quantity demanded as the amount consumers *actually* buy, supply must equal demand in all markets because the quantity demanded and the quantity supplied are *defined* to be the same quantity.

This distinction is important because many people, including politicians and newspaper reporters, are confused on this point. Someone who insists that "demand *must* equal supply" must be defining supply and demand as the *actual* quantities sold.

Because we define the quantities supplied and demanded in terms of people's *wants* and not *actual* quantities bought and sold, we view the statement "supply equals demand" as a theory, not merely a definition. This theory says that the price and quantity in a market are determined by the intersection of the supply curve and the demand curve, and the market clears *if the government does not intervene*. However, the theory also tells us that government intervention can prevent market-clearing. For example, the supply-and-demand model predicts that excess demand will arise if the government imposes a price ceiling below the market-clearing price or excess supply will result if the government imposes a price floor above the market-clearing price.

Sales Taxes

New Jersey's decision to eliminate the tax on Botox has users elated. At least we think they're elated—we can't really tell.

Governments frequently impose sales taxes on goods, such as the carbon tax discussed at the beginning of the chapter.[13] Sales taxes typically raise the price that consumers pay for a good and lower the price that firms receive for it.

A common sales tax is the *specific tax*, where the government collects a specified dollar amount, t, per unit of output. For example, the federal government collects $t = 18.4¢$ on each gallon of gas sold in the United States.[14]

In this section, we examine three questions about the effects of a specific tax:

1. What effect does a specific tax have on the equilibrium price and quantity?
2. Do the equilibrium price and quantity depend on whether the government collects the specific tax from suppliers or their customers?
3. Is it true, as many people claim, that firms pass the entire tax through to their customers—the price that consumers pay rises by the full amount of the tax?

Equilibrium Effects of a Specific Tax. To answer these three questions, we must extend the standard supply-and-demand analysis to take account of taxes. We can illustrate the effect of a specific tax using estimated supply and demand functions for the U.S. corn market.[15]

Many nutritionists argue that to fight obesity, we should reduce the amount of corn syrup (sugar) we consume. One way to do that would be to tax corn. Suppose

[13] MyLab Economics has a *Taxes Experiment* that illustrates the effect of sales taxes. To participate go to the MyLab Economics Multimedia Library, Single Player Experiment, and set the Chapter field to "All Chapters."

[14] The other major type of sales tax is an *ad valorem tax*, where the government collects a percentage of the price that consumers pay. The analysis of ad valorem taxes is similar to the analysis of specific taxes.

[15] Our linear curves are based on Roberts and Schlenker (2013).

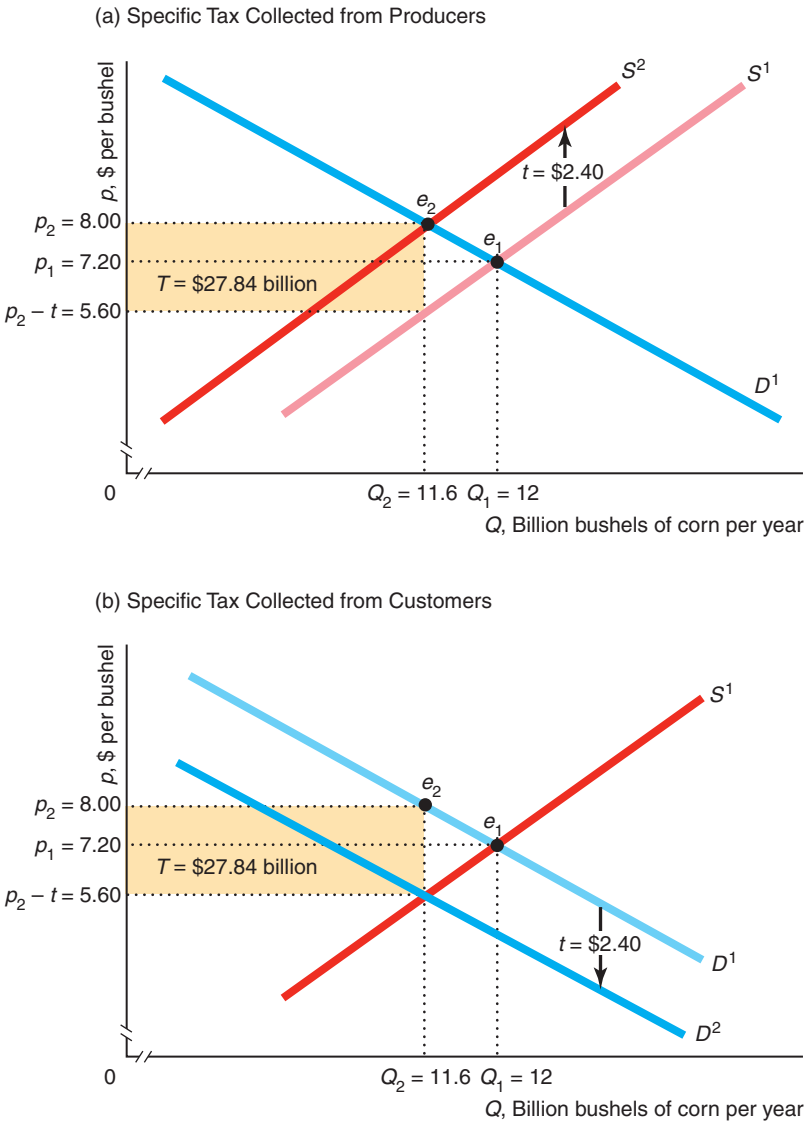
that the government collects a specific tax of $t = \$2.40$ per bushel of corn from sellers (farms). If a customer pays p to a firm, the government takes $t = \$2.40$, so the firm keeps $p - t = p - \$2.40$.

Before the tax, the intersection of the before-tax corn demand curve D^1 and the before-tax corn supply curve S^1 in panel a of Figure 2.9 determines the before-tax equilibrium, e_1, where the equilibrium price is $p_1 = \$7.20$, and the equilibrium quantity is $Q_1 = 12$ billion bushels of corn per year.

The tax causes the supply curve to shift. Before the tax, firms were willing to supply 11.6 billion bushels of corn per year at a price of \$5.60 per bushel, as the pre-tax supply curve S^1 in panel a shows. After the tax, if customers pay \$5.60, firms keep only $\$5.60 - \$2.40 = \$3.20$, so they are not willing to supply as much corn as before

FIGURE 2.9 Effect of a \$2.40 Specific Tax on Corn Collected from Producers MyLab Economics Video

(a) The specific tax of $t = \$2.40$ per bushel of corn collected from producers shifts the pre-tax corn supply curve, S^1, up to the post-tax supply curve, S^2. The tax causes the equilibrium to shift from e_1 (determined by the intersection of S^1 and D^1) to e_2 (intersection of S^2 with D^1). The equilibrium price—the price consumers pay—increases from $p_1 = \$7.20$ to $p_2 = \$8.00$. The government collects tax revenues of $T = tQ_2 = \$27.84$ billion per year.
(b) The specific tax collected from customers shifts the demand curve down by $t = \$2.40$ from D^1 to D^2. The new equilibrium is the same as when the tax is applied to suppliers in panel a.



the tax. For firms to be willing to sell 11.6 units after the tax, customers must pay \$8.00 so that the firms receive \$8.00 − \$2.40 = \$5.60 after paying the tax. As a result, the after-tax supply curve, S^2, is t = \$2.40 above the original supply curve S^1 at every quantity, as the figure shows.

The after-tax equilibrium e_2 is determined by the intersection of S^2 and the demand curve D^1, where consumers pay p_2 = \$8.00, firms receive $p_2 - t = p_2$ − \$2.40 = \$5.60, and Q_2 = 11.6. Thus, the answer to our first question is that the specific tax causes the equilibrium price consumers pay to rise, the equilibrium price that firms receive to fall, and the equilibrium quantity to fall.

Although the customers pay a higher price and producers receive less because of the tax, the government acquires new tax revenue of $T = tQ$ = \$2.40 per bushel × 11.6 billion bushels per year = \$27.84 billion per year. The length of the shaded rectangle in panel a is Q_2 = 11.6 billion per year, and its height is t = \$2.40 per bushel, so the area of the rectangle equals the tax revenue.

The Same Equilibrium No Matter Who Pays the Tax. Does it matter whether the government collects the specific tax from firms or consumers? No: The market outcome is the same regardless of who pays the tax.

The amount suppliers receive, $p - t$, is the price that consumers pay, p, minus the tax, t, that the government collects. Thus, if the final price that consumers pay including the tax is \$8.00, the price that suppliers receive is only \$5.60. Consequently, the demand curve as seen by firms shifts downward by \$2.40 from D^1 to D^2 in panel b of Figure 2.9. The new equilibrium quantity occurs where D^2 intersects the supply curve S^1. This equilibrium quantity, Q_2, is 11.6. Consumers pay p_2 = \$8.00, and firms receive p − \$2.40 = \$5.60. Thus, the market outcome is the same as in panel a, where the government collects the tax from firms.

Pass-Through. Many people believe that if the government imposes a tax on firms, the firms raise their price by the amount of the tax, so that the entire tax is passed through to consumers. This belief is not accurate in general. Full pass-through can occur, but partial pass-through is more common.

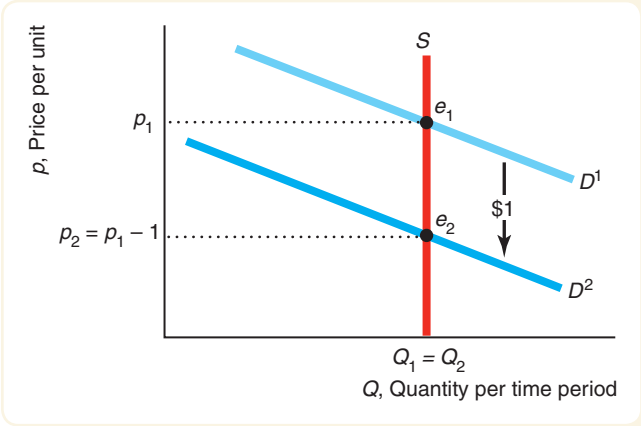
As we just showed for the corn market in panel a of Figure 2.9, the price consumers pay rises from \$7.20 to \$8.00 after a \$2.40 specific tax is imposed on firms. Thus, the firms shift only \$0.80 of the \$2.40 tax to consumers. The firms absorb \$1.60 of the tax, because the price that firms receive falls from \$7.20 to \$5.60. Thus, the fraction of the tax that consumers pay is \$0.80/\$2.40 = $\frac{1}{3}$ and the fraction that firms absorb is \$1.60/\$2.40 = $\frac{2}{3}$. As panel b shows, the allocation of the tax is the same if the government collects it from consumers rather than from firms. However, as the following Q&A shows, the degree of the pass-through depends on the shapes of the supply and demand curves.

Q&A 2.3

If the supply curve is vertical and demand is linear and downward sloping, what is the effect of a \$1 specific tax consumers pay on equilibrium price and quantity, and what share of the tax do consumers pay? Why?

Answer

1. *Determine the equilibrium in the absence of a tax.* The supply curve, S in the graph, is vertical at Q_1 indicating that suppliers will supply Q_1 to the market at any price. The before-tax, downward-sloping linear demand curve, D^1, intersects S at the before-tax equilibrium, e_1, where the price is p_1 and the quantity is Q_1.



2. *Show how the tax shifts the demand curve and determine the new equilibrium*. A specific tax of \$1 shifts the before-tax demand curve downward by \$1 to D^2. The intersection of D^2 and S determines the after-tax equilibrium, e_2, where the price firms receive is $p_2 = p_1 - 1$, the price consumers pay after tax is $p_1 = p_2 + 1$, and the quantity is $Q_2 = Q_1$.
3. *Compare the before- and after-tax equilibria*. The specific tax doesn't affect the equilibrium quantity or the tax-inclusive price that consumers pay, but it lowers the price that firms receive by the full amount of the tax. Thus, the firms do not pass the tax through to consumers. Even though the government collects the tax from consumers, consumers pay the same price as they would without the tax because the price firms receive falls by the amount of the tax.
4. *Explain why*. The reason firms must absorb the entire tax is that, because the supply curve is vertical, the firms sell the same quantity no matter the price. Consumers are willing to buy the entire quantity that firms want to sell only if the price they pay does not change. Therefore, the final price to consumers cannot change, so the firms must absorb the tax: They cannot pass the tax on to consumers.

   For example, suppose that firms at a farmers' market have a fixed amount of melons that will spoil if they do not sell them today. The firms sell the melons for the most they can get (p_2 in the figure) because if they do not sell the melons, they are worthless. Consequently, the farmers must absorb the entire tax or be left with unsold melons.

Managerial Implication

Cost Pass-Through

Managers should use pass-through analysis to predict the effect on their price and quantity from not just a new tax but from *any per unit increase in costs*. Suppose that the cost of producing corn rises \$2.40 per bushel because of an increase in the cost of labor or other factors of production, rather than because of a tax. Then, the same analysis as in panel a of Figure 2.9 would apply, so a manager would know that only 80¢ of this cost increase could be passed through to consumers.

2.6 When to Use the Supply-and-Demand Model

As we have seen, the supply-and-demand model can help us to understand and predict real-world events in many markets. As with many models, the supply-and-demand model need not be perfect to be useful. It is much like a map. A map can leave out many details and still be very valuable—indeed, maps are useful in large

part because they simplify reality. Similarly, the supply-and-demand model gains much of its power from its simplicity. The main practical question concerns whether the model is close enough to reality to yield useful predictions and conclusions. We have learned that the supply-and-demand model provides a very good description of actual events in highly competitive markets. It is precisely accurate in *perfectly competitive* markets, which are markets in which all firms and consumers are *price takers*: no market participant can affect the market price.

Perfectly competitive markets have five characteristics that result in price taking by firms: (1) many buyers and sellers transact in a market, (2) all firms produce identical products, (3) all market participants have full information about price and product characteristics, (4) transaction costs are negligible, and (5) firms can easily enter and exit the market over time.

In a market with a very large number of sellers, no single producer or consumer is a large enough part of the market to affect the price. The more firms in a market, the less any one firm's output affects total market output and hence the market price. If one of the many thousands of wheat farmers stops selling wheat, the price of wheat will not change. Similarly, no individual buyer of wheat can cause price to change through a change in buying patterns.

If consumers believe all firms produce identical products, consumers do not prefer one firm's good to another's. Thus, if one firm raised its price, consumers would all buy from the other firm.

If consumers know the prices that all firms charge and one firm raises its price, that firm's customers will buy from other firms. If consumers have less information about product quality than a firm, the firm can take advantage of consumers by selling them inferior-quality goods or by charging a much higher price than that charged by other firms. In such a market, the observed price may be higher than that predicted by the supply-and-demand model, the market may not exist at all (consumers and firms cannot reach agreements), or different firms may charge different prices for the same good.

If it is cheap and easy for a buyer to find a seller and make a trade, and if one firm raises its price, consumers can easily arrange to buy from another firm. That is, perfectly competitive markets typically have very low **transaction costs**: the expenses, over and above the price of the product, of finding a trading partner and making a trade for the product. These costs include the time and money spent gathering information on quality and finding someone with whom to trade. The costs of traveling and the value of the consumer's time are transaction costs. Other transaction costs may include the costs of writing and enforcing a contract, such as the cost of a lawyer's time. If transaction costs are very high, no trades at all might occur. In less extreme cases individual trades may occur, but at a variety of prices.

The ability of firms to enter and exit a market freely leads to a large number of firms in a market and promotes price taking. Suppose a firm could raise its price and make a higher profit. If other firms could not enter the market, this firm would not be a price taker. However, if other firms can enter the market, the higher profit will encourage entry until the price reverts to the original level.

In markets without these characteristics, firms may not be price takers. For example, in a market with only one seller of a good or service—a *monopoly*—the seller is a *price setter* and can affect the market price. Because demand curves slope downward, a monopoly can increase the price it receives by reducing the amount of a good it supplies. Firms are also price setters in an *oligopoly*—a market with only a small number of firms. In markets with price setters, the market price is usually

higher than that predicted by the supply-and-demand model. That does not make the model wrong. It means only that the supply-and-demand model might not be the right tool to analyze markets with a small number of buyers and/or sellers. In such markets, we use other models.

As a practical matter, it is rare that we would find a market that fully and completely satisfies all the conditions needed for perfect competition. The practical issue concerns whether the market is "competitive enough" for the supply-and-demand model to be useful in the sense that it accurately describes the market and predicts the effects of changes to the equilibrium. Experience has shown that the supply-and-demand model is reliable in a wide range of markets, such as those for agriculture, financial products, labor, construction, many services, real estate, wholesale trade, and retail trade.

Managerial Solution

Carbon Taxes

We conclude our analysis of the supply-and-demand model by returning to the managerial problem posed in the introduction of this chapter: What will be the effect of imposing a carbon tax on the price of gasoline?

The primary targets of carbon taxes are fossil fuels such as oil, natural gas, and coal. These fuels release carbon-based pollutants—including greenhouse gases that contribute to global warming—into the environment. Typically, a carbon tax is a specific tax on the amount of carbon produced by consuming fuels or other products. Currently, the carbon tax in Sweden is $150 per ton of carbon. Because the amount of carbon in a gallon or liter of gasoline is fixed, effectively, a carbon tax is a specific tax on gasoline. Consequently, we can analyze the impact of a carbon tax on gasoline in the same way that we analyzed the effect of a specific tax on corn.

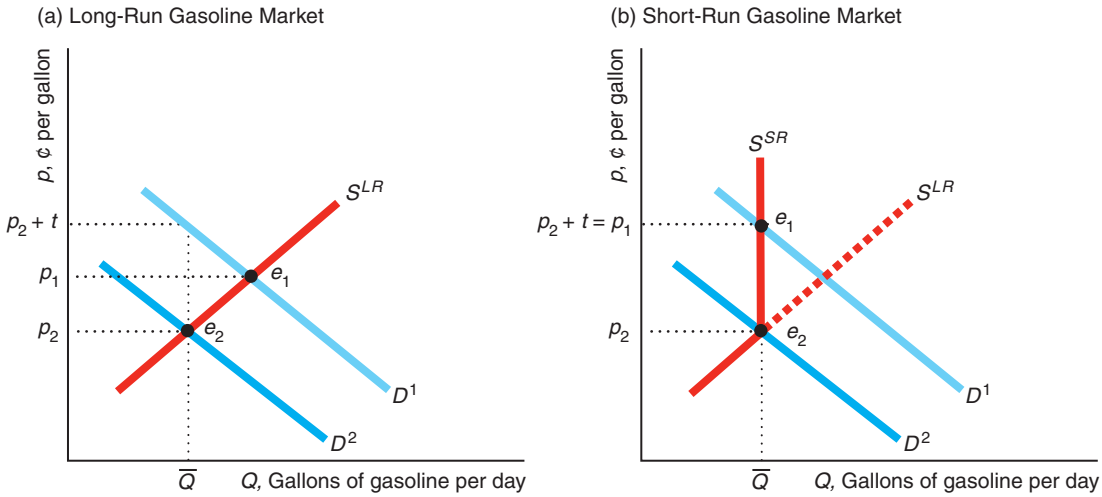
A good manager considers the short-run and long-run price effects of a tax, which are likely to differ. As we've already seen, the degree to which a tax is passed through to consumers depends on the shapes of the demand and supply curves. Typically, short-run supply and demand curves differ from the long-run curves.

In particular, the long-run supply curve of gasoline differs substantially from the short-run curve. In the long run, the supply curve is upward sloping, as in our typical figure. However, the U.S. short-run supply curve of gasoline is very close to vertical. The U.S. refinery capacity has fallen over the last quarter century. Currently the 142 U.S. refineries can process a maximum of only 17.9 million barrels of crude oil per day, compared to 1981 when 324 refineries could process 18.6 million barrels per day. Refineries operate at almost full capacity during the summer, when the gasoline demand curve shifts to the right because families take long car trips during their vacations. Consequently, refineries cannot increase their output in the short run, and the supply curve for gasoline is nearly vertical at the maximum capacity, $\overline{Q}$. That is, even if the price of gasoline rises, producers sell no more gasoline than $\overline{Q}$.

From empirical studies, we know that the U.S. federal gasoline specific tax of $t = 18.4¢$ per gallon is shared roughly equally between gasoline companies

and consumers in the long run. However, based on our analysis in Q&A 2.3, we expect most of the tax to fall on firms that sell gasoline in the short run.

We contrast the long-run and short-run effects of a carbon tax in the figure. In both panels, the carbon tax is equivalent to a specific gasoline tax of t per gallon. If this tax is collected from consumers, the before-tax demand curve D^1 shifts down by t to the after-tax demand curve D^2. Also in both panels, the equilibrium shifts from e_1—the intersection of D^1 and the relevant supply curve—to e_2—the intersection of D^2 and the relevant supply curve (though these equilibrium points are not the same across the two panels).



Panel a shows the effect of the tax in the long run, where the long-run supply curve is upward sloping. The price that firms receive falls from p_1 to p_2, and the price that consumers pay rises from p_1 to $p_2 + t$. As the figure illustrates, the tax is shared roughly equally by consumers and firms in the long run.

In the short run in panel b, the upward-sloping short-run supply curve becomes vertical at full capacity, $\overline{Q}$. The price that consumers pay, p_1, is the same before the tax and after the tax. That is, the price that gasoline firms receive, p_2, falls by the full amount of the tax.

Manufacturing and other firms that ship goods are consumers of gasoline. They can expect to absorb relatively little of a carbon tax when it is first imposed, but half of the tax in the long run.[16]

[16] An alternative approach to using a carbon tax to control pollution is for the government to restrict emissions directly. The government gives each firm a fixed number of emission permits, where each permit allows the owner to release a given quantity of emissions. A market-based variant allows firms to buy or sell these emission permits in a market. The resulting price of an emission permit acts much like a tax on emissions. See Chapter 16.

SUMMARY

1. **Demand.** The quantity of a good or service demanded by consumers depends on the price of a good, the price of goods that are substitutes and complements, consumers' incomes, the information they have about the good, their tastes, government regulations, and other factors. The *Law of Demand*—which is based on observation—says that *demand curves slope downward*: the higher the price, the less quantity of the good demanded, holding constant other factors that affect demand. A change in price causes a *movement along the demand curve*. A change in income, tastes, or another factor that affects demand other than price causes a *shift of the demand curve*. To get a total demand curve, we horizontally sum the demand curves of individuals or other subgroups of consumers. That is, we add the quantities demanded by each individual at a given price to get the total quantity demanded.
2. **Supply.** The quantity of a good or service supplied by firms depends on the price, costs of inputs, the state of technology, government regulations, and other factors. The market supply curve usually but not always slopes upward. A change in price causes a *movement along the supply curve*. A change in the price of an input or in technology causes a *shift of the supply curve*. The total supply curve is the horizontal sum of the supply curves for individual firms.
3. **Market Equilibrium.** Equilibrium arises when no market participant has an incentive to change its behavior. In an unregulated supply-and-demand model, the market equilibrium is a point: a price and a quantity. The intersection of the supply curve and the demand curve determines the market equilibrium. At the equilibrium price, the market for the good clears in the sense that the quantity of the good demanded by consumers exactly equals the quantity of the good that suppliers supply to the market, which is the equilibrium quantity. The actions of buyers and sellers put pressure on price and quantity to move toward equilibrium levels if the market price is initially too low or too high.
4. **Shocks to the Equilibrium.** A change in an underlying factor other than a good's own price causes a shift of the supply curve or the demand curve, which alters the equilibrium. For example, if the price of coffee rises, we would expect the demand for tea, a substitute, to shift outward, putting upward pressure on the price of tea and leading to an increase in the quantity of tea sold.
5. **Effects of Government Interventions.** Some government policies—such as restrictions on who can buy a product—cause a shift in the supply or demand curves, thereby altering the equilibrium. Other government policies, such as price controls, can cause the quantity supplied to be greater or less than the quantity demanded, leading to persistent excesses or shortages. A specific tax, a type of sales tax, typically lowers the equilibrium quantity, raises the price paid by consumers, and lowers the price received by sellers, so firms are unable to pass the entire tax through to consumers.
6. **When to Use the Supply-and-Demand Model.** The supply-and-demand model is a powerful tool used to explain what happens in a market and to make predictions about what will happen if an underlying factor changes. This model accurately predicts what occurs in some markets but not others. The supply-and-demand model performs best in explaining and predicting the behavior of markets with many buyers and sellers, with identical or at least very similar products provided by different producers, with free entry and exit by producers, with full information about price and other market characteristics, and with low transaction costs.

QUESTIONS

*All exercises are available on MyLab Economics; * = answer at the back of this book.*

1. Demand

*1.1 Does an increase in average income cause a shift of the demand curve for coffee or a movement along the demand curve? Explain briefly.

1.2 Given the estimated demand function Equation 2.2 for coffee, $Q = 8.5 - p + 0.1Y$, use algebra (or calculus) to show how the demand curve shifts as per capita income, Y, increases by \$10,000 a year. Illustrate this shift in a diagram.

1.3 Assume that both the U.S. and Canadian demand curves for lumber are linear. The Canadian demand curve lies inside the U.S. curve (the Canadian demand curve hits the axes at a lower price and a lower quantity than the U.S. curve). Draw the

individual country demand curves and the combined (summed) demand curve for the two countries. Explain the relationship between the country and summed demand curves in words. (*Hint*: See the Mini-Case "Summing Corn Demand Curves.")

*1.4 The demand function for a truckload of firewood for college students in a small town is $Q_c = 400 - p$. It is sometimes convenient to rewrite a demand function with price on the left side. We refer to such a relationship as the *inverse demand function*. Therefore, the inverse demand function for college students is $p = 400 - Q_c$. The demand function for other town residents is $Q_r = 400 - 2p$.

a. What is the inverse demand function for other town residents?

b. At a price of $300, will college students buy any firewood? What about other town residents? At what price is the quantity demanded by other town residents zero?

c. Draw the total demand curve, which sums the demand curves for college students and other residents. (*Hint*: See the Mini-Case "Summing Corn Demand Curves.")

2. Supply

2.1 The estimated supply function for avocados is $Q = 58 + 15p - 20p_f$, where p_f is the price of fertilizer. Determine how much the supply curve for avocados shifts if the price of fertilizer rises by $1.10 per lb. Illustrate this shift in a diagram.

*2.2 Explain why a change in the price of fertilizer causes a shift in the supply curve for avocados rather than a movement along the supply curve for avocados.

*2.3 Holding the price of fertilizer constant, by how much would the price of avocados need to rise to cause an increase of 60 million lbs per month in the quantity of avocados supplied?

2.4 The total U.S. supply curve for frozen orange juice is the sum of the supply curve from Florida and the imported supply curve from Brazil. In a diagram, show the relationship between these three supply curves and explain it in words.

3. Market Equilibrium

*3.1 A large number of firms are capable of producing chocolate-covered cockroaches. The linear, upward-sloping supply curve starts on the price axis at $6 per box. A few hardy consumers are willing to buy this product (possibly to use as gag gifts). Their linear, downward-sloping demand curve hits the price axis at $4 per box. Draw the supply and demand curves. Does an equilibrium occur at a positive price and quantity? Explain your answer.

3.2 The demand function is $Q = 200 - 5p$, and the supply function is $Q = -40 + 3p$. Determine the equilibrium price and quantity.

3.3 Using the demand function, Equation 2.2, and the supply function, Equation 2.5, for coffee, determine the equilibrium price and quantity of coffee if $Y = \$55{,}000$ and $p_c = \$5$. Draw the demand and supply curves and illustrate this equilibrium in a diagram.

4. Shocks to the Equilibrium

4.1 Using supply-and-demand diagrams, illustrate and explain the effect of an outward shift in the demand curve on price and quantity if

a. The supply curve is horizontal.

b. The supply curve is vertical.

c. The supply curve is upward sloping.

4.2 Use supply-and-demand diagrams to illustrate the qualitative effect of the following possible shocks on the world coffee market.

a. A new study shows significant health benefits from drinking coffee.

b. An important new use for cocoa is discovered.

c. A recession causes a decline in per capita income.

d. A new coffee plant that allows for much greater output or yield without increasing cost is introduced into the market.

*4.3 The United States is increasingly *outsourcing* jobs to India: having the work done in India rather than in the United States. For example, the Indian firm Tata Consultancy Services, which provides information technology services, increased its work force by 70,000 workers in 2010 ("Outsourcing Firm Hiring 60,000 Workers in India," *San Francisco Chronicle*, June 16, 2011). As a result of increased outsourcing, wages of some groups of Indian skilled workers have increased substantially over the years. Use a supply-and-demand diagram to explain this outcome.

4.4 The estimated monthly demand function for tomatoes in Spain is $Q = 200 - 20p + 10p_r$, where p is the price of tomatoes and p_r is the price of red peppers, a substitute for tomatoes. The estimated supply function for tomatoes is $Q = 160 + 16p - 20p_f$, where the price of fertilizer, p_f, is €1.00, so the supply function can be written as $Q = 140 + 16p$. The initial price of red peppers is €3.00 per kilogram. Using algebra, determine the initial equilibrium price and quantity of tomatoes, and then determine how price and quantity change if the price of red peppers falls to €2.00. (*Hint*: See Q&A 2.1.)

4.5 Suppose it is estimated that the demand for large new cars in Iceland increased by 64.83% between 1982 and 2008 when income increased by 10%. During the same period, the demand fell by 7.83% when car prices increased by 10%. Draw a supply-and-demand diagram and label the axes to illustrate what happened.

*4.6 Coffee is the most popular beverage in Greece. A large proportion of the coffee consumed in Greece is imported from Brazil. What effect would a drought that severely reduces coffee production in Brazil have on the price and quantity of coffee in Greece? What effect would the drought have on the price of tea, a substitute for coffee, in Greece? Use supply-and-demand diagrams in your answer.

4.7 Ethanol, a fuel, is made from corn. Ethanol production in 2014 was approximately 17 times what it was in 1990. (**http://www.ethanolrfa.org/**, June 2015). What effect did this increased use of corn for producing ethanol have on the price of corn and the consumption of corn as food? Illustrate using a supply-and-demand diagram.

4.8 Wheat is the second most important cereal in Sudan, but very little of it is produced domestically. Sudan primarily depends on imported wheat. Use a demand-and-supply diagram to show the effect of a 50% reduction in the import tariff of wheat on its consumption and price in Sudan.

4.9 Increasingly, instead of advertising in newspapers, individuals and firms use Web sites that offer free or inexpensive classified ads, such as ClassifiedAds.com, Craigslist.org, Realtor.com, Jobs.com, Monster.com, and portals like Google and Yahoo. Using a supply-and-demand model, explain what will happen to the equilibrium levels of newspaper advertising as the use of the Internet grows. Will the growth of the Internet affect the supply curve, the demand curve, or both? Why?

4.10 Global warming has had significant negative effects. But it has also had some positive effects. In particular, wine growing regions in several major producing countries have expanded, increasing the overall world supply of wine. But the demand for wine has also increased over this period. Use supply and demand curves to show what happens to price and quantity as a result of these two developments. (*Hint*: See Q&A 2.2.)

*4.11 Increases in the price of petroleum affect the demand curve for aluminum. Petroleum-based chemicals (petrochemicals) are the main raw material used for plastic. Plastics are used to make many products, including beverage containers, auto parts, and construction materials. An alternative to plastic in these (and other) uses is aluminum. Thus, plastic and aluminum are substitutes. An increase in petroleum prices increases the cost of petrochemicals. Petroleum prices also affect the supply curve for aluminum. Increases in petroleum prices tend to raise energy prices, including electricity prices. Electricity is a very important input in producing aluminum. Therefore, increasing petroleum prices tend to increase the cost of electricity. In a supply-and-demand diagram, show how an increase in petroleum prices affects the demand curve and supply curve for aluminum. If the price of petroleum rises, would the price of aluminum rise, fall, remain unchanged, or is the result indeterminate? Would the quantity of aluminum sold rise, fall, remain unchanged, or is the result indeterminate? Explain your answers.

4.12 Use a figure to explain the fisher's comment about the effect of a large catch on the market price in the cartoon in this chapter about catching lobsters. What is the supply shock?

5. Effects of Government Interventions

5.1 Use a supply-and-demand diagram to show the effects of occupational licensing on the equilibrium wage and number of workers in an occupation as described in the Mini-Case "Occupational Licensing."

*5.2 After a severe storm damaged the water supply infrastructure in a city in Europe, the price of drinking water increased sharply in the city. The mayor announced that she would investigate price gouging–charging "too much"—and several members of the local council called for price controls on bottled water. What would have been the likely effect of such a law had it been passed?

5.3 Usury laws place a ceiling on interest rates that lenders such as banks can charge borrowers. Why would we expect low-income households in states with usury laws to have significantly lower levels of consumer credit (loans) than comparable households in states without usury laws? (*Hint*: The interest rate is the price of a loan, and the amount of the loan is the quantity measure.)

5.4 Some cities impose rent control laws, which are price controls or limits on the price of rental accommodations. In 2015, rent control regulations on all new or renewed leases went into effect in Paris, France. Show the effect of a rent control law on the equilibrium rental price and quantity of apartments in

Paris. Show the amount of excess demand on your supply-and-demand diagram.

5.5 If the minimum wage raises the market wage, w, but hours worked, L, fall as a result, total wage payments, wL, may rise or fall. Use supply and demand curves to show that either outcome is possible depending on the shapes (slopes) of the supply and demand curves. (*Hint*: With the wage on the vertical axis and hours worked, L, on the horizontal axis, wage payments equal the area of the box with a height of the equilibrium wage and length of the equilibrium hours worked.)

5.6 Use the demand function and the supply function for the avocado market (given in Question 4.4) to determine how the equilibrium price and quantity change when a 55¢ per lb specific tax is imposed on this market. (*Hint:* See Figure 2.9.)

5.7 Worried about excessive drinking among young people, the British government increased the tax on beer by 42% from 2008 to 2012. Under what conditions would a specific tax substantially reduce the equilibrium quantity of alcohol? Answer in terms of the slopes of the demand and supply curves.

5.8 If the government collects a $1 specific tax, what share of the tax is paid by consumers and firms in each of the following cases? Explain why. (*Hint*: See Q&A 2.3. Depending on the shape of the curves, it may be easier to assume that the tax is collected from consumers or from firms.)

a. The demand curve is vertical at quantity Q and the supply curve is upward sloping.

b. The demand curve is horizontal at price p and the supply curve is upward sloping.

c. The demand curve is downward sloping and the supply curve is horizontal at price p.

5.9 In Australia, home solar heating and cooling systems are subsidized so that the price of a new system is reduced by AU$ 3,500. (*Hint*: A subsidy is a negative tax.)

a. What is the effect of this subsidy on the equilibrium price and quantity?

b. Show the incidence of the subsidy on heating and cooling system producers and consumers using a supply-and-demand diagram.

6. When to Use the Supply-and-Demand Model

6.1 List as many industries as you can for which the supply-and-demand model is likely to be appropriate.

7. Managerial Problem

7.1 During the spring and summer of 2008 when gasoline prices were rising quickly, politicians in several countries proposed a moratorium on some or all gasoline taxes to help consumers. In the United States, John McCain, the Republican candidate for president, proposed suspending the federal gasoline tax of 18.4¢ for the summer when demand tends to be high. (Hillary Clinton, while an active candidate for the Democratic nomination for the president, also pushed this plan.) In the United Kingdom, Prime Minister Gordon Brown proposed delaying a two pence per liter rise in a fuel tax until the fall. How would these short-run policies have affected the prices consumers would pay in these countries if the policies had been enacted?

8. MyLab Economics Spreadsheet Exercises[17]

8.1 Suppose that the market for video games is competitive with demand function $Q_d = 130 - 4p + 2Y + 3p_m - 2p_c$, where Q_d is the quantity demanded, p is the market price, Y is the monthly budget that an average consumer has available for entertainment, p_m is the average price of a movie, and p_c is the price of a controller that is required to play these games.

a. Given that $Y = \$100$, $p_m = \$30$, and $p_c = \$30$, use Excel to calculate quantity demanded for $p = \$10$ to $p = \$80$ in $5 increments. Use Excel's charting tool to draw the demand curve.

b. Now, Y increases to $120. Recalculate the demand schedule in part a. Use Excel's charting tool to draw the new demand curve in the same diagram.

c. Let $Y = \$100$ and $p_c = \$30$ again, but let p_m increase to $40. Recalculate the demand schedule in part a. Use Excel's charting tool to draw the graph of the new demand curve.

d. Let $Y = \$100$, $p_m = \$30$, and p_c increases to $40. Recalculate the demand schedule in part a and use Excel to draw the new demand curve.

8.2 Suppose in Munich, Germany, the demand function for men's haircuts is $Q_d = 720 - 40p + 0.08Y$, where Q_d is quantity demanded per month, p the price of a haircut, and Y the average monthly income in the city. The supply function for men's haircuts is $Q_s = 150 + 20p - 10w$, where Q_s is the quantity supplied and w the average hourly wage of barbers.

a. If $Y = €6{,}000$ and $w = €10$, use Excel to calculate quantity demanded and quantity supplied

[17]The spreadsheet exercises in this chapter are based on the work of Satyajit Ghosh in cooperation with the authors. The answers are available on MyLab Economics.

for $p = €5, €15, €20, €25,$ and $€30$. Calculate excess demand for each price. (Note that excess supply is negative excess demand.) Determine the equilibrium price and quantity. Use Excel's charting tool to draw the demand and supply curves.

b. Assume that Y increases to €9,125 and w increases to €15. Use Excel to recalculate quantity demanded, quantity supplied, and excess demand for $p = €5, €15, €20, €25,$ and $€30$. Determine the new equilibrium price and quantity. Use Excel to draw the new demand and supply curves. How can you explain the change in equilibrium?

8.3 The demand and supply functions for oil in a small isolated country are $Q_d = 210 - 1.5p$ and $Qs = -140 + 2p$, where p is the price per barrel and quantities are in millions of barrels per year.

a. Use Excel to calculate the quantity demanded and quantity supplied for $p = \$70, \$75, \$80, \ldots, \$140$ (in \$5 increments). Determine the equilibrium price and quantity.

b. Use Excel's charting tool to draw the demand and supply curves you derived in part a and graphically determine the equilibrium calculated in part a.

c. Now, assume that the government imposes a price ceiling of \$80 per barrel. Use the spreadsheet from part a to determine the amount of any excess demand or excess supply. How much oil is sold?

d. The government abandons the price ceiling described in part c and imposes a price floor of \$110 per barrel instead. Use your spreadsheet to determine any excess demand or excess supply now. How much oil is sold?

Empirical Methods for Demand Analysis

3

98% of all statistics are made up.

Learning Objectives

1. Define and calculate elasticities.
2. Estimate demand functions using regression analysis.
3. Know how to evaluate the reliability of regression analyses.
4. Use regression methods to forecast.

Managerial Problem

Estimating the Effect of an iTunes Price Change

From the time Apple launched iTunes in mid-2003 through early 2009, it charged 99¢ for each song on its U.S. site. In early 2009 Apple reconsidered its pricing strategy. Music producers wanted Apple to charge more, but price competition from rivals such as Amazon created pressure on Apple to lower its price. In April 2009, Apple changed to a new U.S. pricing scheme: 69¢ a song for the older catalog, 99¢ for most new songs, and $1.29 for the most popular tracks.

In June 2015, Apple introduced a streaming audio service, Apple Music, which allows customers to play as many songs as they want as often as they want for $9.99 per month. This service competes with traditional music downloads, but Apple decided not to change the price of those downloads, keeping a price of $1.29 for hit songs.

Before Apple managers change an iTunes price they predict the likely effect of the price change on sales. Rather than run a potentially costly experiment of trying different possible prices to see how the quantity demanded changes, iTunes managers could ask a focus group consisting of a random sample of music buyers how they would react to a price hike. After collecting their responses, the managers could analyze the data to predict the likely effects of a price change. How could the managers use the data to estimate the demand curve facing iTunes? How could the managers determine if a price increase would be likely to raise revenue, even though the quantity demanded would fall?

Managers commonly use data to estimate economic relationships, such as the relationship between price and quantity shown by a demand curve, or to examine whether a particular economic theory applies in their markets. Data-based analysis of economic relationships is often referred to as *empirical* analysis. This chapter discusses empirical methods that can be used to analyze economic relationships, focusing particularly on the empirical analysis of demand.

In Chapter 2, we focused on market demand curves in highly competitive markets, such as most agricultural markets. In highly competitive markets with many firms selling identical products, each individual firm is a *price taker*. In such markets, no one firm can significantly influence the market price. Any firm that tried to raise its price above the market equilibrium price would lose all of its sales. However, many firms, such as Apple, operate in markets that are not as competitive. Such firms are *price setters* that can raise their prices without losing all their sales. In the market for music downloads, Apple is a price setter.

A price-setting firm is concerned about the demand curve facing the firm rather than a market demand curve. In particular, the manager of a price-setting firm often wants to know how responsive its quantity demanded is to changes in its price or in other variables that affect demand. For example, in deciding whether to raise the price of iTunes songs by 30¢, an Apple manager would want to know how the number of iTunes downloads would fall in response to a 30¢ increase in price. This responsiveness can be measured empirically using the *price elasticity of demand.*

A manager might also wish to estimate the entire demand function to decide how to set the firm's optimal price, plan an advertising campaign, or choose how large a plant to build. In Chapter 2, we used estimated demand (and supply) functions to determine the equilibrium price and to analyze the effects of government policies on the market. This chapter describes how to estimate demand functions using *regression analysis*, which is an empirical method used to estimate a mathematical relationship between a dependent variable, such as quantity demanded, and explanatory variables, such as price and income.

Further, managers often wish to use data to forecast the future value of an important economic quantity such as future sales. This chapter describes major forecasting methods, focusing particularly on the role of regression analysis in forecasting.

Main Topics

In this chapter, we examine five main topics

1. **Elasticity:** An elasticity measures the responsiveness of one variable, such as quantity demanded, to a change in another variable, such as price.
2. **Regression Analysis:** Regression analysis is a method used to estimate a mathematical relationship between a dependent variable, such as quantity demanded, and explanatory variables, such as price and income.
3. **Properties and Statistical Significance of Estimated Coefficients:** A regression analysis provides information for assessing how much confidence can be placed in the coefficients of an estimated regression relationship, allowing us to infer whether one variable has a meaningful influence on another.
4. **Regression Specification:** For a regression analysis to be reliable, the specification—the number and identity of explanatory variables and the functional form of the mathematical relationship (such as linear or quadratic)—must be chosen appropriately.
5. **Forecasting:** Future values of important variables such as sales or revenues can be predicted using regression analysis.

3.1 Elasticity

Managers commonly summarize the responsiveness of one variable—such as the quantity demanded—to a change in another—such as price—using a measure called an **elasticity**, which is the percentage change in one variable divided by the

associated percentage change in the other variable. In particular, a manager can use the elasticity of demand to determine how the quantity demanded varies with price.

The Price Elasticity of Demand

In making critical decisions about pricing, a manager needs to know how a change in price affects the quantity sold. The **price elasticity of demand** (or simply the *elasticity of demand* or the *demand elasticity*) is the percentage change in quantity demanded, Q, divided by the percentage change in price, p. That is, the price elasticity of demand (which we represent by ε, the Greek letter epsilon) is

$$\varepsilon = \frac{\text{percentage change in quantity demanded}}{\text{percentage change in price}} = \frac{\Delta Q/Q}{\Delta p/p}. \tag{3.1}$$

The symbol Δ (the Greek letter delta) indicates a change, so ΔQ is the change in the quantity demanded; $\Delta Q/Q$ is the percentage change in the quantity demanded; Δp is the change in price; and $\Delta p/p$ is the percentage change in price. According to Equation 3.1, if a 1% increase in the price of a product results in a 3% decrease in the quantity demanded of that product, the elasticity of demand is $\varepsilon = -3\%/1\% = -3$.

The elasticity of demand is a pure number: It is not measured in any particular units like dollars or tons. A useful way to think about elasticity is to consider the effect of a 1% change. If the price elasticity of demand is -2, a 1% decrease in price would cause quantity demanded to increase by 2%.

Arc Elasticity. Very often, a manager has observed the quantity demanded at two different prices. The manager can use this information to calculate an *arc price elasticity of demand*, which is a price elasticity of demand calculated using two distinct price-quantity pairs.[1]

Suppose a manager observes that when the price of coffee rises from \$1.80 to \$2.20, the global quantity of coffee demanded falls from 10.2 million tons to 9.8 million tons per year. To use Equation 3.1, the manager needs to determine the percentage change in the quantity, $\Delta Q/Q$, and the percentage change in price, $\Delta p/p$.

The change in the quantity demanded as the price falls is $\Delta Q = 9.8 - 10.2 = -0.4$ million tons. To determine the percentage change in quantity, the manager needs to divide this change by a quantity, Q. Should the manager use the initial quantity, 10.2, the final quantity, 9.8, or something else? When calculating a percentage change, this choice of the base quantity makes a difference. If the manager uses the initial quantity as the base, then the percentage change in quantity is $-0.4/10.2 \approx -3.9\%$ (where $\approx$ means "approximately equal to"). If the manager uses the final quantity as the base, the percentage change is $-0.4/9.8 \approx -4.1\%$.

Another approach is to use the average quantity as the base. The average quantity is $(9.8 + 10.2)/2 = 10$, so the associated percentage change is $-0.4/10 = -4.0\%$. Many analysts use the average quantity because the elasticity is the same regardless of whether we start at a quantity of 10.2 and move to 9.8 or start at 9.8 and move to 10.2. If, instead, the manager consistently uses the initial quantity as the base, or consistently uses the final quantity as the base, then the percentage change would vary depending on the direction of movement.

[1] In mathematics an arc is any segment of a smooth curve, so the arc price elasticity of demand is the elasticity along some segment of the demand curve.

The percentage change in price can also be calculated by using the average price as the base. The price change is \$2.20 − \$1.80 = \$0.40. The average price is (\$1.80 + \$2.20)/2 = \$2.00. Thus, the percentage change in price is \$0.40/\$2.00 = 20%.

An **arc price elasticity** is an elasticity that uses the average price and average quantity as the denominator for percentage calculations.[2] Using Equation 3.1, the arc price elasticity is

$$\varepsilon = \frac{\text{percentage change in quantity demanded}}{\text{percentage change in price}} = \frac{\Delta Q/\overline{Q}}{\Delta p/\overline{p}}, \tag{3.2}$$

where the bars over Q and p indicate average values. In our example, the arc price elasticity is $-(\Delta Q/\overline{Q})/(\Delta p/\overline{p}) = -4\%/20\% = -0.2$.

Managerial Implication

Changing Prices to Calculate an Arc Elasticity

One of the easiest and most straightforward ways for a manager to determine the elasticity of demand for a firm's product is to conduct an experiment. If the firm is a *price setter* and can vary the price of its product—as Apple, Toyota, Kraft Foods, and many other firms can—the manager can change the price and observe how the quantity sold varies. Armed with two observations—the quantity sold at the original price and the quantity sold at the new price—the manager can calculate an arc elasticity. Depending on the size of the calculated elasticity, the manager may continue to sell at the new price or revert back to the original price. It is often possible to obtain very useful information from an experiment in a few markets or even just one small submarket—in one country, in one city, or even in one supermarket. Managers of price-setting firms should consider using such experiments to assess the effect of price changes on quantity sold.

Q&A 3.1

In the first week after Apple's iTunes raised the price on its most popular songs from 99¢ to \$1.29, the quantity demanded of Akon's "Beautiful" fell approximately 9.4% to 52,760 units from the 57,941 units sold in the previous week.[3] What is the arc elasticity of demand for "Beautiful" based on the average price and quantity?

Answer

Use Equation 3.2 to calculate the arc elasticity. The change in the price is Δp = \$0.30 = \$1.29 − \$0.99, and the change in quantity is $\Delta Q = -5{,}181 = 57{,}941 - 52{,}760$. The average price is $\overline{p}$ = \$1.14 = (\$0.99 + \$1.29)/2, and the average quantity is $\overline{Q} = 55{,}350.5 = (52{,}760 + 57{,}941)/2$. Plugging these values into Equation 3.2, we find that the arc price elasticity of demand for this song is

$$\varepsilon = \frac{\Delta Q/\overline{Q}}{\Delta p/\overline{p}} = \frac{-5{,}181/55{,}350.5}{0.30/1.14} \approx -\frac{0.094}{0.263} \approx -0.36.$$

When price rose by 26.3%, the quantity demanded fell by 9.4%, so the arc elasticity of demand was $\varepsilon = -0.36$. Based on this elasticity, a 1% rise in price would cause the quantity demanded to fall by roughly one-third of a percent.

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[2]Because the arc elasticity of demand uses the average price and quantity as the base for percentage calculations it is sometimes called the *midpoint* elasticity.

[3]Glenn Peoples, "iTunes Price Change: Sales Down, Revenue Up in Week 1," *Billboard*, April 15, 2009.