THIRD EDITION

Valuation

THE ART AND SCIENCE OF CORPORATE INVESTMENT DECISIONS

Sheridan Titman ▪ John D. Martin

VALUATION

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VALUATION

The Art and Science of Corporate Investment Decisions

Third Edition

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To my parents, wife (Meg), and sons (Trevor, Elliot, and Gordon)
—S.T.

To the Martin women (Sally and Mel), men (sons David and Jess),
and boys (grandsons Luke and Burke)
—J.D.M.

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About the Authors

SHERIDAN TITMAN holds the McAllister Centennial Chair in Financial Services at the University of Texas. He has a B.S. from the University of Colorado and an M.S. and Ph.D. from Carnegie Mellon University. Prior to joining the faculty at the University of Texas, Professor Titman was a Professor at UCLA, the Hong Kong University of Science and Technology, and Boston College and spent the 1988–89 academic year in Washington, D.C., as the special assistant to the Assistant Secretary of the Treasury for Economic Policy. In addition, he has consulted for a variety of financial institutions and corporations. He has served on the editorial boards of the leading academic finance and real estate journals, was an editor of the *Review of Financial Studies,* and was the founding editor of the *International Review of Finance.* He has served as President of the American Finance Association and the Western Finance Association, and as a director of the American Finance Association, the Asia Pacific Finance Association, the Western Finance Association, and the Financial Management Association and as the President of the Western Finance Association. Professor Titman has published more than 50 articles in both academic and professional journals and a book entitled *Financial Markets and Corporate Strategy*. He has received a number of awards for his research excellence and is a Fellow of the Financial Management Association and a Research Associate of the National Bureau of Economic Research.

JOHN MARTIN holds the Carr P. Collins Chair in Finance in the Hankamer School of Business at Baylor University, where he teaches in the Baylor EMBA programs. Over his career, he has published more than 50 articles in the leading finance journals and served in a number of editorial positions, including the coeditorship of the FMA *Survey and Synthesis Series* for the Oxford University Press. In addition, he has coauthored the following books: *Financial Management,* 12th edition (Prentice Hall Publishing Company); *Foundations of Finance,* 8th edition (Prentice Hall Publishing Company); *Financial Analysis* (McGraw-Hill Publishing Company); *The Theory of Finance* (Dryden Press); and *Value Based Management* (Harvard Business School Press/Oxford University Press).

John and Sally have two wonderful sons, the world's finest daughter-in-law (their youngest son isn't married), and two beautiful grandsons who visit them often on their ranch outside of Crawford, Texas, where they raise hay and enjoy life with their chickens, dogs (Jack, Minnie and Pearl) and miniature donkeys (Lottie, Dottie, Wavy, Gravy, and Biscuit).

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Brief Contents

Detailed Contents

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Preface

Project and Enterprise Valuation

Most valuation books focus on the valuation of entire businesses, or *enterprise* valuation. But by far, the greatest application of valuation methods today is aimed at individual investment projects. With this in mind, we have developed a book that is designed for readers interested in *project* as well as *enterprise valuation*. This broader focus better fits the economic realities of the modern corporation, which acquires productive capacity in one of two basic ways—through internal growth, which requires the evaluation of project value, and through acquisitions of operating business units, which require the evaluation of business or enterprise value.

We see our potential audience comprised of two key groups:

- **Business professionals** who, because of their business needs, want a state-of-the-art book on the practical implementation of advanced valuation methods.
- **Students** in MBA and upper-division undergraduate finance elective courses that focus on the valuation and analysis of investment opportunities. Such courses may be lecture/problem or case based. Our book would be appropriate as the primary information source for the former and as a supplement for the latter.

What's New in the Third Edition?

The first edition of this book was published in 2007, and since its publication, we have been very gratified and encouraged by the book's acceptance around the world. From conversations with adopters, we have learned a great deal that has helped us improve the book's content and pedagogy. In the second edition we made major changes to the book's focus, increasing the emphasis on enterprise valuation and adding a chapter on financial statement analysis and forecasting. Our focus in this third edition is on pedagogy. Overarching enhancements include the following:

Updated Examples and Exercises

With the dedicated assistance of Lynda Livingston, John Butler, and Joe Hahn, we worked through every example and end-of-chapter exercise and made significant changes that both clarified and simplified them. A sample of enhanced examples include:

- Lecion Electronics Corporation and JC Crawford Enterprises in Chapter 2
- The Earthillizer Proposal in Chapter 3
- Better Buys in Chapter 6
- Adjusted Present Value (APV) in Chapter 9
- Bear-Builders.com in Chapter 10

New End-of-Chapter Questions and Problems

We've added a number of new problems, including a set of "starter" problems we designate as Exercises. The exercises are designed to be used in conjunction with a student's first reading of the chapter. Following these exercises are end-of-chapter Problems that are more challenging.

Videos

New to this edition, we've created lecture capture videos for each chapter to focus on key examples. These videos are short (five to 10 minutes) and give us the opportunity to personally walk the students through the examples. It is our hope that students will come to rely on these recorded videos as a guide to better understanding the text examples. These videos are identified in the textbook with a marginal icon and can be accessed at http://www.pearsonhighered.com/titman_martin/.

Updated Chapter Content

Additional enhancements specific to chapters include the following:

- Chapter 2: New discussions of relevant cash flows; calculation of free cash flows; forecasting of future free cash flows; the use of financial statements to derive cash flow estimates; and key learning points from the analysis of free cash flow and pro forma financial statements
- Chapter 4: New material addressing capital structure weights, decomposition of risk and required returns, levering and unlevering beta, and geometric versus arithmetic mean
- Chapter 9: Further distinctions regarding valuing a project and firm; new Technical Insight on short versus long planning periods; revised GRC growth strategy valuation analysis
- Chapter 10: Industry Insight on the biggest buyout deals of all time
- Chapter 12: New discussion of hedging the price of the risk of delaying the decision to invest; more complicated options and the incentive to wait to invest; hedging oil price risk; and changes in model parameters and real option values.

A Holistic Approach to Valuation

Our vision for this book is to provide an up-to-date, integrated treatment of the valuation of investment opportunities that seriously considers industry practice as well as recent advances in valuation methods. We understand that investments cannot be valued in a vacuum, and wise investment decisions must thus account for how the investments relate to the firm's current and future strategies along a number of dimensions:

- What are the relevant risks of the project, and can the firm hedge these risks?
- How can the investment be financed, and how does financing contribute to its value?
- How does the investment affect the firm's financial statements?
- Will the investment initially improve the firm's earnings per share, or will it lead to a short-term reduction in earnings?
- Is there flexibility in the way in which the project can be implemented, and how does this flexibility contribute to value?
- If we choose to delay the initiation of the investment, will the opportunity still be available in the future?
- Do they exploit the firm's existing comparative advantages, and do they create new comparative advantages that will generate valuable projects in the future?

In addition to these dimensions, we offer a broad spectrum of valuation approaches. Although financial economists and business practitioners recognize that evaluating investment opportunities requires much more than just discounting cash flows, they often pay little attention to other elements of the valuation process. Our focus is multifaceted in that we amplify important areas that often receive short shrift in the valuation process.

Pedagogical Features

Our goal in this book is to provide our readers with the very latest valuation tools that are used in industry. After having taught valuation to hundreds of students and been involved in their job placement, we are convinced of two things. First, a successful financial analyst must have a thorough understanding of valuation theory. Second, students must be able to apply their knowledge of that theory in a practical setting. This means that they must be able to deal with information from a variety of sources, construct models that utilize that information, and then summarize their analysis in a meaningful way. This makes it essential that they develop the necessary skills to manipulate data and develop spreadsheet models.

To accomplish this goal, the book incorporates a number of pedagogical features that should help the seasoned financial analyst as well as the student develop a framework for evaluating the simplest to the most complex valuation problems.

Realistic Assumptions

Valuation principles are best illustrated and learned in the context of realistic situations in which decisions are actually made. Thus, we place our examples in practical settings to give a sense of the context in which decision making takes place. Without delving into theoretical arguments, we apply the recent work of financial economists to the practice of finance in a "messy" world where conditions often deviate from the idealized world of academic finance. In doing so, we acknowledge the limitations of our models and give recommendations on how they can be applied in practice.

Extensions and Insights

A number of special features enrich the text presentation.

- *Industry Insights* delve more deeply into how the tools developed in the book are used in practice.
- *Technical Insights* provide further explanations of mathematics, methodologies, and analytical tools.
- *Behavioral Insights* focus on irrational choices and biases that affect how investment choices are made in practice.
- *Practitioner Insights* provide perspectives from a broad spectrum of professionals who use the various valuation methodologies discussed in the text.
- *Did you know?* side comments provide little slices of interesting financial lore.

End-of-Chapter Exercises/Problems and Mini-Cases

Each chapter contains a generous number of exercises and problems designed to review the materials discussed in the chapter and to allow readers to solidify their understanding of key concepts. The material is practical and ranges in difficulty from introductory exercises and more advanced problems designed to illustrate a single point, to mini-cases in selected chapters, to moderate-length case studies with multiple parts designed to delve more deeply into issues.

Spreadsheet Usage and Support

The majority of the end-of-chapter problems require the use of spreadsheet software. We provide templates for use in solving these problems on the Web site accompanying this book at http://www.pearsonhighered.com/titman_martin.

Use of Simulation Software

Where applicable, we use Monte Carlo simulation. Although the book can be used without this feature, the value of the learning experience will be greatly enriched if the reader works directly with this tool. To facilitate the use of Monte Carlo simulation, an access code to Crystal Ball software has been included with this text. Crystal Ball is an add-in to spreadsheet software that allows you to perform Monte Carlo simulations by automatically calculating thousands of different "what if" cases, saving the inputs and results of each calculation as individual scenarios. Analysis of these scenarios reveals to you the range of possible outcomes, their probability of occurring, which input has the most effect on your model, and where you should focus your efforts. Alternatively, readers already familiar with other simulation packages (e.g., @Risk) may use those instead.

Videos

We created these videos for this edition as a way to further students' understanding of key topics in the text. In the five- to 10-minute videos, we walk students through one example for each chapter, which include discussions on the project valuation process, forecasting project cash flows and valuation, estimating a firm's WACC, estimating enterprise value, and valuing a strategy with staged investments. The videos are identified in the text with an icon and can be accessed at http://www.pearsonhighered.com/titman_martin.

Supplements

We provide a number of ancillary materials for the instructor, student, and practitioner.

Excel solutions are available to instructors online for end-of-chapter exercises, in addition to the spreadsheet models that are used. Online PowerPoint® Lecture Outlines set out major points for the entire text, along with slides of figures and tables in the book. A dedicated Web site, http://www.pearsonhighered.com/titman_martin, contains spreadsheet templates for end-of-chapter problems, plus recommendations for case studies.

Structure of the Book

Chapter 1 provides an aerial view of project evaluation and sets out a road map for the remaining chapters. We use Chapter 1 to launch a discussion of our view of the art and science of valuation in general, with an emphasis on the need for a rigorous decision process.

Chapters 2 through 13 are divided into five parts. Part I (*Project Analysis Using Discounted Cash Flow*) is comprised of Chapters 2 and 3. In Chapter 2 we set out the basic tool of discounted cash flow analysis and extend the analysis to other models in Chapter 3. Discounted cash flow (DCF) analysis has been the mainstay of financial analysis since the 1950s and continues to be what most financial analysts think of when they think about project or enterprise (business) valuation. However, DCF analysis is often oversimplified in classroom presentations, so that when the various nuances of practical applications are encountered in the real world, the proper application of DCF is often confusing—even for seasoned professionals. We focus on a three-step approach to DCF analysis that entails carefully defining cash flow estimation, matching cash flows with the proper discount rate, and using the right mechanics to estimate present value.

Part II (*Cost of Capital*), consisting of Chapters 4 and 5, discusses how to estimate the cost of capital, which is an essential building block in the valuation process. The cost of capital can be viewed as the opportunity cost of financing the investment, which, in turn, is the appropriate discount rate for valuation analysis. We evaluate the cost of capital for the firm as a whole and for individual investment proposals or projects. The former is the discount rate used to value an entire business enterprise, while the latter is the discount rate for valuing an individual investment.

Chapters 6 and 7 form a section titled *Financial Statements and Valuation.* In Chapter 6, we review the firm's basic financial statements and discuss the use of pro forma financial statements in forecasting future cash flows. Chapter 7 (Chapter 9 in the first edition) is included in this new section to complete our analysis of accounting information and valuation. Specifically, Chapter 7 focuses on the problem of evaluating financial performance and the role that reported earnings have on financial decision making.

In Chapters 8 through 10, Part IV (*Enterprise Valuation*), we examine the challenging task of estimating the value of a business enterprise. These chapters combine the DCF methodology developed in earlier chapters with the analysis of various accounting ratios. We consider the value of an ongoing business from the perspective of the firm's stockholders as well as from the perspective of the acquiring firm. In addition, we look at the value of the firm through the eyes of the private equity investor, including both the venture capitalist and the LBO firm.

Part V (*Futures, Options, and the Valuation of Real Investments*) features a three-part treatment (Chapters 11–13) of real options. In these chapters, we demonstrate how options are used both at the nitty-gritty level where the value of project cash flows is estimated and at the strategic level where new businesses are evaluated. In Chapter 11, we note that the rapid development of markets for financial derivative products related to basic commodities, foreign exchange, and interest rates has opened the possibility for firms to "lay off" significant risk exposures through hedging transactions and that this opportunity has changed the way we think about valuation. Chapter 12 covers the central issue in real option analysis: the valuation of investments when management has flexibility in how the investment is implemented. In Chapter 13, we use the concepts developed in Chapters 11 and 12 to analyze the value of business strategies.

We also include an Epilogue that discusses the disconnects we have observed between valuation theory and industry practice, and we make a few predictions about the extent to which such gaps may be reduced in the future.

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We would particularly like to thank the following reviewers and colleagues, whose insights were of immense value as we developed this book.

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S.T.
J.D.M.

CHAPTER 1

Introduction to Valuation

Chapter Overview

Chapter 1 focuses on the inherent challenges that arise in the valuation of investments. These investments include routine acquisitions to replace worn or outdated equipment and the acquisition of stand-alone businesses. Whether we are valuing a small investment project or valuing an entire stand-alone business, we need a process to make rational investment decisions.

Chapter 1 is organized as follows: First, we review the notion of project valuation in terms of its anticipated impact on the wealth of the firm's owners. Second, we highlight five key challenges that can arise in valuing a major investment proposal by using a case study involving a large investment made by a group of multinational oil companies.

To deal effectively with the challenges involved in valuing major investments, firms must have a disciplined approach, founded on a sound evaluation process. We present a three-phase investment evaluation process to address this need. This process begins with the identification of an investment idea and ends with the final approval. The process does not eliminate all bad investments because investing is inherently risky; however, it does help to ensure that the firm does not fall victim to decision errors based on flawed analysis.

1.1 Introduction

Valuation is central to most of what we do in financial analysis. When firms evaluate either an internally generated investment project or an external acquisition, one of the first steps in the process is a valuation of the opportunity. Moreover, when firms consider either share issuances or share repurchases, an initial step in the evaluation process is the valuation of the firm's own shares.

To illustrate the key role played by valuation in financial decisions, let's first consider Starbucks' (SBUX) acquisition of Seattle's Best Coffee in 2006. As part of the acquisition process, Starbucks' financial analysts estimated the intrinsic value of the shares of Seattle's Best in order to determine how much they would be willing to pay for the company. Starbucks' management probably also did a valuation of their own shares to gauge whether their stock was under- or overvalued because this would influence whether they would want to make an all-cash offer for Seattle's Best or offer Starbucks shares in exchange for Seattle's Best shares.

If you were a security analyst responsible for advising investors on whether to buy or sell Starbucks common stock, you would also be keenly interested in this acquisition. Your job would require you not only to value each of the companies but also to assess whether their combination would generate new sources of value (i.e., synergies) or be an enormous waste of resources.

Corporate financial analysts also spend considerable amounts of time valuing investment projects. For example, before introducing its new Via® product line of instant coffees, Starbucks' financial analysts performed a valuation of the new product line that included an analysis of the demand for the product as well as the costs of developing, marketing, and producing the new product line. The final go–no go decision on Via® boiled down to a comparison of the value of the investment's future cash flows with the cost of launching the investment.

Whether you are valuing an ongoing business or an investment project, the procedure you follow is essentially the same. In each case, you will need lots of information. Specifically, you will need to

1. make estimates of the cash flows generated by the investment,
2. assess the riskiness of those cash flows and determine the appropriate discount rate to use in valuing the estimated cash flows, and
3. identify comparable investments that are either publicly traded or have recently been bought or sold to serve as a reality check on your analysis of items 1 and 2.

If you are valuing the shares of a publicly traded firm, the process is relatively straightforward. The company has a history that includes past cash flows and stock returns, and in most cases, you will have access to information about other comparable, publicly traded firms. The information about comparable firms will prove to be very helpful in estimating the value of the firm of interest. The valuation of an investment project can be more challenging because you do not typically have the benefit of historical data and are likely to have fewer comparable transactions that you can use to help gauge how other market participants have evaluated similar investments. However, the valuation process in each case is very much the same.

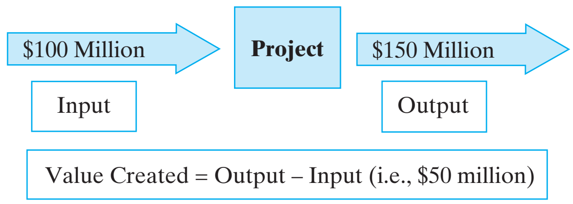
As a financial analyst evaluating a potential acquisition, you are faced with additional challenges. In addition to assessing the cash flows of the acquisition candidate as a standalone company, you must identify any synergies with the acquiring firm that make the value of the combined firms greater than the sum of the values of the two individual companies.

1.2 The Nature of Major Investment Decisions

As the discussion in this chapter indicates, firms grow and expand their operations in one of two ways: They acquire productive capacity by assembling the necessary assets, or they acquire existing businesses. In the first case, we refer to the valuation problem as **project valuation**; in the second case, we refer to the valuation problem as **enterprise valuation**. Throughout this text, we will consider examples of both project and enterprise valuation and provide a common set of tools and underlying principles that can be used for both types of analysis.

Throughout most of the text, we assume that the firm's objective is to create wealth by initiating and managing investments that generate future cash flows that are worth more (i.e., have a higher monetary value) than the costs of the investment. On the

Figure 1-1 Investment Evaluation



surface, the process appears quite simple. Consider the illustration in Figure 1-1: A firm has the opportunity to invest $100 million in a project that generates a stream of cash flows that are valued at $150 million. By making the investment, the firm generates an incremental $50 million in wealth for its shareholders; that is, it expects the project to be worth $50 million more than it costs (in today's dollars). In the jargon of finance, the project has an expected **net present value (NPV)** of $50 million.

It is an unfortunate fact of life, however, that over half of all large investment projects fail to achieve their hoped-for results.[1] The record of merger and acquisition performance is even more problematic, as exemplified by Daimler-Benz's purchase of Chrysler for $35 billion in 1998. Chrysler was later sold in 2007 for only $7.4 billion; it then went bankrupt and was taken over by Fiat in 2009. If project evaluation is as straightforward as depicted in Figure 1-1, then why do so many big investments fail?

One explanation for failed investments is simply that firms invest in risky projects, and we should not expect them to be right all the time. Using a sports analogy, when you swing for the fences, you can expect to strike out a lot. We contend throughout this text, however, that there is more than investment risk and bad luck at work here. The fact is that analyzing capital expenditure choices can be both complex and tedious, and managers must make their investment decisions on the basis of incomplete information about uncertain future events. In the face of this complexity and uncertainty, managers often just "go with their gut" and initiate the investments that feel right.

We agree that managers with reliable intuition (that is, a discriminating gut) and the experience to make sound judgments will—and should—ultimately make the major corporate investment choices. However, analytical tools, as well as sophisticated yet inexpensive and user-friendly computer software, can help managers see through the complexity and work through the tedium inherent in the evaluation of a major investment. It is our belief that, by using these tools and taking a more disciplined approach to valuation, managers' judgment will be enhanced and they will make better investment choices.

[1] Matta and Ashkenas (2003) arrive at this conclusion by analyzing a set of project initiatives that include major technology installations, postmerger integrations, and new-growth strategies (Nadim F. Matta and Ronald N. Ashkenas, "Why Good Projects Fail Anyway," *Harvard Business Review* [September 2003]: 109–114).

1.3 Valuing Projects and Businesses

To provide a brief overview of the kinds of issues that we will be exploring in this text, this section describes two major investments. The first is a project that resulted in the development of the Caspian Sea oil fields, which are currently a major source of oil. The second is the acquisition of Linksys Group by Cisco Systems (CSCO).

Project Valuation—Investing in the Caspian Sea Oil Fields

To illustrate the challenges associated with valuing a large investment opportunity, we begin by describing a major oil investment in the Caspian Sea.[2] Although this investment can be thought of as an investment project, it was in fact the creation of a new firm that was jointly held by lots of oil companies in the early 1990s. Imagine that you are sitting at the table when the analysis began and are trying to get a handle on the risks and potential rewards that might accrue to your firm if it undertakes the investment.

To be more specific, the investment consists of part ownership of a joint-venture consortium comprised of eleven oil companies. The consortium, known as the Azerbaijani International Oil Consortium, includes the state oil company of Azerbaijan, British Petroleum, Amoco, the national oil companies of Russia and Turkey, and several other foreign oil companies. The eleven oil companies jointly have the right to develop three oil fields in the western part of the Caspian Sea that were estimated to contain 4.5 to 5 billion barrels of oil.[3]

The right to develop the three fields would be subject to certain conditions. The consortium will complete a seismic survey, an environmental impact study, and the drilling of a series of test wells. It will then have to submit a development plan to the state oil company of Azerbaijan, outlining the development of the fields based on its preliminary findings. Following the initial work, the consortium will eventually submit a plan involving four stages, which are summarized in Figure 1-2. Both the state oil company of Azerbaijan and the consortium have the right to approve each step in the process based on the results of the prior stage. A production-sharing agreement will define the revenue-sharing agreement for the output from the investment, if it is successful.

As the results of each stage of the project become known, the management of the state oil company of Azerbaijan and the consortium are faced with the decision of whether they should enter the next phase of the project. In essence, if the decision is made to proceed with the early-stage investment, the consortium acquires the *option* to make successive investments in each of the three subsequent stages of the development process. Assuming that all stages of the investment are executed successfully, the fact that the consortium has developed expertise in the region makes it possible for each member of the consortium to compete on favorable terms with would-be competitors for future investment opportunities.

[2] For more information, see Benjamin Esty and Michael Kane, BP Amoco (B): Financing Development of the Caspian Oil Fields, *Harvard Business School Press,* Case #9-201-067, 2001.

[3] "Azerbaijan-Pipeline Knocked Back," *Project Finance International* (March 24, 1999): 45.

Figure 1-2 Stages of Investment in the Caspian Sea Oil Development Investment

1998–1999	Early Oil Project
	■ Develop Chirag field by refurbishing offshore drilling platform and drilling new wells. ■ Construct undersea oil pipeline to terminal (105 miles). ■ Rebuild two export pipelines (total of 1,300 miles). ■ Estimated cost = $1 billion.
Beginning in 2000	**First-Stage Development**
	■ Develop the Azeri field. ■ Estimated cost = between $2.6 and $3.1 billion.
Beginning in 2002	**Second-Stage Development**
	■ Develop the deepwater Gunashli field. ■ Estimated cost = $3 billion.
Beginning in 2003–2004	**Third-Stage Development**
	■ Additional development of the Azeri field. ■ Estimated cost = $2 billion.

Issues to Consider When Valuing an Investment

The Caspian Sea oil-field development project illustrates the complexities of the environment in which companies make investment decisions. In any situation in which a company must value a major new investment, five key issues arise. Figure 1-3 highlights these issues, which we discuss below.

Issue #1: Does the "Story" Make Sense?

Before the firm makes any investment, the investment story, or strategy, must be plausible to decision makers. By "make sense," we mean that management must be convinced that the potential gains from the investment are large enough to warrant initial investigation. Also, management must believe that the firm's management team

Figure 1-3 Important Issues to Think About When Making a Major Investment

1. Does the "story" make sense?
2. What are the risks involved in undertaking the investment?
3. How can the investment be financed?
4. How does the investment affect near-term earnings?
5. Does the investment have inherent flexibilities?

possesses (or can acquire) the expertise required to reap the rewards of investing. Specifically, does the firm have a *competitive advantage* due to specialized knowledge or circumstance that allows it to capture the benefits of the investment?

The ultimate success or failure of an investment is largely driven by the capabilities of the firm that undertakes the investment and how these capabilities compare with the capabilities of possible competitors. This notion is captured by the concept of *comparative advantage.* Therefore, a complete analysis of an investment must address the following strategic issues as part of its "story": Does the firm, and does this project, provide any comparative advantage(s) relative to those of other firms and existing projects? Are the firm's comparative advantages sufficient to deter competitors from making similar investments?

Issue #2: What Are the Risks Entailed in the Investment, and How Can They Be Assessed and Dealt with in the Analysis?

The old adage "Look before you leap" is good advice when evaluating investment opportunities. Specifically, a careful assessment of *what might go wrong* is perhaps even more important than an analysis of what we hope will go right. For example, international investment projects that are made in emerging markets expose the investing company to a myriad of risks.

The financial analyst must then ask, "What are the underlying risks associated with the investment?" "How should these risks be incorporated into the project analysis?" "Do the investment risks affect the rate of return that should be used to evaluate whether to undertake the investment?" "Are there governmental programs (domestic or foreign) that can insure the investment in the event of political instability?" "How does the ability of the firm to transfer investment risk affect the financing of the project and the project's valuation?"

Issue #3: How Can the Investment Be Financed?

The ability to secure attractive financing can be a key determinant of the value of the investment. For example, firms can sometimes obtain debt subsidies in the form of government guarantees or credit enhancements, especially when international investments are involved. In other cases, firms might raise private equity (discussed in Chapter 10) and new debt financing to fund off-balance-sheet investments known as special-purpose entities (SPEs).[4]

The evaluation of financing opportunities addresses issues such as the following: How do the characteristics of the firm and the project (e.g., the extent that the risks of the project can be managed by transferring the risk to another party via a financial contract) affect how it is financed? How does the financing of the project affect how the project can be valued? We will have more to say about the relation between financing and value in Chapter 4.

In addition to asking how much debt to use, the firm should also discuss the type of debt to use. Should the project be financed on the firm's balance sheet, or should it be financed off the balance sheet with nonrecourse debt (i.e., project financing)?[5]

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[4] Although SPEs were made famous by Enron, they have been and continue to be useful vehicles for raising financing for firm investments.

[5] *Nonrecourse debt* or project financing refers to debt for which the lender's only recourse in the event of default is to use the assets of the investment or project. That is, the debt is to be repaid out of the cash flows generated by the project, and there is no recourse to the company sponsoring the investment in the event that the project's cash flows are insufficient to meet the project's financial obligations.

Issue #4: How Does the Investment Affect Near-Term Earnings?

Investors and equity analysts use the firm's reported earnings as an indicator of the firm's success or failure. When considering a large investment, managers are keenly aware of its effect on earnings. They ask whether a project is likely to *dilute* (reduce) or *accrete* (increase) the firm's earnings per share. For example, a major oil project like the one in the Caspian Sea can often dilute the firm's earnings in the early years because of the considerable upfront expenses and deferred cash flows. However, earnings should increase over time as the future benefits from the project materialize.

A project's effect on earnings can influence investment decisions for a variety of reasons. For example, if company executives are paid on earnings-based performance measures, or if they believe that investors focus on earnings per share, then they may be reluctant to invest in a project that affects the firm's earnings negatively. Thus, accounting and the design of pay-for-performance policies often influence a firm's investment decisions. Chapter 7 delves into the potential importance of earnings on a firm's investment decisions, as well as on how residual income (or Economic Value Added™)[6] can be used to help resolve the problems associated with earnings as a performance metric.

Issue #5: Does the Investment Have Inherent Flexibilities That Allow the Firm to Respond to Changing Circumstances?

Firms typically have a specific plan that guides the implementation of their investment projects. However, uncertain future events make it particularly important that the project provide opportunities to react and adapt the implementation plans to changing circumstances. Specifically, these opportunities include the following.

Can the investment be staged? Often, as in the Caspian Sea oil-field case, firms undertake very large investments in stages. Staging allows the firm to manage its risk exposure by making a series of successively larger commitments based on the success of the prior investment. This is clearly the case with large oil-development projects: They typically include an early stage that provides information about the size of the oil reserves before the firm initiates later development stages. This is also true for many new products or services for which the test-marketing phase reveals important information about their sales potential.

When the firm invests in the initial stages, it essentially acquires the option to invest in later stages of the project (if the intermediate investments prove fruitful). The flexibility to delay implementation of a project, to cut one's losses and abandon a project or to expand a successful investment, are examples of options that can add considerable value to a project. We will have more to say in Chapter 12 about the evaluation of such options.

Decision makers should be aware that, in some instances, what appears to be an option turns out to be an obligation. Specifically, if there is no real possibility that an option will *not* be exercised, then it's not an option at all. In the Caspian Sea case, for example, it may turn out to be very difficult for the consortium members to back out after stage 1.

Does the investment offer the opportunity for follow-on investments? The opportunity to invest in a new product, market, or technology can provide valuable follow-on investment opportunities. Most new investment opportunities arise out of previous investments

[6] Economic Value Added™ (EVA™) is a registered trademark of Stern Stewart and Company.

that the firm has made. The Caspian Sea investment may generate additional oil and gas deals or even the opportunity to enter the petrochemical business in central Asia. Consequently, the valuation of investments with follow-on opportunities requires consideration of *two sets* of cash flows: the cash flows provided by the immediate opportunity as well as those from the possible subsequent projects. The fundamental issue is this: How should the company value these follow-on opportunities and incorporate them into the analysis of the initial decision to invest? We will have more to say about this topic in Chapter 13.

Does the investment provide production or marketing synergies with existing products? To the extent that the new investment shares existing production and/or marketing resources, the opportunity exists to gain a comparative advantage over the firm's competitors.

Enterprise Valuation—Mergers and Acquisitions

The five basic issues encountered in analyzing the Caspian Sea investment project also apply to *enterprise valuation*—the valuation of an entire firm. From the financial analyst's perspective, the fundamental question is the same: What is the investment worth, and how does this compare to its cost?

Cisco Systems (CSCO) is noted for its policy of acquiring existing firms. This strategy of expansion through acquisitions entails the same problems that we encountered in the Caspian Sea project valuation. For example, on March 20, 2003, Cisco announced plans to acquire The Linksys Group Inc. of Irvine, California, for a total purchase price of approximately $500 million. Although we do not have detailed information concerning Cisco's analysis of the acquisition, the following discussion (based on a company press release)[7] highlights how Cisco described its assessment of the five basic issues identified earlier.

Issue #1: Does the "story" make sense?

"Fueled by consumer broadband adoption, the home networking space has experienced mass market acceptance. Linksys has captured a strong position in this growing market by developing an extensive, easy-to-use product line for the home and small office."[8] The acquisition is an example of Cisco's strategy to broaden its end-to-end portfolio of network solutions into high-growth markets such as wireless, voice over IP, and storage-area networking.

Issue #2: What are the risks entailed in the investment, and how can they be assessed and dealt with in the analysis?

An important source of risk in the investment relates to technological risks. For example, are there wireless technologies that might be developed that would render Linksys' products noncompetitive? This risk is very real for technology-based companies; however, Cisco has partially mitigated this risk by acquiring the recognized industry leader. The challenge facing Cisco in the future will be to maintain Linksys' competitive edge while operating the company as a division of a much larger firm.

[7] Cisco Systems press release, March 20, 2003, http://newsroom.cisco.com/dlls/corp_032003.html.

[8] "Cisco Systems Announces Agreement to Acquire the Linksys Group, Inc.," news release, March 20, 2003.

Issue #3: How can the investment be financed?

"Under the terms of the agreement, Cisco will issue common stock with an aggregate value of approximately $500 million to acquire the Linksys business and to assume all outstanding employee stock options."

Issue #4: How does the investment affect near-term earnings?

"Exclusive of acquisition charges, Cisco anticipates this transaction will add approximately $0.01 to its FY2004 pro forma EPS. The transaction will be accretive to both GAAP and pro-forma earnings thereafter."

Issue #5: Does the investment have inherent flexibilities that allow the firm to modify the investment in response to changing circumstances?

In particular, can the investment be undertaken in stages?

- Cisco's acquisition of Linksys is another step in a broad strategy to expand its home and small office product line aimed at developing a dominant position in the home and small office networking market.

Does the investment offer the opportunity for follow-on investments?

- "This acquisition represents Cisco's entry into the high-growth consumer/SOHO [small office, home office] networking market. Home networks allow consumers to share broadband Internet connections, files, printers, digital music, photos, and gaming, all over a wired or wireless LAN (local area network)."

Does the acquisition offer production and/or marketing synergies with existing products?

- Clearly, Linksys offers products that can be marketed using channels of distribution similar to those already in place at Cisco. In addition, similarities between small business and home applications should provide synergies with Cisco's existing marketing assets.

1.4 Dealing with Complexity—Process and Discipline

Whether making an investment like the one in the Caspian Sea oil fields or Cisco's acquisition of The Linksys Group, the evaluation can become very complex. To address this complexity in a disciplined way, firms develop policies and procedures that prescribe how to evaluate new investment opportunities. The purpose of these procedures is to ensure that projects receive a thorough analysis and that the project selection process is not subverted by the special interests of one or more managers.

The Investment Evaluation Process

Figure 1-4 summarizes an **investment evaluation process.** This three-phase process captures the critical elements of valuation, beginning with idea generation and ending with a final go–no go investment decision. The process is very general and illustrates how investments are evaluated across a wide variety of industry settings and sizes of firms. Note that these phases are broad enough to cover enterprise evaluation and narrow enough to cover project valuation.

Figure 1-4 Three-Phase Investment Evaluation Process—Covering All the Bases

PHASE I	**Investment (Idea) Origination and Analysis**
Step 1:	Conduct a strategic assessment.
Step 2:	Estimate the investment's value ("crunch the numbers").
Step 3:	Prepare an investment evaluation report and recommendation to management.
PHASE II	**Managerial Review and Recommendation**
Step 4:	Evaluate the investment's strategic assumptions.
Step 5:	Review and evaluate the methods and assumptions used to estimate the investment's NPV.
Step 6:	Adjust for inherent estimation errors induced by bias, and formulate a recommendation regarding the proposed investment.
PHASE III	**Managerial Decision and Approval**
Step 7:	Make a decision.
Step 8:	Seek final managerial and possibly board approval.

Phase I: Investment (Idea) Origination and Analysis

Firms learn about major investment opportunities from a variety of sources. A common source of ideas is the firm's employees and customers. Another source is outside organizations that bring proposals to the firm's attention, such as investment bankers and other firms that want to buy or sell specific assets.

This initial phase of the analysis includes three activities:

1. **Conduct a strategic assessment.** Every investment opportunity has an underlying strategy (value proposition) that provides the basis for making the investment. The initial screening of investment proposals begins with an assessment of the soundness of this underlying strategy. Members of the firm's business development group often do this screening. If the investment (project or enterprise) looks promising after the initial review, then an investment evaluation team further investigates the opportunity and makes a recommendation to management.
2. **Estimate the investment value.** The objective of the estimation part of the process is to determine whether the investment has the potential to create value for the firm's stockholders (to "crunch the numbers"). Traditionally, this analysis involves applying valuation models such as discounted cash flow and market-based multiples (e.g., market to book, price to earnings). However, when the investment's potential to create value has multiple sources, the evaluation can involve many other types of analysis, including (a) projected cash flows from existing or proposed operations, (b) built-in project flexibility that enables management to modify the investment over its life in response to changing market conditions (i.e., real options), (c) opportunities to manage (i.e., control or even eliminate) some of the investment's inherent

sources of risk, (d) the ability to structure the organization (align decision authority and compensation policies) to enhance the investment's value-creation potential, (e) financing alternatives, and (f) the effect of the investment on the firm's near-term earnings.

3. **Prepare the investment evaluation report and recommendation for submission to management.** Combining the strategic and quantitative analyses from steps 1 and 2, the investment analysis team prepares a report summarizing its recommendation to the managerial oversight committee. At a minimum, the report contains (a) an assessment of the investment's strategy and the firm's comparative advantage in carrying out the strategy, (b) an estimate of the value of the investment (net present value), and (c) the supporting information and assumptions used in the analysis.

Phase II: Managerial Review and Recommendation

Managerial review serves a control function: It screens the initial analysis for potential sources of errors and investment-selection bias. To provide an independent review, a different group of employees (employees who did not perform the original analysis) reviews the proposal. Typically, firms use an investment review committee (sometimes known as the *strategic planning committee*) to review new proposals.

The fundamental responsibility of the investment review committee, as the name implies, is to review the recommendation of the initial investment analysis team. The review committee makes sure that the assumptions of the initial evaluation team are reasonable and that nothing has been forgotten in the analysis. If the review process recommends the investment to management, the review committee also assesses how much to invest. In summary, the investment review committee provides a system of checks and balances designed to weed out bad investments and flawed investment analysis.

The activities involved in phase II mirror those of phase I:

1. **Evaluate the investment's strategic assumptions.** The review process, like the initial investment screening (step 1), begins with an assessment of the investment's value proposition or strategy. Does the story underlying its value-creation potential make sense? Do the hedging opportunities offer sources of value to the firm? Do investment-specific financing alternatives make sense, and do they have a reasonable prospect of adding value?
2. **Review and evaluate the methods and assumptions used to estimate the NPV of the investment.** The committee evaluates the quantitative analysis conducted in phase 1. Are the assumptions that underlie earlier price, cost, and quantity estimates reasonable in light of observed market prices and the market shares of competitor firms and products? Are there any additional options (follow-on investments and other important sources of value creation) inherent in the proposal that were not considered in the earlier report? Are there opportunities to expand or contract the scope of the investment (even abandon it altogether)? Although it can be very difficult to estimate their value, it is critical that the firm consider these options in order to value the investment properly.
3. **Adjust for inherent estimation errors induced by bias, and formulate a recommendation regarding the investment.** The origination process can be fraught with the potential for biased estimates of an investment's value. After making appropriate adjustments, the managerial review committee passes its recommendation to the executive responsible for making a final decision.

Phase III: Managerial Decision and Approval

The final responsibility for making the investment rests with an executive in the firm who possesses the appropriate level of authority. Combining top management's sense of the firm's overall business strategy with the recommendation of the investment review committee, a decision is made. The choices are to reject the proposal outright or to accept the proposed investment (either as is or with revisions) for immediate or deferred implementation. Typically, the larger the financial commitment an investment requires, the higher the level in the management hierarchy that is required for commitment approval. For very large investments, board approval is generally necessary.

1.5 Case Study—CP3 Pharmaceuticals Laboratories Inc.

Figure 1-4 presented a three-phase, eight-step process for carrying out a disciplined approach to the investment evaluation and decision process. In this section, we use a hypothetical example to walk through a typical investment evaluation for a relatively small project. It involves the desire of CP3 Pharmaceuticals Laboratories Inc. (a fictional name for a real company) to invest $547,000 to install a new materials-handling system. The example begins with the identification of the idea and concludes with the final go–no go decision.

Example: Investing in a New Materials-Handling System

Susan Chambliss is a vice president for business development at CP3 Pharmaceuticals Laboratories Inc. The members of CP3's business development group scout for new investment opportunities for the company on an ongoing basis. Most firms of any size have such a group. Investment opportunities for CP3 can include new products or new markets for existing products. Therefore, it is not at all unusual that someone from this group, Susan in this instance, identifies a promising investment opportunity.[9]

CP3 operates a medical-packaging operation at its Austin, Texas, facility that has significant costs from product waste. Susan has identified a new materials-handling system that offers the potential for substantial cost savings through waste reduction, reduced head count in the manufacturing area, and savings through plastic recycling. Figure 1-5 provides details of the proposed project, in the format of the company's capital expenditure request form.

Before initiating a formal analysis of the proposed investment, Susan engages in informal discussions with senior executives on CP3's strategic planning committee. This committee reviews all major investment proposals that the firm undertakes and makes recommendations about the projects' viability. The makeup of this committee at CP3 is typical of such committees at other companies: It includes the company treasurer, the chief financial officer (CFO), the chief operating officer (COO), and the chief executive officer (CEO).

[9] This does not mean that all investment ideas originate in business development. To the contrary, in a healthy firm, investment ideas come from all over the firm. At some point, however, if the investment is significant, the business development group is involved.

Figure 1-5 **Capital Expenditure Request Form**

1. Executive Summary

CP3 Pharmaceuticals Laboratories' Austin, Texas, plant is requesting $547,000 to purchase and install a new scrap materials-handling system for its medical-packaging operations. Purchasing the new system will allow the plant to meet the following objectives:

- Reduce waste in the firm's packaging operations, for savings of $300,000 per year.
- Reduce head count from the test area. Estimated savings of $35,000 per year.
- Recycle plastic materials that historically were part of waste, with disposal cost of $8,800 per year.
- Earn a 20% rate of return on invested capital.

2. Proposal and Justification

CP3's medical-packaging unit is expected to produce over 400 million vials of over-the-counter drugs this year. The packaging of these vials will generate 1.5 million pounds of scrap plastics. Of this total, one-third can be recycled, and the remainder becomes scrap. Under the present method, the scrap is collected in bins at the end of each of six production lines. The bins are then collected every 15 minutes and transferred to a grinding room, where the scrap is either ground for resale or transported to trash. At present, the disposal cost for the 1 million pounds of scrap plastic is $8,800 per year.

The proposed scrap materials-handling system involves placing a small grinder at the end of each production line that can grind the plastic, then sending the scrap via vacuum tubes to a scrap collection site in another part of the plant. The ground-up scrap can then all be sold for $300,000 per year, while eliminating the scrap-disposal cost of $8,800 per year.

3. Financial Analysis

	2015	2016	2017	2018	2019	2020
Capital spending	(547,000)					
Impact on revenue/(expense)						
Scrap revenue		300,000	300,000	300,000	300,000	300,000
Labor savings		35,000	35,000	35,000	35,000	35,000
Reduced recycle costs		8,800	8,800	8,800	8,800	8,800
Total impact		343,800	343,800	343,800	343,800	343,800
Less: Depreciation (5 years)		(109,400)	(109,400)	(109,400)	(109,400)	(109,400)
Net operating income b/tax		234,400	234,400	234,400	234,400	234,400
Less: Taxes (40%)		(93,760)	(93,760)	(93,760)	(93,760)	(93,760)
Net operating profit after tax		140,640	140,640	140,640	140,640	140,640
Plus: Depreciation expense		109,400	109,400	109,400	109,400	109,400
Less: Capital expenditures	(547,000)	—	—	—	—	—
Project free cash flow (Project FCF)	(547,000)	250,040	250,040	250,040	250,040	250,040

Net present value (NPV)	$200,773
Payback (in years)	2.19 years
Internal rate of return (IRR)	35.8%

4. Risks

The grinders and vacuum transport systems have been tested for over a month with only two minor failures. The failures relate to stoppages at the end of line 4, which carries some of the larger scrap pieces. This problem has been addressed by increasing the size of the grinder on that line and by installing sensors to provide an alert that a stoppage is about to occur so the operator can stop the process and clear the grinder and vacuum tubes.

5. Project Timeline

It will take three months to get the new system up and running, because the installation must work around production shifts already in place.

Because Susan will ultimately need the approval of this committee, it makes sense that she begins by showing her idea, while still in the formative stage, to one or more of the members. Given the time and effort associated with the analysis of a new investment opportunity, she wants a preliminary indication that the project has a reasonable chance of approval before going forward. For example, maybe company executives are considering the possible closure or sale of the medical-packaging operations. If so, then it clearly would not make sense for Susan to invest time or energy to form a working group to explore her idea further.

After several informal discussions, Susan concludes that the new materials-handling system has promise, so she initiates the study. For a project as small as this one, Susan simply assigns the project to a single financial analyst. For very large and complex projects, she might form a team consisting of several people who possess the requisite skills to understand and evaluate the investment opportunity.

Susan asks the analyst to prepare a report for formal submission of the project to the strategic planning committee. The information in Figure 1-5 is an abbreviated version of a firm's typical investment evaluation report. The report begins with a list of the various reasons why the group believes the project is likely to be successful and includes the project's net present value, internal rate of return, and payback. (These are all concepts that we review in later chapters.) The financial analyst who prepared the analysis also included specific cost and cash flow projections to back up the summary analysis. These estimates span a period of five years, ending in 2020. If this project were larger, the report would probably address several other important issues as well. For example, it might include an estimate of the expected impact of the investment on CP3's reported earnings for several future quarters, an analysis of various scenarios involving key cost and revenue drivers to highlight the risks inherent in the investment, and a discussion of how the firm can finance the project, as well as the project's risks.

When the project analysis report is completed, the strategic planning committee often has another analyst prepare an independent assessment of the proposal's merits. This review checks the assumptions and methodology of the original project valuation estimate. A key concern with regard to the integrity of the investment evaluation process is that the project review and analysis group be truly independent of the analysts who prepared the initial project report.

Addressing the Possibility of Decision Bias

Biases of various sorts can enter into the analysis of new investment proposals. For example, Susan and members of the project analysis team may be biased if they have *incentives* to get the deal approved. Indeed, because Susan's job is to identify good opportunities for the firm, her bonus and her ability to keep her job may depend on her ability to get her ideas approved. Bias may also enter the process simply because of *human nature:* Psychologists have found that individuals tend to be overconfident and overly optimistic about their own ideas.

The Role of the Strategic Planning Committee As the Skeptical Boss

In light of the potential for bias in favor of new investments, the strategic planning committee must play the role of a skeptical boss. Very simply, this committee has the task of reviewing major investment proposals and attempting to ferret out any bias in their analysis that arises out of the natural tendency for project champions to be overconfident and overly optimistic. The members of the strategic planning committee understand that projects are often completed at 50% over budget and are rarely completed under budget. They also understand that realized rates of return are almost always lower than projected rates of return. With this in mind, the strategic planning committee's role requires that its members work through the assumptions and the analysis carefully and question everything. If the controls in the firm are functioning properly, the strategic planning committee must sign off on the analysis before the project can go forward.

Although the strategic planning committee carefully reviews the analysis on which the project is based, its members may also have a broader perspective. They may consider issues that go beyond the attributes of this specific project. For example, they might consider the possibility of moving the business offshore and closing down the Austin plant, in which case the new project makes little sense.

The strategic planning committee is likely to consider carefully the firm's alternatives for financing the project. If the project can be funded internally, it is more likely to be approved than if it requires external funding. If the project were so big that it would require the firm to issue equity, the ultimate approval for the project might depend on whether the firm's top management believed this a good time to issue equity—a decision that has nothing to do with the particular attributes of the project.

If the strategic planning committee recommends approval, the proposal is then sent to the executive who has sign-off authority on the capital expenditure. In the case of the scrap-materials-handling system, CP3's CEO is the decision maker. The CEO is likely to consider the same issues that the strategic planning group considered. He or she, of course, has less time to review the specifics of the proposal than did the strategic planning committee and relies on the analysis done for that group.

The CEO then takes very large projects to the board of directors for final approval. Generally, if the project has the backing of the firm's executive, the board is unlikely to turn down the project, but board members may question some of the aspects of the contractual structure. For example, directors may question the compensation and governance structure of the firms that are being acquired. They may also question how the project is financed, particularly if the project requires an external-equity issue.

1.6 Summing Up and Looking Forward

Final Comments—The Investment Decision-Making Process

Our discussion of the investment decision-making process makes a number of important observations that influence the content and structure of the rest of this text:

- *The process can be very costly.* The process of project origination, evaluation, and approval is expensive and time-consuming. Of course, scrimping on the analysis of major projects can be even more expensive if it leads to project failures or missed opportunities.
- *The process can be subject to biased estimates that arise from conflicts of interest and incentive problems.* It is natural for members of the team that champions a proposal to become personally committed to the success of the project; as a result, their analyses may become biased. There is often a financial incentive attached to getting the project approved. For example, year-end bonuses may be tied to getting deals

approved. This incentive can easily lead employees to portray a project's prospects in a more optimistic way than may be warranted. On the other hand, the members of the various units within the firm who must analyze and sign off on the project are often skeptics. They typically are staff personnel whose role is to ferret out biases in the investment analysis and provide control over overzealous project champions. Members of the internal control group are not rewarded for deal completion but may suffer the consequences when they sign off on projects that fail.

- *The process is affected by problems arising out of differences in the information available to project champions and the internal review or control group (the strategic planning committee in our earlier example).* Specifically, the control group in phase II of the process is generally not as well informed about the project's inner workings as are the project proponents from phase I. In the interest of efficiency, this situation would ordinarily support delegation of decision-making authority to the managers and project champions who know the most about the project. However, incentive issues and the natural bias that project champions often exhibit require that some type of control system (such as the strategic planning and review committee) be put in place.

An unbalanced emphasis on any one of the three phases of project evaluation shown in Figure 1-4 can have disastrous effects on the firm. For example, too much emphasis on the investment origination (idea) phase, to the detriment of managerial review, can lead to the firm adopting questionable investments that have a low probability of success. Equally dangerous is an overemphasis on the managerial review (phase II) relative to the investment origination phase, thus causing excessive caution that keeps the firm from undertaking promising new investments. Finally, overemphasis on the final phase of the analysis can result if executives try to micromanage the firm. This can stifle the initiative of employees working in the origination and review phases. In an extreme case, the origination and review phases become nothing more than attempts to second-guess the preferences of the firm's top manager(s).

Looking Forward—The Structure of the Rest of the Text

Academics who study finance try to strip away the complexities of corporate investment decisions in an effort to focus on the heart of what determines value. By doing this, however, they can create a disconnect between what *should* be done in theory and what *is* done in practice. For example, academics have well-developed theories that describe how firms should determine the **discount rates** used to evaluate investment projects. Corporate executives are aware of these theories, but for a variety of reasons they have corporate **hurdle rates** (i.e., the minimum rate of return on acceptable projects) that often greatly exceed the discount rates suggested by academic theories. These high hurdle rates may be used to counteract the overoptimism of their managers, or they may provide ambitious targets that motivate them to discover better deals. Throughout this text, we emphasize *both* the fundamentals of valuation, as described by academic theories, and the real-world complexities that influence how they are implemented in practice.

PART I

Project Analysis Using Discounted Cash Flow

The critical insight that underlies the application of discounted cash flow (DCF) analysis to project and firm valuation is that cash flows received at different times have different values, and they can be aggregated only after properly adjusting for the time value of money. This core concept in the theory and practice of valuation must be mastered before we can proceed with more sophisticated valuation concepts. The roots of DCF analysis extend back into antiquity, at least to the time of the ancient Greeks, who calculated and used the concepts of simple and compound interest. The modern-day application of DCF can be traced to the seminal work of Irving Fisher[1] and Joel Dean, who popularized the application of discounted cash flow analysis in capital budgeting.[2]

In Part I (Chapters 2 and 3), we discuss the fundamentals of DCF analysis, which has been the mainstay of financial analysts since the 1950s and continues to be what most practitioners think about when they think of project and firm valuation. Although DCF analysis is often oversimplified in classroom presentations, in practice the proper application of DCF can be confusing because of complexities that arise in calculating cash flows. Chapter 2 discusses the problems encountered in defining and estimating cash flows and reviews the standard textbook approach to DCF. Chapter 3 provides a detailed analysis of the estimation of future cash flows. We introduce two basic approaches that can be used to evaluate the inherent uncertainty of future cash flows: breakeven sensitivity analysis and Monte Carlo simulation.

[1] Irving Fisher, *The Nature of Income and Capital* (New York: Macmillan, 1906), *The Rate of Interest: Its Nature, Determination and Relation to Economic Phenomena* (New York: Macmillan, 1907), and *The Theory of Interest: As Determined by Impatience to Spend Income and Opportunity to Invest It* (New York: Macmillan, 1930).

[2] Joel Dean, *Capital Budgeting* (New York: Columbia University Press, 1951).

CHAPTER 2

Forecasting and Valuing Cash Flows

Chapter Overview

Discounted cash flow (DCF) analysis is a key building block for a valuation course. This chapter, which introduces the process for applying DCF analysis, describes the relationship between cash flows and numbers from the firm's financial statements. We first define cash flow to the equity holders and then cash flow available for distribution to both creditors and owners. After defining cash flows, we present a comprehensive cash flow forecasting example that focuses on the process that one goes through to link units sold, unit costs, and unit revenues to investment cash flows. Finally, the chapter reviews the mechanics of discounting investment cash flows to estimate project value.

2.1 Discounted Cash Flows and Valuation

The idea behind **discounted cash flow (DCF) valuation analysis** is simple: The value of an investment is determined by the magnitude and the timing of the cash flows it is expected to generate. The DCF valuation approach provides a method for assessing the value of these cash flows, and consequently it is a cornerstone of financial analysis.

How does DCF analysis fit into the overall investment evaluation process laid out in the previous chapter? You may recall that we discussed the investment valuation process in terms of three phases of analysis that can be broken down into eight key steps (summarized in Figure 1-4). The focus of this and the next chapter is on step 2 of the first phase—estimating the investment's value, or "crunching the numbers."

The popularization of DCF for project analysis is generally attributed to Joel Dean (1951). However, the roots of DCF analysis go back much further. For example, financial mathematics can be traced back to the early writing of Leonardo of Piza (also known as Fibonacci) in 1202. Generations of business school graduates have made DCF one of the most widely used tools in the arsenal of today's finance professional.

Example—Car Wash

To illustrate the role of DCF valuations in analyzing an investment opportunity, let's assume that you invest in a car wash. The car wash generates *cash inflows* each time a customer purchases a wash and *cash outflows* when you purchase supplies, pay taxes and wages, and so forth. In addition, you will sometimes have to make repairs to the equipment, resulting in nonroutine cash outflows.

Let's now assume that you open a bank account for the business, and the cash receipts flow into the account and cash disbursements flow out of it. After a year of operations, you have built up a cash balance of, say, $10,000 after paying all your bills (including any repairs to your equipment). If we assume for the moment that you have not borrowed any of the money used to invest in the car wash, then you have $10,000 that you can distribute to yourself as sole owner of the car wash. This is money you can spend right now, at the end of the first year of operations. Looking forward to years two, three, and so forth, and performing a similar computation, you can determine future cash flows—calculated after paying all the firm's operating expenses and making any added capital expenditures. These cash flows are the key element that determines the value of the business.

The Three-Step DCF Process

From this simple example of the car wash, we can develop a DCF process that takes into account the timing of cash flows. Specifically, the use of DCF valuation entails a three-step process, as depicted in Figure 2-1. The first step involves forecasting the amount and timing of the anticipated

Did You Know?

Forecasting Is Tough: Even the Experts Have Trouble Spotting Market Trends

Forecasting the future is difficult, especially when it comes to new technology, as the following quotes from the Hall of Forecasting Shame will attest:

"I think there is a world market for maybe five computers."

—*Thomas Watson, Chairman of IBM, 1943*

"There is no reason anyone would want a computer in their home."

—*Ken Olson, president, chairman, and founder of Digital Equipment Corporation, 1977*

"640K ought to be enough for anybody."

—*Bill Gates, 1981*

Figure 2-1 Steps in Performing a Discounted Cash Flow Analysis

STEPS	INVESTMENT VALUATION
Step 1: Forecast the amount and timing of future cash flows. *How much cash is the project expected to generate and when?*	Forecast free cash flow (FCF).
Step 2: Estimate a risk-appropriate discount rate (covered in Chapters 4 and 5). *How risky are the future cash flows, and what do investors currently expect to receive for investments of similar risk?*	Combine the debt and equity discount rates (weighted average cost of capital, WACC).
Step 3: Discount the cash flows. *What is the present value "equivalent" of the investment's expected future cash flows?*	Discount FCF using WACC to estimate the value of the project as a whole.

receipt (or payment) of future cash flows. Here the basic issue is, "*How much* cash is the project *expected* to generate and *when*?" This step is the primary focus of this chapter and Chapter 3. The real "heavy lifting" in project evaluation occurs here because the future can never be known with certainty, and forecasts must often be made with little or no historical data to guide the analysis.

Second, the analyst must determine the appropriate discount rate for use in discounting future cash flows back to the present. The fundamental issue here is, "*How risky are the future cash flows?*" This topic is a central focus of finance, and we address it in Chapters 4 and 5, which examine the relationship between risk and required rates of return—the rate used to calculate the present value of future cash flows. But for now, we simply assume that discount rates are known.

Finally, step 3 involves the mechanical process of discounting future cash flows back to the present. Although we leave the rudiments of this analysis to more introductory finance textbooks,[1] we do offer a brief review in Section 2.3.

2.2 Defining Investment Cash Flows

Arriving at an estimate of the value of an investment using DCF analysis requires that the analyst have a good understanding of the investment's cash flows. In this section, we discuss three key issues related to the proper definition of investment cash flows:

1. What cash flows are relevant to the valuation of a project or investment?
2. What are expected cash flows, and when are cash flow estimates likely to be either pessimistic (conservative) or optimistic?
3. What is the difference between equity and project cash flows?

Failure to address each of these issues has led to a great deal of confusion in the application of DCF analysis.

Only Incremental Cash Flows Are Relevant

Only cash flows that are a direct result of the acceptance of an investment are relevant to the valuation of the project. These are often referred to as incremental cash flows because they are the additional cash flows to the firm that are generated by the investment. They include the cash flows generated directly by the investment as well as the indirect effects that the investment may have on the firm's other lines of business. For example, when Frito-Lay evaluates the introduction of a new flavor of Doritos brand tortilla chips (e.g., lime-flavored), the projected revenues and costs of the new product are critical to the analysis. However, the extent to which the new product's sales may cannibalize, or source sales from, other existing products (such as Doritos Nacho Cheese–flavored tortilla chips and Doritos Cool Ranch–flavored tortilla chips) is equally critical, because the incremental cash flows are the new-product cash flows net of cannibalization. See the Practitioner Insight box for a look at Frito-Lay's three-step incremental cash flow analysis.

A common mistake in the calculation of incremental cash flows has to do with what are known as *sunk costs*. Sunk costs are expenditures that either have already been made or must be made regardless of whether the firm proceeds with the investment. As a

[1] For example, Sheridan Titman, Arthur J. Keown and John D. Martin, *Financial Management: Principles and Applications,* 12th ed. (Upper Saddle River, NJ: Pearson Prentice Hall, 2014), Chapter 5.

result, sunk costs are not incremental costs and should thus be ignored in the investment analysis.

For example, suppose that Merck previously invested $10 million in the research and development of a new methodology for extracting stem cells from adult donor cells that does not require the use of embryos. The procedure looked very promising for the development of cancer treatments; however, it failed to deliver any significant improvements over less expensive and more conventional treatments during clinical trials. Suppose that subsequent Merck researchers develop a way to apply the new procedure to carry out embryo transplants more efficiently in beef and dairy cattle. In calculating the value of an investment associated with commercializing this procedure, how should Merck treat the original $10 million R&D expenditure?

In general, the research and development (R&D) costs (incurred in the past) should be viewed as sunk costs and should not be relevant to the analysis of the value of marketing the process for the cattle embryo-transplant project. However, the past research would become relevant if Merck receives an offer from Pfizer to acquire the technology for $8 million under the proviso that Merck give up all rights to the further

Did You Know?

Men Tend to Be More Overconfident Than Women

Psychologists have shown that men tend to be more confident than women in a number of settings, including those involving financial forecasts. A study by Barber and Odean* shows that among individual investors, men tend to trade more than women (showing more confidence) but perform worse!

*Brad M. Barber and Terrance Odean, “Boys Will Be Boys: Gender Overconfidence and Common Stock Investment,” *Quarterly Journal of Economics* (February 2001): 261–292.

PRACTITIONER INSIGHT

Relevant Cash Flows and Revenue Cannibalization*

Frito-Lay, one of four divisions of PepsiCo Inc., is currently the market leader for potato chips and other salty snack products. Consequently, when Frito-Lay evaluates a new salty snack product, it realizes that a portion of the new-product sales will come from the lost sales from existing products (i.e., revenue cannibalization). Such a challenge is common in mature firms with large market share. The evaluation of incremental cash flows is thus an extremely important issue for Frito-Lay and has led the company to develop a formal approach to the incremental effects of new-product offerings on the firm’s cash flows.

Frito-Lay uses the following three-step approach when estimating incremental cash flows:

Step 1: Estimate the total revenue that will be generated by the product.

Step 2: Estimate what percentage of the revenue is true incremental revenue.

Step 3: Estimate the incremental cash flow.

To estimate the percentage of the revenue that is incremental, we classify new-product offerings into one of three types. The first type includes projects that have a high likelihood of cannibalizing existing product sales. Examples include products such as a new flavor of Doritos brand tortilla chips. The expectation here is that a low percentage of the sales of this type of product can be viewed as incremental sales from the product, with the remainder coming from reductions in existing product sales. The second type of product provides the potential for additional store shelf space because they provide some new benefit (e.g., baked chips). For this type of product, Frito-Lay assigns a higher percentage of the revenue as true incremental sales. Finally, the third type of product, such as Frito-Lay’s natural line, provides the opportunity to enter new channels and/or develop new shelf space in a different part of the store. These products carry the lowest risk of cannibalization and are therefore assigned the highest percentage of incremental sales.

*Based on interview with Keith Crider, new-product finance manager, Frito-Lay, Dallas, TX.

development and applications of the technology. In this instance, the relevant cost to Merck of using the technology to develop its application for the cattle embryo-transplant market is now equal to the $8 million offer from Pfizer (assuming this is the highest bid received), not the $10 million Merck invested in R&D to develop the methodology. The reason for this is that the original $10 million has been spent and cannot be recovered. If Merck proceeds with plans to apply the technology to the embryo-transplant market, however, it must forgo the opportunity to sell the technology to Pfizer for $8 million. Clearly, the $8 million represents an opportunity cost to Merck.[2]

The determination of relevant cash flows can sometimes be very difficult, as we have just illustrated. However, it is critical that only the incremental revenues and incremental costs that are a direct result of the firm's decision to undertake the investment be considered in performing the valuation of the project.

Expected Versus Conservative and Optimistic Cash Flow Estimates

When academics talk about valuing an investment by discounting cash flows, they generally assume that the cash flows represent *expected* cash flows. In the statistical sense, they assume that managers estimate the cash flows that the firm *expects* to realize in various scenarios and sum these cash flows after weighting them by their probabilities of occurrence. For example, if a firm's manager expects to generate a cash flow of either $50,000 or $100,000, each with a 50% probability, the expected cash flow is $75,000. In theory, as we noted in Figure 2-1, the firm should discount these expected cash flows, using a risk-adjusted rate of interest that reflects the risk of the cash flows. (We will have more to say about how these rates are determined in Chapters 4 and 5.) In practice, however, the cash flow forecasts that managers use are frequently not the same as the expected cash flows that academics describe in their theories. Depending on the situation, the cash flow forecasts can be biased as a result of managers being either too conservative or too optimistic. For example, managerial bonuses are sometimes tied to getting new projects approved. Such an incentive might encourage managers to be very aggressive in their cash flow forecasts. In addition, managers may be overly optimistic in their forecasts simply because of overconfidence in their own analyses. (See the Behavioral Insight entitled "Overconfidence.") In either of these cases, the cash flow forecasts would be biased upward. Managerial forecasts can also be biased downward, which might occur, for example, when managerial pay is tied to meeting and exceeding the cash flow forecasts. In this instance, managers may bias their cash flow estimates downward to increase the likelihood that they will be able to meet and exceed the cash flow forecast.

To understand how managers make cash flow forecasts in practice, it is useful to reconsider the investment process described in Chapter 1 and to consider the incentives of the various players who are involved in making the forecasts. Suppose, for example, that you are proposing an investment that you will be managing; your cash flow forecasts

[2] One easy way to trap incremental costs is to take the difference between cash flows that would arise if the project is undertaken and the free cash flows that would arise if the project is rejected. For instance, the $10 million R&D expense would occur in either case (project taken up or rejected), whereas the $8 million opportunity loss (cost) would arise only if the project is rejected (and the technology is sold to Pfizer).

will serve as performance targets that will influence your future bonuses. In this situation, you might choose relatively conservative forecasts. Now consider a situation where you get a bonus for identifying a promising investment opportunity that the firm initiates. In this case, you might choose relatively optimistic forecasts.

We believe that top executives may encourage their managers to develop forecasts that represent *hoped-for* or optimistic rather than expected cash flows because these forecasts provide future targets that may serve as motivation when the project is implemented. We also observe management cash flow forecasts that are based on the following reasoning: "If all goes as planned, these are the cash flows that we expect to achieve." These optimistic cash flow forecasts ignore various unanticipated glitches that may arise when the project is implemented. When evaluating hoped-for cash flows, firms should use very high discount rates to adjust for the difference between dreams and reality.

Two examples where we tend to observe what are clearly hoped-for rather than expected cash flows are in emerging markets and venture capital investments. In both cases, the firm may have a strategic partner—that is, the government of a developing country in former case and an entrepreneur in the latter—who prefers a business plan that is not so specific about possible negative events that could occur. For example, in a proposed joint venture with the government of Venezuela, you might not want to account explicitly for the possibility of a collapse in the current regime. You may prefer to calculate hoped-for cash flows and account for the risk of collapse with an adjustment in the required discount rate. Similarly, as a venture capitalist, you may not want to express explicitly a lack of confidence in the viability of the entrepreneur's new product, but may again adjust for the optimistic, hoped-for cash flows by requiring a very high discount rate to adjust for the difference between dreams and reality.

Behavioral Insight

Overconfidence

Psychological studies show that most people are overconfident about their abilities and tend to be optimistic about the future. For example, one study found that most people claim to be better-than-average drivers, yet we know that, by definition, half are above average and half are below average.* Are corporate executives likely to be more or less optimistic and overconfident than the average individual? We would argue that they are likely to be more optimistic and overconfident. Psychologists claim that individuals tend to be subject to what they call self-attribution bias, which means that they want to attribute good things that happen to them to their own efforts and ability. This suggests that top executives are likely to attribute their success to their own abilities rather than to being in the right place at the right time; thus, they may be overconfident about their success going forward. It's also likely to be the case that the most optimistic managers work the hardest (because they place a high value on being promoted), which suggests that optimistic people are more likely to be promoted. What this means is that even well-intentioned executives who set out to estimate true expected cash flows may end up with cash flow forecasts that are overly optimistic.

*Ola Svensson, "Are We All Less Risky and More Skillful Than Our Fellow Drivers?" *Acta Psychologia* 47 (1981): 143–148.

We return to our discussion of hoped-for cash flows in Chapter 10; for the balance of this text, we assume that all cash flow estimates represent *expected* cash flows.

Equity Versus Project Free Cash Flow

Keep in mind that an investment project's cash flow is simply the sum of the cash inflows and outflows from the project. As we have already noted, however, analysts typically structure their analysis of investment cash flows using projected financial statements, commonly referred to as pro forma statements, for the project or firm being valued. That is, they develop their cash flow analysis by first projecting the income or earnings consequences of the project (following accrual accounting—see the Technical Insight box) and then use this information to calculate the project's cash flows.

Two definitions of cash flow are commonly used, and we will use both at different times in this text. We refer to the first simply as free cash flow (FCF). When discussing project valuation, we often use the adjective *project* before *free cash flow,* or **project FCF**. Later, when we discuss the valuation of a business enterprise, we use the term **firm FCF**. In either case, the definition of cash flow is the same. Specifically, FCF is the amount of cash flow (produced by an individual investment project or an entire firm) that is available for distribution to the various claimants (debt and equity holders) after paying all the firm's expenses and funding any new projects the firm undertakes during the period for which cash flow is being calculated.

In addition to project and firm free cash flow, we will also discuss equity FCF in Chapter 4. **Equity FCF** refers to the amount of cash flow that is available for distribution to the firm's equity holders. Therefore, equity FCF equals firm or project FCF, minus the sum of the after-tax interest paid to the firm's creditors, plus the net new debt (i.e., new

TECHNICAL INSIGHT

Accrual and Cash-Basis Accounting

Accounting *income* is not the same as cash flow because it is calculated using the accrual basis of accounting. Unlike cash accounting, **accrual accounting** distinguishes between the recording of costs and benefits associated with economic activities and the actual payment and receipt of cash. For example, under accrual accounting, revenues are recognized (recorded) *when earned,* not when cash actually changes hands. Likewise, under accrual accounting, expenses are matched to the revenues they helped generate rather than being recorded when cash is actually paid.

Why accrual rather than cash accounting? Investors' demands for *periodic financial reports* that can be used to assess performance gave rise to the need for the accrual system. The problem with cash-basis accounting is that cash expenditures made in one period may have an impact on revenues and profits over multiple future periods. Accrual accounting is thus designed to match expenses with revenues. For example, the cost of a piece of capital equipment that will be productive over many years is spread over multiple years rather than being expensed entirely in the period of the purchase. Cash-basis accounting would expense the equipment cost, which distorts the performance of the firm's operations during the period.

debt issued by the firm less principal repayments) for the period. For now, we focus strictly on firm or project FCF, or simply FCF.

Calculating Project Free Cash Flow (FCF)

It is worth taking a moment to consider what we mean by the term *free* in the context of cash flow. The idea is not that the cash flow is in any sense free of cost. Instead, *free* refers to the fact that the cash flow under discussion is available—not needed for any particular purpose. The cash flow equals the amount of cash left over after paying all expenses, including any additional investments made during the period. The firm can distribute the remaining cash because the firm does not, by definition, need it. Consequently, our cash flow calculations result in a cash flow figure that is free of any encumbrances or commitments and can therefore be distributed back to the sources of capital used to finance the investment. **Free cash flow (FCF),** therefore, represents the amount of cash produced (by a project or a firm) during a particular period of time that can be distributed to the firm's creditors (principal and interest payments) and stockholders (dividends and share repurchases).

The procedure for computing project FCF is described in Figure 2-2. Note that the calculation of FCF begins with the same elements that are included in a firm's income statement. Specifically, the calculation begins with a pro forma or planned income statement because we are forecasting future cash flow as we discuss in detail at the close of this chapter and in Chapter 6. The process begins with a prediction of future sales or revenues, the cost of goods sold that are associated with these sales, and the operating expenses incurred in producing the goods and services sold during the period. Deducting cost of goods sold and operating expenses from sales provides an estimate of the firm's operating income, which we refer to as earnings before interest and taxes (EBIT).

Figure 2-2 Calculation of Free Cash Flow (FCF)

Sales

Less: Cost of goods sold

Gross Profit

Less: Operating expenses (including depreciation expense)

Earnings Before Interest and Taxes

> Note that interest expense is *not* deducted before calculating the firm's tax liability. This is because FCF represents the cash flow available for both creditors (interest plus principal) and owners. In Chapter 9, where we calculate equity FCF, we will deduct interest expense before calculating the firm's tax liability.

Less: Taxes

Equals: Net operating profit after taxes (NOPAT)

Plus: Depreciation expense

Less: Capital expenditures (CAPEX)

Less: Increases in net working capital (ΔNWC)

Free cash flow (FCF)

> Note that from this point, the FCF calculation differs from the normal format of the income statement:
>
> (i) depreciation expense is added back to reflect the fact that although tax deductible, it does not represent a cash outflow;
>
> (ii) capital expenditures are deducted because they represent a cash outflow; and
>
> (iii) increases in net working capital are deducted because they, like capital expenditures for fixed assets, represent a cash outflow for an investment in the firm or project.

At this point, the computation of FCF deviates from the income statement because we compute the firm's tax liability on EBIT without first deducting interest expense, as is done in the income statement. The reason for this is that we are computing the cash flow that will be available for payment to all the firm's sources of financing, including both its creditors (who receive principal plus interest) and equity investors.

Net operating profit after taxes (NOPAT) is simply after-tax operating income or EBIT less taxes. Next, we add back depreciation expense to NOPAT. As you recall from accounting, depreciation expense does not entail an out-of-pocket cash payment, but it is a tax-deductible expense. Rather, depreciation expense arises out of the matching principle of accounting, which dictates that expenses be matched with revenues whenever it is reasonable and practicable to do so. Therefore, firms use *depreciation expense* to match expenditures made for long-lived assets (such as plant, machinery, and equipment) against the revenues those assets help generate. However, the actual expenditure of cash may have taken place many years earlier when the assets were acquired. Thus, *the allocation of the original cost against revenues in the form of depreciation expense does not represent an actual cash payment.*[3]

Finally, to complete our computation of FCF, we deduct any expenditures the firm has planned for the period to cover the cost of acquiring new capital equipment (CAPEX) and any additions to the firm's operating net working capital (i.e., accounts receivable plus inventory less non-interest-bearing short-term liabilities such as accounts payable).

We can define project FCF algebraically using Equation (2.1) as follows:

$$\underbrace{\begin{matrix}\text{Free Cash}\\ \text{Flow (FCF)}\\ \text{for Year } t\end{matrix} = \begin{pmatrix}\text{Earnings before Interest}\\ \text{and Taxes (EBIT)}\\ \text{for Year } t\end{pmatrix} \times \left(1 - \begin{matrix}\text{Tax}\\ \text{Rate (T)}\end{matrix}\right) + \begin{pmatrix}\text{Depreciation}\\ \text{Expense (D)}\\ \text{for Year } t\end{pmatrix} - \begin{pmatrix}\text{Change in Operating}\\ \text{Net Working Capital}\\ (\Delta\text{ONWC) for Year } t\end{pmatrix} - \begin{pmatrix}\text{Capital}\\ \text{Expenditures (CAPEX)}\\ \text{for Year } t\end{pmatrix}}_{\text{Net operating profit after tax (NOPAT) for year } t} \quad (2.1)$$

We will have more to say about the estimation of both CAPEX and operating net working capital later in the chapter.

To see how an analyst can assemble a cash flow forecast, let's consider the following comprehensive example.

[3] The net result of first deducting depreciation expense to determine taxable income and then adding it back to compute FCF is that we add an amount back to the FCF equal to the tax savings on the depreciation expense. Defining EBITDA as earnings before interest, taxes, and depreciation, or EBIT + D, we can restate the FCF formula from Equation 2.1 as follows:

$$\text{FCF} = (\text{EBITDA} - \text{D})(1 - \text{T}) + \text{D} - \Delta\text{ONWC} - \text{CAPEX}$$

or, rearranging terms,

$$\text{FCF} = (\text{EBITDA})(1 - \text{T}) + \text{T} \times \text{D} - \Delta\text{ONWC} - \text{CAPEX}$$

where T × D represents the tax savings that accrue to the firm from depreciation and amortization expense.

2.3 Comprehensive Example—Forecasting Project Free Cash Flows

Forecasting the cash flows of a prospective investment is not an exact science; rather, it is a mixture of science, intuition, and experience. To illustrate the techniques that firms use to determine cash flow forecasts, we analyze an investment involving a high-tech product—liquid crystal display (LCD) panels for large-screen televisions.

By the close of 2003, flat-panel wall-hanging TVs were fast becoming the preferred format for high-end TVs. Plasma-screen models were the most popular technology for monitors larger than 30 inches diagonally. When plasma screens are compared to LCDs, however, they have some rather serious limitations, including a shorter life span (30,000 hours compared to 50,000) and screen burn-in. If a plasma-screen TV is left on with a channel logo or other fixed image displayed for many hours, burned-in images sometimes remain as shadows on the screen. The LCDs, on the other hand, have superior resolution in daylight hours and do not suffer from burn-in problems. In 2003, however, the technology for making LCDs larger than 30 inches was only starting to be developed.

By the end of 2003, Lecion Electronics Corporation had been involved in the manufacture of flat-panel LCDs for use as computer monitors for ten years. The company possessed some of the leading technology for both the design and manufacture of large-screen LCDs, and it was considering the cash flow consequences of an investment of $200 million in a new fabrication plant in South Korea to produce 42-inch LCDs using the firm's proprietary technology. Lecion's marketing group forecast that the firm would eventually capture an estimated 20% market share.

Lecion's Strategic Assessment of the LCD Investment Opportunity

Very early in the project evaluation analysis, Lecion Electronics Corporation engaged in a thorough assessment of the proposed strategy. This **strategic assessment** process was designed to answer one overarching question: What are the specific capabilities of the firm and the competitive circumstances that will allow it to realize this positive-NPV opportunity?

To address this question, it helps to have a systematic approach that incorporates all the fundamental questions that a firm should answer each time it contemplates a project. Specifically, one must *state explicitly* the assumptions underlying the investment plan. Lecion's project management team addressed the potential strategic implications of the new investment (using the strategic assessment questions set forth in Chapter 1). The team came to the following conclusions:

- *Assumptions regarding competitor responses.* The four major manufacturers with the technological expertise and capacity to compete in the large flat-panel television market are expected to continue their efforts to compete for market share. However, the meltdown of the dot-com market in 2000 led these manufacturers to cut back on their development programs, giving Lecion a clear technological lead that is expected to hold up for at least a year and possibly two. The market share that the firm anticipates capturing during this period will help it weather any storm of competitor products over the five-year projected life of the investment project being contemplated.
- *Assumptions regarding producers of complementary products.* Lecion has worked closely with producers of high-end audio products to ensure the compatibility of its

LCDs in all its newest product offerings. The firm continues to monitor developments in new wireless technology that will greatly reduce the cost of installing home-theater systems. The firm expects to grow its share of the home-theater market as its LCDs grow in popularity.

- *Assumptions regarding customer responses.* The early demand for the 42-inch LCDs is expected to come from customers in the upper tiers of consumable income who are not expected to be particularly price-sensitive. This will eventually change over the five-year life of the project, and the firm's estimate of the price per unit of its LCDs incorporates consideration for this declining product price.
- *Assumptions regarding how employees will respond.* With the economy having moved out of a recessionary period and employment levels growing, Lecion expects the job market to become increasingly more competitive and tight. As a consequence, it anticipates having to pay higher wages to its employees. However, because the plant is located in South Korea, where wage costs are substantially lower than in the United States, the pressures of wage inflation are not considered to be a significant factor driving the economics of the new plant investment.

Before we embark on our analysis of "the numbers," it is important to stress that the numbers must be consistent with the strategic assessment story that underlies the investment. If the story is inconsistent with the forecasts that are the basis for the cash flow estimates, then the analysis is fatally flawed. The strategic analysis process is necessarily subjective and appears unsophisticated in comparison with the apparent precision of the cash flow numbers. However, it is crucial that the story and the numbers are consistent and build on one another.

Estimating the Investment's Project Free Cash Flow

To facilitate the estimation of project FCF, defined earlier in Equation (2.1), we expand the definition of operating income or EBIT as follows:

$$FCF_t = \underbrace{\underbrace{\left[\begin{pmatrix}\text{Firm}\\ \text{Revenues}_t\end{pmatrix} - \begin{pmatrix}\text{Cost of}\\ \text{Goods Sold}_t\end{pmatrix} - \begin{pmatrix}\text{Operating}\\ \text{Expenses}_t\end{pmatrix} - \begin{pmatrix}\text{Depreciation}\\ \text{Expense}_t\end{pmatrix}\right]}_{\text{EBIT or net operating income for year } t} \times \begin{pmatrix}1 - \begin{matrix}\text{Tax}\\ \text{Rate}\end{matrix}\end{pmatrix}}_{\text{Net operating profit after tax (NOPAT) for year } t}$$

$$+ \begin{pmatrix}\text{Depreciation}\\ \text{Expense}_t\end{pmatrix} - \begin{pmatrix}\text{Change in}\\ \text{Operating Net}\\ \text{Working Capital}_t\end{pmatrix} - CAPEX_t \tag{2.2}$$

It is apparent from this equation that the firm's cash flow forecasting problem involves developing estimates for *each* of these components of FCF for *each year* of the project's anticipated life. Throughout our discussion, we refer to these key components as value drivers because they determine the investment's value.

Forecasting Incremental Revenues

The first value driver found on the right-hand side of Equation (2.2) is firm revenues. Here we refer to the incremental revenues that result from undertaking the LCD investment. Because the LCD investment will provide revenues only if the investment is undertaken, all of the plant's revenues are incremental to Lecion and are therefore relevant to our analysis.

To develop our forecast of revenues from the investment in the new LCD fabrication plant (or simply "fab"), we begin by defining the key determinants of revenues. To keep matters as uncluttered as possible, we assume that Lecion's new plant will produce a single product (42-inch LCD panels). This means that the plant's revenues for any given period are equal to the estimated volume of units sold by the firm multiplied by the market price received for each unit sold. In addition, it is often helpful to think of the firm's units produced and sold as a fraction of the total number of units of the product sold by all firms (i.e., Lecion's market share).

Thus, in our example, Lecion's revenues for the period are equal to the product of total unit sales for all firms in the industry (industry sales units) multiplied by Lecion's projected market share, which is then multiplied by the market price per unit. Thus, we define Lecion's revenues for period t as follows:

$$\begin{matrix}\text{Lecion's} \\ \text{Revenues}_t\end{matrix} = \underbrace{\begin{pmatrix}\text{Total} \\ \text{Industry} \\ \text{Units Sold}_t\end{pmatrix} \times \begin{pmatrix}\text{Lecion's} \\ \text{Market} \\ \text{Share (\%)}_t\end{pmatrix}}_{\text{Lecion unit sales}_t} \times \begin{pmatrix}\text{Market} \\ \text{Price per} \\ \text{Unit}_t\end{pmatrix} \quad (2.3)$$

Using this approach to revenue forecasting requires an estimate of total industry sales for each year of the forecast period, Lecion's market share, and the price per unit that Lecion expects to receive for each unit.

Column two of Table 2-1 contains projected industry sales units for 2004–2008. This forecast is a key determinant of Lecion's revenues, and the methodology used to make the forecast depends on the type of product or service being analyzed. In this instance, the product is a new consumer electronics product. Marketers of this type of product use something called a diffusion model to estimate the speed of adoption of new products. In general terms, the adoption process categorizes purchasers as *innovators*, who make their purchase decision without reference to others, and *imitators*, who acquire a product only after they see others making purchases. This simple characterization is used to develop a forecast of demand over time that

Table 2-1 Market Demand and Revenue Projections for Lecion's LCD Fabricating Plant

Year	Projected Total Market Unit Sales (000)	Lecion's Unit Sales (000)	Sale Price per Unit	Lecion's Revenue Forecast (000)
2004	10,000	2,000	$8,000	$16,000,000
2005	15,000	3,000	5,959	17,877,676
2006	20,000	4,000	4,932	19,727,751
2007	20,000	4,000	4,381	17,525,479
2008	15,000	3,000	4,098	12,294,285

is a function of the cumulative number of units sold.[4] Fully describing this forecast technique is beyond the scope of this text; however, it is important to note that making these projections is the heavy lifting involved in project analysis and is where the analysis is unique. Units sold by Lecion are estimated to equal 20% of the industry total based on the firm's prior experience with new-product innovations. The final element of the revenue forecast is the price forecast for the 42-inch LCDs. The team predicts that the price of these panels will be $8,000 in 2004 but that this price will drop to $4,098 by the end of 2008. This forecast reflects the use of a *price decay function,* which is commonly used to forecast prices of high-tech products, such as computer semiconductors. In this instance, the decay function assumes a rate of price decay of 20%, which means that every time the cumulative market volume of LCDs produced and sold doubles, the price of an LCD drops by 20%. This relationship is sometimes referred to as the *experience curve*. This functional relationship between product price and cumulative market units produced and sold has been observed again and again in a wide variety of high-tech products.[5] Obviously, Lecion's revenue forecast is subject to a high level of uncertainty, and some type of sensitivity analysis on this variable is appropriate. (We return to this point in Chapter 3 when we simulate investment cash flows.)

Estimating Total Annual Expenses

Lecion's total annual operating expenses are comprised of cost of goods sold, cash operating expenses, and depreciation expenses for plant and equipment:

$$\begin{matrix}\text{Total} \\ \text{Expenses} \\ \text{for Year } t\end{matrix} = \begin{matrix}\text{Cost of Goods} \\ \text{Sold for} \\ \text{Year } t\end{matrix} + \begin{matrix}\text{Cash Operating} \\ \text{Expenses} \\ \text{for Year } t\end{matrix} + \begin{matrix}\text{Depreciation} \\ \text{Expense} \\ \text{for Year } t\end{matrix}$$

To forecast these expenses, we forecast the sum of cost of goods sold and cash operating expenses, and add depreciation to this total. Cost of goods sold and cash operating expenses can be decomposed into variable and fixed components. Thus, for forecasting purposes, we define the sum of the firm's annual cost of goods sold and operating expenses as shown in Equation (2.4):

$$\left(\begin{matrix}\text{Cost of Goods} \\ \text{Sold for} \\ \text{Year } t\end{matrix} + \begin{matrix}\text{Cash Operating} \\ \text{Expenses for} \\ \text{Year } t\end{matrix}\right) = \left(\begin{matrix}\text{Variable Cost} \\ \text{per Unit} \\ \text{in Year } t\end{matrix} \times \begin{matrix}\text{Lecion's Unit} \\ \text{Sales in} \\ \text{Year } t\end{matrix}\right) + \begin{matrix}\text{Fixed Operating} \\ \text{Costs in Year } t\end{matrix} \tag{2.4}$$

[4] The use of the diffusion model to forecast consumer durable product sales was pioneered by F. Bass, "A New Product Growth Model for Consumer Durables," *Management Science* 15: 215–227.

[5] For example, Lee et al. (1997) observed that a 20% price decay function explained more than 88% of the variation in unit semiconductor prices for a major supplier of microprocessors during the early 1990s (Winyih Lee, John Martin, and Hirofumi Matsuo, "Valuing Investments That Reduce Time-to-Market in the Semiconductor Industry," *Advances in Financial Planning and Forecasting* 7 [1997]: 19–23).

TECHNICAL INSIGHT

Salvage Values and Terminal Values

The terms *salvage value* and *terminal value* are often used interchangeably when referring to the final cash flow that is realized at the end of the period used to value an investment (i.e., the analysis period). However, we want to draw a subtle but meaningful distinction between these terms for purposes of discounted cash flow analysis. Specifically, when valuing individual projects that have a finite life (as we do in this chapter and in Chapter 3), we use the term *salvage value* to refer to the disposal value of the project assets at the end of the term of our analysis. This value is typically what the term *salvage* connotes; in other words, we dispose of the project assets and the proceeds make up the terminal value of the investment.

In some very long-term investments, however, where the productive life of the project assets is expected to continue indefinitely, the terminal value represents the present value of all investment cash flows beyond the end of the analysis period. In Chapters 8 and 9, when we evaluate the value of a firm, the terminal value estimate is critical because it can often contain the majority of the value of the enterprise. For our purposes in this chapter and the next, however, we will assume that the analysis period is equal to the productive life of the investment such that the terminal value of the project is actually the salvage value of the investment assets.

In Equation (2.4), we need to forecast variable cash operating cost per unit and the firm's total fixed cash operating expenses per year. (We have the other amounts from our previous discussion.) Lecion estimates the variable cost per unit in 2015 to be $9,000 (see Table 2-2).

Lecion's analysts estimate that the variable cost per unit will decline by 30% each time the cumulative volume of production doubles. In this case, the cost estimate reflects a 70% *learning curve model*.[6] That is, each time production volume doubles, Lecion

Table 2-2 Variable and Fixed Costs per Unit Estimates for the Lecion LCD Plant

Year	Lecion's Estimated Annual Units Sold (000)	Estimated Variable Operating Cost per Unit	Annual Variable Cash Operating Cost (000)	Estimated Fixed Cash Operating Costs (000)	Depreciation Expense (000)	Estimated Total Expenses (000)
2015	2,000	$(9,000)	$(18,000,000)	$(50,000)	$(40,000)	$(18,090,000)
2016	3,000	(6,238)	(18,713,642)	(50,000)	(40,000)	(18,803,642)
2017	4,000	(4,610)	(18,438,850)	(50,000)	(40,000)	(18,528,850)
2018	4,000	(3,815)	(15,259,903)	(50,000)	(40,000)	(15,349,903)
2019	3,000	(3,428)	(10,285,091)	(50,000)	(40,000)	(10,375,091)

[6] The idea is that manufacturers learn by doing, and this learning drives down the costs of production. The learning curve is simply a tool for describing how doing (i.e., manufacturing more and more units) is connected to declining manufacturing costs. Willyard and McClees provide empirical evidence for the use of learning curves in high-tech manufacturing: Charles H. Willyard and Cheryl W. McClees, "Motorola's Technology Roadmap Process," *Research Management* 30, no. 5 (September–October 1987): 13–19.

estimates that the per-unit variable cost will drop to 70% of the previous variable cost per unit, corresponding to half the current volume. For example, if variable costs were $10,000 for 500,000 units, then Lecion would expect them to drop by 30%, to $7,000, when the cumulative volume produced reaches 1,000,000 units. Of course, there's nothing magical about the notion of a learning curve. It simply represents a tool for describing the effects of learning and continuous improvements on the manufacturing process over the life cycle of the product. Such learning, in turn, lowers the variable costs of production.

Lecion's analysts made four simplifying assumptions in compiling investment cash flow estimates: First, they assumed that no new investments in net working capital will be required over the life of the project. Second, they assumed that plant and equipment will be depreciated using straight-line depreciation, resulting in a zero estimated salvage value at the end of year 5. Third, the plant is analyzed as if it had no continuing or terminal value. This is probably an overly conservative assumption because the plant is likely to have some value either as scrap or possibly as a plant site for a later technology fab. Nonetheless, for purposes of the analysis here, the estimated salvage value is zero. Finally, investment income is assumed to be taxed at a constant 30% rate for all periods and all levels of income.

A review of the FCF estimates found in Table 2-3 indicates that Lecion's analysts expect the project to have a positive cash flow by the end of 2006 and then to remain positive throughout the project's remaining life. The contribution margin in the final column of Table 2-3 reveals a growing margin of profits over the project's life. (*Contribution margin* is defined as price per unit less variable cost per unit divided by price per unit.) These forecasts are, of course, predictions and subject to forecast error. We return to a discussion of forecast error in Chapter 3. For now, with the forecasts of the FCF in hand, we focus on the process of valuing Lecion's expected future cash flows as a next step.

Table 2-3 Estimated Project Free Cash Flow for the Lecion LCD Investment

Year	Revenues (000)	Total Expenses (000)	NOPAT (000)	Depreciation (000)	Project Free Cash Flows (000)	Contribution Margin
2004	$16,000,000	$(18,090,000)	$(1,463,000)	$40,000	$(1,423,000)	−12.5%
2005	17,877,676	(18,803,642)	(648,176)	40,000	(608,176)	−4.7%
2006	19,727,751	(18,528,850)	839,231	40,000	879,231	6.5%
2007	17,525,479	(15,349,903)	1,522,903	40,000	1,562,903	12.9%
2008	12,294,285	(10,375,091)	1,343,436	40,000	1,383,436	16.3%

Legend:

NOPAT = (Revenues in Year t − Total Expenses in Year t)(1 − Tax Rate)

FCF in Year t = NOPAT in Year t + Depreciation Expense in Year t

$$\text{Contribution Margin in Year } t = \frac{(\text{Price per Unit in Year } t - \text{Variable Cost per Unit in Year } t)}{\text{Price per Unit in Year } t}$$

Note: There are no capital expenditures after 2003 and no investments in operating net working capital.

2.4 Valuing Investment Cash Flows

Once the analyst has estimated the future cash flows from an investment, it is time to value them. Very simply, we need to discount the forecasted future cash flows back to the present time using a discount rate that properly reflects the anticipated risks of the future cash flows.

Figure 2-1 summarized the DCF process. Up to this point, we have dealt *only* with step 1, which involves estimating investment cash flows. For convenience, we will assume that we have performed step 2 and that we know the appropriate discount rate for use in calculating the present value of future cash flows.[7]

Example—Valuing Lecion's Project Cash Flows

To illustrate the procedure used to carry out step 3 of the DCF valuation process, we will value the FCFs estimated for the Lecion LCD project described in Table 2-3. (For a quick review of the mathematics of discounting see the discussion found in the Technical Insight box on the mechanics of time value of money calculations.)

The opportunity cost of capital for the Lecion project is 18% per year. The discount factor for each year's cash flow is defined as follows:

$$\text{Discount Factor for year } t = \left(\frac{1}{1 + .18}\right)^t$$

The present value of each year's cash flow is simply the product of the cash flow and the discount factor for the year. Summing the present values of the cash flows generated by the project in each year of the project's operations (years 1 through 5, found in Table 2-4), Lecion estimates the intrinsic value of the investment to be $303,253,010.

Using NPV and IRR to Evaluate the Investment

If Lecion invests $200 million to initiate the project, as indicated in Table 2-4, then the project will generate about $103 million more, in present value terms, than it costs.[8] This difference between the present value of the project's expected

Industry Insight

Do Corporate Executives Use DCF?

When asked whether they always or almost always use Internal Rate of Return (IRR), 75.7% of corporate CFOs responded in the affirmative. Similarly, 74.9% said they always or almost always used NPV. These results came from a survey done by John Graham and Campbell Harvey of 392 CFOs* and they reveal a dramatic increase in the reliance on NPV compared to IRR. In a survey completed in 1977, fewer than 10% of the respondents relied on NPV as their primary method of capital budgeting, while more than 50% said they relied primarily on IRR.†

*John Graham and Campbell Harvey, "The Theory and Practice of Corporate Finance: Evidence from the Field," *Journal of Financial Economics* 60 (2001), 187–243.

†L. Gitman and J. Forrester, Jr., "A Survey of Capital Budgeting Techniques Used by Major U.S. Firms," *Financial Management* (1977): 66–71.

[7] We discuss the choice of the proper discount rate and the calculation of the cost of capital in Chapters 4 and 5.

[8] For simplicity, we have assumed that the total investment in the project is made immediately. Obviously, this cannot be the case because it would take some period of time for new plant facilities to be constructed and equipment to be ordered and put into operation. Also, as noted in Chapter 1, firms typically stage investments of the magnitude considered in this text. For example, when an oil company enters into a mineral rights lease, the lease typically has a finite life of three to five years. If the oil company does not initiate the exploration of the lease within this timeframe, it loses the mineral rights. So, companies often engage in the minimal level of development required to hold the lease and come back to develop the property fully if it shows promise.

Table 2-4 Valuation and Discounting Cash Flows

Year	Estimated Project FCF (000)	Discount Factor	Present Value (000)
2003	$ (200,000)	1.0000	$ (200,000)
2004	(1,423,000)	0.8475	(1,205,932)
2005	(608,176)	0.7182	(436,783)
2006	879,231	0.6086	535,127
2007	1,562,903	0.5158	806,128
2008	1,383,436	0.4371	604,713
		Project intrinsic value	$ 303,253
		Less: Initial investment	(200,000)
		Equals: Net present value	$ 103,253

Initial Cash Outlay

Project Intrinsic Value equals the sum of the present values of the annual FCFs

future cash flows and the initial cost of making the investment is commonly referred to as the **net present value (NPV)**.

Another popular indicator of the anticipated wealth created by an investment is the **internal rate of return (IRR)** of the project. We define the IRR as the compound rate of return earned on the investment, and we calculate it by solving the expression in Equation (2.5):

$$\text{Investment Outlay}_0 = \sum_{t=1}^{N} \frac{FCF_t}{(1 + IRR)^t} \tag{2.5}$$

Solving Equation 2.5 for the IRR, Lecion's analysts get 20.24%.[9] Comparing the 20.24% IRR to the 18% cost of capital used as the discount rate in calculating the value of the investment, Lecion concludes that the investment should be viewed favorably.

Both the NPV and IRR of the investment indicate that the investment creates value. Does this imply that Lecion should commit to the project and invest $200 million over the coming year? In a world of certainty where forecasts are made without error,

Did You Know?

Excel's NPV Function Does Not Calculate NPV

Excel includes an NPV function with the following arguments:

$$NPV(\text{rate, value 1, value 2, \ldots})$$

where rate is the discount rate, and value 1, value 2, and so forth, are cash flows received one, two, and more periods in the future. Consequently, the NPV function calculates the present value of a stream of future cash flows, with the first being received one period hence. NPV, on the other hand, incorporates consideration for an initial outlay in the current period that is not discounted at all. Therefore, we can use the NPV function to calculate net present value as follows:

$$\text{Net Present Value} = NPV(\text{rate, value 1, value 2, \ldots}) - \text{initial cash outlay}_0$$

[9] Solving for IRR can be quite laborious if done without the help of a calculator or spreadsheet. Excel has a built-in IRR function, and almost all business calculators have a similar feature. If you are relying on these tools, however, you should be aware that multiple IRRs can and often do exist and that these built-in functions do not tell you that there is more than one IRR. See the Technical Insight box on multiple internal rates of return for a discussion of this issue.

the answer is an unqualified yes. In this particular case, however, the analysis is based on very uncertain cash flow estimates. It is possible that overconfident managers, or managers with a vested interest in getting the project approved, provided optimistic forecasts rather than true expected cash flows. Thus, firms generally do not accept projects simply because an analyst generates numbers that suggest the project has a positive NPV or an IRR that is at least as large as the appropriate cost of capital. Financial analysts generally dig deeper to understand the uncertainties that underlie both the assumptions and forecasts made in generating the NPV estimate before making the final decision. In Chapter 3, we discuss two different forms of sensitivity analysis that are very helpful in this regard.

Mutually Exclusive Projects

Up to this point in our analysis, we have been evaluating a single project or investment. Often, however, the analysis requires consideration of multiple alternatives or competing projects, where the firm must select only one. We refer to these alternatives as **mutually exclusive investments** because the selection of one precludes investment in the others.

For example, when Duke Energy is faced with the opportunity to construct a new power plant, the firm has a number of choices it can make regarding the fuel that is to be used in firing the plant (e.g., natural gas, fuel oil, nuclear energy, coal, or some mixture). Each technology has its particular advantages and disadvantages, but ultimately Duke must select one and only one. When ranking the alternatives, the NPV still provides the best metric because it measures the expected contribution of the project to the value of Duke Energy. In some cases, however, firms need to choose between or among competing (mutually exclusive) investments because their ability to finance new investments is limited. In this situation, the NPV criterion is not necessarily the best way to choose between or among the investments. The firm may also want to consider the rate of return, or IRR, of the investments as well as how quickly the projects generate cash that can be used to fund other projects.

Mutually exclusive alternatives are inherent in many investment choices. For example, an investment like Lecion's LCD opportunity is not necessarily a simple yes or no decision. Managers can also choose to delay the decision, which is the case whenever the firm has some degree of flexibility about how quickly it moves to capitalize on the opportunity. For example, if Lecion could delay initiation of the LCD fab for up to one year, the information gained about market acceptance for similar products and the rate of price decay could make the project even more valuable to Lecion. Consequently, the firm's analysts should consider not only alternative technologies but also delayed execution of the investment as mutually exclusive alternatives. We return to a discussion of the option to delay or defer investing when we discuss real options in Chapter 12. But for now, it is critical that the analyst consider whether the firm indeed has a viable option to delay and, if so, what the firm might learn by deferring the initiation of the investment that would make the valuation more concrete.

The problems encountered when analyzing the possibility of delaying project initiation provide an opportunity to emphasize an important fact of life that analysts face daily. That is, no matter how sophisticated the tools that are brought to bear on the valuation problem, there is always a need to exercise judgment. The point of the analysis is to inform the analyst so that ultimately he or she can make a better decision.

Technical Insight

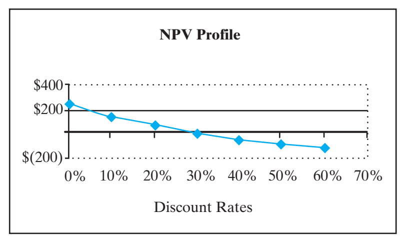
Multiple Internal Rates of Return (IRRs)

The IRR is defined simply as the compound annual rate of return earned on an investment. In introductory analyses of investment projects, we generally assume that the negative cash flows associated with a project, such as the development costs, come early in the project's life and that the positive cash flows come later. In reality, positive and negative cash flows are often interspersed. When this is the case, there can be multiple rates of return, or IRRs, that make the NPV of the investment zero.

We can use the NPV profile (a graph of NPV for various discount rates) to illustrate the problem. First, consider a typical investment with the following cash flow pattern:

Year 0	Year 1	Year 2	Year 3
$(500)	$400	$300	$50

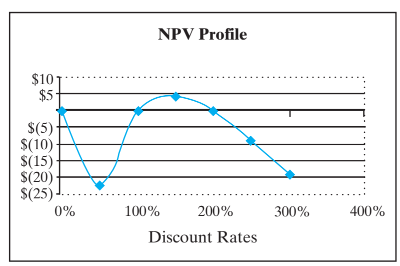
The IRR for these cash flows is 31.44%, which is readily identifiable in the project's NPV profile, found at the right.



Now consider the following set of project cash flows:

Year 0	Year 1	Year 2	Year 3
$(200)	$1,200	$(2,200)	$1,200

Note that these cash flows change sign from year to year on three occasions. It turns out that this fact drives the result that there are up to three different IRRs (see right). In this example, there are three IRRs that make the NPV equal to zero: 0%, 100%, and 200%.



Sometimes no IRR can be computed. We leave the illustration to the reader. Consider the following pattern of cash flows:

Year 0	Year 1	Year 2
$100	$(300)	$350

What is your estimate of the IRR for this stream of cash flows?

INDUSTRY INSIGHT

The Payback Model

Although it is widely derided among academic scholars, the payback model is often used in corporate practice as a tool for evaluating new investments.* The method is straightforward and involves estimating the number of years of expected future cash flows that are required to sum to the investment's initial outlay. For example, a $4 million investment today that produces annual cash flows of $1 million per year over a seven-year period has a payback period of four years.

Payback has three well-known drawbacks. First, it does not account for the time value of money. Second, it ignores the value of cash flows received after the payback period. And third, the cutoff is not tied to market conditions; it depends on the manager's biases and may often be outdated.

To respond to the first issue, some calculate a discounted payback by using cash flows that are discounted to account for the time value of money. For example, using a 10% discount rate and the earlier example, discounted payback is calculated as follows:

	Years						
	1	2	3	4	5	6	7
Project free cash flow (FCF)	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000
Present value of FCF	909,091	826,446	751,315	683,013	620,921	564,474	513,158
Cumulative present value	$ 909,091	$1,735,537	$2,486,852	$3,169,865	$3,790,787	$4,355,261	$4,868,419
Discounted payback	—	—	—	—	—	5.37	—

The discounted payback is 5.37 years, rather than 4 years. Although the project returns its initial investment in only four years, the value of the investment (using the present value of future cash flows) is not recovered for 5.37 years.

Although it is never optimal to ignore future payouts, payback may provide a simple screen for project risk because a quick payback means that the firm's investment is at risk for a shorter period of time. It is not uncommon for firms to adopt a screening standard for new projects that precludes consideration of projects with payback periods longer than some threshold, such as three years.

*Over 55% of the CFOs who responded to a study by John Graham and Campbell Harvey ("The Theory and Practice of Corporate Finance: Evidence from the Field," *Journal of Financial Economics* 60 [2001], pp. 187–243) indicated that they either always or almost always use payback when valuing new capital expenditure proposals.

TECHNICAL INSIGHT

Quick Review of the Mechanics of Time Value of Money Calculations

The majority of the projects that we analyze in this text are *long-lived* in the sense that they provide cash flows over many years. Thus, an important step in the valuation of such projects involves collapsing these future cash flows down to their present value so that we can compare that amount to the cost of making the investment. The present value of a future stream of cash flows is the equivalent sum in today's dollars to the set of future cash flows promised by the project.

To illustrate, consider a project that offers three years of future cash flows: C_1, C_2, and C_3. If we assume that the cash flows are risk free, then the appropriate discount rates for the three cash flows are the rate of interest corresponding to one-, two-, and three-year risk-free securities. These rates can be inferred from market prices of one-, two-, and three-year risk-free bonds as follows:

$$P_{\text{1-Year}} = \frac{\text{Face}_{\text{Year 1}}}{(1+r_1)^1}, \quad P_{\text{2-Year}} = \frac{\text{Face}_{\text{Year 2}}}{(1+r_2)^2}, \quad \text{and} \quad P_{\text{3-Year}} = \frac{\text{Face}_{\text{Year 3}}}{(1+r_3)^3}$$

where

P represents the current market values of the one-, two-, or three-year discount bonds

r represents the current market rates of interest on the bonds

Face is the maturity or face value of the bond that is paid to the holder at the end of each year.

Note that the discount bonds pay no interest but simply return their full principal amount (Face) at maturity.

Using the risk-free rates for years 1 through 3, we find the value of the three-year investment by the following formula:

$$\text{PV} = \frac{C_1}{(1+r_1)^1} + \frac{C_2}{(1+r_2)^2} + \frac{C_3}{(1+r_3)^3} \qquad (1)$$

2.5 Calculating Project Free Cash Flows Using Pro Forma Accounting Statements

When financial analysts forecast project free cash flows (FCFs) (as part of the firm's planning process), they tend also to prepare what are known as pro forma or planned financial statements for the investment. In this section, we examine the relationship between these pro forma financial statements and our FCF estimates; we also present an example where the FCFs can be extracted from the pro forma financial statements and used as the basis for project analysis and valuation.

The example that follows includes two elements that are part of the FCF formula found in Equation (2.2) but were ignored in the Lecion example for simplicity. These elements, which we describe in more detail below, are capital expenditures and changes in net working capital:

1. *Capital expenditures (CAPEX).* To sustain a firm's productive capacity and provide for future growth, the firm must periodically invest in new long-lived assets that are typically

Note that we have specified a different discount rate for each annual cash flow. To simplify matters, and because we are dealing with estimates, it is customary to use the same discount rate, *r,* for all future periods. That is,

$$PV = \frac{C_1}{(1+r)^1} + \frac{C_2}{(1+r)^2} + \frac{C_3}{(1+r)^3} = \sum_{t=1}^{3} \frac{C_t}{(1+r)^t} \tag{2}$$

The single discount rate assumption is particularly convenient for problems associated with estimating the appropriate discount rate for risky projects. (We discuss the cost of capital for risky projects in Chapter 5.)

A popular variant of Equation (2) describes the present value of a stream of cash flows that grows at a constant rate g such that $C_2 = C_1(1+g)^1$ and $C_3 = C_1(1+g)^2$. If g is less than r, then we can rewrite Equation (2) as follows:

$$PV = \left(\frac{C_1}{r-g}\right)\left(1 - \frac{(1+g)^2}{(1+r)^3}\right) \tag{3}$$

If the number of periods in which cash flows are received gets very large, then Equation (3) is approximated by:

$$PV = \left(\frac{C_1}{r-g}\right) \tag{4}$$

Equation (4) is commonly referred to as the **Gordon growth formula** because it was originally specified in a paper by Myron Gordon.*

*The Gordon growth model is another well-known DCF relationship in finance and represents the sum of the following geometric progression:

$$\sum_{t=1}^{\infty} \frac{C_0(1+g)^t}{(1+r)^t} = C_0 \sum_{t=1}^{\infty} \frac{(1+g)^t}{(1+r)^t},$$

which can be reduced to

$$C_0\left(\frac{1+g}{r-g}\right) \quad \text{or} \quad C_1\left(\frac{1}{r-g}\right),$$

where $r > g$, and C_1 is equal to $C_0(1+g)$.

referred to as property, plant, and equipment. These expenditures are referred to as capital expenditures (CAPEX). CAPEX can be calculated from changes in net property, plant, and equipment (net PPE) on the balance sheet. For example, consider the change in net PPE from 2014 to 2015.[10]

Net PPE (2014)
Less: depreciation expense for 2015
Plus: CAPEX for 2015
Equals: net PPE (2015)

[10] Net property, plant, and equipment is equal to the difference in the accumulated cost of all property, plant, and equipment (gross PPE) less the accumulated depreciation for those assets. Note that capex(t) is also equal to Gross PP&E(t) − Gross PP&E$(t-1)$.

Therefore, CAPEX for 2015 can be calculated as follows:[11]

$$\begin{array}{c}\text{CAPEX}\\ \text{for 2015}\end{array} = \begin{pmatrix}\text{Net PPE}\\ \text{for 2015}\end{pmatrix} - \begin{pmatrix}\text{Net PPE}\\ \text{for 2014}\end{pmatrix} + \begin{pmatrix}\text{Depreciation}\\ \text{Expense}\\ \text{for 2015}\end{pmatrix} \tag{2.6}$$

Based on this relationship, it follows that the capital expenditure for a particular year tends to be related to the firm's depreciation expense for the year, which is determined by a firm's prior expenditures on plant and equipment. The amount of CAPEX in any given period reflects the amount of plant and equipment that physically wears out and needs replacement, in combination with the demands of growing revenues, which require added plant and equipment capacity. The amount of CAPEX may exceed the depreciation expense for growing firms, and CAPEX may exceed the depreciation expense if the cost of new assets is rising or if existing assets are depreciated at a rate that is slower than the actual rate at which the assets physically deteriorate. Similarly, CAPEX may sometimes be less than depreciation expense.

2. *Changes in operating net working capital ($\Delta ONWC$)* Just as the firm must invest in property, plant, and equipment as it grows, it must also invest in current assets such as inventories and accounts receivable. However, the additional investment in inventories and receivables is partially financed by increases in the firm's trade credit that arise naturally in the course of the firm's purchases from its suppliers. The end result is that the firm incurs an outlay for working capital equal to what we refer to as the change in operating net working capital. We define **operating net working capital** for year t as follows:[12]

$$\begin{array}{c}\text{Operating}\\ \text{Net Working}\\ \text{Capital}_t\end{array} = \left(\begin{array}{c}\text{Current}\\ \text{Assets}_t\end{array} - \begin{array}{c}\text{Cash and}\\ \text{Marketable}\\ \text{Securities}_t\end{array}\right) - \left(\begin{array}{c}\text{Current}\\ \text{Liabilities}_t\end{array} - \begin{array}{c}\text{Current Portion of}\\ \text{Interest-Bearing}\\ \text{Debt/Notes}_t\end{array}\right)$$

The cash flow impact of a change in the firm's investment in operating net working capital is equal to the *change* in operating net working capital for the period. For any arbitrary year t, the change in operating net working capital is calculated as follows:

$$\begin{array}{c}\text{Change in}\\ \text{Operating Net}\\ \text{Working Capital}_t\end{array} = \begin{pmatrix}\text{Operating}\\ \text{Net Working}\\ \text{Capital}\end{pmatrix}_t - \begin{pmatrix}\text{Operating}\\ \text{Net Working}\\ \text{Capital}\end{pmatrix}_{t-1} \tag{2.7}$$

We used *change* in operating net working capital rather than *increase* because the change can be either positive or negative. For example, as a firm's or

[11] To predict CAPEX using this relationship requires that we estimate the change in net PPE for 2015 and depreciation expense. Typically, the former involves relating changes in net PPE and predicted changes in project revenues.

[12] The typical accounting definition of net working capital is current assets less current liabilities. In calculating FCF, we exclude cash and marketable securities from current assets under the assumption that they are not operating assets required to carry out the business. In addition, we exclude interest-bearing current liabilities from the calculation because we will incorporate the cost of these funds in the firm's cost of capital later (discussed in Chapters 4 and 5).

project's revenues grow, more will have to be invested in working capital such that the change will be positive (representing a cash outflow). However, as a project winds down and revenues stabilize and then decline, the firm's need for working capital decreases, which means that the change in operating net working capital becomes negative. When this happens, the change actually results in a net inflow of cash.

Note that failure to consider an investment's need for additional working capital and the funds required to finance those needs results in an overestimate of the value of the investment. This is especially true for high-growth projects that require frequent infusions of capital to finance the growing need for inventories and accounts receivable.

Example—Extracting FCF from Pro Forma Financial Statements

JC Crawford Enterprises is a privately held firm located in the suburbs of St. Louis, Missouri. The firm is a holding company that sells and supports six different franchise businesses. JC Crawford grew rapidly from revenues of $16.5 million and 101 employees in 2002 to more than $150 million and 500 employees today.

JC Crawford's management is considering the construction of a regional distribution center for its franchise businesses located in and around Miami, Florida. The plan is to create a distribution center that will be a wholly owned subsidiary of JC Crawford, operate the center for five years, and then sell it. Although JC Crawford will operate the distribution center initially to support its own franchise businesses in the southern Florida area, it can be expanded to serve other franchisee distribution needs.

Constructing Pro Forma Financial Statements

To launch the analysis of cash flow, JC Crawford's CFO asked one of his analysts, Cheryl Mosbach, to prepare pro forma income statements and balance sheets for the distribution center. These statements rely on a forecast of distribution center sales in combination with a number of assumptions and predictions, which are laid out in panel (a) of Table 2-5.

Panels (b) and (c) of Table 2-5 contain the pro forma income statements and balance sheets for JC Crawford spanning 2016 to 2018 as well as the firm's 2015 balance sheet. The construction of each line item in the pro forma statements is described in the second column. In practice, the pro forma financial statements might be more detailed to include many more line items; however, their content would remain basically the same as shown in Table 2-5.

Looking through the pro forma statements found in panels (b) and (c) of Table 2-5, we make the following observations:

- The revenues in panel (a) for 2016 are estimated to be $1 million and this total is expected to grow at a rate of 10% per year through 2018.
- At the end of 2015, the proposed investment in panel (b) requires $450,000, which is comprised of $200,000 in current assets (accounts receivable plus inventories equal 20% of sales) and $400,000 in plant and equipment (property, plant, and equipment are estimated to be 40% of next period's sales). Because the firm can finance $150,000 of this total from accounts payable (i.e., 15% of next period's

sales), the increased investment in operating net working capital for 2015 is \$50,000 = \$200,000 − 150,000. Consequently, the net cash expenditure by the firm at the end of 2015 that requires financing is \$450,000, which equals the estimated \$600,000 in total assets less the \$150,000 in trade credit financing. Note that the entire \$450,000 is raised using equity because we assumed in panel (a) that the firm does not use debt (i.e., interest-bearing debt).

- As the firm's revenues grow over time, it will have to invest more in plant and equipment (i.e., CAPEX). Specifically, the firm will need to invest an amount equal to the sum of the depreciation expense for the period plus 40% of the increase in sales. Thus, in 2016, JC Crawford will have CAPEX equal to 40% of the \$100,000 growth in sales for 2017 plus the \$40,000 in depreciation expense for 2016 (the replacement of worn-out plant and equipment)[13] for a total of \$80,000. In addition, operating net working capital will increase by 5% of 2016's estimated \$100,000 in sales, or \$5,000. The 5% figure comes from the difference in current assets, which are estimated to equal 20% of sales and current liabilities, which are 15% of sales.
- Notice that JC Crawford has no cash in its current assets and no (interest-bearing) debt in its current liabilities, so its operating net working capital is simply current assets minus current liabilities. Finally, the firm pays taxes equal to 30% of its taxable income and depreciates plant and equipment over a ten-year-life toward a zero salvage value using straight-line depreciation.[14]

Computing FCFs Using Pro Forma Financial Statements

Panel (d) of Table 2-5 presents the calculation of the Project FCFs for 2015 through 2020. Note that each of the required estimates needed to calculate FCF are taken from the pro forma income statement or were calculated in preparation of the pro forma balance sheet (i.e., CAPEX and the change in operating net working capital). We can make the following observations about the computation of FCF:

- FCF for 2015 (panel d) equals the expenditure for property, plant, and equipment or CAPEX of \$400,000 plus the increase in operating net working capital of \$50,000. Note that the increase in current assets is \$200,000, but JC Crawford receives \$150,000 in payables and accruals and thus needs only \$50,000 to finance operating net working capital in 2015.
- Beginning in 2016, JC Crawford has estimated FCF of \$32,000, which is equal to NOPAT of \$77,000 plus depreciation expense of \$40,000 less \$80,000 in CAPEX and less \$5,000 for additional operating net working capital.

[13] We assume that the physical wear on the firm's plant and equipment has a cost exactly equal to depreciation expense. If we should estimate that this total is either more or less than depreciation, then we should adjust CAPEX for the period to equal the actual estimated cost of worn-out equipment.

[14] Recall that straight-line depreciation involves allocating an equal amount of the cost of the asset over its life. For example, the \$400,000 CAPEX made in 2015 will lead to depreciation expenses of \$40,000 per year over the next ten years such that it will have a zero salvage value at the end of its ten-year life. For tax purposes, the Internal Revenue Service (IRS) allows firms to use an accelerated depreciation method called the modified accelerated cost recovery system (MACRS). For illustration purposes, however, we use the straight-line method.

- FCF for 2020 is $31,944 from firm operations plus the sale price for the project (assumed to be equal to the book value of assets) equal to $966,306, for a total of $998,250. This FCF total is driven primarily by the assumption that the project is sold for the book value of JC Crawford's assets.

Computing Project NPV

Now that we have estimates of the project's initial outlay for 2015 and the annual FCFs for 2016 to 2020, we are prepared to evaluate the profitability of committing to the investment. We assume an 18% discount rate from panel (a) of Table 2-5 and estimate the value of the future cash flows (including the residual value resulting from sale of the distribution center for the book value of its assets). JC Crawford invests $450,000 to make the investment which leaves an estimated positive NPV of $73,275:

Estimated Value of Project FCFs for 2016 to 2020	$ 523,275
Less: Initial Investment	(450,000)
Equals NPV	$ 73,275

Clearly, the investment meets and exceeds JC Crawford's 18% discount rate. Of course, the cash flow estimates are subject to uncertainty, and no attempt has been made to account for this other than requiring an 18% rate of return. In Chapter 3, we address the topic of project cash flow estimation risk directly and discuss some tools often used to analyze the issue.

Key Learning Points—Pro Forma Financial Statements and FCF

As the Lecion and JC Crawford examples illustrate, financial analysts use two sets of skills when they forecast FCFs. The analyst must have the economic skills needed to forecast the revenues that will be generated by the prospective project, along with an understanding of the costs associated with creating those revenues. These costs include the costs of goods sold, the required capital expenditures, and the project's working capital needs. Because accounting is the language of business, the analyst must also have the accounting skills that are needed to translate these forecasts into pro forma accounting statements. As illustrated in the JC Crawford example, financial analysts are not only expected to create these pro forma statements but they are also expected to be able to determine FCF forecasts from the pro forma statements created by others.

Although it may not be readily apparent from our discussion, the analysis of an investment in a freestanding division, such as JC Crawford's distribution center, is very similar to valuing a stand-alone business. For example, if JC Crawford were considering the purchase of an existing distribution center, the analysis would be very similar. An equity analyst evaluating an investment in a public trading firm offering distribution services to franchisees would also examine pro forma financial statements in much the same way. In all cases, the analyst is comparing the present value of the cash flows generated by the investment with the cost of the investment.

Table 2-5 Estimating Project Free Cash Flows for the Proposed Warehouse Distribution Center

Panel (a) Assumptions and Predictions

Predicted sales for 2016	$ 1,000,000
Sales growth rate for 2017–2021	10%
Gross profit margin (t) = Gross profit (t)/Sales (t)	40%
Operating expenses (before depreciation)(OEBD) (t)/Sales (t)	25%
Tax rate	30%
Net Property, Plant, and Equipment (Net PP&E) (t)/Sales (t + 1)	40%
Accounts receivable and inventories (AR&Inv) (t)/Sales (t + 1)	20%
Accounts payable plus accrued expenses (t)/Sales (t + 1)	15%
Short-term debt (STD) (t)/total assets (t)	0%
Short-term debt (STD) borrowing rate (RateSTD)	5%
Long-term debt (LTD) (t)/total assets (t)	0%
Long-term debt (LTD) borrowing rate (RateLTD)	6%
Depreciable life of plant and equipment	10 years
Depreciation method	Straight line
Residual values of working capital and net fixed assets/Book Value	100%
Cost of capital	18%

Panel (b) Pro Forma Income Statements

(% of Sales corresponds to the estimates found in Panel a)	Formulas	2016	2017	2018	2019	2020
Sales	Sales (t − 1) × (1 + Sales growth rate)	$1,000,000	$1,100,000	$1,210,000	$1,331,000	$1,464,100
Cost of goods sold (COGS)	Sales (t) × (1 − Gross profit margin)	(600,000)	(660,000)	(726,000)	(798,600)	(878,460)
Gross profit (GP)	Sales (t) − COGS (t)	$ 400,000	$ 440,000	$ 484,000	$ 532,400	$ 585,640
Operating expenses before depreciation (OEBD)	Sales (t) × (OEBD/Sales)	(250,000)	(275,000)	(302,500)	(332,750)	(366,025)
Depreciation expense (Depr)	Depr (t − 1) + CAPEX (t − 1)/Asset Life	(40,000)	(48,000)	(57,200)	(67,760)	(79,860)
Earnings before interest and taxes (EBIT)	GP (t) − OEBD (t) − Depr (t)	$ 110,000	$ 117,000	$ 124,300	$ 131,890	$ 139,755
Interest expense (IntExp)	STD (t − 1) × RateSTD + LTD(t − 1) × RateLTD	—	—	—	—	—
Earnings before taxes (EBT)	EBIT (t) − IntExp (t)	$ 110,000	$ 117,000	$ 124,300	$ 131,890	$ 139,755
Taxes	EBT (t) × Tax Rate	(33,000)	(35,100)	(37,290)	(39,567)	(41,927)
Net Income (NI)	EBT (t) − Taxes (t)	$ 77,000	$ 81,900	$ 87,010	$ 92,323	$ 97,829

Panel (c) Pro forma Balance Sheet

	Formulas	2015	2016	2017	2018	2019	2020
Accounts receivable plus inventories (AR&Inv)	(AR&Inv/Sales) × Sales $(t + 1)$	$ 200,000	$ 220,000	$ 242,000	$ 266,200	$ 292,820	$ 322,102
Gross plant and equipment (Gross PP&E)	Gross PP&E $(t - 1)$ + CAPEX (t)	400,000	480,000	572,000	677,600	798,600	937,024
Less: Accumulated depreciation expense (AccDepr)	AccDepr $(t - 1)$ + Depr (t)	—	(40,000)	(88,000)	(145,200)	(212,960)	(292,820)
Net property, plant and equipment (Net PP&E)	Gross PP&E (t) − AccDepr (t)	$ 400,000	$ 440,000	$ 484,000	$ 532,400	$ 585,640	$ 644,204
Total Assets (TA)		$ 600,000	$ 660,000	$ 726,000	$ 798,600	$ 878,460	$ 966,306
Accounts payable plus accrued expenses (AP)	Sales $(t + 1)$ × (AP/Sales (t))	$ 150,000	$ 165,000	$ 181,500	$ 199,650	$ 219,615	$ 241,577
Short-term notes payable (STD)	Assumed to equal zero	—	—	—	—	—	—
Current Liabilities (CL)	AP (t) + STD (t)	$ 150,000	$ 165,000	$ 181,500	$ 199,650	$ 219,615	$ 241,577
Long-term debt (LTD)	Assumed to equal zero	—	—	—	—	—	—
Common Equity (CE)	TA (t) − CL (t) − LTD (t)	450,000	495,000	544,500	598,950	658,845	724,730
Total Liabilities plus Common Equity (TL + CE)	CL (t) + LTD (t) + CE (t)	$ 600,000	$ 660,000	$ 726,000	$ 798,600	$ 878,460	$ 966,306

Panel (d) Project Free Cash Flows (FCF)

	Formulas	2015	2016	2017	2018	2019	2020
Earnings before interest and taxes (EBIT)	See income statement	$ —	$ 110,000	$ 117,000	$ 124,300	$ 131,890	$ 139,755
Taxes	See income statement	—	(33,000)	(35,100)	(37,290)	(39,567)	(41,927)
Net operating profit after taxes (NOPAT)	See income statement	$ —	$ 77,000	$ 81,900	$ 87,010	$ 92,323	$ 97,829
plus: Depreciation expense (Depr)	See income statement	—	40,000	48,000	57,200	67,760	79,860
less: Capital expenditures (CAPEX)	See legend	(400,000)	(80,000)	(92,000)	(105,600)	(121,000)	(138,424)
less: Change in operating net working capital (ChgONWC)	See legend	(50,000)	(5,000)	(5,500)	(6,050)	(6,655)	(7,321)
Residual value	Assumed equal to book value of assets in 2020						$ 966,306
Free Cash Flow (FCF)	NOPAT (t) + Depr (t) − CAPEX (t) − ChgONWC (t)	$ (450,000)	$ 32,000	$ 32,400	$ 32,560	$ 32,428	$ 998,250

(*Continued*)

Table 2-5 *continued*

Legend:							
Analysis of the Investment in Operating Net Working Capital		**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Operating net working capital (ONWC)		$ 50,000	$ 55,000	$ 60,500	$ 66,550	$ 73,205	$ 80,526
Change (increase or decrease) in operating net working capital	ONWC (t − 1) − ONWC (t)	$ (50,000)	$ (5,000)	$ (5,500)	$ (6,050)	$ (18,205)	$ (7,321)
Analysis of Property, Plant and Equipment Needs							
	Formulas	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Sales	[Sales (t + 1) − Sales (t)] × [Net PP&E (t)/Sales (t + 1)]		$1,000,000	$1,100,000	$1,210,000	$1,331,000	$1,464,100
Capex (purchases plus sales of fixed assets)		$(400,000)	$ (80,000)	$ (92,000)	$ (105,600)	$ (121,000)	$ (138,424)
		2015	**2016**	**2017**	**2018**	**2019**	**2020**
Net Property, Plant, and Equipment (Beginning Balance)	Ending PP&E (t − 1)	—	$ 400,000	$ 440,000	$ 484,000	$ 532,400	$ 585,640
less: Depreciation Expense (Depr)	See Income Statement	—	(40,000)	(48,000)	(57,200)	(67,760)	(79,860)
plus: Capital Expenditures (Capex)	See above	$ 400,000	$ 80,000	$ 92,000	$ 105,600	$ 121,000	$ 138,424
Net Property Plant and Equipment (Ending Balance)	Beginning Net PP&E (t) − Depr (t) + Capex (t)	$ 400,000	$ 440,000	$ 484,000	$ 532,400	$ 585,640	$ 644,204

2.6 Summary

The value of an investment project is determined by the cash flows it is expected to produce. In this chapter, we have discussed valuing investment opportunities using discounted cash flow (DCF) analysis that can be implemented using the three-step process outlined below:

Steps	Project Valuation
Step 1: Forecast the amount and timing of future cash flows.	Forecast project FCF.
Step 2: Estimate a risk-appropriate discount rate (covered in Chapters 4 and 5).	Combine the debt and equity discount rate, which is the weighted average cost of capital (WACC).
Step 3: Discount the cash flows.	Discount the project's FCF using the WACC to estimate the value of the project as a whole.

The main focus of this chapter is on identifying and forecasting the *incremental* revenues and costs that are required to estimate expected cash flows. Although cash flow analysis is a key element in investment valuation, the process used to make forecasts is necessarily subjective and fraught with potential estimation errors. Consequently, cash flow forecasting is part art and part science. This does not mean that the analyst should simply throw caution to the wind and engage in crystal-ball gazing. Good forecasting is grounded in sound economic analysis and rigorous attention to the details of proper cash flow definition.

Key learning points from this chapter are that forecasting is hard work and it is subject to potentially very large errors. To minimize the effect of these forecast errors, good analysts follow a three-pronged approach: First, they take the forecasting problem very seriously and utilize all the information and technology they have at their disposal to arrive at their forecast. Second, as we will discuss in Chapter 3, they do post-forecast risk analysis, which helps them prepare for a wide range of possible outcomes. Third, to the extent possible, they try to maintain flexibility in how the investment is implemented so that they can respond to unforeseen future events. We will have more to say about this latter point in Chapters 3 and 12.

Exercises

2-1 CALCULATING PRESENT VALUES Calculate the present value of each of the following cash flow streams. Use a discount rate of 10%.

a. \$500 received at the end of five years
b. \$500 received annually for each of the next five years
c. \$500 received annually for each of the next fifty years
d. \$500 received annually for 100 years

2-2 CALCULATING THE INTERNAL RATE OF RETURN Singular Construction is evaluating whether to build a new distribution facility. The proposed investment will cost Singular

$4 million to construct and provide cash savings of $500,000 per year over the next ten years.

a. What rate of return does the investment offer?
b. If Singular were to invest another $200,000 in the facility at the end of five years, it would extend the life of the project by four years, during which time it would continue receiving cash savings of $500,000. What is the internal rate of return for this investment?

2-3 CALCULATING PROJECT FCF In the spring of 2015, Jemison Electric was considering an investment in a new distribution center. Jemison's CFO anticipates additional earnings before interest and taxes (EBIT) of $100,000 for the first year of operation of the center, and, over the next five years, the firm estimates that this amount will grow at a rate of 5% per year. The distribution center will require an initial investment of $400,000 that will be depreciated over a five-year period toward a zero salvage value using straight-line depreciation of $80,000 per year. Jemison's CFO estimates that the distribution center will need operating net working capital equal to 20% of EBIT to support operation.

Assuming the firm faces a 30% tax rate, calculate the project's annual project free cash flows (FCFs) for each of the next five years where the salvage value of operating network-ing capital and fixed assets is assumed to equal their book values, respectively.

2-4 PRO FORMA FINANCIAL STATEMENTS In the JC Crawford example, capital expenditures (CAPEX) are estimated using projected balances for net property, plant, and equipment (net PPE), which is determined by the firm's projected sales. In 2016, the estimated ending balance for net PPE is projected to be $440,000, which represents an increase of $40,000 over the ending balance for 2015. However, CAPEX for 2016 is estimated to be $80,000. Why is the change in net PPE not equal to CAPEX? (*Hint:* Consider the effect of annual depreciation expense on net PPE.)

2-5 COMPUTING FREE CASH FLOW The free cash flow estimated for 2008 in the Lecion example was equal to $1,383,436,000. Verify this computation using the assumptions underlying the model. Compute the free cash flow for 2008 if the revenues for the year were 10% higher than those forecast in Table 2-1.

PROBLEMS

2-6 COMPREHENSIVE PROJECT FCF The TCM Petroleum Corporation is an integrated oil company headquartered in Fort Worth, Texas. Historical income statements for 2014 and 2015 are found below (dollar figures are in the millions):

	December 2015	**December 2014**
Sales	$ 13,368.00	$12,211.00
Cost of goods sold	(10,591.00)	(9,755.00)
Gross profit	2,777.00	2,456.00
Selling, general, and administrative expense	(698.00)	(704.00)

	December 2015	December 2014
Operating income before depreciation	2,079.00	1,752.00
Depreciation, depletion, and amortization	(871.00)	(794.00)
Operating profit	1,208.00	958.00
Interest expense	(295.00)	(265.00)
Nonoperating income or expense	151.00	139.00
Special items		20.00
Pretax income	1,064.00	852.00
Taxes	(425.60)	(340.80)
Net income	$ 638.40	$ 511.20

In 2014, TCM made capital expenditures of $875 million, followed by $1,322 million in 2015. TCM also invested an additional $102 million in net working capital in 2014, followed by a decrease in its investment in net working capital of $430 million in 2015.

a. Calculate TCM's FCFs for 2014 and 2015. TCM's tax rate is 40%.
b. Estimate TCM's FCFs for 2016 to 2020 using the following assumptions: Operating income continues to grow at 10% per year over the next five years, CAPEX is expected to be $1,000 million per year, new investments in net working capital are expected to be $100 million per year, and depreciation expense equals the prior year's total plus 10% of the prior year's CAPEX. Note that because TCM is a going concern, we need not be concerned about the liquidation value of the firm's assets at the end of 2020.

2-7 INTRODUCTORY PROJECT VALUATION Steve's Sub Stop (Steve's) is considering investing in toaster ovens for each of its 120 stores located in the southwestern United States. The high-capacity conveyor toaster ovens, manufactured by Lincoln, will require an initial investment of $15,000 per store plus $500 in installation costs, for a total investment of $1,860,000. The new capital (including the costs for installation) will be depreciated over five years using straight-line depreciation toward a zero salvage value. Steve's will also incur additional maintenance expenses totaling $120,000 per year to maintain the ovens. At present, firm revenues for the 120 stores total $9 million, and the company estimates that adding the toaster feature will increase revenues by 10%.

a. If Steve's faces a 30% tax rate, what expected project FCFs for each of the next five years will result from the investment in toaster ovens?
b. If Steve's uses a 9% discount rate to analyze its investments in its stores, what is the project's NPV? Should the project be accepted?

2-8 INTRODUCTORY PROJECT VALUATION South Tel Communications is considering the purchase of a new software management system. The system is called B-Image, and it is expected to reduce drastically the amount of time that company technicians spend installing new software. South Tel's technicians currently spend 6,000 hours per year on installations, which costs South Tel $25 per hour. The owners of the B-Image system claim that their software can reduce time on task by at least 25%. The system requires an initial investment of $55,000 and an additional investment of $10,000 for technician training on the new system. Annual upgrades will cost the firm $15,000 per year. The tax treatment of software purchases sometimes calls for amortization of the initial cost over time; sometimes the cost can be expensed in the year of the purchase. Before the tax experts are consulted and for purposes of this initial analysis, South Tel has decided that it will expense the cost of the software in the year of the expenditure. South Tel faces a 30% tax rate and uses a 9% cost of capital to evaluate projects of this type.

a. Assume that South Tel has sufficient taxable income from other projects so that it can expense the cost of the software immediately. What are the free cash flows for the project for years zero through five?
b. Calculate the NPV and IRR for the project.

2-9 INTRODUCTORY PROJECT VALUATION The CT Computers Corporation is considering whether to begin offering customers the option to have their old personal computers (PCs) recycled when they purchase new systems. The recycling system would require CT Computers to invest $600,000 in the grinders and magnets used in the recycling process. The company estimates that for each system it recycles, it would generate $1.50 in incremental revenues from the sale of scrap metal and plastics. The machinery has a five-year useful life and will be depreciated using straight-line depreciation toward a zero salvage value. CT Computers estimates that in the first year of the recycling investment, it could recycle 100,000 PCs and that this number will grow by 25% per year over the remaining four-year life of the recycling equipment. CT Computers uses a 15% discount rate to analyze capital expenditures and pays taxes equal to 30%.

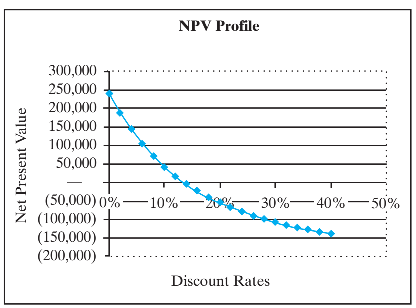
a. What are the project cash flows? You can assume that the recycled PCs cost CT Computers nothing.
b. Calculate the NPV and IRR for the recycling investment opportunity. Is the investment a good one based on these cash flow estimates?
c. Is the investment still a good one if only 75,000 units are recycled in the first year?
d. Redo your analysis for a scenario in which CT Computers incurs a cost of $0.20 per unit to dispose of the toxic elements from the recycled computers. What is your recommendation under these circumstances?

2-10 PROJECT VALUATION Glentech Manufacturing is considering the purchase of an automated parts handler for the assembly and test area of its Phoenix, Arizona, plant. The handler will cost $250,000 to purchase plus $10,000 for installation. If the company undertakes the investment, it will automate part of the semiconductor test area and reduce operating costs by $70,000 per year for the next ten years. Five years into the life of the investment, however, Glentech will have to spend an additional $100,000 to update and refurbish the handler. The investment in the handler will be depreciated using straight-line depreciation over ten years, and the refurbishing costs will be depreciated over the remaining five-year life of the handler (also using straight-line depreciation). In ten years, the handler is expected to be worth $5,000, although its book value will be zero. Glentech's tax rate is 30%, and its opportunity cost of capital is 12%. Exhibit P2-10.1 contains cash flow calculations for the project that can be used in performing a DCF evaluation of its contribution to firm value. Answer each of the following questions concerning the project:

a. Is this a good project for Glentech? Explain your answer.
b. What can you tell about the project from the NPV profile found in Exhibit P2-10.1?

Exhibit P2-10.1 Glentech Manufacturing Company Cash Flow Estimates

	0	1	2	3	4	5	6	7	8	9	10
Investment Outlays											
Equipment purchases	(250,000)					(100,000)					
Installation costs	(10,000)										
Initial outlay	(260,000)										
After-tax salvage value											3,500
Free Cash Flows											
Operating exp. savings		70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000
Less: Depreciation exp.		(26,000)	(26,000)	(26,000)	(26,000)	(26,000)	(46,000)	(46,000)	(46,000)	(46,000)	(46,000)
Added oper. income		44,000	44,000	44,000	44,000	44,000	24,000	24,000	24,000	24,000	24,000
Less: Taxes		(13,200)	(13,200)	(13,200)	(13,200)	(13,200)	(7,200)	(7,200)	(7,200)	(7,200)	(7,200)
NOPAT		30,800	30,800	30,800	30,800	30,800	16,800	16,800	16,800	16,800	16,800
Plus: Depreciation		26,000	26,000	26,000	26,000	26,000	46,000	46,000	46,000	46,000	46,000
Less: CAPEX	(260,000)	—	—	—	—	(100,000)	—	—	—	—	—
Free cash flow	(260,000)	56,800	56,800	56,800	56,800	(43,200)	62,800	62,800	62,800	62,800	66,300



c. If the project were partially financed by borrowing, how would this affect the investment cash flows? How would borrowing a portion of the investment outlay affect the value of the investment to the firm?
d. The project calls for two investments: one immediately and one at the end of year 5. How much would Glentech earn on its investment? How should you account for the additional investment outlay in your calculations?
e. What are the considerations that make this investment somewhat risky? How would you investigate the potential risks of this investment?

2-11 PROJECT VALUATION HMG Corporation is considering the manufacture of a new chemical compound that is used to make high-pressure plastic containers. An investment of $4 million in plant and equipment is required. The firm estimates that the investment will have a five-year life, and will use straight-line depreciation toward a zero salvage value. However, the investment has an anticipated salvage value equal to 10% of its original cost.

The number of pounds (in millions) of the chemical compound that HMG expects to sell over the five-year life of the project are as follows: 1.0, 1.5, 3.0, 3.5, and 2.0. To operate the new plant, HMG estimates that it will incur additional fixed cash operating expenses of $1 million per year and variable operating expenses equal to 45% of revenues. HMG also estimates that in year t it will need to invest 10% of the anticipated increase in revenues for year $t + 1$ in net working capital. The price per pound for the new compound is expected to be $2.00 in years 1 and 2, then $2.50 per pound in years 3 through 5. HMG's tax rate is 38%, and it requires a 15% rate of return on its new-product investments.

a. Exhibit P2-11.1 contains projected cash flows for the entire life of the proposed investment. Note that investment cash flow is derived from the additional revenues and costs associated with the proposed investment. Verify the calculation of project cash flow for year 5.
b. Does this project create shareholder value? How much? Should HMG undertake the investment? Explain your answer.
c. What if the estimate of the variable costs were to rise to 55%? Would this affect your decision?

2-12 PROJECT VALUATION Carson Electronics is currently considering whether to acquire a new materials-handling machine for its manufacturing operations. The machine costs $760,000 and will be depreciated using straight-line depreciation toward a zero salvage value over the next five years. During the life of the machine, no new capital expenditures or investments in working capital will be required. The new materials-handling machine is expected to save Carson Electronics $250,000 per year before taxes of 30%. Carson's CFO recently analyzed the firm's opportunity cost of capital and estimated it to be 9%.

a. What are the annual free cash flows for the project?
b. What are the project's NPV and IRR? Should Carson Electronics accept the project?
c. Carson's new head of manufacturing was concerned about whether the new handler could deliver the promised savings. In fact, he projected that the savings might be 20% lower than projected. What are the NPV and IRR for the project under this scenario?

2-13 STRATEGY AND FORECASTING At the end of 2013, the executives at Apple evaluated a number of competitive threats to their very profitable iPhone business and decided

Exhibit P2-11.1 HMG Project Analysis

Given:

Investment	4,000,000	
Plant life	5	
Salvage value	400,000	
Variable cost %	45%	
Fixed operating cost	1,000,000	
Tax rate	38%	
Working capital	10%	of the change in revenues for the year
Required rate of return	15%	

	0	1	2	3	4	5
Sales volume		1,000,000	1,500,000	3,000,000	3,500,000	2,000,000
Unit price		2.00	2.00	2.50	2.50	2.50
Revenues		2,000,000	3,000,000	7,500,000	8,750,000	5,000,000
Variable operating costs		(900,000)	(1,350,000)	(3,375,000)	(3,937,500)	(2,250,000)
Fixed operating costs		(1,000,000)	(1,000,000)	(1,000,000)	(1,000,000)	(1,000,000)
Depreciation expense		(800,000)	(800,000)	(800,000)	(800,000)	(800,000)
Net operating income		(700,000)	(150,000)	2,325,000	3,012,500	950,000
Less: Taxes		266,000	57,000	(883,500)	(1,144,750)	(361,000)
NOPAT		(434,000)	(93,000)	1,441,500	1,867,750	589,000
Plus: Depreciation		800,000	800,000	800,000	800,000	800,000
Less: CAPEX	(4,000,000)	—	—	—	—	248,000
Less: Working capital	(200,000)	(100,000)	(450,000)	(125,000)	375,000	500,000
Free cash flow	(4,200,000)	266,000	257,000	2,116,500	3,042,750	2,137,000

Net present value	419,435
Internal rate of return	18.01%

that the iPhone 6 would need to exhibit some fundamental improvements. For example, they considered an increase in screen size, possibly to 5.5 inches, and a Bluetooth connection to an accompanying watch, which would display incoming emails and texts along with the number of incoming calls.

Apple estimates that the more aggressive product launch will require a development budget of $1.5 billion versus $800 million for a more modest effort. Discuss how you would estimate the incremental cash flows associated with this decision. To answer this question, consider both the Frito Lay and Lecion examples in the chapter. (*Hint:* There are no calculations involved; simply describe how you would approach the forecasting problem Apple faces.)

CHAPTER 3

Project Risk Analysis

Chapter Overview

In this chapter, we investigate how analysts incorporate *uncertainty* in forecasts of future cash flows. Although the presentation of project cash flows is based on accounting income statements, these are not historical statements. They are pro forma, or forecasted, statements that reflect best guesses about an uncertain future. To analyze this uncertain future, analysts use various approaches, including sensitivity analysis, scenario analysis, breakeven sensitivity analysis, and Monte Carlo simulation. In addition to examining each of these approaches, we provide an initial discussion of the role that investment flexibility can have on expected cash flows and the role that decision trees can play in organizing the analysis of decision flexibility. We pick up this discussion again in Chapters 12 and 13, where we consider real option analysis.

3.1 Introduction

The use of discounted cash flow (DCF) analysis to evaluate major long-term investments is now accepted practice throughout the world. In its simplest form, analyzing capital expenditures using DCF involves estimating a single stream of expected cash flows, discounting it, and then making a decision based on a single estimate of the investment's net present value (NPV). In practice, however, investment decisions take place in a more complex world of uncertain future outcomes. In this chapter, we explicitly confront the challenge of uncertainty; we consider various techniques that financial analysts use to learn more about an investment's primary value drivers and the risks they generate.

To understand how uncertainty is accounted for in an investment analysis, it is useful to think about how financial analysts evaluate new investment opportunities in terms of two phases:

- In phase I, the analyst tries to envision the possible outcomes from an investment and to determine an estimate of what he or she *thinks* or *expects* will happen. This analysis forms the basis for estimating the NPV, internal rate of return (IRR), and other measures of investment value.

- In phase II, the analyst details the underlying sources of risk. This involves identifying the investment's value drivers and the uncertainty that characterizes each. Once these risks are identified, the analyst seeks ways to either mitigate or at least monitor the risks carefully throughout the life of the project.

The challenge to the financial analyst in implementing DCF analysis, then, is twofold: First, the analyst must make the forecasts and assumptions necessary to generate an estimate of the investment's NPV—as we illustrated in Chapter 2. Second, the analyst must perform an in-depth analysis of the assumptions used when estimating NPV to come to grips with what might happen to the project when (not if) things do not go as planned. In this chapter, we describe a variety of tools that analysts can use to test and probe their estimates of the NPV of a proposed project. These tools include scenario analysis, breakeven sensitivity analysis, and Monte Carlo simulation.

Although the tools of investment analysis that we discuss in this chapter may give an impression of a high level of scientific precision, the underlying basis for using them is inherently subjective and relies on the judgment of the individual(s) performing the analysis. Realization of this fact is often disconcerting to number-focused financial analysts who look for answers in techniques and tools. Indeed, it is crucial for a financial analyst to come to grips with the inherently subjective nature of the investment evaluation process and the critical role that judgment and experience must play.[1]

3.2 Uncertainty and Investment Analysis

Our discussion throughout this chapter focuses on **project valuation**—the evaluation of investments in projects that an individual or firm might consider. However, the tools and discussion apply equally well to **enterprise valuation**—the evaluation of acquisitions of entire firms, which we discuss in Chapters 8 through 10.

The Investment Process with Risky Cash Flows

The approach we took in Chapter 2 involved the use of a three-step valuation process to estimate the value of an investment project:

1. Estimate the amount and timing of future cash flows for each year of the proposed investment's life.
2. Identify a risk-appropriate discount rate.
3. Calculate the present value of future cash flows. If the expected NPV of the project's cash flows is positive after considering all the relevant cash inflows and outflows, then the firm should undertake the project.

In theory, this approach provides the best estimate of the value created by the investment project; in practice, the cash flow estimates are at best educated guesses and at worst out-and-out fiction. Hence, the initial DCF analysis should be viewed as only the first phase of the valuation process. This calculation is followed by phase II, in which the analyst performs a form of exploratory surgery on the initial estimate. The object of this follow-on analysis is to explore the investment's value drivers—those factors that are

[1] We often advise our more technique-oriented students that if there were no need for human judgment, there would be no need for financial analysts!

most critical to the project's success. The analyst cannot eliminate uncertainty, but she or he can better understand the relative sensitivity of the project's NPV to different key variables. As an illustration, consider the investment opportunity in an organic fertilizer product being considered by CSM Inc. and described in the next section.

Example—The Earthilizer Proposal

CSM Inc. is considering an investment in a project that requires an initial investment of $580,000 to produce and market a new organic fertilizer made from dairy-farm waste. The product, Earthilizer, has been developed by CSM's agricultural division over the past three years in response to two factors: First, there is a growing demand from organic farmers; second, dairy farmers face increasingly more restrictive environmental rules regarding the disposal of cattle manure. CSM's management feels that these forces of change present a very promising investment opportunity.

CSM has tested the product extensively as a liquid-fertilizer replacement for the more expensive and conventional chemical fertilizers that farmers and ranchers have used since the World War II. The product will be marketed in a concentrated form, with 1 gallon of Earthilizer producing about 100 gallons of usable fertilizer.

Not only is the product wholly organic, it is also cheaper to use than chemical fertilizers. Traditional chemical fertilizers are made from petroleum and cost approximately $25 an acre for grass and hay production. Earthilizer utilizes dairy waste and costs less than $20 per application, with no more applications required over the growing season.

CSM's analysts estimate that an initial investment of $580,000 will put the Earthilizer project in place. This investment is comprised of $250,000 in working capital plus $330,000 in plant and equipment.

Did You Know?

Barnyard Animals: An Important Source of Green Energy*

Manure and other waste products from cows, pigs, and other livestock have long been recognized as a source of groundwater pollution. However, new technology for converting this waste to an energy source indicates it is a largely untapped source of energy in the United States. For example, fed by the waste from 900 cows, a Wisconsin dairy farm now produces about 6.5 million kilowatt hours a year—enough to power 600 homes annually. Meatpacker Swift & Co. recently signed a letter of intent to build a biogas production facility. The biogas from all seven of Swift's plants has the potential to generate the equivalent of 25,000 barrels of heating oil a day.

*http://news.com/Manufacturing+power+from+manure/2009-11395_3-6057795.html

Estimating Earthilizer's Project Free Cash Flows (FCFs)

If the project is approved, the agricultural division of CSM plans to begin construction on the new facilities immediately. The manufacture and distribution of Earthilizer will be up and running by the end of 2015, with the project's first year of revenues in 2016. Table 3-1 contains a set of financial projections for the project. These consist of pro forma income statements, shown in panel (a) of Table 3-1; balance sheets, shown in panel (b); and cash flows, shown in panel (c) spanning the five years used by CSM to evaluate the investment. Of course, if the project is successful, it could operate for many years; however, it is standard practice among many firms to select an arbitrary investment life and analyze the investment as if it will be shut down at the end of that period.

CSM Inc. is a very conservatively financed firm that finances all its investments out of internally generated cash flows (i.e., the firm does not borrow to obtain funds for new investments). Consequently, the project is all equity financed, which means that there is no interest expense in the pro forma income statements (panel [a] of Table 3-1), nor is there any debt financing in the pro forma balance sheets for the project (panel [b]).

Panel (c) of Table 3-1 details management's estimates of the project's FCFs. Note that the project is expected to be cash flow positive in 2016, which is the first year of

Table 3-1 CSM Inc. Earthilizer Investment Project

Panel (a) Pro Forma Income Statements ($000)

Income Statements	**2016**	**2017**	**2018**	**2019**	**2020**
Sales (10% growth per year)	$1,000.00	$1,100.00	$1,210.00	$1,331.00	$1,464.10
Cost of goods sold	(674.00)	(741.40)	(815.54)	(897.09)	(986.80)
Gross profit	326.00	358.60	394.46	433.91	477.30
Operating expenses before depreciation	(215.00)	(225.00)	(236.00)	(248.10)	(261.41)
Depreciation expense	(33.00)	(33.00)	(33.00)	(33.00)	(33.00)
Earnings before interest and taxes	78.00	100.60	125.46	152.81	182.89
Interest expense	—	—	—	—	—
Earnings before taxes	78.00	100.60	125.46	152.81	182.89
Taxes	(23.40)	(30.18)	(37.64)	(45.84)	(54.87)
Net income	$ 54.60	$ 70.42	$ 87.82	$ 106.96	$ 128.02

Panel (b) Pro Forma Balance Sheets ($000)

Balance Sheets	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Net working capital	$250.00	$250.00	$275.00	$302.50	$332.75	$366.03
Gross plant and equipment	330.00	330.00	330.00	330.00	330.00	330.00
Less: accumulated depreciation	—	(33.00)	(66.00)	(99.00)	(132.00)	(165.00)
Net plant and equipment	$330.00	$297.00	$264.00	$231.00	$198.00	$165.00
Total	$580.00	$547.00	$539.00	$533.50	$530.75	$531.03

Panel (c) Expected Project Free Cash Flows ($000)

	2015	**2016**	**2017**	**2018**	**2019**	**2020**
EBIT (earnings before interest and taxes)	$ —	$ 78.00	$100.60	$125.46	$152.81	$182.89
Less: taxes	—	(23.40)	(30.18)	(37.64)	(45.84)	(54.87)
NOPAT (net operating profit after taxes)	$ —	$ 54.60	$ 70.42	$ 87.82	$106.96	$128.02
Plus: depreciation expense	—	33.00	33.00	33.00	33.00	33.00
Less: CAPEX (capital expenditures)	(330.00)	—	—	—	—	—
Less: changes in net working capital	(250.00)	—	(25.00)	(27.50)	(30.25)	(33.28)
Plus: liquidation of net working capital						366.03
Plus: liquidation of PPE (property, plant, and equipment)						165.00
Equals: project FCF	$ (580.00)	$ 87.60	$ 78.42	$ 93.32	$109.71	$658.77

operations, and every year thereafter. The cash flow calculations for 2016 to 2020 are based on a number of key estimates and assumptions:

- Sales revenues are expected to be $1,000,000 in 2016 and are expected to grow at an annual rate of 10% throughout the five-year planning period; see panel (a) of Table 3-1.
- Cost of goods sold is equal to 67.40% of sales,[2] while operating expenses before depreciation are 10% of sales revenues plus a fixed component equal to $115,000 per year (panel [a]).
- A 30% tax rate is used in the analysis (panel [a]).
- The firm uses straight-line depreciation, with plant and equipment assumed to have a ten-year life and a zero salvage value (panels [a] and [b]).
- The project requires an initial investment of $580,000 at the end of 2015, which includes $250,000 in net working capital (panel [b]) and $330,000 in property, plant, and equipment (panel [c]).
- For 2016 through 2020, net working capital requirements are expected to equal 25% of Earthilizer's sales. Capital equipment (CAPEX) is assumed to be $330,000 in 2015 and zero in all future years[3] (panel [c]).

CSM assumes that it will terminate the project in 2020, at which time it will produce a terminal cash flow of $658,770. This terminal cash flow is equal to the sum of net operating profit after taxes (NOPAT) of $128,020 plus depreciation expense for 2020 of $33,000, plus the liquidating value (which is expected to equal the book value) of the firm's investment in net working capital (i.e., $366,030 in panel [b]) and the book value of plant and equipment at the end of 2020 (i.e., $165,000 in panel [b]).[4]

Although the project may not operate for the full five years or it may operate for more years, the analysis follows industry practice, which assumes a termination date for the project and the expected cash flows that are realized from either liquidating or selling the business. We will discuss the estimation of what is generally referred to as *terminal value* in more detail in Chapters 8 and 9. However, to simplify our analysis of the Earthilizer investment, we assume that the terminal value for the Earthilizer assets is equal to their liquidation value (i.e., working capital plus net property, plant, and equipment [PPE]), which we assume in turn to be equal to their book value.

Valuing Earthilizer's Project FCFs

Our estimates of the expected project FCFs generated by the Earthilizer project are found in panel (c) of Table 3-1. To evaluate their present value, we discount the expected values of the FCFs using a discount rate that reflects the operating risk characteristics and financial structure of the project (the fact that the project is all equity financed). For now, we assume that the appropriate (risk-adjusted) discount rate for these

[2] This ratio implies a gross profit margin of 32.6% = 100% − 67.4%.

[3] We are assuming that no new plant capacity is required over the five-year planning period. CSM simply spends $330,000 in 2015.

[4] We assume that when the project is shut down, CSM will realize a cash flow equal to the book values of its investments in the project's net working capital and property, plant, and equipment (PPE). If the firm has better estimates of the values of these assets, then they (and the taxes on any gains or losses from those assets) should be used to estimate the terminal cash flow from the investment.

unlevered FCFs is 13.25%.[5] Using this rate to discount the FCFs found in panel (c) of Table 3-1, we estimate the present value of the *expected project FCFs* to be $623,070:

$$\$623{,}070 = \frac{\$87{,}600}{(1 + .1325)^1} + \frac{\$78{,}420}{(1 + .1325)^2} + \frac{\$93{,}320}{(1 + .1325)^3} + \frac{\$109{,}710}{(1 + .1325)^4} + \frac{\$658{,}770}{(1 + .1325)^5}$$

The Decision to Invest (or Not)—NPV and IRR

If the proposed project is worth $623,070, should it be undertaken? The quick answer is yes. We have estimated a value for the project's future cash flows that exceeds the $580,000 initial cost associated with making the investment. In NPV terms, the project offers an NPV equal to the difference in the expected value we have placed on it (its DCF value equals $623,070) and the cost of making the investment ($580,000), or $43,070.

A second metric that managers use to evaluate an investment is the project's *rate of return.* In Chapter 2, we defined IRR as the discount rate that results in a zero NPV for the investment. In the above example, the IRR is estimated to be 15.36%. Hence, if the required rate of return is 13.25%, the investment earns an excess rate of return of 2.11%, which, like the positive NPV calculated above, suggests that the investment should be accepted.[6]

It should be emphasized, however, that this analysis does not mean that CSM is *guaranteed* a net present value of $43,070 or that the return on the investment will be 15.36%. Because this is a risky project and things will not go exactly as planned, CSM needs to learn more about the project to get a better understanding of how confident it should be about the NPV estimate.

3.3 Sensitivity Analysis—Learning More About the Project

Phase I of our analysis is now complete: We have an estimate of the NPV of the Earthilizer investment. But how confident can we be that the project will unfold as we expect? What are the key value drivers of the project that the firm should monitor over the life of the investment to ensure its success? We now enter Phase II, where we use a variety of tools to address these concerns. Specifically, we will discuss three such tools: scenario analysis, breakeven sensitivity analysis, and simulation analysis.

Scenario Analysis

Scenario analysis is a technique that helps analysts explore the sensitivity of an investment's value under different future situations or scenarios. Here, we use the term *scenario* to refer to different sets of assumptions about the realized values of each of the value drivers.

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[5] We discuss the estimation of the discount rate in Chapters 4 and 5.

[6] We noted in Chapter 2 that IRR is not always unique because there can be as many IRRs as there are changes in signs in the cash flows. For the Earthilizer project, there is only one change in sign (i.e., the initial outlay is negative, and all the remaining Project FCFs are positive); thus, there is only one possible IRR.

For example, we might ask what would be the value of the Earthilizer project if the initial sales level were to drop to the marketing department's most pessimistic estimate of only $500,000. In this case, the DCF value of the project drops to $342,790, and the project becomes a negative NPV investment, (i.e., the project NPV drops to $342,790 − $580,000 = −$237,210). We could also analyze scenarios involving *multiple sets* of changes in assumptions and forecasts. For example, we might evaluate the project first using the most optimistic estimates for the value drivers and then the most pessimistic estimates. Although scenario analysis is very useful, there is no systematic way to define the scenarios. The number of possible scenarios is limited only by the imagination of the analyst performing the analysis. One approach that is often used to systematize the sensitivity analysis is something called *breakeven sensitivity analysis.*

Breakeven Sensitivity Analysis

In **breakeven sensitivity analysis**, we ask the question: "What is the critical value of the particular value driver that pushes the NPV down to zero?" Although we could use the trial-and-error analysis of a spreadsheet model to determine the critical values that answer this question, it is much easier to use the Goal Seek function in Excel.[7]

To illustrate, consider the analysis presented in Table 3-2. The first column of the table identifies six key variables that are important for determining the NPV of the Earthilizer investment opportunity. The second column contains the expected values for each of the value drivers that we used in our analysis of the project's expected NPV.

BEHAVIORAL INSIGHT

Scenario Analysis as a Strategic Planning Tool at Shell

Shell Oil (RDS) found that scenario analysis was a valuable exercise to help its executives avoid thinking that was constrained by what Warren Buffet refers to as the institutional imperative. This is the tendency for firms to resist change even in the face of overwhelming evidence that pursuing the current strategy is misguided.

Scenario analysis enables key executives to prepare a carefully crafted story about the future. The process of writing such a story provides an opportunity for executives to learn about what can happen to an investment and, in so doing, to prepare for the future accordingly. This idea does not make managers better forecasters; instead, the value of the process is that managers will make themselves aware of potential problems and opportunities so that they can be prepared to take advantage of them when and if they arise. The very act of identifying conditions under which the plug should be pulled on a project can make managers aware of when and why it should be done.

Sources: Shell.com, March 2004; and P. de Geus, "Planning Is Learning," *Harvard Business Review* (March–April).

[7] Excel contains a function called Goal Seek under the Data tab and What If menu that makes this type of analysis easy to do once the cash flows and NPV have been modeled. See the Technical Insight box on page 62.

Table 3-2 Breakeven Analysis of the Assumptions and Forecasts Underlying the CSM Inc. Earthilizer Project

Variable—Forecast or Assumption (1)	Expected Value (2)	Critical Value* (3)	Percentage Change (4)
Sales growth rate	10.00%	5.66%	−43.40
Gross profit margin = gross profit/sales	**32.60%**	**31.12%**	**−4.54**
Operating expenses (before depreciation)	**10.00%**	**11.48%**	**14.80**
Tax rate	30.00%	40.14%	33.80
Net working capital/sales	25.00%	33.40%	33.59
Base-year sales for 2016 ($000)	**$1,000,000**	**$923,171**	**−7.68%**

*Critical value for each variable is the value of that variable, holding all other variables equal to their expected value, that would result in a zero NPV. This critical value is more descriptively called the breakeven value because it produces a zero NPV. These estimates were found using the Goal Seek function in Excel.

The third column contains the critical or breakeven values for each of the value drivers that result in a zero NPV for the project. The final column of the table compares the expected and critical values for these variables; it calculates the percentage change in each variable from its expected value required to produce a zero NPV. This analysis suggests that three variables are particularly critical to the outcome of the Earthilizer investment; slight deviations from their expected value have a significant impact on project NPV:

- Gross profit margin (percentage change for breakeven = −4.54%)[8]
- Operating expenses as a percent of sales (percentage change for breakeven = +14.80%)
- Base-year sales for 2016 (percentage change for breakeven = −7.68%)

For example, if the gross profit margin declines to 31.12%, which is only 4.54% below the expected value of 32.60%, the project's NPV will drop to zero. Similarly, if operating expense as a percentage of sales rises to 11.48% from the expected level of 10%, or if the initial year's sales are only $918,942 rather than the projected $1 million, then the NPV will drop to zero.

Knowing that these three value drivers are critical to the Earthilizer investment's success allows CSM's management to explore additional information regarding the likely values of each. If the firm undertakes the investment, management can monitor each of these value drivers very closely and thus be ready to take corrective actions quickly if the drivers deteriorate.

[8] Gross profit margin is technically an indicator of success or failure that is driven by two important value drivers: cost of goods sold and the markup the firm is able to charge over its costs. When we analyze the gross profit margin as a determinant of value, we are implicitly evaluating the combined effects of the cost of goods sold (cost leadership) and the price markup over cost (product differentiation).

TECHNICAL INSIGHT

Using Microsoft Excel's Goal Seek Function

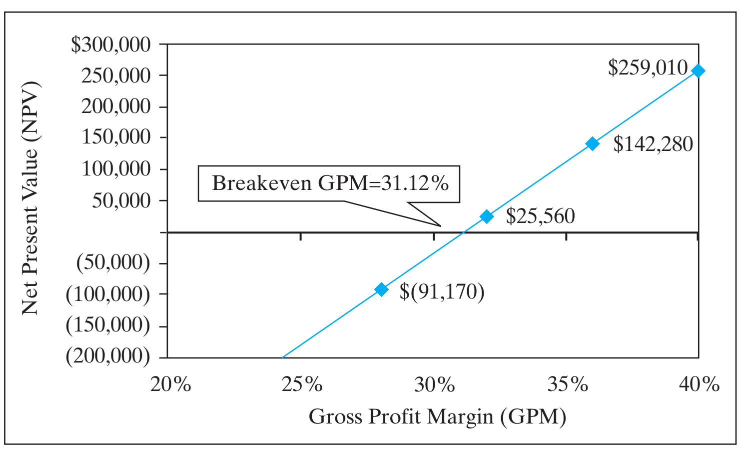
Goal Seek is a function within Excel (found under the Tools tab) that provides a powerful tool for performing what-if analyses. For example, when you know the desired result of a single-cell formula (e.g., NPV = 0) but do not know the input value the formula needs to determine this result (e.g., revenue growth rate over the project's life), you can use the Goal Seek feature to find the critical value of the input variable. In this example, Goal Seek iterates the value of the revenue growth rate until NPV is equal to zero.

The Solver tool in Excel is even more general than Goal Seek. Specifically, Solver allows us to solve maximization, minimization, or break-even analysis problems in the presence of multiple constraints.

Figure 3-1 contains an NPV breakeven chart that illustrates the critical importance of gross profit margin to the success of the Earthilizer project. Our analysis assumes that the gross profit margin remains constant throughout the life of the project and that a gross profit margin of 31.12% in each year of the project's life produces a zero NPV. Note that even very modest changes in the gross profit margin can have dramatic effects on the project's NPV. For example if CSM achieves a 36% gross profit margin (less than a 10.43% increase over the projected 32.6%), the estimated NPV for the project will more than triple in value, to $142,280. Similar changes in NPV occur if gross profit margins *drop* below the anticipated level. The clear message to the analyst is that gross profit margin is one of the most critical success factors for the project.

Although breakeven sensitivity analysis can be very helpful in identifying value drivers that are critical to project success, it has its limitations. First, this type of

Figure 3-1 **NPV–Gross Profit Margin Breakeven Chart for the Earthilizer Investment Proposal ($000)**



analysis considers only *one* value driver at a time, with the others held constant, which can produce misleading results if two or more of the critical value drivers are correlated with one another. For example, if the gross profit margin and the initial sales level both tend to be lower (or higher) than their respective expected values at the same time, the breakeven sensitivity analysis understates the true risks of the project. It is important to consider these types of interrelationships between the value drivers. Second, the analysis does not provide information about the probabilities associated with exceeding or dropping below the breakeven value drivers. For example, what is the probability that the gross profit margin will drop below 31.12% or that the initial sales level for the first year of the project will be $923,171 or less? To address these shortcomings, we turn to a more powerful tool: simulation analysis.

Simulation Analysis

Monte Carlo simulation provides a powerful tool that can help the analyst evaluate what *can happen* to an investment's future cash flows and summarize the possibilities in a probability distribution.[9] Simulation is particularly helpful in project analysis because the outcomes from large investment projects are often the result of the interaction of a number of interrelated factors (or value drivers). This setting makes it very difficult to determine the probability distribution of a project's cash flows directly or analytically. However, we can simulate the distribution quite easily, as we illustrate in this section.

Using Scenario Analysis as a Prelude to Building a Simulation Model

Scenario analysis and simulation can be complementary tools because a scenario analysis can be an important prelude to the construction of a simulation model. Note that scenario analysis depends solely on the intuition of the decision maker; it helps the analyst think through the possible project outcomes and identify the key value drivers.

Preparing and Running a Simulation

Figure 3-2 outlines the simulation process in three steps. In step 1, we prepare a spreadsheet model that defines the investment's cash flows. In step 2, we characterize each of the value drivers using a probability distribution. For example, we might ask the marketing department to describe its optimistic, most likely, and pessimistic estimates for the annual sales growth rate. The response might be that the highest annual growth rate (optimistic estimate) for the Earthilizer investment is 30% per year, the lowest possible (pessimistic estimate) growth rate is −10%, and the most likely growth rate is +10%. This intuitive information fully describes a triangular probability distribution (see the Technical Insight box on two popular probability distributions for simulation on page 65).

To illustrate how this analysis might be carried out, we provide in Table 3-3 a set of hypothetical assumptions for the probability distributions used to describe the key value drivers in CSM's Earthilizer investment proposal. Specifically, there are eight value drivers that underlie the uncertainty in the investment outcome: (1) base-year sales; (2–5)

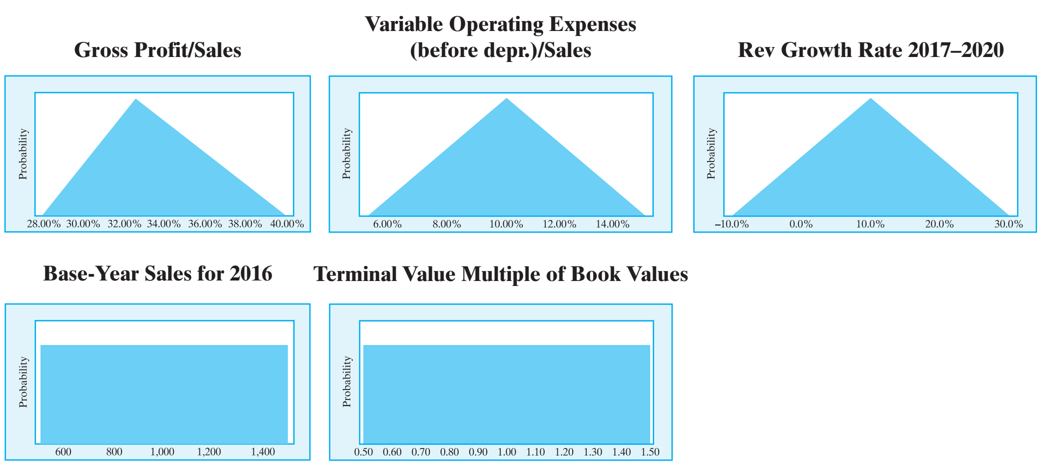
[9] The term *Monte Carlo* as a form of simulation comes from the famous gambling casinos in Monaco. Gambling, in its pure form, is based on the rules of chance or probability, as is simulation.

Figure 3-2 Steps in Running a Simulation Using the Earthilizer Example

Step 1: Prepare the spreadsheet model in Excel.

($000)	2015	2016	2017	2018	2019	2020
EBIT	$ —	$ 78.00	$ 100.60	$ 125.46	$ 152.81	$ 182.89
Less: Taxes	—	(23.40)	(30.18)	(37.64)	(45.84)	(54.87)
NOPAT	$ —	$ 54.60	$ 70.42	$ 87.82	$ 106.96	$ 128.02
Plus: Depreciation expense	—	33.00	33.00	33.00	33.00	33.00
Less: CAPEX	(330.00)	—	—	—	—	—
Less: Changes in net working capital	(250.00)	—	(25.00)	(27.50)	(30.25)	(33.28)
Plus: Liquidation of net working capital						366.03
Plus: Liquidation of PPE						165.00
Equals: Project free cash flow (Project FCF)	$(580.00)	$ 87.60	$ 78.42	$ 93.32	$ 109.71	$ 658.77

Step 2: Characterize the value drivers using a probability distribution.



Step 3: Run the simulation and interpret the results.

Generate random numbers for each value driver. → Calculate the entire spreadsheet to estimate Project FCFs for each year. → Save the values for the key forecast variables: Project FCFs for each year.

Summarize the simulation results:
- Charts and distributions
- Summary statistics
- Probability statements

Repeat this process until the maximum number of iterations has been completed.

annual rates of growth in revenues for 2017 through 2020, respectively (four random growth rates); (6) the gross profit margin; (7) operating expenses (before depreciation expense) to sales; and (8) the 2020 terminal value, which is a multiple of the book value of the capital invested in the project. Everything else in the model is assumed to be fixed.

TECHNICAL INSIGHT

Two Popular Probability Distributions for Use in Simulation Models: The Uniform and Triangular Distributions

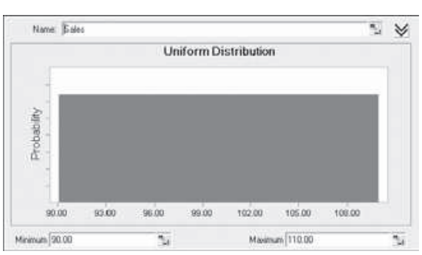
Among the set of distributions that can be used to model the uncertainty inherent in an investment, the uniform and triangular distributions are two of the most popular. An important reason for this is that the variables needed to define the shape of both distributions (known as their *parameters*) are very intuitive. Consequently, when the financial analyst is trying to elicit information about the proper distribution to use, he or she can ask straightforward questions of individuals who understand the underlying randomness of the variables being modeled.

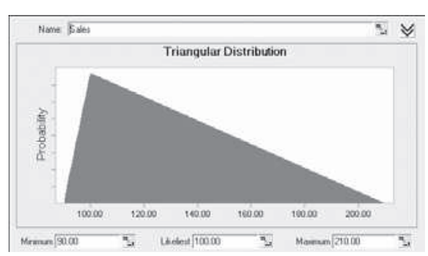
A second reason for the popularity of these distributions relates to the fact that, although they are simple, they are very flexible and can be used to capture the essence of the randomness of lots of random variables. This is particularly true of the triangular distribution: Its form can be shaped and stretched (by adjusting the parameter values) to capture both symmetric and skewed distributions.

For example, in the uniform distribution, all values between the minimum and maximum are equally likely to occur. Consequently, the only details we need to know in order to define a uniform distribution completely (i.e., the parameters) are the minimum and maximum values that the random variable can take on. The mean of the uniform distribution is simply the sum of the maximum and minimum values divided by 2 because all values in the distribution have an equal probability of occurring. The left-hand figure below depicts a uniform distribution for sales, with a minimum value of $90 and a maximum of $110.

The triangular distribution, on the other hand, can be described by the minimum, maximum, and most likely values. The mean of the triangular distribution is equal to the sum of the minimum, most likely, and maximum values divided by 3. The right-hand figure depicts a triangular distribution for sales where the minimum value is $90, the most likely value is $100, and the maximum value is $210.

Note that the triangular distribution presented here is highly skewed toward larger values. However, the triangular distribution is very flexible and can be skewed in either direction and can also be symmetrical. For example, if you can imagine what would happen to the graph if you were able to grasp the peak of the triangle and stretch it to the right or left (within the minimum and maximum bounds of the distribution), you can envision the flexibility of the triangular distribution to reflect both skewed and symmetric probability distributions.





We will limit our analysis to the *triangular* and *uniform* distributions. The parameters of both distributions are intuitive, making the distributions straightforward to use in practice (see the Technical Insight box on choosing a probability distribution on page 65). We use the triangular distribution to characterize the sales growth rate, gross profit margin, and operating expense to sales ratio, and use the uniform distribution to characterize the base-year sales for 2016 and the terminal value multiple.[10]

Simulating Project Revenues The annual cash flows of the Earthilizer investment are determined largely by the project's revenues, which we have modeled using two important drivers: the initial sales level for 2016 and the growth rates in revenue for 2017 through 2020. The initial sales level for 2016 has an expected value of $1 million, which we assume is drawn from a uniform distribution with a minimum value of $500,000 and a maximum value of $1.5 million. These estimates are just that, estimates, and in most cases they come from the intuition and experience of the members of the firm's marketing staff.

The sales level for 2017 is estimated using the simulated 2016 revenue number multiplied by 1 plus the rate of growth in revenues for 2017. We assume that the rate of growth in revenues for 2017 comes from a triangular distribution with a minimum value of −10%, a most likely value of 10%, and a maximum value of +30%. The dispersion of the minimum and maximum growth rates reflects the degree of uncertainty the analyst has about sales growth. Revenues for 2018 to 2020 are estimated in a similar fashion.

Table 3-3 Monte Carlo Simulation Assumptions for the CSM Earthilizer Investment

		Distributional Assumption	
Variable	**Expected Value**	**Distribution**	**Parameter Estimates**
Base-year sales for 2016	$1,000,000	Uniform	Minimum = $500,000 and maximum = $1,500,000
Sales growth rates (2017–2020)*	10.0%	Triangular	Maximum = 30%, most likely = 10%, and minimum = −10%
Gross profit margin = gross profit/sales	32.6%	Triangular	Maximum = 37.2%, most likely = 32.6%, and minimum = 28%
Variable operating expenses (before depreciation)/sales	10.0%	Triangular	Maximum = 15%, most likely = 10%, and minimum = 5%
Terminal value multiple of book value	1.00	Uniform	Minimum = .5 and maximum = 1.5

*There are actually four growth rates, one for each year, beginning with 2017 and ending with 2020.

[10] Note that the parameter estimates for both the triangular and uniform distributions are consistent with the expected value used in the deterministic analysis of the investment. You can verify this by calculating the expected value for the triangular distribution as the sum of the minimum, most likely, and maximum values divided by 3. For the uniform distribution, the mean is simply the sum of the minimum and maximum values divided by 2.

Technical Insight

Choosing a Probability Distribution

When building a simulation model, it is necessary to identify not only the key value drivers but also an appropriate probability distribution to describe the randomness and estimate the parameters of that distribution. This is a daunting task, but there are some basic rules that can help the analyst:

- *First, if you have relevant data, then by all means use it.* Although we will not utilize the *distribution fitting* capability of Crystal Ball in this text, the more advanced user will find this an excellent way to take advantage of historical data related to the distributions being estimated.
- *Second, does the variable you are modeling assume only discrete values?* For example, if the variable you are estimating can be only zero or one (or yes or no), then a discrete distribution constructed using the custom category in Crystal Ball will work for you.
- *Third, select distributions that fit the wisdom of the experts from whom you will elicit parameter estimates.* For example, if your experts can tell you only the maximum and minimum values of a variable you are estimating, then the uniform distribution may be a reasonable choice because it assigns the same probability to each value between a minimum and a maximum value. If your expert is willing to specify a minimum and maximum as well as a most likely value, then the triangular distribution is a good candidate for you. In this distribution, the probability associated with all values below the minimum or above the maximum value is zero, and the probabilities between the maximum and minimum increase in a linear fashion from either extreme up to the most likely value (thereby forming a triangle).
- *Fourth, consider theoretical reasons for selecting a particular distribution.* For example, it is common to use a log-normal distribution to characterize market prices for financial securities.
- *Finally, the KISS (keep it simple, stupid) principle is always appropriate.* Remember that you must elicit information from experts. Because this may require having discussions with individuals not well versed in the language of probability and probability distributions, it is probably best to err on the side of oversimplification rather than on the side of precision and sophistication.

Forecasting Project Cash Flows Once we have forecasts of annual revenues, we calculate project cash flows by constructing a set of pro forma financial statements such as those presented earlier in Table 3-1. Note that the gross profit margin and operating expense to sales ratios are random variables (described in Table 3-3) that are determined in each of the iterations of the simulation. Based on the estimated revenues, the gross profit margin, and the operating expenses, we can calculate the project's pro forma income statement, which is found in panel (a) of Table 3-1.

To complete our estimate of project FCF, we must estimate any new investment that might be needed for capital equipment (CAPEX) and net working capital. CSM's management estimates that, after the initial capital expenditure of $330,000, the project will not require any more CAPEX over the period from 2016 to 2020. As firm revenues change over time, however, the managers estimate that the project's need for net working capital will also rise and fall. Specifically, CSM estimates that the project requires

TECHNICAL INSIGHT

Simulation Add-Ins for Excel

There are two principal competing tools for adding easy-to-use simulation capabilities to your spreadsheet program: *@Risk* from the Palisade Corporation (www.palisade.com) and *Crystal Ball Professional Edition* from Decisioneering Inc. (www.crystalball.com). Both software packages offer similar capabilities. We have selected Crystal Ball for all our illustrations. If you are not familiar with Crystal Ball, the short video presentation on Decisioneering's website is helpful in getting started.

net working capital equal to 25% of firm sales revenues. To accommodate this required investment, we include 25% of the revenues for 2016 as part of the initial investment outlay for 2015. In 2016, we adjust net working capital to equal 25% of realized (simulated) sales. Similarly, in 2017 to 2020 we set the project's net working capital requirement equal to 25% of simulated sales for the year.[11]

Project free cash flows are then calculated following the method found in panel (c) of Table 3-1. Specifically, for 2016 through 2020, we add depreciation expense back to NOPAT and subtract the added investment in net working capital. Recall that CAPEX is assumed to be zero. The 2020 cash flow calculation involves one additional step—adding back the estimated terminal value of the Earthilizer project's assets.

Liquidating the Investment and the Terminal Value The cash flow in 2020 includes both an operating component and a terminal value component. The latter deserves a bit of added explanation. We assume that in 2020 when the project is shut down, its accumulated working capital (current assets less current liabilities) plus the net property, plant, and equipment can be sold for a multiple of their book value. This multiple is assumed to be a random variable drawn from a uniform distribution with a minimum value of .5 and a maximum value of 1.5 (this implies an expected value of 1.0). Note that if the terminal value multiple is equal to 1.0, there is no taxable gain or loss realized on the sale of the assets. However, if the multiple is greater than 1.0, the sale creates a taxable gain that is taxed at the firm's 30% tax rate; if the assets are sold for a multiple less than 1.0, the resulting loss offsets taxable income in 2020 and results in a tax credit to CSM.

[11] We set the 2015 investment in net working capital equal to 25% of expected sales for 2016. In 2016, we simply adjust net working capital to reflect 25% of actual revenues. A more involved procedure can also accommodate an estimate of expected needs for net working capital for 2017. However, we have opted for simplicity in the model presented here and make the adjustments to net working capital at the end of the year when we know what annual sales for the period turned out to be. The effects of accommodating expected working capital needs have very little impact on the model outcome in this example.

Simulation Software The simulation analysis is carried out for the Earthilizer example using a spreadsheet add-in program known as *Crystal Ball Professional Edition.* (See the Technical Insight box on simulation add-ins for Excel.) Several other options are available, including *@Risk,* as well as proprietary simulation software written for use in specialized applications of a given firm. A brief appendix at the end of the chapter summarizes the use of *Crystal Ball Professional Edition* for the beginner.

Interpreting Simulation Results

The simulation uses 10,000 iterations to produce a distribution of project FCFs for 2016 to 2020. To illustrate the nature of the simulation results, consider panel (a) of Figure 3-3, which contains the distribution of simulated FCFs for 2016, as generated by Crystal Ball. The frequency distribution reflects 10,000 FCF values, characterized in terms of both the frequency with which they occurred (measured on the right vertical axis) and the corresponding probability of occurrence (measured on the left vertical axis).

The simulated distribution of FCFs for 2016 (found in panel [a] of Figure 3-3) provides some interesting insights into the prospects of the investment. First, there is substantial dispersion in the simulated cash flows for 2016, ranging from a minimum of −$29,140 up to a maximum of $161,760, with a mean value of $87,680. The Certainty cell found at the bottom of the graph indicates that 99.47% of the total area under the frequency distribution of FCFs lies above $0.00 (i.e., the simulated FCFs are positive 99.47% of the time). Although we do not display them here, the FCF distributions for the remaining years of the project exhibit similar characteristics to those already described for 2016.

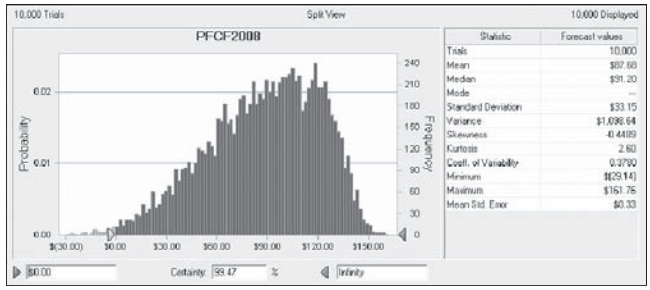
From the simulated cash flows in each year, we calculate the mean or average cash flow for each year from 2015 to 2020. These expected cash flows are found below ($000):

	2015	2016	2017	2018	2019	2020
Expected project FCF (from the simulation)	$ (580,000)	87,680	78,150	93,460	109,740	660,970
Expected value of the project	$624,218.13					
Expected NPV	$ 44,218.13					
Expected IRR	15.42%					

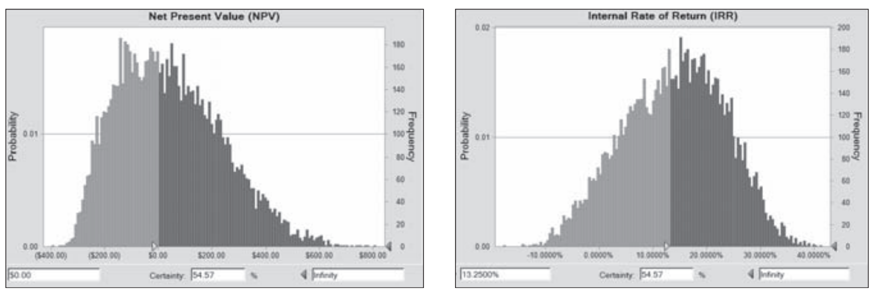
Discounting the expected cash flows at the 13.25% cost of capital produces a $624,218.13 present value, and subtracting the $580,000 initial cost of the project in 2015 produces an expected NPV of $44,218.13. Based on the future project FCFs and initial investment, we calculate an expected IRR of 15.42%. Note that the expected values of the NPV and IRRs calculated using the simulation differ slightly from our earlier estimates of NPV equal to $43,070 and IRR equal to 15.36%. These differences reflect the fact that the simulated values approximate, but do not exactly

Figure 3-3 **Simulation Analysis of the Earthilizer Investment**

Panel (a) Distribution of Project FCFs for 2016 ($000)



Panel (b) Distributions of NPV and IRR from the Simulation



Legend:

Number of trials—the number of iterations in the simulation.

Number displayed—the number of iterations actually reflected in the frequency distribution. In the above analysis, all 10,000 iterations are included. However, the default in Crystal Ball is to omit outliers so that the number of observations displayed is often less than the number of trials.

Split view—combines the frequency distribution with descriptive statistics. In addition to this view, a number of options are available, including cumulative frequency plots.

Probability—the left vertical axis describes the simulated values in terms of their appearance as a fraction of the 10,000 iterations.

Frequency—the right vertical axis describes the simulated values in terms of the number of occurrences.

Certainty—displays the percentage of the area either above or below the critical value selected. In panel (a), the critical value is an FCF of $0.00; in panel (b), it is an NPV of 0 and an IRR equal to the risk-free rate of 6%.

equal, their expected values. With large numbers of iterations, the difference should be very small.

To this point, we have simply replicated our analysis of project valuation by simulating the distributions of cash flows that underlie the expected values reported earlier in Table 3-1. But this is just the beginning of our analysis. Let's now discover what we can learn about the project by analyzing the simulated distributions of NPV and IRR.

Analyzing the Distributions of NPV and IRR

By simulating the distributions of NPV and IRR, we can calculate the probability that the investment will indeed realize an IRR that exceeds any given hurdle, like the firm's cost of capital or the risk-free rate. To estimate these values, we treat the yearly cash flows from 2016 to 2020 from each of the iterations in the simulation as a possible realization of project free cash flows and calculate the realized IRR and NPV given these cash flows.[12] Thus, if we do this simulation 10,000 times, we will have a distribution of 10,000 realized NPVs and IRRs.[13]

Panel (b) of Figure 3-3 presents the distributions of NPV and IRR generated from such a simulation. From these simulated values, we see that there is a 54.49% chance that the investment will generate cash flows that are sufficient to make the investment a positive NPV investment at the firm's cost of capital (see the Certainty box at the bottom of the frequency distribution found in panel (b) of Figure 3-3).[14] However, this also implies that there is a 45.51% chance that the realized NPV of the project will be negative. It is also the case that there is a 78.13% probability of realizing an IRR that exceeds the risk-free rate of 6%.[15] This indicates that the investment does have some risk because there is a nontrivial probability that this risky investment will return less than the return on a perfectly safe investment like Treasury bonds.

What we have learned in the simulation does not provide a clear go–no go choice for CSM with regard to the Earthilizer project. However, we can further explore the sensitivity of the project NPV to each of the random variables in the model using a tool known as a *tornado diagram.*

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[12] The NPV and IRR for each of the iterations are part of the same simulation experiment that created the distributions of project FCFs. We simply calculate a value for the NPV and IRR for each simulated set of project FCFs.

[13] We need to be a bit careful here in the way that we interpret the distributions of NPV and IRR. The mean of the distribution of NPV and IRR that we simulate and report in panel (b) of Figure 3-3 is *not* equal to the NPV of the expected cash flows. The divergence in these numbers comes from something called Jensen's inequality. The issue of Jensen's inequality applies to nonlinear functions of random variables. Therefore, if the uncertainties arise in multiplicative form (for instance, sales (t) is sales $(t - 1)(1 + g)$, where both sales $(t - 1)$ and growth are random variables—as in the case of the Earthilizer problem), Jensen's inequality will matter. Now project FCF and NPV will be nonlinear functions of underlying random variables. The key point to remember is that we have already estimated the expected NPV and IRR from the simulated distributions of cash flows for the project. From now on, we are simply investigating the underlying determinants of NPV and IRR (not their expected values).

[14] An observant reader will notice that the average IRR in this simulation is not equal to the IRR of the investment calculated using expected cash flows. The reason for this difference was explained in footnote 13.

[15] We deliberately selected the risk-free rate as the bar over which we are asking the project to leap because this analysis is designed to explore risk, not value the project. We did the latter when we calculated the expected NPV and expected IRR using the expected FCFs from the simulation.

Using the Tornado Diagram to Perform Sensitivity Analysis

Earlier, we used breakeven sensitivity analysis to analyze the importance of the value drivers in a simple setting, where we analyzed possible changes in the value drivers one at a time. We now introduce a more powerful tool that combines scenario analysis and simulation to provide a systematic way to analyze how changes in each of the investment's value drivers affect the project NPV. Specifically, we can evaluate the sensitivity of the project valuation to variation in each of the value drivers using the **tornado diagram** found in Figure 3-4. The chart places the assumptions that have the greatest impact on project NPV at the top of the diagram and successively smaller ones down the figure, creating a funnel-shaped diagram—thus the name *tornado diagram.* (See the Technical Insight box about tornado diagrams on page 74.)[16]

Here is how you interpret the numbers reflected in the tornado diagram. First, the initial or base-year level of sales for 2016 has the greatest impact on the NPV of the Earthilizer investment, which should not come as a surprise. For example, if the 2016 sales level is set equal to its 10th percentile value of $600,000 (the expected value is $1 million), NPV falls to ($181,160). However, if the 2016 sales level is equal to its 90th percentile value, which is $1.4 million, the NPV rises to $267,290. Clearly, the value of the investment is closely tied to the initial customer response to the product, which is critical to its overall success.

Behind the initial sales level in 2016, the next most important variable that drives the success or failure of the Earthilizer investment is the operating expense to sales ratio, followed by the gross profit margin and the terminal value multiple of the book value of invested assets. These results suggest the following responses:

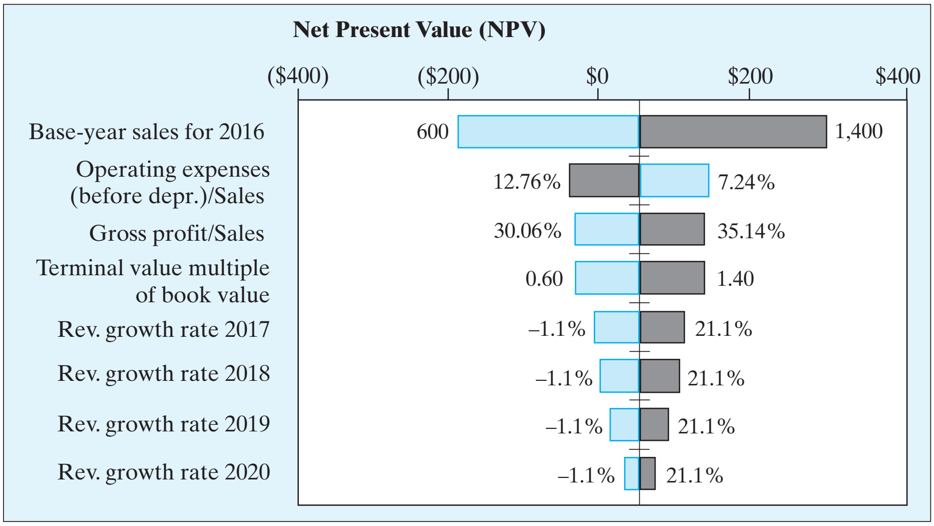
- First, to the extent that the viability of the investment is still in question, the analyst might invest additional time and money into learning more about these critical value drivers—specifically, the initial market response that drives 2016 sales. Might CSM take actions to learn more about the potential success of market entry (e.g., hold focus groups with potential customers or engage in pilot programs)? Is there anything that CSM might do to ensure that initial sales (market penetration) are maximized? For example, promoting market awareness through an initial advertising campaign may be an effective tool for improving the chances of success of the project.
- Second, because operating costs are a critical value driver, management should pay particular attention to putting in place processes that can be used to monitor and improve operating efficiency.

Summarizing the Simulation Results

So what have we learned from the simulation analysis about the Earthilizer investment? First and foremost, the project is likely to be a wealth-enhancing venture (i.e., it has a positive NPV). However, the outcome is far from certain. Although our analysis indicates that there is a 77.94% chance that the project will return more than the 6% rate of return on risk-free Treasury bonds, there is a 22.06% chance that it will earn less. In addition, we learned that the key value drivers are the initial sales level for 2016, the

[16] The tornado diagram provides a one-at-a-time form of sensitivity analysis. Crystal Ball also provides a sensitivity analysis tool that uses the simulated values to analyze the rank correction between forecast variables and each of the assumptions.

Figure 3-4 Tornado Diagram for the Earthilizer Investment Proposal (NPV $000)



	Net Present Value (NPV)			Input		
Variable	*Downside*	*Upside*	*Range*	*Downside*	*Upside*	*Base Case*
Base-year sales for 2016	($169.46)	$255.59	$425.04	600	1,400	1,000
Operating expenses (before depr.)/Sales	$123.72	($37.59)	$161.31	7.24%	12.76%	10.00%
Gross profit/Sales	($31.14)	$117.27	$148.41	30.06%	35.14%	32.60%
Terminal value multiple of book value	($36.75)	$122.88	$159.63	0.60	1.40	1.00
Rev. growth rate 2017	($1.83)	$87.96	$89.79	–1.1%	21.1%	10.0%
Rev. growth rate 2018	$9.29	$76.85	$67.56	–1.1%	21.1%	10.0%
Rev. growth rate 2019	$20.08	$66.05	$45.97	–1.1%	21.1%	10.0%
Rev. growth rate 2020	$30.57	$55.56	$24.99	–1.1%	21.1%	10.0%

Legend:

Tornado chart—measures the input of each variable one at a time, independently, on the target forecast (NPV in this example).

Range bars—illustrate the impact of each of the input variables (gross profit/sales, and so forth) on NPV when the input variables are set equal to their 10th and 90th percentile values. For example, if the gross profit/sales ratio drops to its 10th percentile value of 30.06%, then NPV is equal to ($31,140). If the gross profit/sales ratio is equal to its 90th percentile value of 35.14%, then NPV rises to $148,410. The color of the bar indicates whether the change in the input is positive or negative. For example, an increase in the gross profit/sales ratio produces a positive effect on NPV, whereas an increase in the operating expenses (before depreciation)/sales ratio results in a decline in NPV. The order of the input variables in the chart ranks them from the greatest to the least impact on NPV.

TECHNICAL INSIGHT

Tornado Diagrams

The tornado diagram can be used to evaluate each assumption's relationship to the forecast variables. In Figure 3-4, the assumptions are set equal to, say, their 10th and 90th percentile values and these extreme values are used to calculate the forecast variable of interest (e.g., project NPV or IRR). Note that the value of the forecast variable is read along the horizontal axis at the top of the diagram, and the 10th and 90th percentile values of the assumption are printed at the end of the bar that identifies their impact on the forecast variable. The assumptions that have the greatest impact on the forecast variable are placed at the top of the diagram, followed by the assumptions that have the next largest impact.

operating expenses to sales ratio, the terminal valuation multiple for the working capital and fixed assets that are sold at the end of the project's life, and the gross profit margin. Consequently, a key determinant of the success or failure of the investment will be the ability of the firm's management to market the product aggressively from the outset and contain the manufacturing costs underlying the cost of goods sold and the operating costs associated with running the business.

Ultimately, however, the decision to undertake the investment is a matter of judgment, and it depends on the availability of other projects, the amount of capital at risk, and the individuals involved. Simulation analysis is simply another tool for adding information about the nature of the uncertainty underlying the project and its prospects for success. It should be viewed as a decision tool, not a decision maker that provides clear yes or no criteria.

Reflections on the Use of Simulation

Building a simulation model requires the analyst to think deeply about the underlying sources of uncertainty that affect an investment's profits and forces him or her to be very explicit about assumptions that might otherwise be implicit. Consequently, simulation analysis provides benefits that arise from the process itself as well as from the actual output of the simulation.

For example, an analyst could forecast the cash flows generated by the Earthilizer investment without the benefit of a simulation model. These estimates would rely on estimates of the expected values of each of the value drivers (i.e., sales growth rates, gross profit margins, operating expense ratios, and so forth). However, without the need to model the distributions of the value drivers, the analyst might simply rely on the "best guess" for expected values. Such forecasting based on intuition may work reasonably well for very simple investments, but it is likely to be unreliable for more complex cases with multiple sources of uncertainty that interact with one another to determine the distribution of project cash flows.

It is sometimes argued that the difficulty encountered in making these distributional assumptions is reason enough not to do them. However, the fact is that the analyst who fails to address the underlying complexities of an investment's cash flows explicitly is simply making the assumptions implicit in the analysis. As a general rule, we think that it is better to be as explicit as possible when evaluating major investments.

PRACTITIONER INSIGHT

Sensitivity Analysis at Saddle Operating, LLC: A Conversation with Doug Ramsey and Alex Gnutti*

The risks we face in drilling and producing oil and gas come from a number of well-known sources. There's the risk associated with the volume of gas you will find, the cost of drilling and completing the well, cost overruns related to lifting and delivering the gas, interest rate risk on debt, and finally there's the risk of price fluctuations for oil and natural gas. Sensitivity analysis is a long-established technique used in the oil and gas industry to address each of these sources of investment risk when analyzing large investment opportunities. Here at Saddle Operating we follow a disciplined approach to valuing new drilling opportunities that uses both sensitivity and scenario analysis.

With modern horizontal drilling techniques used in the basins where we invest, the risk associated with finding gas in sufficient volumes to be economic is not our biggest concern. We have a pretty good idea about what we will find by looking at production data from wells in the immediate vicinity as well as seismic test data. The two big risks we face are the cost of drilling and completing a new well, which can be anywhere from $2.5 to $4 million where we drill, and the cost of getting the gas to the surface and delivered (i.e., lifting costs). The latter are typically $0.50 to $1.25 per thousand cubic feet (Mcf). Although lifting costs may not sound high, they are substantial given that natural gas prices have hovered around $4.00 per Mcf in recent years. To address the effects of variation in these costs on the value of the project we typically investigate the sensitivity of project net present value to different cost scenarios.

Another key risk to our business relates to the volatility of the price for oil and natural gas. However, we typically hedge the price of oil and natural gas for a large fraction of our expected production. This is not unusual since hedging or selling your production via a swap or forward contract is typically required by the banks who lend to the industry.

*Doug Ramsey is CFO and Alex Gnutti is VP—Financial Planning for Saddle Operating Company, LLC in Dallas, Texas.

Extensions of the Earthilizer Model

Possibilities for refining and modifying the simulation model we used to analyze the Earthilizer investment proposal are almost limitless. For example, the model can be improved if we take into account the randomness that drives the different value drivers, that is, the dependence between or among value drivers. This dependence may affect how these value drivers evolve over time. For example, if project revenues in 2016 are higher than expected, this may suggest that the revenues will grow more quickly. A second form of dependence relates to the possibility that within any given year, some of the expenses may vary together. For example, cost of goods sold, which is captured in the gross profit margin, and operating expenses as a percentage of firm sales may move together. This would be the case if the factors that affect the firm's ability to operate efficiently and at relatively low cost (labor cost, and so forth) are also linked to the factors that drive the firm's costs of goods sold.

If dependencies of the types described above are important, then the simulation can be modeled to capture them. Although we will not dig deeper into the techniques, the analyst can model the dependence directly either by linking the values of one value driver to another or by incorporating correlations into the process using Crystal Ball.

The final modeling extension we consider relates to the notion of **mean reversion** in year-to-year revenue growth rates. We are referring to the fact that it is quite common for growth rates in revenues and earnings to demonstrate the following behavior. If the growth rate in revenues for 2017 is above the expected rate of growth for that year, the rate of growth in revenues for 2018 is likely to be lower than expected. This particular pattern of growth rates can be included in the simulation model by incorporating negative correlations between the rates of growth in revenue in adjacent years.

Using Simulations to Estimate an Investment's Contribution to Firm and Market Risk

Simulation provides a powerful tool for learning about the value-creation potential of a proposed investment. Specifically, it provides a method for simultaneously incorporating multiple and interacting sources of uncertainty into the analysis of the distribution of an investment's cash flows. Consequently, we can use simulation to solve what would otherwise be very complex estimation problems.

To get a more complete picture of an investment's risk, one should also conduct simulations that examine how the risk of the evaluated project contributes to the overall risk of the firm. For example, one might consider the realization of the firm's overall cash flows in the different scenarios and then use simulations to determine the covariance between the proposed investment cash flows and the overall firm cash flows. An investment with a lower covariance would be deemed less risky because it helps diversify the firm.

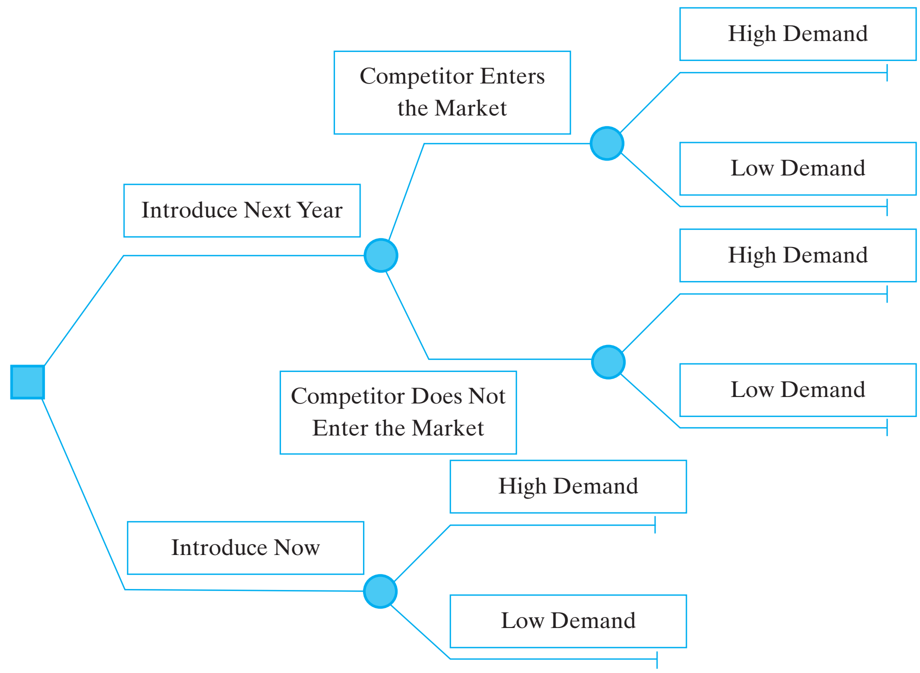
3.4 Decision Trees—Valuing Project Flexibility

Up to this point, we have assumed that the firm has a set way to implement the investment project and will not deviate from this plan. While this greatly simplifies the analysis, in reality, most investment projects offer the firm some flexibility with regard to the inputs used or even the final products produced. For example, rather than fixing their production schedule, firms tend to expand capacity and thus generate greater cash flows when market demand is higher, and similarly, cut back on capacity when market demand is lower. The astute student of finance will recognize that what we are talking about are known as *real options,* which we will discuss in more depth in Chapter 12. For now, we will introduce the topic so that readers can recognize how flexibility in the implementation of an investment affects the expected cash flows that are used in a DCF analysis.

We will use what are known as decision trees to illustrate the degree of flexibility in a project's implementation and how future decisions can affect values. For example, the decision tree found in Figure 3-5 describes the consequences of a decision to introduce a new product next year versus now. If the firm delays the product introduction, there is the possibility that a competitor may enter; offering the product immediately reduces the likelihood of competition but also reduces the chances of a successful launch.

Note that the decision tree contains a number of nodes identified by vertical lines, circles, and boxes. The vertical lines denote terminal nodes that signal the ends of decision processes. The circles signify event nodes that represent points where nature intervenes and something happens that is subject to chance. In this decision tree, there are only two possible outcomes (high demand and low demand). The square at the origin

Figure 3-5 Decision Tree for Timing a New Product Offering



of the decision tree depicts a decision node that represents a point where the decision maker determines what happens. For example, will the new product be introduced immediately or will it be delayed for one year?

Although we do not include additional decision nodes, it is conceivable that there might be many opportunities to make decisions over the life of the investment. For example, if the product is introduced now and the firm faces low demand, it might then face the decision either to continue marketing the product or to abandon the investment altogether.

Example—Decision Tree Analysis of the Abandonment Option

To illustrate how we can use decision trees to incorporate flexibility considerations into the analysis of investment projects, consider the following modification of the Earthilizer example. Assume that CSM faces an Environmental Protection Agency (EPA) test of the runoff effects of Earthilizer on groundwater. If the EPA determines that the project poses no hazard at the end of one year, it will give Earthilizer its approval for continued sale in its current form and there will be no effect on cash flows. On the other hand, if the EPA finds that Earthilizer has a detrimental effect on groundwater, then further processing will be required that will cost CSM an estimated \$80,000 per year in processing costs (after taxes). Based on its own studies, CSM's management estimates that there is a 20% chance that the EPA will force the company to spend the additional funds.

Evaluating the Revised Earthilizer Project Without the Abandonment Option

Let's evaluate the project cash flows and corresponding NPV for the Earthilizer investment, which is revised to take into account the EPA test. To illustrate the importance of the option to abandon after one year if the EPA ruling goes against the firm, we will first evaluate the revised cash flows assuming that the firm continues to operate even if it incurs the EPA costs.

In this case, the expected cash flows are equal to a weighted average of the original cash flows from panel (c) of Table 3-1 and the revised cash flows. The latter amount is simply the original expected cash flows less the \$80,000 in additional processing costs. The weights we apply to the two cash flows equal the probability that the EPA ruling will be favorable and the probability that it will go against the firm (i.e., 1 minus the probability of a favorable outcome). Consequently, for 2016, the revised estimate of the expected FCF is calculated as follows:

$$\text{Revised FCF}_{2016} = 0.8 \times \$87{,}600 + (1.0 - 0.8)(\$87{,}600 - 80{,}000) = \$71{,}600$$

Panel (a) of Table 3-4 presents the complete set of revised FCFs for each year. The expected NPV for the Earthilizer project using these revised cash flows is a negative (\$12,872). In other words, the risk of having to incur \$80,000 in added costs makes the NPV of the project negative. This suggests that the project should not be undertaken at all. Note, however, that we are assuming the project will be continued for the complete five-year planning period, regardless of what the EPA ruling turns out to be. Let's see the effect of the option to abandon.

The Value of the Abandonment Option

Panel (a) of Figure 3-6 describes the situation faced by Earthilizer: The firm has the option to abandon after one year should an unfavorable EPA ruling require that the firm spend an additional \$80,000 per year (after taxes). If CSM decides to shut down its Earthilizer operations, it anticipates that it can recoup \$380,000 of its \$580,000 initial investment, plus the first-year expected free cash flow of \$87,600. The character of the investment in Earthilizer changes substantially when we add this additional source of uncertainty to the problem, in combination with the potential for shutting down operations and recouping most of the firm's initial investment.

In panel (b) of Figure 3-6, we evaluate the NPVs of each of the four possible circumstances the firm might face after one year:

- If the EPA ruling is favorable, then operating the Earthilizer project over its full five-year expected life has an NPV of \$43,062.
- If CSM abandons the project after one year, it will experience a negative expected NPV of (\$167,108).[17]

Given these two choices, if the EPA ruling is favorable, CSM will obviously want to operate the project. This alternative is highlighted, and the inferior alternative (abandoning) is eliminated from consideration in the analysis.

[17] Note that this is the NPV of abandoning the project at the end of year 1 whether the EPA rules favorably or unfavorably.

Table 3-4 Revised Cash Flows and NPVs for the Earthilizer Project

Panel (a) No Option to Abandon						
	2015	**2016**	**2017**	**2018**	**2019**	**2020**
Favorable EPA ruling—expected FCFs	$ (580,000)	$ 87,600	$ 78,420	$93,320	$109,710	$658,770
NPV (favorable EPA ruling)	$ 43,062					
Unfavorable EPA ruling—expected FCFs	$ (580,000)	$ 7,600	$ (1,580)	$13,320	$ 29,710	$578,770
NPV (unfavorable EPA ruling)	$ (236,608)					
Revised expected FCFs	(580,000)	71,600	62,420	77,320	93,710	642,770
Expected NPV with no option to abandon	$ (12,872)					
Panel (b) Option to Abandon						
	2015	**2016**	**2017**	**2018**	**2019**	**2020**
Project not abandoned (favorable EPA ruling)	(580,000)	87,600	78,420	93,320	109,710	658,770
NPV (favorable EPA ruling)	43,062					
Project abandoned (unfavorable EPA ruling)	(580,000)	467,600	—	—	—	—
NPV (unfavorable EPA ruling)	$ (167,108)					
Expected NPV with abandonment option	$ 1,028.31					

What if the EPA ruling is unfavorable? Again, panel (b) of Figure 3-6 presents the numbers:

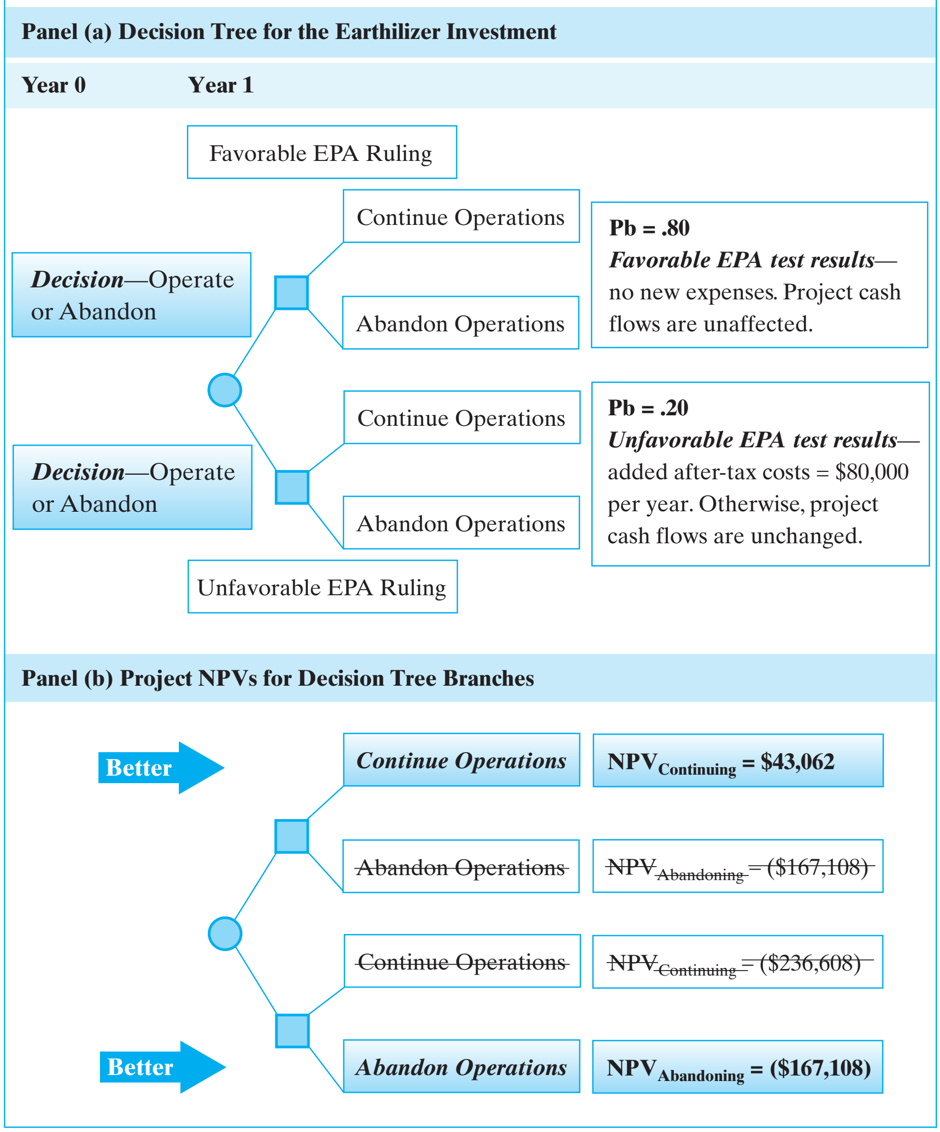
- If the EPA ruling is unfavorable, the expected NPV of continuing operations is ($236,608).
- The NPV of abandoning the project is only ($167,108).

In the event of an unfavorable ruling, CSM should abandon the project. Once again, the superior alternative is highlighted, while the inferior alternative is dropped from the analysis.

If the probability of a favorable ruling is 80%, the expected NPV for the project in the presence of the option to abandon is now:

$$\begin{gathered}\text{Expected}\\ \text{Net Present Value}\\ \text{(with the abandonment option)}\end{gathered} = \begin{bmatrix}\text{Expected Net Present Value}\\ \text{Continue Operations} - \text{Favorable}\\ \text{EPA Response}\end{bmatrix} \times \begin{bmatrix}\text{Probability}\\ \text{of a Favorable}\\ \text{Ruling}\end{bmatrix} + \begin{bmatrix}\text{Expected Net Present Value}\\ \text{Discontinue Operations} -\\ \text{Unfavorable EPA Response}\end{bmatrix} \times \begin{bmatrix}1 - \begin{matrix}\text{Probability of}\\ \text{a Favorable}\\ \text{Ruling}\end{matrix}\end{bmatrix} \quad (3.1)$$

Figure 3-6 **Decision Tree—Abandonment Option**



Therefore,

$$\begin{array}{c}\text{Expected}\\ \text{Net Present Value}\\ \text{(with the abandonment option)}\end{array} = (\$43{,}062 \times .80) + [-\$167{,}108 \times (1 - .80)] = \$1{,}028$$

In the event of a negative ruling from the EPA, the option to shut down or abandon the Earthilizer project at the end of year 1 makes the expected NPV of the project positive.

The key here is that the firm can *abandon the project* and avoid the losses incurred by operating the project.

Abandonment truncates the lower tail of the distribution of a project's NPV. The truncation eliminates negative NPV outcomes and, as a result, increases the mean of the now-truncated distribution to \$1,028. Without the option to abandon, the expected NPV is negative and equal to −\$12,872. Essentially, the abandonment option mitigates some of the risk of an unfavorable EPA ruling. Clearly, considering the effects of project flexibility (in this case, the flexibility to reconsider the investment and possibly abandon it should the EPA ruling prove unfavorable) in the analysis of the project has a material effect on project valuation.

Using Option Pricing Theory to Evaluate the Abandonment Option

In Chapter 12, we reconsider the option to abandon an investment in the context of an option pricing model. In our current example, we simply assume that we knew what the project would be worth both with and without a favorable response from the EPA. In Chapter 12, we consider more complex problems in which the investment can be abandoned on a number of future dates. Stay tuned!

3.5 Summary

Determining the value of an investment opportunity is straightforward when future cash flows are known. We live in a very uncertain world, however, and very few investments generate cash flows that can be predicted with any degree of precision. While uncertainty clearly complicates the valuation process, a number of tools help the analyst deal with this complexity more effectively.

This chapter introduced three basic tools used to assess the impact of uncertainty on project outcomes: scenario analysis, breakeven sensitivity analysis, and simulation analysis. All three tools provide information that the analyst can use to understand the key factors that drive a project's success or failure. This information helps the analyst develop a better understanding of how confident the firm should be in the project's prospects.

This chapter also introduced the important role played by *project flexibility.* By this we mean the opportunities for the firm to modify an investment over its life in response to changing circumstances and new opportunities. We will discuss real options later in the text, but it is useful to begin thinking now about how flexibility can affect expected cash flows as well as cash flow risks.

Exercises

3-1 SCENARIO ANALYSIS Family Security is considering the introduction of a child security product consisting of tiny Global Positioning System (GPS) trackers that can be inserted in the sole of a child's shoe. The trackers allow parents to track the child if he or she were ever lost or abducted. The estimates, plus or minus 10%, associated with this new product are as follows:

Unit price: $125
Variable costs per unit: $75
Fixed costs: $250,000 per year
Expected sales: 10,000 per year

Because this is a new product line, the firm's analysts are not confident in their estimates and would like to know how well the investment would fare if the estimates on the items listed above are 10% higher or 10% lower than expected. Assume that this new product line will require an initial outlay of $1 million, with no working capital investment, and will last for ten years, being depreciated down to zero using straight-line depreciation. In addition, the firm's management uses a discount rate of 10% and a 34% tax rate in its project analyses.

a. Calculate the project's NPV under each of the following sets of assumptions: (1) the best-case scenario (use the high estimates—unit price 10% above expected, variable costs 10% less than expected, fixed costs 10% less than expected, and unit sales 10% higher than expected), (2) the base case using expected values, and (3) the worst-case scenario.

b. Given your estimates of the range of NPVs for the investment, what is your assessment of the investment's potential?

c. What are the limitations of this type of scenario analysis? *(Hint:* What are the chances that all variables will deviate from their expected values in a best- or worst-case scenario?)

3-2 BREAKEVEN SENSITIVITY ANALYSIS The expected annual free cash flow for the GPS tracker investment from Problem 3-1 is computed as follows:

Revenues	$1,250,000
Variable cost	750,000
Fixed expenses	250,000
Gross profit	$ 250,000
Depreciation	100,000
Net operating income	$ 150,000
Income tax expense	51,000
NOPAT	$ 99,000
Plus: depreciation	100,000
Less: CAPEX	—
Less: working capital investment	—
Free cash flow	$ 199,000

a. Construct a spreadsheet model to compute free cash flow that relies on the following assumptions or estimates:

Base Case Estimates	Values
Initial cost of equipment	\$1,000,000.00
Project and equipment life	10 years
Salvage value of equipment	\$0
Working capital requirement	\$0
Depreciation method	Straight-line
Depreciation expense	\$100,000.00
Discount rate	10.00%
Tax rate	34.00%
Unit sales	10,000
Price per unit	\$125.00
Variable cost per unit	\$75.00
Fixed costs	\$250,000.00

b. What level of annual unit sales does it take for the investment to achieve a zero NPV? Use your spreadsheet model to answer this question. (*Hint:* Use the Goal Seek function in Excel.)

c. If unit sales were 15% higher than the base case, what unit price would it take for the investment to achieve a zero NPV?

3-3 SIMULATION ANALYSIS Nextron Distribution is performing an analysis of the cash flows it hopes to earn from a major expansion of the firm's operations into a new product line. The estimates needed for computing the annual free cash flow for the first year of operations are found below:

	Expected Values	Distributional Assumptions	Parameter Estimates
Sales units	100,000	Uniform	Maximum = 150,000, minimum = 50,000
Unit price	\$ 50	Normal	Mean = \$50, standard deviation = \$10
Fixed operating costs	120,000	NA	NA
Variable operating costs per unit	35	Triangular	Minimum = \$30, most likely = \$35, and maximum = \$40
Tax rate	30%	NA	NA
Depreciation expense	\$ 60,000	NA	NA
CAPEX	75,000	Uniform	Minimum = \$60,000, maximum = \$90,000
Working capital investment	20,000	Triangular	Minimum = \$18,000, most likely = \$20,000, and maximum = \$22,000

a. Construct a spreadsheet model for year 1 free cash flow. What is your estimate of the expected cash flow?

b. Utilize the probability distributions and associated parameter estimates to construct a simulation model for the investment opportunity where free cash flow is the forecast variable in the model.
   1. What is the expected free cash flow?
   2. What is the probability that the free cash flow will drop below $500,000?

PROBLEMS

3-4 BREAKEVEN SENSITIVITY ANALYSIS The Clayton Manufacturing Company is considering an investment in a new automated inventory system for its warehouse that will provide cash savings to the firm over the next five years. The firm's CFO anticipates additional earnings before interest, taxes, depreciation, and amortization (EBITDA)[18] from cost savings equal to $200,000 for the first year of operation of the center; over the next four years, the firm estimates that this amount will grow at a rate of 5% per year. The system will require an initial investment of $800,000 that will be depreciated over a five-year period using straight-line depreciation of $160,000 per year and a zero estimated salvage value.

a. Calculate the project's annual free cash flow (FCF) for each of the next five years, where the firm's tax rate is 35%.
b. If the cost of capital for the project is 12%, what is the projected NPV for the investment?
c. What is the minimum year 1 dollar savings (i.e., EBITDA) required to produce a breakeven NPV = 0?

3-5 PROJECT RISK ANALYSIS—SENSITIVITY ANALYSIS Refer to the HMG example found in Problem 2-11 (page 52) and answer the following questions:

a. What are the key sources of risk that you see in this project?
b. Use the Goal Seek function in Excel to find the breakeven values (i.e., values that force the project NPV to equal zero) for each of the following variables: the initial CAPEX, the working capital percentage of revenue growth, variable cost percentage of sales, and sales volume. (*Hint:* Scale the sales volume for all five years up and down by the same percentage.)
c. Which of the variables analyzed in Problem 3-5(b) do you think is the greatest source of concern? What, if anything, could you do to reduce the risk of the project?
d. Should you always seek to reduce project risk?

3-6 PROJECT RISK ANALYSIS—COMPREHENSIVE Bridgeway Pharmaceuticals manufactures and sells generic over-the-counter medications in plants located throughout the Western Hemisphere. One of its plants is trying to decide whether to automate a portion of its packaging process by purchasing an automated waste disposal and recycling machine. The proposed investment is $400,000 to purchase the necessary equipment and

[18] EBITDA is a widely used measure of firm earnings that we will encounter many times throughout the balance of the text. It is simply earnings before interest and taxes (EBIT), plus depreciation and amortization expense.

get it into place. The machine will have a five-year anticipated life and will be depreciated at a rate of $80,000 per year, toward a zero anticipated salvage value. The firm's analysts estimate that the purchase of the new waste-handling system will bring annual cost savings of $40,000 from reduced labor costs, $18,000 per year from reduced waste disposal costs, and $200,000 per year from the sale of reclaimed plastic waste net of selling expenses. Bridgeway requires a 20% return from capital investments and faces a 35% tax rate.

a. Using the estimates provided, should Bridgeway purchase the new automated waste-handling system?

b. The manager at the plant where the handling system is being contemplated has raised some questions regarding the potential savings from the system. He asked the financial analyst in charge of preparing the proposal to evaluate the impact of variations in the price of plastic waste materials, which have proven to be volatile in the past. Specifically, what would be the impact of price reductions for the waste that drive the revenues from the sale of waste down to half their estimated amounts in years 1 through 5?

c. (Simulation problem) Model the new investment, whose value is determined by the following random variables: Annual revenues from reclaimed waste in year 1 follow a triangular distribution with a minimum value of $100,000, a most likely value of $200,000, and a maximum value of $300,000. In year 2 (and each year thereafter), the distribution is still triangular; however, the most likely value is now equal to the value observed in the previous year. The minimum value is equal to 50% of the observed value in the previous year, and the maximum is equal to 150% of the observed value in the previous year. The revenues from reclaimed waste exhibit a correlation coefficient from year to year of .90. Labor cost savings can be forecast with a high degree of certainty because they represent the savings from one hourly worker that will no longer be needed once the new waste-handling system has been put into place. The reductions in waste disposal costs come from a uniform distribution, with a minimum value of $15,000 and a maximum value of $21,000. The waste disposal costs are assumed to be uncorrelated over time.

1. What is the probability of a cash flow less than $150,000 in year 1? In year 5? (*Hint:* Define the annual project FCFs for years 1 through 5 as *forecast* variables. You will use only the years 1 and 5 cash flow distributions for this question, but you will use all of them to answer part 3.)
2. What are the expected NPV and IRR for the project?
3. (Optional) What are the means and standard deviations of the simulated distribution of cash flows for years 1 through 5? What is the effect of the positive correlation in the underlying determinants of the project's cash flows? (*Hint:* Look at the standard deviations in annual cash flows through time.)

3-7 PROJECT RISK ANALYSIS—BREAKEVEN SENSITIVITY The TitMar Motor Company is considering the production of a new personal transportation vehicle (PTV). The PTV would compete directly with the innovative new Segway. The PTV will utilize a three-wheel platform capable of carrying one rider for up to six hours per battery charge thanks to a new battery system developed by TitMar. TitMar's PTV will sell for substantially less than the Segway but will offer equivalent features. The pro forma financials for the proposed PTV project, including the forecasts and assumptions that underlie them, are set out in Exhibit P3-7.1. Note that revenue is calculated as follows: price per unit × market

Exhibit P3-7.1 TitMar Motor Company PTV Project

Assumptions and Predictions	Estimates
Price per unit	$ 4,895
Market share (%)	15.00%
Market size (year 1)	200,000 units
Growth rate in market size beginning in year 2	5.0%
Unit variable cost	$ 4,250
Fixed cost	$9,000,000
Tax rate	50.0%
Cost of capital	18.00%
Investment in net working capital	5.00% of the predicted change in firm revenue
Initial investment in PPE	$7,000,000
Annual depreciation (5-year life with no salvage)	$1,400,000

Solution

	Cash Flows					
Project Analysis	**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Investment	(7,000,000)					
Revenue		146,850,000	154,192,500	161,902,125	169,997,231	178,497,093
Variable cost		(127,500,000)	(133,875,000)	(140,568,750)	(147,597,188)	(154,977,047)
Fixed cost		(9,000,000)	(9,000,000)	(9,000,000)	(9,000,000)	(9,000,000)
Depreciation		(1,400,000)	(1,400,000)	(1,400,000)	(1,400,000)	(1,400,000)
NOI (net operating income)		8,950,000	9,917,500	10,933,375	12,000,044	13,120,046
Less: Tax		(4,475,000)	(4,958,750)	(5,466,688)	(6,000,022)	(6,560,023)
Net operating profit after tax (NOPAT)		4,475,000	4,958,750	5,466,688	6,000,022	6,560,023
Plus: depreciation expense		1,400,000	1,400,000	1,400,000	1,400,000	1,400,000
Less: CAPEX	(7,000,000)	—	—	—	—	—
Less: change in NWC	(7,342,500)	(367,125)	(385,481)	(404,755)	(424,993)	8,924,855
Free cash flow	(14,342,500)	5,507,875	5,973,269	6,461,932	6,975,029	16,884,878

Net present value	$ 9,526,209
Internal rate of return	39.82%

share (%) $\times$ market size and units sold = revenues/price per unit. The project offers an expected NPV of \$9,526,209 and an IRR of 39.82%. Given TitMar's stated hurdle rate of 18%, the project looks like a winner. Even though the project looks very good based on management's estimates, it is risky and can turn from a positive NPV investment to a negative one with relatively modest changes in the key value drivers. Develop a spreadsheet model of the project valuation and answer the following questions:

a. If the firm's market share turns out to be only 5%, what happens to the project's NPV and IRR?

b. If the market share remains at 15% and the price of the PTV falls to \$4,500, what is the resulting NPV?

3-8 SIMULATION ANALYSIS Use your model from Problem 3-4 to construct a simulation model for the TitMar PTV. Incorporate two random (i.e., stochastic) variables in your model to capture the size of the market for scooters. Each of these variables is modeled differently, as follows:

MARKET SHARE Market share follows a triangular distribution with a most likely value of 15%, a minimum of 10%, and a maximum of 20%.

GROWTH RATE IN MARKET SIZE The growth rate in market size for year 1 is assumed to be normally distributed with a mean of 5% and standard deviation of 2%. For year 2, the expected market-size growth rate is equal to the simulated growth rate for year 1 and has a standard deviation of 2%. The growth rates for years 3 and beyond follow the pattern described for year 2. Run 10,000 random trials and define two output variables—NPV and IRR. What is the probability that the NPV will be zero or lower? What is the probability of an IRR less than 18%?

3-9 DECISION TREE AND BREAKEVEN SENSITIVITY ANALYSIS Reevaluate the Earthilizer decision tree analysis found in Table 3-7, where the abandonment value is only \$350,000. What is the expected NPV of the project under these circumstances? What is the minimum abandonment value required to produce an expected NPV for the project of zero with the abandonment option? (*Hint:* Use the Goal Seek function to solve for the abandonment value that produces an expected NPV of zero.)

3-10 INTRODUCTORY SIMULATION EXERCISES Construct a spreadsheet model for each of the following exercises and then use the model to build a simulation model.

a. Jason Enterprises faces uncertain future sales. Specifically, for the coming year, the firm's CFO described her sales expectations as follows: "Sales could be as high as \$10,000,000 or as low as \$7,000,000, but I could not tell you anything more." Gross profits are typically 25% of firm sales, what would you estimate gross profits to be for next year? If Jason's operating earnings are typically 25% of firm sales, what would you estimate earnings to be for next year? Construct a spreadsheet model and incorporate consideration for the uncertainty in future revenues to estimate the expected gross profit for the firm.

b. In spring 2015, Aggiebear Dog Snacks Inc. estimates its gross profits (revenue less cost of goods sold) for 2016. The firm's CFO recently attended a two-day seminar on the use of simulation and asked his analyst to construct a simulation model to make the estimate. To help guide the analyst, the CFO prepared the following table:

Income Statement	Variable Description
Revenue	Minimum = \$18 million, most likely = \$25 million, maximum = \$35 million
Cost of goods sold	70% to 80% of revenue

1. Construct a spreadsheet model for Aggiebear's gross profit.
2. Use the information provided above to convert your spreadsheet model into a simulation model.
3. Run your simulation model for 10,000 iterations. What is the expected level of gross profit for 2016? What is the probability that the gross profit will fall below \$3.5 million?

3-11 PROJECT RISK ANALYSIS USING SIMULATION Rayner Aeronautics is considering a \$12.5 million investment that has an estimated project free cash flow (FCF) of \$2 million in its first year of operations. The project has a five-year life, and Rayner requires a return of 18% in order to justify making the investment.

a. What rate of growth in project FCF for years 2 through 5 is required for the project to break even (i.e., have an NPV = 0)?

b. Construct a simulation model for the investment opportunity to estimate the expected values of the project FCF for years 1 through 5. The first year's cash flow is normally distributed with an expected value of \$2 million and a standard deviation of \$1 million. The rate of growth in project FCF for years 2 through 5 follows a triangular distribution with the following parameter estimates:

Year	Most Likely Growth Rate (ML)	Minimum Growth Rate	Maximum Growth Rate
2	40%	$\frac{1}{2}$ of ML	2 times ML
3	Actual growth rate for the previous year	$\frac{1}{2}$ the actual growth rate for the previous year	2 times the actual growth rate for the previous year
4	Actual growth rate for the previous year	$\frac{1}{2}$ the actual growth rate for the previous year	2 times the actual growth rate for the previous year
5	Actual growth rate for the previous year	$\frac{1}{2}$ the actual growth rate for the previous year	2 times the actual growth rate for the previous year

c. What are the expected NPV and IRR for the project, based on your simulation analysis from part b?

PROBLEM 3-12 **MINI-CASE** CONOCOPHILLIPS GAS ACQUISITION PROJECT[19]

ConocoPhillips's (COP) Natural Gas and Gas Products Department (NG&GP) manages all of the company's activities relating to the gathering, purchasing, processing, and sale of natural gas and gas liquids. Chris Simpkins, a recent graduate, was recently hired as a financial analyst to support the NG&GP department. One of Chris's first assignments was to review the projections for a proposed gas purchase project that were made by one of the firm's field engineers. The cash flow projections for the ten-year project are found in Exhibit P3-12.1 and are based on the following assumptions and projections:

- The investment required for the project consists of two components: First, there is the cost to lay the natural gas pipeline of $1,200,000. The project is expected to have a ten-year life and is depreciated over seven years using a seven-year modified accelerated cost recovery system (MACRS).[20] Second, the project will require a $145,000 increase in net working capital that is assumed to be recovered at the termination of the project.
- The well is expected to produce 900,000 cubic feet (900 MCF) per day of natural gas during year 1 and then decline over the remaining nine-year period (365 operating days per year). The natural gas production is expected to decline at a rate of 20% per year after year 1.
- In addition to the initial expenditures for the pipeline and additional working capital, two more sets of expenses will be incurred. First, a fee consisting of 50% of the wellhead natural gas market price must be paid to the producer. In other words, if the wellhead market price is $6.00 per MCF, 50% (or $3.00 per MCF) is paid to the producer. Second, gas processing and compression costs of $0.65 per MCF will be incurred.
- There is no salvage value for the equipment at the end of the natural gas lease.
- The natural gas price at the wellhead is currently $6.00 per MCF.
- The cost of capital for this project is 15%.

ANSWER THE FOLLOWING QUESTIONS.

a. What are the NPV and IRR for the proposed project, based on the forecasts made above? Should Chris recommend that the project be undertaken? Explain your answer. What reservations, if any, should Chris have about recommending the project to his boss?

b. Perform a sensitivity analysis of the proposed project to determine the impact on NPV and IRR for each of the following scenarios:

   1. Best case: a natural gas price of $8.00 and a year 1 production rate of 1,200 MCF per day that declines by 20% per year after that.

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[20] Modified accelerated cost recovery system (MACRS) uses a shorter depreciable life for assets, thus giving businesses larger tax deductions and cash flows in the earlier years of the project life relative to those of straight-line depreciation.

Exhibit P3-12.1 Analysis of the ConocoPhillips Gas Purchase Project

Year	**0**	**1**	**2**	**3**
Investment	$ 1,200,000			
Increase in NWC	145,000			
MACRS depreciation rate (7 years)		0.1429	0.2449	0.1749
Natural gas wellhead price (per MCF)		$ 6.00	$ 6.00	$ 6.00
Volume (MCF/day)		900	720	576
Days per year		365		
Fee to producer of natural gas (per MCF)		$ 3.00	$ 3.00	$ 3.00
Compression and processing costs (per MCF)		0.65	0.65	0.65
Cash Flow Calculations				
Natural gas wellhead price revenue		$ 1,971,000	$ 1,576,800	$1,261,400
Lease fee expense		985,500	788,400	630,720
Compression and processing costs		213,525	170,820	136,656
Depreciation expenses		171,480	293,880	209,880
Net operating profit		600,495	323,700	284,184
Less taxes (40%)		(240,198)	(129,480)	(113,674)
Net operating profit after tax (NOPAT)		360,297	194,220	170,510
Plus depreciation		171,480	293,880	209,880
Return of net working capital				
Project free cash flow	$(1,345,000)	$ 531,777	$ 488,100	$ 380,390

2. Most likely case: a natural gas price of $6.00 and a year 1 production rate of 900 MCF per day that declines by 20% per year after that.
3. Worst case: a natural gas price of $3.00 and a year 1 production rate of 700 MCF per day that declines by 20% per year after that.

c. Do breakeven sensitivity analysis to find each of the following:
1. Breakeven natural gas price for an NPV = 0
2. Breakeven natural gas volume in year 1 for an NPV = 0
3. Breakeven investment for an NPV = 0

d. Given the results of your risk analysis in parts b and c, would you recommend this project? Explain your answer.

	4	5	6	7	8	9	10
	0.1249	0.0893	0.0893	0.0893	0.0445		
	$ 6.00	$ 6.00	$ 6.00	$ 6.00	$ 6.00	$ 6.00	$ 6.00
	461	369	295	236	189	151	121
	$ 3.00	$ 3.00	$ 3.00	$ 3.00	$ 3.00	$ 3.00	$ 3.00
	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	$1,009,152	$807,322	$645,857	$516,686	$413,349	$330,679	$264,543
	504,576	403,661	322,929	258,343	206,674	165,339	132,272
	109,325	87,460	69,968	55,974	44,779	35,824	28,659
	149,880	107,160	107,160	107,160	53,400	—	—
	245,371	209,041	145,801	95,209	108,495	129,516	103,613
	(98,148)	(83,616)	(58,320)	(38,083)	(43,398)	(51,806)	(41,445)
	147,223	125,425	87,480	57,125	65,097	77,710	62,168
	149,880	107,160	107,160	107,160	53,400	—	—
							145,000
	$ 297,103	$232,585	$194,640	$164,285	$118,497	$ 77,710	$207,168

PROBLEM 3-13 MINI-CASE SOUTHWEST AIRLINES WINGLET PROJECT[21]

As a low-fare airline, Southwest Airlines constantly focuses on ways to improve the efficiency of its operations and maintain a cost structure below that of its competition. In spring 2002, Scott Topping, the director of corporate, was approached by Aviation

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Partners Boeing (APB) regarding an innovative way to save on fuel costs—the installation of a new technology known as the blended winglet. The winglets, made of carbon-graphite, were designed for the Boeing 737-700 aircraft. Southwest currently had 142 planes of this model in its fleet.

The blended winglet system was developed by APB, a joint venture between Aviation Partners Inc. and The Boeing Company. The main purpose of the winglet is to reduce turbulence, leading to higher flying efficiency. As a result, the winglets provided three important benefits that allowed the airplane to extend its range, carry a greater payload, and save on fuel consumption. The winglets accomplished this by increasing the spread of the wings' trailing edge and creating more lift at the wingtips.

To complete his financial analysis, Scott had to verify potential costs and benefits as well as get the approval of the Maintenance Engineering Department, the Flight Operations Department, and the Facilities Department. However, Scott was well aware that regardless of the potential financial benefits, safety was the first priority. This process took several months due to the complexity of the project. After discussing the project with the requisite departments, Scott made the following estimates of the costs and benefits of the winglet system to Southwest:

- The winglets, which cost \$700,000 a pair, could be installed at an additional cost of \$56,000 per aircraft. Installation could be scheduled at each maintenance facility to coincide with regular maintenance. As a result, each aircraft was expected to experience downtime for only one extra day, at a cost of \$5,000.
- After considering the short- and long-term effects of the winglets, the Maintenance Engineering Department estimated that repair costs would average \$2,100 yearly per aircraft due primarily to incidental damage.
- The increased wingspan was expected to allow each of Southwest's aircraft to fly up to 115 nautical miles further and to decrease fuel usage by 4% to 6%. This meant that Southwest could expect to save 178,500 gallons of jet fuel per airplane per year.
- Flight Operations[22] estimated that the additional lift capability provided by the winglets would reduce Southwest's costs of using restricted runways, with an estimated savings of \$500 per aircraft per year.
- The Facilities Department assessed the effect of the added wingspan on each of the fifty-nine airports Southwest utilized in its current route structure. The department estimated that the necessary facilities modifications could be achieved at a onetime cost of about \$1,200 per aircraft.
- The blended winglet project qualified for accelerated tax write-off benefits under the Job Creation and Worker Assistance Act of 2002. With a marginal tax rate of 39% and using a seven-year depreciation schedule (see Exhibit P3-13.1 below), Southwest would be allowed to depreciate an additional 50% of the project in the first year.

[22] Southwest Airlines estimated the salvage value to be approximately 15% of the winglets' cost; however, this salvage value is very uncertain because this is a new technology with no historical data on which to base an estimate. Scott felt that the winglets would definitely have some residual value, so 15% seemed like a reasonable salvage value to use based on the limited data available. In the analysis, the winglets should be depreciated to zero and the salvage value in year 20 should be treated as taxable income.

Exhibit P3-13.1 Depreciation Details

Year	Normal MARCS Table	Normal Table Times 50%	Year 1 (Additional 50%)	Total (Modified Table)
1	14.29%	7.15%	50.00%	**57.15%**
2	24.49%	12.25%		**12.25%**
3	17.49%	8.75%		**8.75%**
4	12.49%	6.25%		**6.25%**
5	8.93%	4.47%		**4.47%**
6	8.92%	4.46%		**4.46%**
7	8.93%	4.47%		**4.47%**
8	4.46%	2.23%		**2.23%**

- The blended winglet project is expected to have a life of at least twenty years, at the end of which the winglets are anticipated to have a salvage value of $105,000. Assume a jet fuel cost of $0.80 per gallon and a cost of capital of 9.28% in your analysis. Items other than fuel are expected to escalate at a 3% rate. Conduct the analysis on a per-plane basis.

Evaluate the project by analyzing the following:

a. Estimate the project's annual project free cash flow (FCF) for each of the next twenty years, as well as the initial cash outflow.
b. Calculate the NPV and IRR of the blended winglet project.
c. What is the breakeven jet fuel cost for the project? What is the breakeven fuel savings in gallons for the project, assuming jet fuel costs $0.80 per gallon?
d. How sensitive is the blended winglet project's NPV to changing assumptions regarding expected future fuel costs and fuel savings? Use scenario analysis to analyze a best-case scenario (jet fuel price of $1.10 per gallon and fuel savings of 214,000 gallons per year) and a worst-case scenario (jet fuel price of $0.50 per gallon and fuel savings of 142,000 gallons per year).
e. What potential risks and benefits do you see that are not incorporated into the quantitative analysis?
f. What is the impact on the project's NPV or IRR if the winglets have no salvage value?
g. Would you suggest Southwest Airlines undertake this project? Explain your answer.

An Introduction to Simulation Analysis and Crystal Ball

What Is Simulation?

Simulation refers to the process of constructing a model that imitates a real-life situation: for example, the cash flows resulting from the operation of a power plant.

Why Build Simulation Models?

When cash flows are determined from multiple sources of uncertainty, determining expected cash flows is incredibly complex. In these cases, simulation provides a tool that can be used to characterize the solution. Essentially, computer power is used to develop a distribution of possible solutions that reflects the underlying sources of uncertainty in the problem.

What Is Crystal Ball Software?

Crystal Ball is an add-in software package that allows you to construct simulation models within Microsoft Excel spreadsheet software. Crystal Ball is a product of Decisioneering Inc.[23] Although we use Crystal Ball throughout this text, an alternative simulation add-in called @*Risk* is provided by the Palisade Corporation.[24]

How Do I Build a Simulation Model Using Crystal Ball?

Excel models are deterministic, which means that the inputs are fixed (one value to one cell). You can see only one solution at a time. If you want to view alternative results, you need to change the inputs in the model manually. Crystal Ball software provides the user with the ability to make changes in the inputs to the model dynamically so that many solutions to the model can be calculated and stored for later analysis. To convert a deterministic spreadsheet model into a dynamic simulation model requires three steps:

- First, we must identify the inputs to the model that are subject to uncertainty and assign each a probability distribution. In Crystal Ball, these uncertain, or stochastic, inputs are called assumptions.

[23] http://www.crystalball.com/index.html

[24] http://www.palisade.com/

- Second, we must identify the particular output measures that are important to the analysis of the problem being analyzed. Crystal Ball refers to these as forecasts.
- Third, when the assumptions and forecasts have been identified (we will talk about how in just a moment), we can start the simulation. This process entails selecting a value for each of the assumptions in the model, calculating the value of each of the forecast variables, and storing the result. This process is repeated for the number of iterations we specify.

The output of the simulation experiment consists of all the stored values of the forecast variables (e.g., NPV or IRR). The stored forecast variable data can be summarized using descriptive statistics such as the mean, median, and standard deviation—or by constructing a histogram or frequency distribution.

To illustrate the use of Crystal Ball in a very simple setting, consider the situation faced by WiseData Corporation. The firm is evaluating an investment in a new product line that it expects to produce sales revenues for only one year. The firm's management is trying to forecast the gross profit that might be produced by the investment (as part of its analysis of project cash flows). Management's initial estimate of gross profit is $20,000 and is found in the static Excel model in Exhibit 3A-1.

Exhibit 3A-1 Static Excel Model for WiseData Corporation

	2015
Sales	$100,000.00
Less: Cost of goods sold	$ (80,000.00)
Gross profit	$ 20,000.00

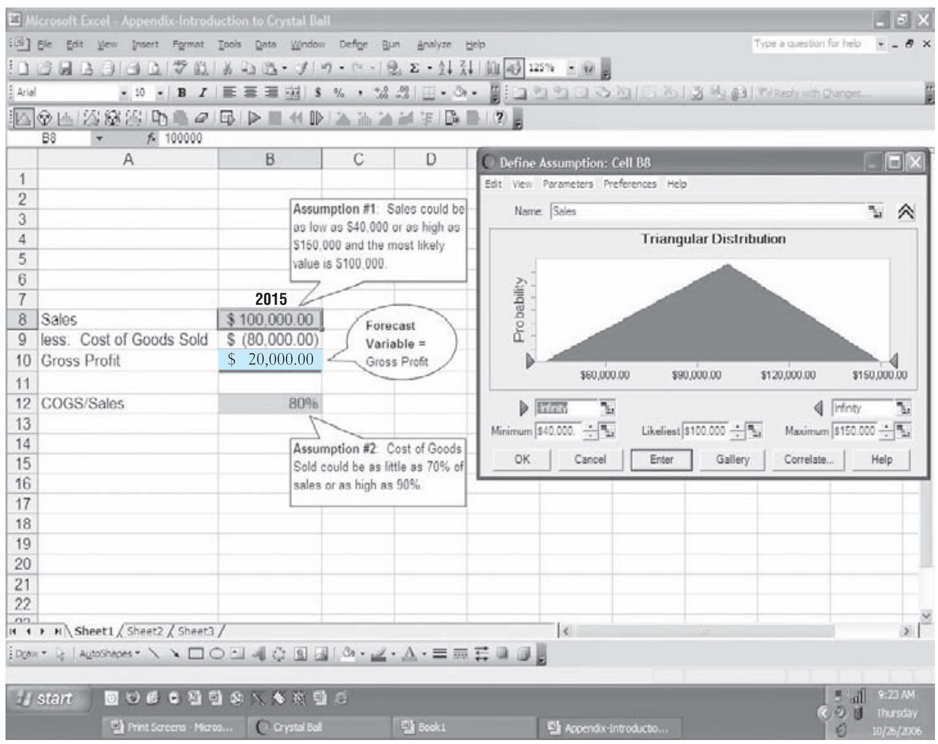
However, management realizes that both the level of sales and the cost of goods sold are not known with certainty, and thus gross profit is also uncertain. To model gross profit using simulation and thus evaluate its underlying uncertainty, management has assessed as follows the uncertainty of sales and cost of goods sold:

Exhibit 3A-2 Assumptions and Their Probability Distributions

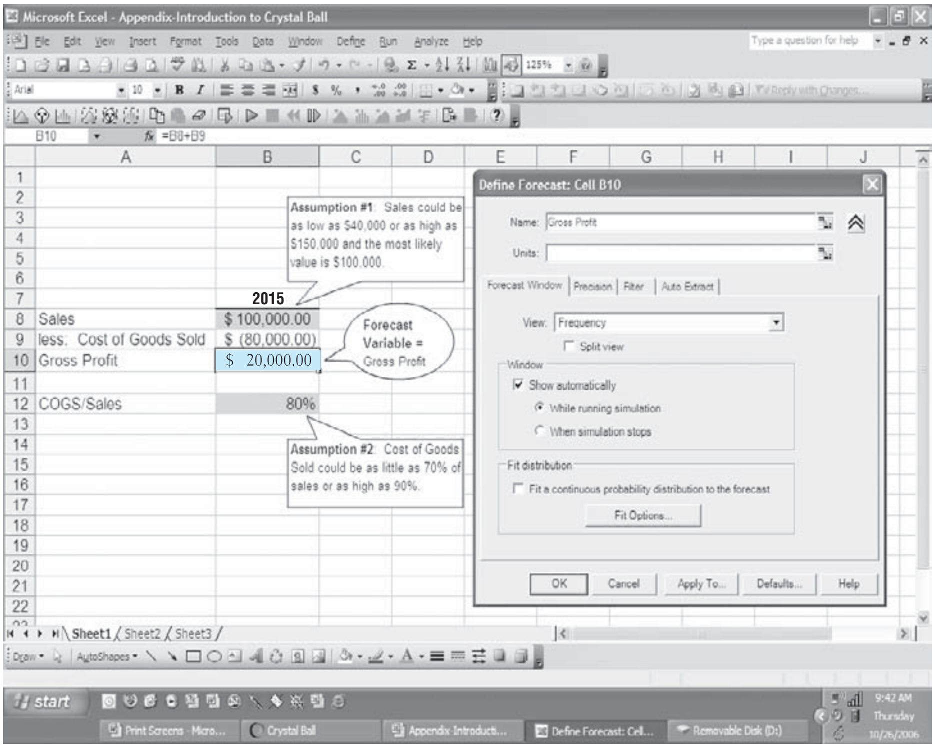
Variable (Assumption)	**Description of Uncertainty**	**Probability Distribution**
Sales	Could be as low as $40,000 or as high as $150,000, but the most likely value is $100,000.	Triangular with minimum value of $40,000, most likely value of $100,000, and maximum value of $150,000.
Cost of goods sold	Could be as little as 70% of sales or as much as 90%.	Uniform distribution with a minimum value of 70% and a maximum value of 90%.

Note that the firm's management has identified the variables in the model that are subject to uncertainty, described the nature of the uncertainty (perhaps with the direct input of individuals within the company who are most familiar with the problem), and translated the description of underlying uncertainty into an appropriate probability distribution. Each of these steps requires skill and managerial judgment that can be developed with practice.

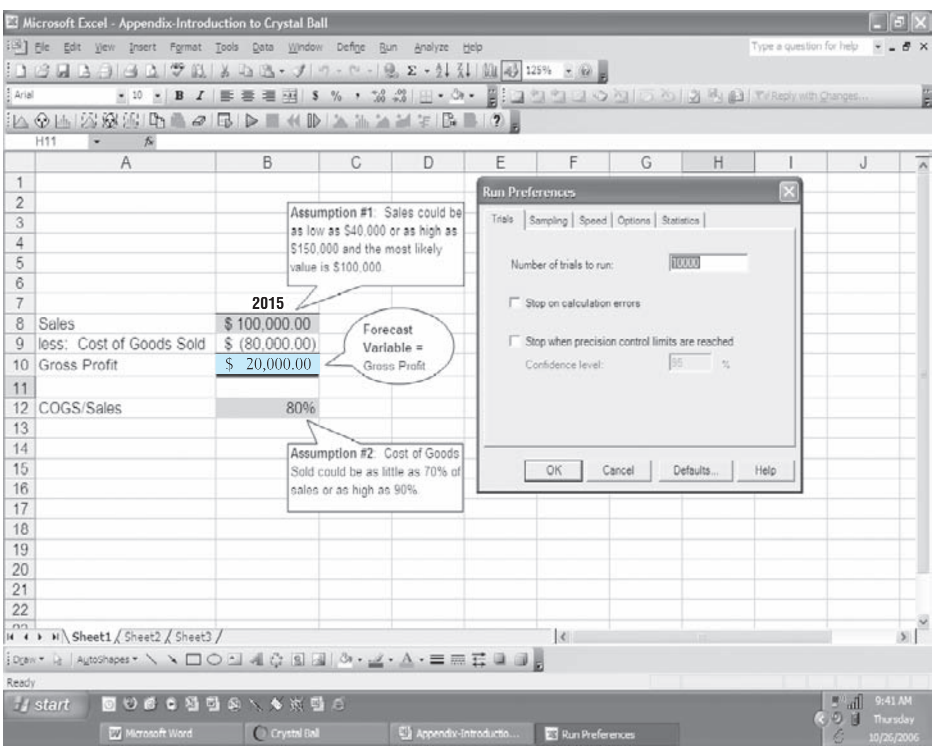
Crystal Ball adds icons to the spreadsheet toolbar that facilitate the process of defining assumptions and identifying forecasts. The screen containing the final model (which appears if you place the cursor on cell B8 (sales); select the and enter the minimum, most likely (likeliest), and maximum parameter estimates for the triangular distribution) appears as follows:



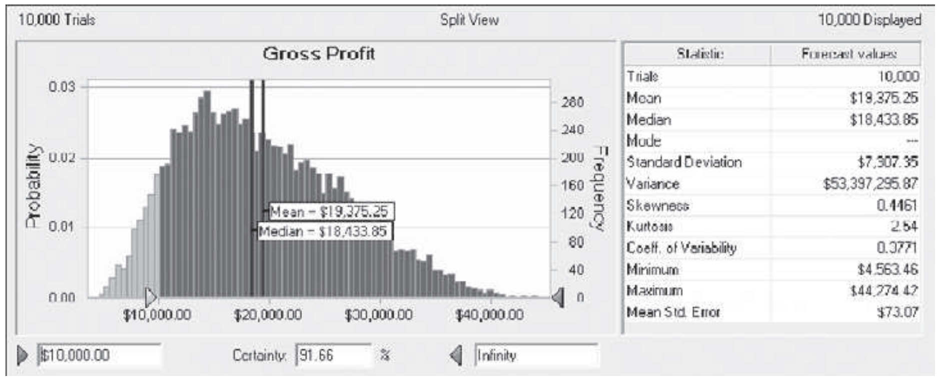
We assign a uniform distribution to cell B9 to make the cost of goods sold to sales ratio stochastic, following the same procedure we used in defining sales. Note that in the final model, shown above, the shaded cells identify the assumptions (i.e., random or stochastic variables), which include sales and cost of goods sold as a percentage of sales; the blue cell identifies the one output or forecast variable in the model that is also the object of the analysis. To define the forecast variable, we select the in the toolbar. The Excel screen appears as follows:



The final step before running the simulation involves selecting the icon on the toolbar to define the number of iterations we wish to include in the simulation experiment. The Excel screen appears as follows:



To run the simulation, we select the ▷ icon on the toolbar. We ran the simulation 10,000 times (iterations), and Crystal Ball compiled the resulting 10,000 estimates of gross profit into the following histogram (frequency distribution):



Let's review the basic elements of the histogram of gross profit. First, this is the split view of the results; it contains both the frequency distribution and statistics. (Crystal Ball offers other options to view the forecast output, but we do not review them here.) Next, there are 10,000 simulation trials and 10,000 iterations displayed in the chart. At the bottom of the frequency distribution are three values: $10,000.00, 91.66%, and infinity. The first number refers to the truncation point in the frequency distribution that appears above, and the certainty of 91.66% is the percentage of the simulated gross profit values that were above $10,000. In other words, there is a 91.66% chance that gross profit will be at least $10,000 or an 8.34% chance that it will be less than $10,000.

PART II

Cost of Capital

Up to now, our focus has been on estimating cash flows. To value those cash flows, we need a discount rate, or a cost of capital that reflects the risks of the cash flows. In this section, we introduce the idea of an investment's opportunity cost of capital, which we define as the rate of return that an investor expects to obtain on an investment in financial securities with equivalent risk characteristics.

Chapter 4 considers the cost of capital for the firm as a whole and focuses on the firm's weighted average cost of capital (WACC), which is the weighted average of the firm's cost of debt and equity. The firm's WACC is the appropriate discount rate for valuing an entire firm; as we explain, however, it may not provide the appropriate cost of capital for individual investment projects that the firm might be considering.

In Chapter 5, we address the problem of estimating the cost of capital for an individual project. In theory, each individual investment project should have a unique discount rate that reflects its unique risks. In practice, however, most firms either evaluate all of their investment projects with one, firmwide cost of capital, or they use multiple discount rates that correspond to each of the firm's operating divisions. We will discuss some organizational reasons for this and offer some alternatives that can be used to tailor the cost of capital estimate to the risk attributes of individual projects. These methods balance the organizational costs that can arise in using multiple discount rates against the benefits of using a risk-appropriate opportunity cost of capital for project analysis.

CHAPTER 4

Estimating a Firm's Cost of Capital

Chapter Overview

In earlier chapters, we referred to the *discount rate* simply as the interest rate used to calculate present values. To describe the appropriate discount rate that should be used to calculate the value of an investment's future cash flows, financial economists use terms like *opportunity cost of capital* or simply *cost of capital.* In this chapter, we focus our attention on the firm's overall weighted average cost of capital (WACC), which is the discount rate that should be used to value an entire firm. In addition to describing the WACC, we consider the determinants of its various components—the cost of debt and the cost of equity.

4.1 Introduction

The firm's **weighted average cost of capital (WACC)** is the weighted average of the expected after-tax rates of return of the firm's various sources of capital. As we will discuss in this chapter, WACC (pronounced like the word *whack*) is the discount rate that should be used to discount the firm's expected free cash flows (FCFs) to estimate firm value.

A firm's WACC can be viewed as its **opportunity cost of capital,** which is the expected rate of return that its investors can earn from alternative investment opportunities with equivalent risk. This may sound like "finance-speak," but it illustrates a very important concept. Because investors can invest their money elsewhere, providing money to a firm by purchasing its securities (bonds and shares of stock) has an opportunity cost. That is, if an investor puts her money into stock from Google (GOOG), she gives up (forgoes) the return she could have earned by investing in Microsoft (MSFT) stock. What this means is that if Google and Microsoft have equivalent risks, the expected rate of return on Microsoft stock can be viewed as the opportunity cost of capital for Google, and the expected return on Google stock can be viewed as the opportunity cost of capital for Microsoft.

In addition to providing the appropriate discount rate to calculate the firm's value, firms regularly track their WACC and use it as a benchmark for determining the appropriate discount rate for new investment projects, for valuing acquisition candidates, and for evaluating their own performance (we return to this topic in Chapter 7).

4.2 Value, Cash Flows, and Discount Rates

Figure 4-1 reviews the three-step DCF valuation methodology that we described in Chapters 2 and 3. Up until this point, we have focused entirely on project valuation (the right-hand column). We now introduce equity valuation (the middle column) and firm valuation.

The key learning point from the second and third columns is that cash flow calculations and discount rates must be properly aligned. If you are trying to estimate the value of the equity invested in the project (i.e., **equity value**), as we do in Chapter 9, then you will estimate equity free cash flows and use a discount rate that is appropriate for the equity investors. On the other hand, if you are estimating the value of an entire firm, which equals the value of the combined equity and debt claims, then the appropriate cash flow is the combination of debt and equity cash flows. In that case, the appropriate discount rate is a combination of the debt- and equity-holder rates, or what we refer to as the weighted average cost of capital.

It should be emphasized that in all of these cases, we are assuming that the estimated cash flows are what we defined in Chapter 3 as expected cash flows. If we are using conservative cash flows, then we would want to use a lower discount rate. Similarly, if the estimated cash flows are really "hoped-for" or optimistic cash flows, then we will need a higher discount rate to offset the optimistic cash flow forecasts.

Defining a Firm's WACC

WACC is a weighted average of the after-tax costs of the various sources of invested capital raised by the firm to finance its operations and investments. We define the firm's

Figure 4-1 Matching Cash Flows and Discount Rates in DCF Analysis

	Object of the Valuation Exercise	
Steps	**Equity Valuation**	**Project or Firm Valuation (Debt Plus Equity Claims)**
Step 1: Estimate the amount and timing of future cash flows (covered in Chapter 2).	Equity free cash flow	Project (firm) free cash flow
Step 2: Estimate a risk-appropriate discount rate (covered in Chapters 4 and 5).	Equity required rate of return	Combine debt and equity discount rates (weighted average cost of capital—WACC).
Step 3: Discount the cash flows (covered in Chapter 2).	Calculate the present value of the estimated Equity FCFs using the equity discount rate to estimate the value of the equity invested in the project.	Calculate the present value of the Project or Firm FCF using the WACC to estimate the value of the project (firm) as an entity.

invested capital as capital raised through the issuance of interest-bearing debt and equity (both preferred and common). Note that the above definition of invested capital specifically excludes all non-interest-bearing liabilities such as accounts payable, as well as unfunded pension liabilities and leases, because we will be calculating what is known as the firm's **enterprise value,** which is equal to the sum of the values of the firm's equity and interest-bearing liabilities. Note, however, that these excluded sources of capital (e.g., unfunded pension liabilities and leases) do affect enterprise value because they affect the firm's future cash flows.

Equation (4.1) defines WACC as the average of the estimated required rates of return for the firm's interest-bearing debt (k_d), preferred stock (k_p), and common equity (k_e). The weight used for each source of funds is equal to the proportions in which funds are raised. That is, w_d is the weight attached to debt, w_p is the weight associated with preferred stock, and w_e is the weight attached to common equity.

$$\text{WACC} = k_d(1 - \text{T})w_d + k_p w_p + k_e w_e \tag{4.1}$$

Note that the cost of debt financing is the rate of return required by the firm's creditors, k_d, adjusted downward by a factor equal to 1 minus the corporate tax rate $(1 - \text{T})$ to reflect the fact that the firm's interest expense is tax-deductible. Thus, the creditors receive a return equal to k_d, but the firm experiences a net cost of only $k_d(1 - \text{T})$. Because the costs of preferred and common equity are not tax-deductible, there is no need for a similar tax adjustment to these costs.

The mechanics of calculating a firm's WACC can be summarized with the following three-step procedure:

- **Step 1:** Evaluate the firm's capital structure and determine the relative weight of each component in the mix.
- **Step 2:** Estimate the opportunity cost of each of the sources of financing and adjust it for the effects of taxes where appropriate.
- **Step 3:** Finally, using Equation (4.1), calculate the firm's WACC by computing a weighted average of the estimated after-tax costs of the various capital sources used by the firm.

As you might suspect, some estimation issues arise with respect to both weights and opportunity costs that need to be addressed. Let's consider each in turn.

Use Market Value Weights

First, with regard to the capital structure weights, it is important that the components used to calculate WACC reflect the current importance of each source of financing to the firm. This means that the weights should be based on the market rather than book values of the firm's securities because market values, unlike book values, represent the relative values placed on the firm's securities at the time of the analysis (rather than at some previous time when the securities were issued).

Use Market-Based Opportunity Costs

The second estimation issue that arises in calculating the firm's WACC relates to the rates of return or opportunity costs of each source of capital. Just as was the case with the capital structure weights, these costs should reflect the current required rates of return, rather than historical rates at the time the capital was raised. This reflects the fact that the WACC is an estimate of the firm's opportunity cost of capital today.

Use Forward-Looking Weights and Opportunity Costs

Firms typically update their estimate of the cost of capital periodically (e.g., annually) to reflect changing market conditions. In most cases, however, analysts apply WACC in a way that assumes that it will be constant for all future periods. This means that analysts assume that the weights for each source of financing, the costs of capital for debt and equity, and the corporate tax rate are constant. Although it is reasonable to assume that the components of WACC are constant as long as the firm's financial policies remain fixed, financial policies sometimes change in predictable ways over the life of the investment. We encounter one such case in Chapter 9 when we discuss leveraged buyouts (LBOs). LBO financing typically involves a very high level of debt that is subsequently paid down. In this case, we find it useful to apply another variant of the discounted cash flow (DCF) model (the adjusted present value model), which we discuss in detail in Chapter 8.

Discounted Cash Flow, Firm Value, and WACC

The connection of WACC to the DCF estimate of firm value is captured in Equation (4.2):[1]

$$\begin{matrix}\text{Firm} \\ \text{Value}_0\end{matrix} = \sum_{t=1}^{N} \frac{E(\text{Firm FCF}_t)}{(1 + \text{WACC})^t} \tag{4.2}$$

E (firm FCF_t) is the expected free cash flow earned by the firm in period t, where firm FCF is analogous to project FCF. For our purposes, a project can be considered a mini-firm, and thus a firm is simply the combination of many projects. Consequently, firm and project free cash flows are calculated in exactly the same way. Equation (4.2) expresses firm value with a 0 subscript to indicate that we are determining firm value *today* (time zero) based on cash flows starting one period hence. In general, analysts assume that the period length is one year, and they ignore the fact that the cash flow accrues over the course of the year. We follow this *end-of-year convention* throughout the text; however, we recognize that many financial analysts assume that cash flows arrive at the middle of the year to account for the fact that, for most projects, cash flows are generated throughout the year.

Illustration—Using Discounted Cash Flow Analysis to Value an Acquisition

To illustrate the connection between WACC and valuation, consider the situation faced by an analyst working for Morgan Stanley, who has a client interested in acquiring OfficeMart Inc., a retailer of office products. This client is interested in purchasing the entire firm, which means that he or she will acquire all of its outstanding equity and assume its outstanding debt. Although valuations of company acquisitions can be quite involved, the Morgan Stanley analyst has made a simple first-pass analysis of the

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[1] Equation (4.2) does not reflect the value of the firm's nonoperating assets nor does it capture the value of the firm's excess liquidity (i.e., marketable securities). We return to the consideration of these points in Chapters 6 and 7.

intrinsic value of OfficeMart following the three-step discounted cash flow process from Chapter 2:[2]

Step 1: *Forecast the amount and timing of free cash flows.* Because we are interested in valuing the firm as an entity (both debt- and equity-holder claims), we estimate firm FCFs in the same way that we calculated project free cash flows in Chapter 2. Thus, for the coming year, the Morgan Stanley analyst estimates that OfficeMart's cash flow will be $560,000, as follows:

Sales	$ 3,000,000
Cost of goods sold	(1,800,000)
Depreciation	(500,000)
Earnings before interest and taxes (EBIT)	700,000
Taxes[3](20%)	(140,000)
Net operating profit after taxes (NOPAT)	560,000
Plus: Depreciation	500,000
Less: Capital expenditures (CAPEX)	(500,000)
Less: Change in net working capital (WC)	(0)
Firm FCF	$ 560,000

Step 2: *Estimate the appropriate discount rate.* Because we are valuing the entire company (debt plus equity claims), the discount rate we choose should represent a combination of the rates that are appropriate for both debt and equity, or the weighted average cost of capital.

OfficeMart finances 40% of its assets using debt costing 5%; equity investors in companies similar to OfficeMart (in terms of both the industry and their capital structures) demand a 14% return on their investment. Combining OfficeMart's after-tax cost of borrowing (interest expense is tax-deductible and the firm's tax rate is 20%) with the estimated cost of equity capital, we calculate a weighted average cost of capital for the firm of 10% (i.e., $5\% \times [1 - 20\%] \times 0.4 + 14\% \times 0.6 = 10\%$).

Step 3: *Discount the estimated cash flows.* OfficeMart's estimated cash flows form a level perpetuity. That is, each year's cash flow is equal to the prior year's cash flow, or $560,000. Consequently, we can calculate the present value of the firm's future cash flows as follows:

$$\text{Value of Office Mart Inc.} = \frac{\$560{,}000}{.10} = \$5{,}600{,}000$$

Thus, this first-pass analysis suggests that the value of OfficeMart is $5,600,000. Recall that we have estimated firm value, which is the sum of both the firm's debt and equity claims. If we want to estimate the value of the firm's *equity,* we need to subtract the value of its debt claims from the $5,600,000 valuation of the firm. Because OfficeMart has $2,240,000 worth of debt outstanding, the value of the firm's equity is $5,600,000 − $2,240,000 = $3,360,000.

[2] In Chapters 6 through 9, we delve further into the details of firm valuation.

[3] Recall from our earlier discussion in Chapter 2 that this is *not* the firm's actual tax liability because it is based on earnings before interest expense has been deducted. See the Technical Insight box on interest tax savings.

TECHNICAL INSIGHT

What About Interest Tax Savings?

Note that the taxes in the project FCF and firm FCF calculations are based on the level of operating profits or earnings *before* interest has been deducted. In other words, we are calculating the after-tax cash flows of an all-equity firm. However, interest expense and its tax deductibility are not ignored in our valuation. We use the *after-tax* cost of debt when calculating the weighted average cost of capital, which accounts for the tax savings associated with the tax deductibility of interest. For example, if the required rate of return for debt is 7% and the firm pays taxes at a rate of 30%, the after-tax cost of debt is 4.9%—that is, $.07(1 - .30) = .049$, or 4.9%, while the pretax cost of debt is 7%.

Equity Valuation

In the middle column of Figure 4-1, we note that the value of the firm's equity can also be calculated directly by discounting the equity free cash flow, or equity FCF, back to the present using the equity holder's required rate of return. Because we have not yet defined equity FCF, let's take a moment to reflect on how equity FCFs are related to firm FCFs.

Equity Free Cash Flow To calculate equity FCF, recall that a firm's FCF is equal to the sum of the cash flows needed to pay the firm's creditors (creditor cash flows) and owners (equity FCF), that is:

$$\begin{matrix}\text{Firm} \\ \text{FCF}\end{matrix} = \begin{matrix}\text{Creditor} \\ \text{Cash Flows}\end{matrix} + \begin{matrix}\text{Equity} \\ \text{FCF}\end{matrix}$$

such that, when we solve for equity FCF, we get the following:

$$\begin{matrix}\text{Equity} \\ \text{FCF}\end{matrix} = \begin{matrix}\text{Firm} \\ \text{FCF}\end{matrix} - \begin{matrix}\text{Creditor} \\ \text{Cash Flows}\end{matrix}$$

Creditors receive two types of cash flows: interest and principal. Because interest expenses are tax-deductible, we adjust interest payments to reflect the interest tax savings; that is, we subtract the tax savings resulting from the deduction of interest from the interest payments. The principal payments are cash inflows when the firm initiates new borrowing, and they are cash outflows when the firm repays debt. We can summarize the calculation of creditor cash flows as follows:

$$\begin{matrix}\text{Creditor} \\ \text{Cash Flows}\end{matrix} = \underbrace{\begin{matrix}\text{Interest} \\ \text{Expense}\end{matrix} - \begin{matrix}\text{Interest} \\ \text{Tax Savings}\end{matrix}}_{\text{After-Tax Interest Expense}} + \underbrace{\begin{matrix}\text{Principal} \\ \text{Payments}\end{matrix} - \begin{matrix}\text{New Debt Issue} \\ \text{Proceeds}\end{matrix}}_{\substack{\text{Net Debt Proceeds} \\ \text{(Change in Principal)}}}$$

Thus, we define equity FCF as follows:

$$\frac{\text{Equity}}{\text{FCF}} = \frac{\text{Firm}}{\text{FCF}} - \left(\frac{\text{Interest}}{\text{Expense}} - \frac{\text{Interest}}{\text{Tax Savings}} + \frac{\text{Principal}}{\text{Payments}} - \frac{\text{New Debt Issue}}{\text{Proceeds}} \right)$$

If we remove the parentheses from around the creditor cash flows, equity FCF can also be calculated as follows:

$$\frac{\text{Equity}}{\text{FCF}} = \frac{\text{Firm}}{\text{FCF}} - \frac{\text{Interest}}{\text{Expense}} + \frac{\text{Interest}}{\text{Tax Savings}} - \frac{\text{Principal}}{\text{Payments}} + \frac{\text{New Debt Issue}}{\text{Proceeds}}$$

Equity Valuation Example—OfficeMart Inc. Let's return to our OfficeMart example to compute equity FCF and the value of the firm's equity. Earlier, we learned that OfficeMart has borrowed \$2,240,000 on which it pays 5% interest before deducting the interest from the firm's taxes, which are 20% of its income. This means that the firm pays \$112,000 in interest expense each year. If we assume the debt is not repaid but remains outstanding forever, then the firm has no principal repayments, and if it borrows no added funds, the creditor cash flows equal $\$89{,}600 = \$112{,}000 - 112{,}000 \times .20$. Given that the firm's FCF is \$560,000, we calculate equity FCF as follows:

$$\frac{\text{Equity}}{\text{FCF}} = \frac{\text{Firm}}{\text{FCF}} - \frac{\text{Interest}}{\text{Expense}} + \frac{\text{Interest}}{\text{Tax Savings}} - \frac{\text{Principal}}{\text{Payments}} + \frac{\text{New Debt Issue}}{\text{Proceeds}}$$

$$\frac{\text{Equity}}{\text{FCF}} = \$560{,}000 - 112{,}000 + 22{,}400 - 0 + 0 = \$470{,}400$$

To value the equity in the project, we discount the equity FCF stream (note that the equity FCFs are a level perpetuity—a constant cash flow received annually in perpetuity) using the cost of equity capital, which was earlier assumed to be 14%, that is:

$$\begin{array}{c}\text{Value of}\\ \text{Office Mart's}\\ \text{Equity}\end{array} = \frac{\$470{,}400}{.14} = \$3{,}360{,}000$$

So the value of OfficeMart's equity is equal to the residual value remaining after the firm's debt obligations are deducted from the value of the firm (i.e., $\$5{,}600{,}000 - \$2{,}240{,}000 = \$3{,}360{,}000$), and it is also equal to the present value of the equity free cash flows! Whether equity value is estimated directly by discounting equity FCFs or indirectly by subtracting the value of the firm's debt from firm value varies in practice. For example, as we point out in Chapter 9, it is common practice among private equity investors to value equity directly. When evaluating firms in the context of mergers and acquisitions, however, the valuations generally focus on the firm as a whole.

4.3 Estimating WACC

In this section, we introduce techniques for estimating a firm's WACC. In our discussion, we will frequently reference the practices of Ibbotson Associates, which is a prominent source of information (see the Practitioner Insight box on p. 107). Ibbotson follows the same three-step process we discussed earlier for the estimation of a firm's WACC but applies the procedure to *industry groups*. The rationale for focusing on the

PRACTITIONER INSIGHT

Roger Ibbotson on Business Valuation and the Cost of Capital*

The appraisal of a firm's value using discounted cash flow is a relatively straightforward process. The standard procedure involves estimating the firm's cost of capital and future cash flows and then discounting the cash flows back to the present using the cost of capital. Unfortunately, estimates of cash flows as well as discount rates are fraught with errors. The potential for estimation errors is probably greatest for cash flow estimates because no anchors or boundaries can be used to provide guidance about what reasonable estimates might be. In contrast, in making cost of capital estimates, the analyst has historical market returns on risk-free securities and common stock (in total and by industry), which provide an approximation of a firm's cost of capital.

At Ibbotson Associates, we provide historical information about stock and bond returns that indicates appropriate required rates of return on investments with different risks. We also provide alternative models that can be used to calculate the cost of capital. Some of the cost of capital models can seem overly complex when conveyed to upper management, board members, or others who lack financial sophistication. Moreover, estimated costs of capital (particularly equity capital) can, and often do, vary widely. My experience suggests that the following guidelines can be useful when addressing the estimation of a company's cost of capital:

- *Use the simpler models when possible.* Our experience suggests that some of the more sophisticated models of the cost of equity have the highest estimation errors.
- *Account for company size and industry.* These variables are unambiguously measured and have been reliably demonstrated to be related to the firm's cost of capital.
- *Calculate the cost of capital using several methods.* Even though you may rely principally on simpler models, each method is informative.

*Roger Ibbotson is founder and former chairman of Ibbotson Associates Inc. Ibbotson Associates is the largest provider of cost of capital information in the United States. Currently, its *Cost of Capital Quarterly* includes industry cost of capital analysis on more than 300 US-based industries for help in performing discounted cash flow analysis. The data include industry betas, costs of equity, weighted average costs of capital, and other important financial statistics presented by industry.

industrywide cost of capital is based on the beliefs that (1) the variation in the cost of capital within industries is modest when compared to the variation across industries, and (2) estimation errors are minimized if we focus on groups of similar firms from the same industry.[4]

Evaluate the Firm's Capital Structure Weights—Step 1

The first step in our analysis of WACC involves the determination of the weights used for the components of the firm's capital structure. These weights represent the fraction of the firm's **invested capital,** for example, the firm's interest-bearing debt, preferred equity, and common equity, contributed by each of the sources of capital.

In theory, we should calculate the weights using observed market prices for each of the firm's securities (be they debt or equity), multiplied by the number

[4] For a complete discussion of its methodology, see Ibbotson Associates, *Cost of Capital—Yearbook*.

INDUSTRY INSIGHT

Estimating the Cost of Debt in Practice

Ibbotson Associates estimates the industry cost of debt using the yield curve for various debt ratings based on the Merrill Lynch US Domestic Bond Indices. As a practical matter, bonds are classified into one of three groups (see Figure 4-2): investment grade (S&P ratings of AAA, AA, A, and BBB), below investment grade (S&P ratings of BB, B, CCC, CC, and D), and not rated. Yields for each group and maturity are then averaged to arrive at an estimate of the yield curve for debt. The average yields for the lower two groups are used as proxies for bonds that are not rated. A weighted average cost of debt can then be calculated for each company in an industry using yields for the firm's debt rating and weights determined by the actual debt maturing in a particular year compared to all debt outstanding. To get an industry cost of debt, the average yields for each company in the industry are averaged. Ibbotson Associates uses debt maturing in each of the next five years and then assumes that all remaining debt matures in year 6.

of outstanding securities. The market prices of equity securities are readily available, so an analyst can simply multiply the current market price of the security by the number of shares outstanding to calculate total market values. For debt securities, book values are often substituted for market values because market prices for corporate debt are often difficult to obtain (see the Industry Insight box). When market values of debt are available, however, they should be used in place of book values.

Calculate the Cost of Debt—Step 2

In theory, we would like to estimate the expected return that investors require on the firm's debt. In practice, analysts typically use the promised *yield to maturity* on the firm's outstanding debt as their estimate of the expected cost of debt financing.

Promised or Contractual Yields to Maturity on Corporate Bonds

Estimation of the yield to maturity (YTM) on a corporate bond issue is straightforward when the analyst has access to information regarding the maturity of the bond, its current market price, the coupon rate of interest, and the schedule of principal payments. For example, in fall 2009, Home Depot (HD) had a bond issue that was due in 2016 (i.e., seven years to maturity), carried an annual coupon rate of 5.4%, paid semiannual interest and therefore had 14 payments, and had a market price of $1,049. The YTM on the bond issue can be calculated by solving for YTM in the following bond valuation equation:

$$\$1{,}049 = \frac{(.054/2)\times\$1{,}000}{(1+\text{YTM})^1} + \frac{(.054/2)\times\$1{,}000}{(1+\text{YTM})^2} + \frac{(.054/2)\times\$1{,}000}{(1+\text{YTM})^3} + \cdots + \frac{(.054/2)\times\$1{,}000+\$1{,}000}{(1+\text{YTM})^{14}}$$

The semiannual YTM is 2.287%, which converts to an annualized YTM of 4.63%.[5] Based on a marginal tax rate of 35%, the after-tax cost of Home Depot's bond issue is then 3.007% = 4.63 × (1 − .35).

Calculating the YTM of a firm's debt is difficult for firms with a large amount of debt that is privately held and thus does not have market prices that are readily available. Because of this, it is standard practice to estimate the cost of debt using the yield

[5] Annual YTM $= (1 + \text{semiannual YTM})^2 - 1 = (1 + .02288)^2 - 1 = .0463$ or 4.63%. This quantity is often referred to as the effective annual rate, or just yield.

Figure 4-2 A Guide to Corporate Bond Ratings

Moody's	S&P	Fitch	Definitions
Aaa	AAA	AAA	Prime (maximum safety)
Aa1	AA+	AA+	High grade, high quality
Aa2	AA	AA	
Aa3	AA–	AA–	
A1	A+	A+	Upper medium grade
A2	A	A	
A3	A–	A–	
Baa1	BBB+	BBB+	Lower medium grade
Baa2	BBB	BBB	
Baa3	BBB–	BBB–	
Ba1	BB+	BB+	Noninvestment grade
Ba2	BB	BB	Speculative
Ba3	BB–	BB–	
B1	B+	B+	Highly speculative
B2	B	B	
B3	B–	B–	
Caa1	CCC+	CCC	Substantial risk
Caa2	CCC	—	In poor standing
Caa3	CCC–	—	
Ca	—	—	Extremely speculative
C	—	—	May be in default
—	—	DDD	Default
—	—	DD	
—	D	D	

to maturity on a portfolio of bonds with similar credit ratings and maturity as the firm's outstanding debt.

Reuters provides average spreads to Treasury data that are updated daily and cross-categorized by both default rating and years to maturity, similar to that found in Figure 4-3. Using our Home Depot bond issue, we can estimate the YTM for a seven-year bond with a default rating of Aa3/AA−. Such a bond has a spread comparable to the seven-year Treasury bond YTM of .52%, or 52 basis points (see boxed number in Figure 4-3). The seven-year Treasury YTM was 3.00% at the time of this writing, which provides an estimate of 3.00% + .52% = 3.52% for the YTM on Home Depot's bonds.

Promised Versus Expected Rates of Return

The yield to maturity is calculated using the promised interest and principal payments and thus can be considered a reasonable estimate of the cost of debt financing *only* when the risk of default is so low that promised cash flows are reasonable estimates of expected cash flow. For lower-rated debt, however, promised and expected cash flows are not the same, and an explicit adjustment for the prospect of loss in the event of default becomes necessary.

Figure 4-3 Representative Corporate Spreads (in Basis Points) for Industrials

Rating	1 yr	2 yr	3 yr	5 yr	7 yr	10 yr	30 yr
Aaa/AAA	5	10	15	20	25	25	40
Aa1/AA+	8	10	15	25	30	37	61
Aa2/AA	10	17	22	27	36	44	63
Aa3/AA–	15	25	30	40	47	52	73
A1/A+	20	30	35	45	50	60	80
A2/A	30	39	50	55	60	68	85
A3/A–	40	54	63	70	75	84	105
Baa1/BBB+	50	60	75	85	89	99	118
Baa2/BBB	55	70	95	100	107	117	138
Baa3/BBB–	70	85	105	110	119	135	168
Ba1/BB+	100	110	125	155	165	195	220
Ba2/BB	120	160	190	185	190	230	280
Ba3/BB–	145	180	210	215	215	250	300
B1/B+	170	195	230	230	255	315	340
B2/B	195	200	240	280	295	330	430
B3/B–	245	290	330	380	415	460	505
Caa/CCC	1105	1205	1230	1180	1180	1255	1380

*Methodology—Reuters Pricing Service (RPS) has eight experienced evaluators responsible for pricing approximately 20,000 investment-grade corporate bonds. Corporate bonds are segregated into four industry sectors: industrial, financial, transports, and utilities. RPS prices corporate bonds at a spread above an underlying Treasury issue. The evaluators obtain the spreads from brokers and traders at various firms. A generic spread for each sector is created using input from street contacts and the evaluator's expertise. A matrix is then developed based on sector, rating, and maturity.

To elaborate on the distinction between promised yields and expected returns on debt, consider the calculation of YTM on a bond with one year to maturity in Equation (4.3a):

$$\begin{matrix}\text{Bond}\\ \text{Price}\end{matrix} = \frac{\text{Interest} + \text{Principal}}{(1 + \text{YTM})} \tag{4.3a}$$

Note that the cash flows used to determine YTM are the contractual or promised cash payments, which equal expected cash flows *only* for default-free bonds. For debt with default risk, the expected cash flows must reflect the probability of default (Pb) and the recovery rate (Re) on the debt in the event of default. For our one-period bond issue, the cost of debt k_d can be calculated using expected cash flows to the bondholder as follows:

Bond Price

$$= \frac{[\text{Interest} + \text{Principal}] \times (1 - Pb) + [\text{Interest} + \text{Principal}] \times Pb \times Re}{(1 + k_d)} \tag{4.3b}$$

The expected cash flow to the bondholder is the promised principal and interest payments, weighted by the probability that the debt does not default $(1 - Pb)$, plus the cash flow that is received in the event of default, weighted by the probability of default (Pb). To illustrate this, consider a bond with a \$1,000 face value and one year to maturity that is currently selling for \$985.00 and paying a 9% interest payment annually. Using Equation (4.3a), we estimate the bond's YTM to be 10.66%, that is:

$$\begin{matrix}\text{Bond}\\ \text{Price}\end{matrix} = \frac{\text{Interest} + \text{Principal}}{(1 + \text{YTM})1} = \frac{.09 \times \$1{,}000 + \$1{,}000}{(1 + .1066)} = \$985$$

The 10.66% YTM represents the rate of return an investor would realize if the bond does not default. If the probability of default on the bond is 15% and the recovery rate is 75%, however, the expected rate of return to the investor, using Equation (4.3b), is 6.51%.

In practice, the differences between YTM and k_d are relatively modest for investment-grade debt (i.e., debt rated BBB or higher), and the YTM provides a reasonable estimate of the cost of debt. For firms with debt that is rated below investment grade, however, there can be a meaningful difference between the *promised yield to maturity* on the debt and the *expected return* or cost of the debt (as we demonstrated in the above example).

The cost of debt rated below investment grade can be estimated in one of two ways. The first method involves estimating the expected cash flows of the debt using expected rates of default and recovery rates, and using these expected cash flows to calculate the internal rate of return on the debt. We illustrate how this can be done in the appendix to this chapter. The second method applies the capital asset pricing model (CAPM), which we discuss in more detail later in the chapter when we discuss the cost of equity capital. Briefly, the CAPM requires an estimate of the beta of the debt, along with an expected return premium on the stock market. For example, betas of low-rated bonds are approximately .4, while bonds with AAA ratings generally have betas that are about .1. If we assume a market risk premium of 5%, then the spread between the expected returns of a AAA bond and a below-investment-grade bond is approximately $(0.4 - 0.1)$ times 5%, which equals 1.5%. Therefore, if the yield to maturity and expected return on a AAA bond (our proxy for the risk-free rate) is 6%, then the expected return on the lower-rated bond is about 7.5%.

Estimating the Cost of Convertible Corporate Bonds

Convertible bonds represent a hybrid form of financing that is both debt and equity because the holder of the bond can, at his or her discretion, convert the bond into a prescribed number of common shares. Because of the conversion feature, convertible bonds typically carry a lower rate of interest; consequently, their estimated yield to maturity understates the true cost of this form of financing. Indeed, the cost of convertible bond capital is a weighted average of the cost of issuing straight bonds and the cost of the exchange feature (call option), where the weights equal the relative contributions of the two components to the value of the security. We delve into the estimation of the cost of convertible debt in the appendix to this chapter.

Calculate the Cost of Preferred Equity—Step 2 (continued)

A straight (i.e., nonconvertible) preferred stock pays the holder a fixed dividend each period (quarterly) forever.[6] The value of such a stream of dividends can be found as follows:

$$\begin{array}{c}\text{Preferred}\\ \text{Stock}\\ \text{Price }(P_{ps})\end{array} = \frac{\text{Preferred Dividend }(Div_{ps})}{\text{Required Return }(k_{ps})} \tag{4.4a}$$

Using the preferred dividend and observed price of preferred stock, we can infer the investor's promised rate of return as follows:

$$k_{ps} = \frac{Div_{ps}}{P_{ps}} \tag{4.4b}$$

To illustrate, consider the preferred shares issued by Alabama Power Company (ALP-PP), which pay a 5.3% annual dividend on a $25.00 par value, or $1.33 per share. On February 26, 2014, these preferred shares were selling for $24.96 per share, implying a promised return of 5.33%, which is calculated as follows:

$$k_{ps} = \frac{\$1.33}{24.96} = .0533 \text{ or } 5.33\%$$

Note that the preferred dividend is also a *promised* dividend, in the same way that the interest on corporate bonds is *promised* interest, and thus does *not* necessarily represent the dividend that the preferred stockholder expects to receive. This means that the 5.33% return calculated above provides an upper limit on the cost of preferred stock because the firm may decide to suspend payment or file for bankruptcy.[7]

Practitioners often use this promised return as the preferred stock cost of capital. Remember, however, that the promised return is higher than the expected cost of this form of financing. If possible, one should adjust the cost of preferred stock in the same way we adjusted the cost of non-investment-grade debt, by accounting for the probability of default and the recovery rate.

Calculate the Cost of Common Equity—Step 2 (continued)

The cost of common equity capital (k_e) is the most difficult estimate we have to make in evaluating a firm's cost of capital. The difficulty arises from the fact that the common shareholders are the residual claimants of the firm's earnings. That is, the common stockholders receive what is left over after all other claimants (bondholders and preferred stockholders) have been paid. Hence, there is no promised or prespecified return based on a financial contract (as is the case with both bondholders and preferred stockholders).

[6] We discuss a method for evaluating the conversion feature with respect to corporate bonds in the appendix to this chapter. A similar approach can be taken for the evaluation of convertible preferred shares.

[7] In contrast to corporate bond interest and principal payments, the issuing firm can suspend payment of the preferred dividend without being forced into bankruptcy. This makes the difference in promised and expected dividends even more dramatic than with bonds because the issuing firm is less likely to default on interest and principal payments.

The relevant cost of equity is simply the rate of return investors *expect* from investing in the firm's stock. We review two broad approaches that are each widely used to estimate the cost of equity. The first consists of what financial economists refer to as asset pricing models. Specifically, we present three variants of the capital asset pricing model (CAPM).

The second approach has a much older heritage in finance and comes out of the pioneering work of John Burr Williams (1938) and later Myron Gordon (1962).[8] This approach, which is often referred to as the discounted cash flow approach, first estimates the expected stream of dividends and then calculates the implied cost of equity capital (or the internal rate of return) that makes the present value of the dividend stream equal the firm's stock price. This implied return is then used as the firm's cost of equity.

Method 1—Asset Pricing Models

Asset pricing theories entered the finance literature in the 1960s with the introduction of the **capital asset pricing model (CAPM).** The traditional CAPM was followed by a host of modified versions that relaxed some of the more stringent assumptions on which the original theory was based. We consider three versions: the traditional CAPM, the size-adjusted CAPM, and multifactor models.

The Traditional CAPM One of the basic tenets of finance is that if investors are risk-averse, they will require a higher rate of return to hold riskier investments. The important question addressed by CAPM is how one should measure risk. The foundation of the CAPM is that investors are most concerned about how the risk of a stock contributes to the volatility of their total portfolio, which is assumed to be a well-diversified market portfolio. As it turns out, some stocks are quite volatile; that is, their returns vary a lot from month to month, but despite their volatility, they contribute very little to the volatility of a well-diversified portfolio. According to the CAPM, these stocks should require lower rates of return than their counterparts that are less volatile but contribute more to the volatility of well-diversified portfolios.

To understand the relation between risk and return, it is useful to decompose the risk of an investment into two components. The first component, which captures variability that contributes to the risk of a diversified portfolio, is generally referred to as either **systematic risk** or **nondiversifiable risk.** The second component, which captures variability that does not contribute to the risk of a diversified portfolio, is generally referred to as **nonsystematic risk** or **diversifiable risk.** Sources of systematic risk include market factors such as changes in interest rates and energy prices that influence almost all stocks. Stocks that are very sensitive to these sources of risk contribute more to the variability of diversified portfolios and thus require higher rates of return. Sources of nonsystematic risk include random, firm-specific events such as lawsuits, product defects, and various technical innovations. These sources of risk contribute very little to the overall variability of diversified portfolios and thus have very little influence on required rates of return.

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[8] J. B. Williams, *Theory of Investment Value* (Cambridge, MA: Harvard University Press, 1938), and M. Gordon, *The Investment, Financing, and Valuation of the Corporation* (Homewood, IL: Irwin, 1962).

The CAPM can be expressed as shown in Equation (4.5), which relates the required expected return of an investment to systematic risk:

$$k_e = k_{rf} + \beta_e(k_m - k_{rf}) \tag{4.5}$$

where

k_{rf} = the risk-free rate of interest

β_e = the beta, or systematic risk of the company's common equity, which is estimated from a regression of a stock's return minus the risk-free rate on a market return, such as the S&P 500 return, minus the risk-free rate

k_m = the expected return on the overall market portfolio comprised of all risky assets

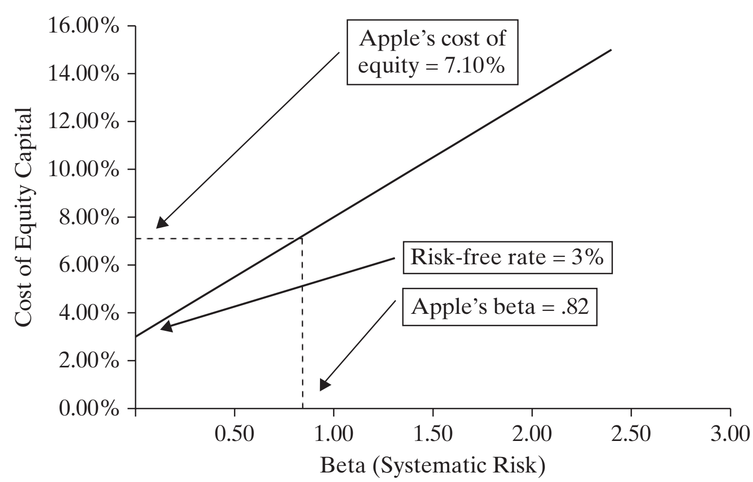
$(k_m - k_{rf})$ = the expected market risk premium (the expected return on the overall market minus the risk-free rate)

Figure 4-4 illustrates the connection between systematic risk and the expected rate of return on common equity. For example, to determine the cost of Apple's stock, let's assume that we estimate its beta coefficient to be .82, the risk-free rate of interest to be 3.00%, and the market risk premium to be approximately 5%. We can substitute into Equation (4.5) to estimate the expected cost of equity capital for the firm as 7.10%.

We now turn to a more in-depth discussion of the three CAPM inputs: the risk-free interest rate, beta, and the market risk premium.

Selecting the Risk-Free Rate of Interest The risk-free rate of interest is the least controversial estimate we have to make for the CAPM inputs. Nevertheless, we must answer two questions: What is a risk-free security? What maturity should we use?

Figure 4-4 Estimating Apple's Cost of Equity Using CAPM



Identifying the Risk-Free Rate Analysts typically use yields to maturity of government bonds, like US Treasury securities, to define the risk-free rate of interest.[9]

Choosing a Maturity As a general rule, we want to match the maturity of the risk-free rate with the maturity of the cash flows being discounted. In practice, however, maturity matching is seldom done. Most textbooks suggest that short-term rates be used as the risk-free rate because they are consistent with the simplest version of the CAPM. Because the estimated cost of equity is typically used to discount distant cash flows, however, it is common practice to use a long-term rate for, say, 10- or 20-year maturities as the risk-free rate.[10] We agree with this practice; as we note below, however, the beta estimate used in the CAPM equation should also reflect this longer-maturity risk-free rate.

Estimating the Beta The firm's **beta** represents the sensitivity of its equity returns to variations in the rates of return on the overall market portfolio. That is, if the value of the market portfolio of risky investments outperforms Treasury bonds by 10% during a particular month, then a stock with a beta of 1.25 is expected to outperform Treasury bonds by 12.5%. A stock's beta should be estimated by regressing the firm's excess stock returns on the excess returns of a market portfolio, where excess returns are defined as the returns in excess of the risk-free return, as shown in Equation (4.6):

$$(k_e - k_{rf})_t = \alpha_e + \beta_e(k_m - k_{rf})_t + e_t \tag{4.6}$$

where

k_e = the realized rate of return from investing in the firm's equity in period t
k_{rf} = the risk-free rate of interest observed in period t
α_e = a constant (intercept) term
β_e = the realized beta for the company's common equity
$(k_m - k_{rf})$ = the equity risk premium in period t
e_t = the error term (that part of the equity return that is not explained by overall market movements)

Note that many analysts fail to match the maturity of the risk-free rate, used in Equation (4.6) to calculate beta, with the maturity of the rate used to calculate the equity risk premium. Very simply, if you use a long-term Treasury bond yield as the risk-free rate, then the excess return on the market used to calculate beta should be the return of the market portfolio minus the long-term Treasury bond return.[11]

[9] Because Treasury securities have special appeal to foreign central banks and are exempt from state taxes, we cannot expect a zero-beta stock to have a return as low as the yield on a Treasury security. Because of this, one might want to use the AAA corporate bond or equivalent commercial paper rate instead of the Treasury rate. We follow industry practice, however, and use the long-term Treasury rate.

[10] For example, Ibbotson Associates uses the long-term government bond yield to approximate the risk-free rate in its cost of capital calculations.

[11] It is our understanding that most publicly available betas are estimated with short-term risk-free rates or simply by regressing stock returns on market returns.

TECHNICAL INSIGHT

Equity Betas and Financial Leverage

When using the CAPM to estimate the cost of equity, it is standard practice to estimate the firm's equity beta by computing averages of equity betas of comparable firms with similar operating risk characteristics. Because equity betas vary with the use of financial leverage, we need to adjust the betas of the comparison firms for differences in how the firms are financed. This requires an understanding of the relationship between financial leverage and beta.

To develop an understanding of this relationship, we begin by noting that the beta for a firm is simply a weighted average of the betas of each of the sources of capital in the firm's capital structure. So the beta for firm j can be defined as follows:

$$\beta_{\text{Firm}_j} = \beta_{\text{Equity}_j}\left(\frac{\text{Equity Value}_j}{\text{Firm Value}_j}\right) + \beta_{\text{Debt}_j}\left(\frac{\text{Debt Value}_j}{\text{Firm Value}_j}\right) \tag{1}$$

Because firm value = equity value + debt value, we can solve for the equity beta by solving equation (1) for β_{Equity_j} as follows:

$$\beta_{\text{Equity}_j} = \beta_{\text{Firm}_j}\left(1 + \frac{\text{Debt Value}_j}{\text{Equity Value}_j}\right) - \beta_{\text{Debt}_j}\left(\frac{\text{Debt Value}_j}{\text{Equity Value}_j}\right) \tag{2}$$

Note that equation (2) does not explicitly account for the effects of corporate taxes. When corporate taxes favor debt financing, firm values are affected by the level of debt, and this in turn affects the beta of the firm as well as the beta of its equity. For example, if corporate income is subject to income taxes at a rate of T_c and interest is tax-deductible, the value of the firm is equal to the sum of the hypothetical value of the firm, assuming that it is unlevered (that it has no debt), plus the value of the interest tax savings resulting from the use of debt in the firm's capital structure, that is:[12]

$$\begin{matrix}\text{Firm}\\ \text{Value}_j\end{matrix} = \begin{matrix}\text{Debt}\\ \text{Value}_j\end{matrix} + \begin{matrix}\text{Equity}\\ \text{Value}_j\end{matrix} = \begin{matrix}\text{Firm}\\ \text{Value}_{\text{Unlevered}_j}\end{matrix} + \begin{matrix}\text{Value of}\\ \text{the Interest}\\ \text{Tax Savings}_j\end{matrix} \tag{3}$$

The firm's beta can now be expressed in terms of the beta of the unlevered firm and the firm's interest tax savings:

$$\beta_{\text{Firm}_j} = \beta_{\text{Unlevered Firm}_j}\left(\frac{\text{Firm Value}_{\text{Unlevered}_j}}{\text{Firm Value}_j}\right) + \beta_{\text{Interest Tax Savings}_j}\left(\frac{\text{Value of Interest Tax Savings}_j}{\text{Firm Value}_j}\right) \tag{4}$$

[12] This result is from Franco Modigliani and Merton Miller, "Corporate Income Taxes and the Cost of Capital: A Correction," *American Economic Review* 53, no. 3 (June 1963): 433–443.

An important component of Equation (4) is $\beta_{\text{Interest Tax Savings}_j}$, which is affected by how the firm changes its capital structure over time. We will consider first the case where the level of debt used by the firm is fixed or constant, which implies that the interest tax savings are the same for all future years. We will then consider the case where the debt to value ratio is fixed, which implies that the interest tax savings vary from year to year in direct relation to changes in the value of the firm.

Case 1: Constant Level of Debt

When the amount of debt used by the firm is constant and risk-free, the interest tax savings are also risk-free. Then $\beta_{\text{Debt}_j} = 0$ and $\beta_{\text{Interest Tax Savings}_j} = 0$. Substituting the zero betas for debt and the interest tax savings into Equations (1) and (4), we get the following result:

$$\beta_{\text{Firm}_j} = \beta_{\text{Equity}_j}\left(\frac{\text{Equity Value}_j}{\text{Firm Value}_j}\right) = \beta_{\text{Unlevered Firm}_j}\left(\frac{\text{Firm Value}_{\text{Unlevered}_j}}{\text{Firm Value}_j}\right)$$

Solving Equation (3) for the value of the unlevered firm and substituting it into the above equation, we find the following relation between the beta of the equity of the levered firm and the beta of the unlevered firm:

$$\beta_{\text{Equity}_j} = \left[1 + (1 - T_c)\frac{\text{Debt Value}_j}{\text{Equity Value}_j}\right]\beta_{\text{Unlevered Firm}_j} \tag{5}$$

Note that Equation (5) is appropriate only for the special case where the level of debt financing is fixed and the tax savings from the interest deduction is risk-free. Although these are strong assumptions, equation (5) is widely used in practice to describe the relationship between levered and unlevered equity betas.

Case 2: Constant Debt to Value Ratio

In the alternative case (which we will encounter throughout the text), assume that the firm's ratio of debt to firm value, rather than the level of debt, is fixed. In other words, if the value of the firm increases, the firm increases its debt level so that its debt to value ratio remains constant. As a result, the firm's debt level (and consequently its interest tax savings) is perfectly correlated with the value of the firm. In this case, the risk of the interest tax savings is the same as the risk of the firm, implying that the beta of the firm's interest tax savings is equal to β_{Firm_j}.[13]

Substituting $\beta_{\text{Interest Tax Savings}_j} = \beta_{\text{Firm}_j}$ into Equation (4) results in $\beta_{\text{Firm}_j} = \beta_{\text{Unlevered Firm}_j}$. What this means is that the beta of the total firm is unaffected by how the firm is financed, which means that the beta of equity can be solved using Equation (2).

[13] This insight is due to J. Miles and R. Ezzell, "Reforming Tax Shield Valuation: A Note," *Journal of Finance*, XL (1985): 1485–1492.

Thus, in Case 2, we get the following relationship between the equity and firm, or unlevered betas:

$$\beta_{\text{Equity}_j} = \beta_{\text{Unlevered}_j}\left(1 + \frac{\text{Debt Value}_j}{\text{Equity Value}_j}\right) - \beta_{\text{Debt}_j}\left(\frac{\text{Debt Value}_j}{\text{Equity Value}_j}\right) \tag{6}$$

Solving for the unlevered beta, we get the following:

$$\beta_{\text{Unlevered}_j} = \frac{\beta_{\text{Equity}_j} + \beta_{\text{Debt}_j}\left(\dfrac{\text{Debt Value}_j}{\text{Equity Value}_j}\right)}{1 + \left(\dfrac{\text{Debt Value}_j}{\text{Equity Value}_j}\right)} \tag{7}$$

Summary of Equity Betas and Financial Leverage

Case 1 and Case 2 can be viewed as two extremes. In the first, the debt level is never updated and the firm maintains the same level of debt (in dollar terms) for all future periods. In the second case, the firm's capital structure is updated continuously to maintain a constant debt to value ratio.[14] Unless otherwise stipulated throughout the rest of the text, we will assume that the firm maintains a constant debt to value ratio and that it makes adjustments to its debt continuously. Consequently, we unlever beta estimates using Equation (7).

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[14] A more realistic case is one where the firm makes these adjustments annually. In this situation, the relationship between the levered equity beta and the unlevered firm's beta is:

$$\beta_{\text{Unlevered}_j} = \beta_{\text{Equity}_j}\left(\frac{1}{1 + \left(1 - T_c \times \dfrac{r_d}{1 + r_d}\right)\dfrac{\text{Debt}_j}{\text{Equity}_j}}\right) + \beta_{\text{Debt}_j}\left(\frac{\left(1 - T_c \times \dfrac{r_d}{1 + r_d}\right)\dfrac{\text{Debt}_j}{\text{Equity}_j}}{1 + \left(1 - T_c \times \dfrac{r_d}{1 + r_d}\right)\dfrac{\text{Debt}_j}{\text{Equity}_j}}\right) \tag{8}$$

Note that the only difference in the beta relationships found in Equations (7) and (8) is the presence of the product of the tax rate and the ratio of the annual rate of interest on the firm's borrowing, r_d, divided by 1 plus this rate, that is, $T_c \times \dfrac{r_d}{1 + r_d}$. Equation (8) is the appropriate relationship between the firm's equity beta with debt financing and the unlevered equity beta if the firm is assumed to update or readjust its capital structure annually. Equation (7), on the other hand, is the appropriate relationship if updating is continuous, the time between capital structure updates approaches zero, and the ratio $\dfrac{r_d}{1 + r_d}$ also approaches zero because r_d is the rate of interest applicable to the time between capital structure adjustments.

Although we typically estimate a company's beta using historical returns, we should always be mindful that our objective is to estimate the beta that reflects the relationship between risk and return in the future. The beta estimate is just that—an estimate—and is subject to estimation error. Fortunately, estimation errors can be addressed in a number of ways (see the Industry Insight box on page 120 on alternative beta estimation methods).

The most common approach involves using an average of a sample of beta estimates for similar companies, which has the effect of reducing the influence of random estimation errors. However, it is not enough just to select similar firms, say, from the same industry. Beta coefficients vary not only by industry (or with business risk) but also by the firm's capital structure. Firms that use more financial leverage have higher betas. Consequently, computing a beta from a sample of similar firms' betas is a multistep process. First, we must identify a sample of firms that face similar business risk (usually from the same industry). For example, in Table 4-1, we use three firms from the drug industry as well as Pfizer to calculate a beta for Pfizer. Second, we must "unlever" the betas for each of the sample firms to remove the influence of their particular capital structures on their beta coefficients. The relationship between levered and unlevered beta coefficients is defined in Equation (4.7) in Table 4-1. Third, we average the unlevered beta coefficients and finally relever them to reflect the capital structure of the firm in question.

In Table 4-1, the average unlevered beta for Pfizer and the other drug firms is .6582. If we relever this average beta (step 3) using Pfizer's debt-to-equity capitalization ratio of 17.86%, we get a levered beta estimate for Pfizer of .74. In this calculation, we place the same weight on Pfizer that we do on each of the other firms. But because Pfizer is obviously the best match for Pfizer, we may want to increase the weight assigned to Pfizer, say, to be equal to that of all the other firms. If we use this weighting scheme, we get an unlevered beta estimate of .6548, which produces a levered beta estimate of .72. In this instance, the difference in levered betas is not significant; however, this is not always the case, so the analyst may want to assign higher weight to the subject firm whose beta is being estimated.

Estimating the Market Risk Premium Determining the market risk premium requires a prediction of the future spread between the rate of return on the market portfolio and the risk-free return. Remember that the discount rate must reflect the opportunity cost of capital, which is in turn determined by the rate of return associated with investing in other risky investments. If one believes that the stock market will generate high returns over the next ten years, then the required rate of return on a firm's stock will also be quite high.

Common Valuation Mistakes: Failure to Risk-Adjust Comparison Firms

It is common practice when valuing a firm that is privately owned (i.e., its common stock is not publicly traded) to estimate the firm's beta using the observed betas of comparable firms that are publicly traded. For a variety of reasons, however, the **comparison firms (comps)** may have debt ratios that are very different than the debt ratio of the private company that is being valued. In this situation, the analyst should adjust the observed beta of the comparison firm for differences in the debt ratio by using Equation (4.7).

In the preceding analysis, we made the implicit assumption that the only difference between the private firm being valued and the publicly traded comps is related to their use of financial leverage. This is not always the case, however, and analysts often fail to ask why the comparison firm has a different debt ratio than that of the firm being valued. Very simply, the comparison firms may have a different debt ratio because their

Table 4-1 Estimating the Beta for Pfizer Using a Sample of Comparable Drug Firms—Unlevering and Levering Beta Coefficients

Step 1: Identify firms that operate in the same line of business as the subject firm (i.e., Pfizer). For each, either estimate directly or locate published estimates of its levered equity beta, β_{equity}; the book value of the firm's interest-bearing debt; and the market capitalization of the firm's equity.[15]

Company Name	Levered Equity Beta	Debt/Equity Capitalization	Assumed Debt Betas	Unlevered Equity Betas
Abbott Laboratories	0.7200	10.73%	0.30	0.6793
Johnson & Johnson	0.5800	6.88%	0.30	0.5620
Merck	0.8100	15.00%	0.30	0.7435
Pfizer	0.7100	17.86%	0.30	0.6479
			Average	0.6582

Step 2: Unlever the equity beta for each firm to get an estimate of the beta for each of the sample firms (including Pfizer) as if it used no financial leverage (i.e., $\beta_{unlevered}$), and

INDUSTRY INSIGHT

Alternative Beta Estimation Methods

The problems we noted with the estimated betas from historical return data led to the development of alternative methods for estimating betas. We will present two of those methods that have gained widespread usage: the BARRA method and the Bloomberg method.

The BARRA method is named for its founder, University of California professor of finance Barr Rosenberg. The basic thesis underlying BARRA's methodology is that a stock's beta is not stationary over time but varies with changes in the fundamental attributes of the firm. Consequently, BARRA developed a forward-looking beta that accounts for current firm characteristics in its beta estimates.

The method is based on research showing that betas estimated from historical returns alone were not as good at predicting future betas as betas that also incorporated consideration for fundamental variables such as an industry variable and various company descriptors. The BARRA method accounts for the fact that firms in some

[15] Typically, debt is estimated using the book value of the firm's interest-bearing liabilities (short-term notes payable, the current portion of the firm's long-term debt, plus long-term debt). Although we should use the market value of the firm's debt, it is customary to use book values because most corporate debt is thinly traded, if traded at all. The equity capitalization of the firm is estimated using the current market price of the firm's shares multiplied by the number of outstanding shares. Betas for individual stocks can be obtained from a number of published sources, including almost all online investment-information sources such as Yahoo! Finance or Microsoft's MoneyCentral website.

Table 4-1 *continued*

calculate the average for the four unlevered betas. We unlever the equity beta using the following relationship between levered (β_{Equity_j}) and unlevered ($\beta_{\text{Unlevered}_j}$) beta:[16]

$$\beta_{\text{Unlevered}_j} = \frac{\beta_{\text{Equity}_f} + \beta_{\text{Debt}_j}\left(\dfrac{\text{Debt Value}_j}{\text{Equity Value}_j}\right)}{1 + \left(\dfrac{\text{Debt Value}_j}{\text{Equity Value}_j}\right)} \tag{4.7}$$

where equity value$_j$ is equal to the current stock price times the number of outstanding shares of stock. We assume a debt beta of .30 for all firms.[17]

In the preceding example, the average unlevered beta is .6582.

Step 3: Relever the average unlevered equity beta to reflect the target firm's debt-to-equity capitalization ratio and corporate tax rate. The process of relevering equity betas is simply the reverse of the unlevering process. Technically, we solve Equation (4.7) for β_{equity} as follows:[18]

$$\beta_{\text{Equity}_j} = \beta_{\text{Unlevered}_j}\left(1 + \frac{\text{Debt Value}_j}{\text{Equity Value}_j}\right) - \beta_{\text{Debt}_j}\left(\frac{\text{Debt Value}_j}{\text{Equity Value}_j}\right)$$

then substitute the average unlevered beta of .6582 and Pfizer's debt-to-equity capitalization ratio of 17.86% and solve for $\beta_{\text{levered}} = .72$.

industries (such as agriculture and regulated utilities) tend to have low betas, while firms in others (such as electronics, air transportation, and securities firms) tend to have high betas. Income statement and balance sheet variables are also included in the model, since variables like dividend payout ratios and book-to-market also predict future betas.

A second alternative beta estimation model is provided by Bloomberg, a financial data company. The Bloomberg model adjusts betas estimated using historical data to account for the tendency of historical betas to regress toward the mean. To account for this tendency, the Bloomberg adjusted beta uses the following adjustment:

$$\begin{matrix}\text{Bloomberg}\\ \text{Adjusted Beta}\end{matrix} = .33 + .67\begin{pmatrix}\text{Unadjusted}\\ \text{Historical Beta}\end{pmatrix}$$

This adjustment makes all of the estimated betas closer to 1.

[16] It should be noted that analysts often apply Equation (4.7) under the assumption that the debt beta is zero.

[17] The beta on debt is in fact close to zero in cases where default is not too likely and when the firm's debt has approximately the same maturity as the maturity of the risk-free debt used to calculate betas. Because most analysts tend to use excess returns using short-term debt to calculate betas, the relevant betas of corporate bonds are between .2 and .4, depending on their default rating and maturity.

[18] If the corporate bond beta is assumed to be zero (as many analysts do), then the last term on the right-hand side of this expression drops out.

TECHNICAL INSIGHT

Geometric Mean Versus Arithmetic Mean

On January 3, 2015, the shares of Carebare Inc. were trading for \$100 a share. One year later, the shares had dropped to only \$50. In 2016, however, the firm experienced a banner year that doubled the share price, leaving it at \$100 on January 1, 2017. If you purchased the shares of Carebare on January 1, 2015, what rate of return did you realize when you sold them on January 1, 2017?

The obvious answer (not considering transaction costs) is 0% because you ended up exactly where you started, that is:

$$\begin{aligned}\text{Stock Price}_{2017} &= \text{Stock Price}_{2015}(1 + \text{HPR}_{2015})(1 + \text{HPR}_{2016})\\ &= \text{Stock Price}_{2015}(1 + \text{HPR}_{\text{Mean}})^2\end{aligned}$$

Thus, the mean annual holding period return (HPR) for the two-year period is found by solving for HPR_{Mean}:

$$\text{Stock Price}_{2015}(1 + \text{HPR}_{2015})(1 + \text{HPR}_{2016}) = \text{Stock Price}_{2015}(1 + \text{HPR}_{\text{Mean}})^2$$

Dividing thru by $\text{Stock Price}_{2015}$ and solving for HPR_{Mean}, we get the following:

$$\text{HPR}_{\text{Mean}} = [(1 + \text{HPR}_{2015})(1 + \text{HPR}_{2016})]^{1/2} - 1$$

It turns out that HPR_{Mean} is the *geometric mean* of the HPRs. For example, we can calculate this return by estimating the geometric mean of the returns earned in 2015 and 2016 as follows:

$$\begin{matrix}\text{Geometric}\\ \text{Mean}\end{matrix} = [(1 + -.50)(1 + 1.00)]^{1/2} - 1 = 0\%$$

On the other hand, the *arithmetic mean* of the HPRs for 2015 and 2016 is calculated as follows:

$$\begin{matrix}\text{Arithmetic}\\ \text{Mean}\end{matrix} = \frac{-50\% + 100\%}{2} = 25\%$$

business risk is more or less than the risk of the firm being valued. For example, small independent refineries can take on less debt than large public refineries like Valero Energy Corp. (VLO) because smaller refineries generally have higher cost operations and face greater product market risks than their large, publicly traded counterparts.

When there are important differences in the business risks of the subject firm and the comps used to estimate the subject firm's beta, the adjustment for financial leverage in Equation (4.7) will be incomplete because it adjusts only for financial risk and not business risk. To address this problem, the analyst must spend lots of effort selecting the best possible matching firms to use as comps.

Historical Estimates There is no getting around the fact that the market risk premiums that are used in applications of the CAPM are simply guesses. However, they should be educated guesses that are based on sound reasoning.

The difference between the geometric mean and the arithmetic mean is generally not as stark as in this example, but it serves to emphasize the points we want to make. The geometric mean return is the appropriate way to measure the annual rate of return earned during a particular historical return sequence. However, the geometric mean is not the best estimator of future returns unless we expect this sample path to be repeated in the future.

When all future sample paths are equally likely, the best estimate of the forward-looking returns is the arithmetic mean. Technically, we are assuming that each HPR is an independent observation from a stationary, underlying probability distribution. If we observe annual returns of 10%, −5%, 25%, and 20%, and these annual rates of return are assumed to represent random draws from a single underlying distribution of annual returns, then the best estimate of the mean of this distribution is the arithmetic mean, that is:

$$\begin{matrix}\text{Arithmetic} \\ \text{Mean}\end{matrix} = \frac{10\% - 5\% + 25\% + 20\%}{4} = 12.5\%$$

Note that we have calculated the expected rate of return for one year (not four years) to be 12.5%. What if we wanted to estimate the annual rate of return expected over the next five years? In this instance, we might estimate the annual rate of return realized over the previous five years using the geometric mean for that five-year period, for the five years before that, and so forth. Let's say that we estimated ten such geometric means for nonoverlapping five-year periods going back fifty years. Now, to estimate the expected annual rate of return over the next five years, we calculate the arithmetic mean of these five-year geometric rates of return.[19]

The idea, again, is that the geometric mean is the appropriate way to measure a historical return. However, if returns are drawn from independent and identically distributed distributions, the best estimator of the mean of that distribution is the arithmetic mean.

The approach taken by many analysts is to use past history as a guide to estimate the future market return premium. Figure 4-5 contains summary statistics on historical rates of return for US stocks and bonds spanning the period 1926–2013. Note that the geometric averages are always lower than arithmetic averages.[20] Although most textbooks use the arithmetic average, practitioners often prefer geometric averages. (For a discussion of geometric means versus arithmetic means, see the Technical Insight box.)

[19] It is obvious that our methodology for estimating five-year returns is limited by the number of five-year periods we observe. The problem gets even worse if we try to estimate the distribution of longer-period returns (say, of ten or twenty years). In practice, analysts restrict their attention to annual holding period returns because of the convention of quoting returns as annual rates.

[20] This reflects the fact that the geometric mean captures the effects of compound interest, whereas the arithmetic mean does not.

Figure 4-5 **Historical Stock and Bond Returns: Summary Statistics for 1926–2012**

	Mean		
	Geometric	Arithmetic	Standard Deviation
Large company stocks	9.8%	11.8%	20.2%
Small company stocks	11.9%	16.5%	32.3%
Long-term corporate bonds	6.1%	6.4%	8.3%
Long-term government bonds	5.7%	6.1%	9.7%
Intermediate-term government bonds	5.4%	5.5%	5.6%
Treasury bills	3.5%	3.6%	3.1%
Inflation	3.0%	3.1%	4.1%

Source: Ibbotson Associates, *SBBI 2013 Yearbook*.

Did You Know?

Do Estimates of the Market Risk Premium Change over Time?

Investment bankers often advise their clients about capital market conditions, including estimates of the market risk premium to use in determining their cost of equity capital. What you may not know is that their estimates of the market risk premium can vary with general economic conditions. For example, from the 1990s up until 2007, the market risk premiums recommended by investment bankers declined from over 7% to as low as 4% in some instances. However, the economic turmoil beginning in 2007 and the uncertainties surrounding the recovery in the years since, have led to the use of higher market risk premiums in investment bankers' cost of capital estimates.

Historical data suggest that the equity risk premium for the market portfolio has averaged 6% to 8% a year over the past seventy-five years. However, there is good reason to believe that, looking forward, the equity risk premium will not be this high. Indeed, current equity risk premium forecasts can be as low as 4%. For the examples in this text, we will use an equity risk premium of 5%, which is commonly used in practice.

CAPM with a Size Premium The CAPM is taught in almost all major business schools throughout the world. Unfortunately, the theory has only weak empirical support. Indeed, academic research has failed to find a significant cross-sectional relationship between the beta estimates of stocks and their future rates of return. Research finds that firm characteristics, like market capitalization and book-to-market ratios, provide much better predictions of future returns than do betas.[21] In response to these observations, academics have proposed modifications of the CAPM that incorporate consideration for differences in stock returns related to these firm characteristics.

To illustrate how a size premium might be added to the CAPM, consider the methodology followed by Ibbotson Associates in their 2013 yearbook, which divides firms into four discrete groups based on the total market value of their equity: *Large-cap firms,* those with more than $7.687 billion in market capitalization, receive no size premium; *mid-cap firms,* with between $7.687 billion and $1.912 billion in equity

[21] E. Fama and K. French, "The Cross-Section of Expected Stock Returns," *Journal of Finance* 47 (1992): 427–465.

value, receive a size premium of 1.12%; *low-cap firms,* with equity value between \$1.912 billion and \$514 million, receive a size premium of 1.85%; and *micro-cap firms,* with equity values below \$514 million, receive a size premium of 3.81%. Thus, the expected rate of return on equity using the size-adjusted CAPM is described in Equation (4.8) below:

$$k_e = k_{rf} + \beta(k_m + k_{rf}) + \begin{cases} \text{Large cap: } 0.0\% \text{ if Market cap} > \$7.687 \text{ billion} \\ \text{Mid cap: } 1.12\% \text{ if } \$7.687 \text{ billion} \geq \text{Market cap} > \$1.912 \text{ billion} \\ \text{Low cap: } 1.85\% \text{ if } \$1.912 \text{ billion} \geq \text{Market cap} > \$.514 \text{ billion} \\ \text{Micro cap: } 3.81\% \text{ if Market cap} \leq \$.514 \text{ billion} \end{cases} \quad (4.8)$$

Factor Models A second approach that was introduced in the 1980s is the use of multifactor risk models that capture the risk of investments with multiple betas and factor risk premiums. These risk factors can come from macroeconomic variables, like changes in interest rates, inflation, or gross domestic product (GDP), or from the returns of what are known as factor portfolios. Factor portfolios can be formed using purely statistical procedures, like factor analysis or principal components analysis, or by grouping stocks based on their characteristics.

For example, the *Fama-French three-factor model* captures the determinants of equity returns using three risk premiums:[22] the market risk premium of CAPM, a size risk premium, and a risk premium related to the relative value of the firm when compared to its book value (historical cost-based value). The Fama-French equation for the cost of equity capital includes three factors with their associated risk premiums (thus the use of the term *three-factor model*), as shown in Equation (4.9):

$$k_e = k_{rf} + b \times (\text{ERP}) + s \times (\text{SMBP}) + h \times (\text{HMLP}) \quad (4.9)$$

where

k_e = the required rate of return for the common stock of the firm

k_{rf} = the risk free rate of interest (assumed to be 3%)

b, s, and *h* are estimated coefficients for the particular firm whose cost of equity is being evaluated

ERP = equity risk premium, equal to the difference in the expected rate of return from investing in the market portfolio of equities and the long-term risk-free rate of interest (as noted earlier, we use an ERP of 5%)

SMBP = the small-minus big-risk premium, estimated from historical return differences in large- and small-cap stocks (3.23%)

HMLP = the high-minus low-risk premium, estimated as the difference between the historical average annual returns on the high book-to-market (value) and low book-to-market (growth) portfolios (4.08%).[23]

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[22] E. Fama and K. French, "Common Risk Factors in the Returns on Stocks and Bonds," *Journal of Financial Economics* 33 (1993): 3–56.

[23] The equity risk premium (ERP) used here is our estimate, while the two remaining risk premia represent average risk premia as reported in Ibbotson Associates, *Cost of Capital Yearbook for 2013,* p. 12.

Implementing the Fama-French model requires estimates of the three factor coefficients (i.e., b, s, and h). These coefficients can be estimated from the following multiple regression of a firm's common stock returns on the historical returns of the three factor portfolios. We illustrate the use of the Fama-French three-factor model for Apple Computer Corporation. Estimates of b, s, and h are found below, using returns for the 60-month period ending with December 2013, and using the regression model in Equation (4.10).

$$(R_{\text{Apple}} - R_f)_t = \alpha + b(R_m - R_f)_t + s(R_S - R_B)_t + h(R_H - R_L)_t + \epsilon_t \quad (4.10)$$

where

$(R_m - R_f)_t$ = the market's return minus the risk free rate (ERP) for month t

$(R_s - R_B)_t$ = the difference in returns from portfolios of small and large company stock returns for month t (i.e., SMBP)

$(R_H - R_L)_t$ = the difference in returns from portfolios of high and low book-to-market stocks for month t (i.e., HMLP)

ϵ_t = the regression error term

Historical monthly values for the three factor portfolio returns dating back to 1927 and daily data back to 1963 can be found on Kenneth French's website.[24] (See the Technical Insight box on calculating the Fama-French risk premia.)

We estimate Apple's (APPL) cost of equity by substituting into Equation (4.10) as follows:

Coefficients	Coefficient Estimates	Risk Premia	Product
b	0.9718	5.00%	4.86%
s	0.1482	3.23%	0.48%
h	−0.5795	4.08%	−2.36%
		Risk premium =	2.98%
		+ risk-free rate =	3.00%
		cost of equity	5.98%

The resulting estimate of Apple's cost of equity in this example is 5.98%, which is less than the 7.10% we got using the standard CAPM.

To explore the magnitude of the differences between the cost of equity estimates using the Fama-French three-factor model and the standard CAPM, we present the cost of equity using each method for a variety of stocks in Table 4-2. A quick review of the two estimates of the cost of equity (Fama-French and traditional CAPM) found in this table indicates that the estimates are very similar for most firms. However, the average difference in estimates of the cost of equity across this small sample of firms is slighly more than 2%.

Which model provides a better estimate of the cost of equity? The empirical evidence shows that the three-factor model better explains historical returns than the traditional one-factor CAPM does, which is not surprising, given that the model was designed to

[24] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

Table 4-2 **Fama-French Versus CAPM Estimates of the Cost of Equity**

Company Name	Fama-French Coefficients *b*	*s*	*h*	FF Cost of Equity	CAPM Beta	CAPM Cost of Equity	CAPM Minus FF Cost of Equity
Apple Inc	0.9716	0.1586	(0.5859)	5.98%	0.82	7.10%	1.12%
IBM	0.6801	(0.0017)	(0.5720)	3.84%	0.49	5.43%	1.59%
Merck & Co	0.7705	(1.0911)	(0.0308)	3.20%	0.52	5.58%	2.38%
Pepsico	0.4957	(0.4501)	(0.0300)	3.90%	0.37	4.83%	0.92%
Pfizer	0.9404	(1.1152)	(0.3177)	5.40%	0.78	6.88%	1.48%
Wal Mart	0.1597	0.2979	(0.2502)	5.78%	0.35	4.74%	−1.04%

explain these returns. However, the cost of equity is a forward-looking concept, and we consider historical returns only because they provide guidance about what we can expect to observe in the future. If we believe that the past is a good indicator of the future, then we should use the three-factor model. However, one might believe that the relatively high returns of value stocks and low returns of growth stocks represent a market inefficiency that is not likely to exist in the future, now that the value effect is very well known. In this case, one might prefer traditional CAPM, which is better grounded in theory.

TECHNICAL INSIGHT

Calculating the Fama-French Risk Premia

Annual, monthly, and daily estimates for each of the three sources of risk in the Fama-French three-factor model can be found on Ken French's website. Each of the factors is defined as follows:

- $R_m - R_f$, the excess return on the market, is the value-weighted return on all NYSE, AMEX, and NASDAQ stocks (from CRSP) minus the one-month Treasury bill rate (from Ibbotson Associates).
- $R_S - R_B$ is the average return on three small portfolios minus the average return on three big portfolios:

$$R_S - R_B = 1/3\,(\text{small value} + \text{small neutral} + \text{small growth}) - 1/3\,(\text{big value} + \text{big neutral} + \text{big growth})$$

- $R_H - R_L$ is the average return on two value portfolios minus the average return on two growth portfolios:

$$R_H - R_L = 1/2\,(\text{small value} + \text{big value}) - 1/2\,(\text{small growth} + \text{big growth})$$

See E. Fama and K. French, "Common Risk Factors in the Returns on Stocks and Bonds," *Journal of Financial Economics* 33 (1993): 3–56, for a complete description of the factor returns.

Limitations of Cost of Equity Estimates Based on Historical Returns The problems that arise with the use of historical returns to estimate the cost of equity relate to the fact that the past returns and consequently risk premia are frequently not very reliable predictors of future risk premia. Specifically, three fundamental problems are associated with using historical returns as the basis for estimating the equity risk premium: (1) Historical returns vary widely over time, resulting in large estimation errors; (2) recent changes in the tax status of equity returns and the rapid rate of expansion in access to global equity markets may have driven down the equity risk premium; and (3) historical returns over the long term, at least in the United States, may be too high relative to what we can expect in the future. The US economy did exceptionally well in the last century, and we don't necessarily expect that performance to be repeated.

Historical Security Returns Are Highly Variable From Figure 4-5, we see that the average historical return on a portfolio of large stocks over the period 1926 through 2012 was about 11.8%. Over this period, the average long-term Treasury bond return was 6.1%, implying that the excess return on large stocks was about 5.7%. The standard deviation of these returns was 20.2%, which implies that the standard error of the equity risk premium is approximately 2%.[25] What this means is that the 95% confidence interval of the estimate of the equity risk premium is from 1.7% to 9.7%. Clearly, the breadth of this confidence interval suggests that the most prudent course of action is to interpret historical data as suggestive rather than definitive.

Market Conditions Are Changing Looking forward, we can say that there are at least three key market factors that have changed over time and that can potentially lead to an equity risk premium that is lower in the future than it was in the past. The first has to do with taxes; the second, with increased participation in the stock market; and the third, with the increased globalization of security markets.

The tax rate on dividend income, interest income, and capital gains fluctuates over time, making equity more or less tax-favored in different time periods. When equity is more tax-favored, the return premium on equity should be lower relative to the rates on Treasury bonds. In the United States, equity is more tax-favored today than at any time in recent history. The Jobs and Growth Tax Relief Reconciliation Act of 2003 reduced the maximum tax rate on dividends to 15%. Previously, dividend income was taxed as ordinary income, with rates up to 35%. Thirty years ago, dividends were taxed at 70%.

A second change in market conditions that is likely to affect the equity risk premium in the future relates to the growing number of individuals who participate in the equity market either by direct investments or by indirect investing via their retirement funds. Whereas the equity markets were once dominated by a limited number of wealthy investors, this is no longer the case. An important factor underlying this change was the passage of the Employment Retirement Income Security Act (ERISA) in 1974 and the growth in pension plans that ensued. Today, more than half the equity securities in the United States are held by institutional investors, including mutual funds and pension plans. The broadening participation of more individuals in the public equity markets has led to a sharing of the risk of equity ownership and may have driven down the equity risk premium.

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[25] The standard error of the sample mean return is calculated as follows: $\sigma_{\text{Annual Returns}} \div \sqrt{n-2}$, where the standard deviation in annual returns is 20.2% and n is the number of annual returns in the sample, which here is 78, resulting in an estimate of the standard error of the sample mean of 2.3%.

Still another factor that can lead to a lower equity risk premium in the future relates to the effects of improved investor access to global markets. This increased access tends to drive down required rates of return (and consequently the equity risk premium) due to the increased opportunities for diversification and greater participation by more investors who share the risks associated with equity investments.[26]

Historical Returns Exhibit Survivor Bias The final problem that we encounter when using historical returns to estimate future equity risk premia relates to the fact that the historical market returns used by researchers reflect the performance of stock markets that have done relatively well. That is, only the winners in the financial markets, such as the United States and the United Kingdom, survive to be analyzed and incorporated into the record of historical returns. Indeed, very few markets have an uninterrupted period of surviving for over seventy-five years. History teaches us that we cannot confidently forecast that the next seventy-five years will be equally successful.

Method 2—Discounted Cash Flow or Imputed Rate of Return Approaches

Up to this point, we have estimated expected rates of return using the past return history as our guide. As the above discussion indicates, however, past returns may be an overly optimistic indicator of expected future returns. In this section, we will describe a method of estimating the return on the market that uses *forward-looking* rather than *historical* estimates of *equity risk premia.*

Our forward-looking approach starts with the familiar DCF model. Instead of using the DCF model to determine the value of an investment, however, the method takes observed values and estimated cash flows and uses the DCF model to calculate the internal rate of return, or the *implied* cost of equity capital. As we discuss below, analysts apply this methodology in two related ways. Some use the method to arrive at an estimate of the market return premium that can be used to generate a CAPM-based estimate of the cost of equity. Others use the method to estimate directly a forward-looking cost of equity for individual firms.

Single-Stage DCF Growth Model We discuss two variants of the DCF model. The first is the Gordon growth model, which assumes that the firm's dividends grow at a constant rate forever (i.e., that there is a single growth rate or single stage of growth). The resulting single-stage DCF model of equity value can easily be deduced from the general DCF model found in Equation (4.11a):

$$\text{Stock Price}_0 = \sum_{t=1}^{\infty} \frac{\text{Div}_{\text{Year } t}}{(1 + k_e)^t} \tag{4.11a}$$

where

Stock price_0 = the current stock price of the firm's shares

$\text{Div}_{\text{Year}\,t}$ = expected dividend for year t

k_e = the cost of equity capital

[26] Rene Stulz suggests that the increased investment opportunity set would reduce the expected risk premium to about two-thirds of the average since 1926 (Rene Stulz, "Globalization of Capital Markets and the Cost of Capital: The Case of Nestlé," *Journal of Applied Corporate Finance* 8, no. 3 (Fall 1995).

When the firm's dividends are expected to grow at a constant rate, g, forever and this rate is less than the firm's cost of equity capital, the above valuation expression can be reduced to the following:

$$\text{Stock Price}_0 = \frac{\text{Div}_{\text{Year}\,0}(1 + g)}{k_e - g} = \frac{\text{Div}_{\text{Year}\,1}}{k_e - g} \qquad (4.11b)$$

Consequently, the cost of equity can be found by solving for k_e in Equation (4.11c):

$$k_e = \frac{\text{Div}_{\text{Year}\,1}}{\text{Stock Price}_0} + g \qquad (4.11c)$$

Analysts typically solve for k_e by observing the most recent dividend paid over the last twelve months, $\text{Div}_{\text{Year }0}$, along with the most recent stock price for the company's shares, and using analysts' earnings growth rate estimates to estimate the growth rate in the firm's dividends. Depending on how the cost of equity estimate is to be used, firms will either use dividend growth estimates from stock analysts who cover the firm or they will use their own internal estimates.

To illustrate, consider the case of Duke Energy Corporation (DUK), which is involved in a number of businesses, including natural gas transmission and electric power production. In 2013, the company paid a dividend of \$3.12 per share, and on February 26, 2014, the firm's stock closed trading at a price of \$70.91. The analysts' expected rate of growth in earnings for 2014 through 2019 is 3.92% per annum.[27] Because Equation 4.11c assumes that the firm's dividends grow forever at a constant rate, we use the five-year estimate to estimate Duke's cost of equity capital as follows:

$$k_e = \frac{\text{Div}_{\text{Year}\,0}(1 + g)}{P_E} + g = \frac{\$3.12(1 + .0392)}{\$70.91} + .0392 = .085 \text{ or } 8.5\%$$

Aggregating the Forward-Looking Equity Risk Premia The method we have just used to impute the equity required rate of return for one firm can also be used to estimate the market's equity risk premium. The method requires that the equity risk premia for a broad sample of individual firms be estimated and then aggregated across the sample. A number of recent studies have performed this analysis, and the principal feature of the empirical evidence regarding forward-looking equity risk premia is that they are much lower than the estimates based on historical data.[28]

Three-Stage Growth Model The second variant of the DCF model differs from the first only in that it provides for *three* different growth rates, corresponding to three stages of a company's growth. Specifically, this model provides for different dividend

[27] Based on the Yahoo! Finance five-year earnings growth rate estimate (http://finance.yahoo.com/q/ae?s=DUK+Analyst+Estimates).

[28] Specifically, forward equity risk premia estimated in recent years for the US equity market have been 3% or less. Some researchers have argued that the historical estimates of an 8% equity risk premium (using the Treasury bills to proxy for the risk-free rate) and 5% (where long-term US Treasury bonds are used to proxy the risk-free rate) have never been realistic except at market bottoms or at times of crisis (i.e., war).

BEHAVIORAL INSIGHT

Managerial Optimism and the Cost of Capital

The tendency of managers to be overly optimistic about their own firm's prospects is a well-documented behavioral bias. However, this bias may be a less serious problem when the cost of capital is calculated using an inputed rate of return. Very simply, the effect of overoptimism on the firm's earnings and dividend estimates leads to an offsetting upward bias in the cost of equity estimate.

To illustrate, let's consider the estimate of Duke Energy Corporation's (DUK) cost of equity from the above example. If Duke's internal analysts are making their own estimates about future growth in the firm's earnings and dividends, they may feel that 5% is a reasonable estimate, whereas market analysts used 3.92%. The effect of Duke's optimistic estimate of the future rate of growth in earnings and dividends is to increase the cost of equity from 8.45% to 9.6%. This higher discount rate tends to counter the effects of excessive optimism that these same analysts may exhibit when estimating the future cash flows of Duke's investment opportunities.

growth rates for years 1 through 5, 6 through 10, and 11 and beyond. The corresponding three-stage growth model can be written as shown in Equation (4.12):

$$\begin{aligned}\text{Stock Price}_{\text{Year}_0} = {} & \sum_{t=1}^{5} \frac{\text{Div}_{\text{Year}0}(1 + g_{\text{Years 1 to 5}})^t}{(1 + k_e)^t} \\ & + \sum_{t=6}^{10} \frac{\text{Div}_{\text{Year}0}(1 + g_{\text{Years 1 to 5}})^5 (1 + g_{\text{Years 6 to 10}})^{t-5}}{(1 + k_e)^t} \\ & + \left(\frac{\text{Div}_{\text{Year}0}(1 + g_{\text{Years 1 to 5}})^5 (1 + g_{\text{Years 6 to 10}})^5 (1 + g_{\text{Years 11 and beyond}})}{k_e - g_{\text{Years 11 and beyond}}} \right) \\ & \times \frac{1}{(1 + k_e)^{10}} \end{aligned} \tag{4.12}$$

Given estimates of the three growth rates ($g_{\text{Years 1 to 5}}$, $g_{\text{Years 6 to 10}}$, and $g_{\text{Years 11 and beyond}}$), the current period dividend ($\text{Div}_{\text{Year 0}}$), and the current stock price ($\text{Stock Price}_{\text{Year 0}}$), we can solve for the cost of equity (k_e).

The advantage of the three-stage model is its flexibility to incorporate different growth rates over the life cycle of the firm. The corresponding disadvantage, of course, is that it requires that these growth rates be estimated. Ibbotson Associates uses the I/B/E/S expected rate of growth in earnings to estimate the first growth rate and the average rate of historical growth in earnings for the firm's industry to estimate the second. For the third growth rate, it uses a rate that reflects the long-term rate of growth in GDP and long-term inflation forecast; for 2013, this growth rate was 3.22%.[29]

[29] One further caveat needs to be mentioned with regard to Ibbotson's three-stage growth model. Because many firms do not pay dividends, Ibbotson Associates replaces dividends with cash flow in the first two terms and uses earnings per share before extraordinary items in the third term. In the latter case, the earnings substitution for cash flow reflects the assumption that, over time, depreciation and capital expenditures will be roughly equal so that cash flow is equal to earnings.

PRACTITIONER INSIGHT

Market-Implied (Ex Ante) Market Risk Premia—An Interview with Justin Pettit*

Wall Street analysts estimate the market risk premium (MRP) in one of two ways. The MRP is typically estimated using the average spread of historical equity returns over a US Treasury yield. Because this method uses only historical data, we can think of it as the ex post method. The MRP is also estimated using professional analysts' expectations of future performance and the Gordon growth model [see Equation (4.11b)], which is the ex ante method.

The Gordon dividend discount model is a single-stage growth model [see Equation (4.11b)] that can be rewritten for purposes of estimating the MRP. If we apply the Gordon model to the market for all common equity, then solve for the required rate of return on equity and subtract the risk-free rate of interest, we estimate the MRP as follows:

$$\text{MRP} = \left(\frac{\text{Div}_{\text{Year}\,0}(1+g)}{\text{Market Cap}} + g\right) - k_f$$

where

$\text{Div}_{\text{Year}\,0}$ = the most recent year's annual dividend payment for the market as a whole market cap = the total market value of all equities

g = the estimated long-term dividend growth rate for all stocks in the economy

Because the constant growth rate assumption of the single-stage Gordon model is problematic for a single company, analysts feel that it is more useful for a broad market.[30]

Analysts typically estimate the growth rate as the product of the average return on equity (ROE) and the reinvestment rate for all equities, where the reinvestment rate is simply 1 minus the fraction of firm earnings distributed to shareholders

To illustrate the methodology, consider Rushmore Electronics, which is a small but fast-growing company headquartered in Portland, Oregon. The firm went public two years ago, and the firm's stock currently sells for \$24.00 per share, with cash dividends per share of \$2.20. Over the past ten years, Rushmore's earnings grew at a compound annual rate of 10% per year. Analysts project that the firm's earnings will grow at a rate of 14% per year over the next five years. The economy is expected to grow at a rate of

[30] The ex ante model described here follows a top-down approach because it focuses on the aggregate return to the market for equities as a whole. An alternative method that we discuss in the text begins by estimating the ERP for individual stocks and then aggregating them to form an estimate of the ERP for all equities. This is the bottom-up approach.

through dividends and share repurchases. This is an ex ante approach to estimating future growth rates because it uses current market information to impute the market's expected Market Risk Premium (MRP). For example, a 10% ROE and 65% reinvestment rate implies a 6.5% growth rate. Note that we are using total distributions rather than the dividend yield because firms increasingly pay out cash via share repurchases rather than dividends. Regardless of the mechanism, these funds are not reinvested.

The following table which assumes a risk-free rate of 4.7%, shows a range of potential market risk premia as a function of assumed perpetual growth rates and distributed yields (i.e., ratios of cash distributions through dividends and share repurchases divided by the current market capitalization):

Market Risk Premium		**Nominal Perpetual Growth Rate**				
		4%	5%	6%	7%	8%
Distributed Yield	1%	0.3%	1.3%	2.3%	3.3%	4.3%
	2%	1.3%	2.3%	3.3%	4.3%	5.3%
	3%	2.3%	3.3%	4.3%	5.3%	6.3%
	4%	3.3%	4.3%	5.3%	6.3%	7.3%

Analysts typically arrive at an estimate of 4% to 5% for the MRP under growth-rate assumptions of 5% to 7% and distributed yields of 3% to 4%. The 5% to 7% consensus estimates of long-term sustainable (nominal) growth rates are consistent with expected inflation of 2% to 3% and real GDP growth of 3% to 4%.

*Justin Pettit is a partner at Booz Allen Hamilton in New York City.

6.5%. Substituting into Equation (4.12), we get the following equation, in which the only unknown is the cost of equity, k_e:

$$\$24.00 = \sum_{t=1}^{5} \frac{\$2.20(1 + .14)^t}{(1 + k_e)^t} + \sum_{t=6}^{10} \frac{\$2.20(1 + .14)^5(1 + .10)^{t-5}}{(1 + k_e)^t} + \left(\frac{\$2.20(1 + .14)^5(1 + .10)^5(1 + .065)}{k_e - .065}\right)\frac{1}{(1 + k_e)^{10}}$$

Solving for k_e produces an estimate of Rushmore's cost of equity of 20.38%.[31]

[31] This problem is easily solved in a spreadsheet using built-in functions (for example, in Excel, the function is Goal Seek).

In this example, we have followed the Ibbotson Associates approach by making the first two growth periods five years long and by using their prescription for the estimation of stages 2 and 3 growth rates. If the analyst has good reason to believe that either the length of the growth periods or the specific growth rates should be different, these estimates should be used.

Calculating the WACC (Putting It All Together)—Step 3

The final step in the estimation of a firm's WACC involves calculating a weighted average of the estimated costs of the firm's outstanding securities. To illustrate the three-step process used to estimate WACC, consider the case of Champion Energy Corporation, which was founded in 1987 and is based in Houston, Texas. The company provides midstream energy services, including natural gas gathering, intrastate transmission, and processing in the southwestern Louisiana and Texas Gulf Coast regions. The company operates approximately 5,500 miles of natural gas gathering and transmission pipelines and seven natural gas processing plants.

Evaluating Champion's Capital Structure

A condensed version of Champion's liabilities and owners' equity is found in the first two columns of Table 4-3. Champion wants to reevaluate its cost of capital in light of its plans to make a significant acquisition to expand its operations in January and needs

Table 4-3 Liabilities and Owners' Equity for Champion Energy Corporation

	December 31, 2014	
Liabilities and Owners' Capital ($000)	**Balance Sheet (Book Values)**	**Invested Capital (Market Values)**
Current liabilities		
Accounts payable	$ 150,250.00	
Notes payable	—	$ —
Other current liabilities	37,250.00	
Total current liabilities	$ 187,500.00	$ —
Long-term debt (8% interest paid semiannually, due in 2020)	750,000.00	2,000,000.00
Total liabilities	$ 937,500.00	2,000,000.00
Owners' capital		
Common stock ($1 par value per share)	$ 400,000.00	
Paid-in-capital	1,250,000.00	
Accumulated earnings	2,855,000.00	
Total owners' capital	$4,505,000.00	8,000,000.00
Total liabilities and owners' capital	$5,442,500.00	$10,000,000.00

an additional \$1.25 billion. Based on discussions with the firm's investment banker, Champion's management plans to increase the firm's long-term debt from the current level of \$0.75 billion up to \$2 billion. Given current market conditions, the yield on the additional debt is 5.25%. Increasing the firm's use of borrowed funds is appealing to Champion's management because the interest expense offsets taxable income at the 25% tax rate faced by the firm.

Champion's CFO called in his chief financial analyst and asked that she make an initial estimate of the firm's WACC, assuming the firm went through with the \$1.25 billion debt offering and assuming that the nature of the firm's operations and business risk are not affected by the use of the net proceeds. The analyst began by evaluating the firm's capital structure under the assumption that the new debt offering was consummated. Because the effect of the offering on the value of the firm's equity was uncertain, she assumed, as a first approximation, that the total market value of the firm's shares would be unchanged. Based on the current market price of \$20.00 per share, she calculated the market capitalization of the firm's equity to be \$8 billion.

The third column of Table 4-3 contains the results of the analyst's investigation into Champion's proposed capital structure following the new debt issue. Champion's total invested capital is equal to \$10 billion, which includes interest-bearing debt of \$2 billion and the firm's equity capitalization of \$8 billion (\$20.00 per share multiplied by 400 million shares). Consequently, the capital structure weights are 20% debt and 80% equity.

Estimating Champion's Costs of Debt and Equity Capital

Based on current yields to maturity for Champion's new debt offering, we estimate the before-tax cost of debt financing to be 5.25%. Because Champion enjoys an investment-grade bond rating, we can use the yield to maturity as a reasonable approximation to the cost of new debt financing. Adjusting the 5.25% yield for the firm's 25% tax rate produces an after-tax cost of debt of $3.94\% = 5.25\%(1 - .25)$.

To calculate the cost of equity, three estimates were used: the CAPM, the three-factor Fama-French, and the three-stage DCF models.[32] The resulting estimates are found below:

Cost of Equity Model	Estimated Cost of Equity
CAPM	6.25%
Three-factor Fama-French	7.25%
Three-stage DCF models	8.55%

The average of the three estimates of the cost of equity is 7.35%, and the analyst decided to use this as her initial estimate of the cost of equity capital to calculate the firm's WACC.

[32] These cost of equity estimates represent the large industry composite for SIC 4924 (Natural Gas Distribution), as estimated by Ibbotson and Associates, *Cost of Capital 2013 Yearbook* (data through 2012).

Calculating Champion's WACC

The WACC for Champion's proposed capital structure is calculated as follows:

Source of Capital	Capital Structure Weight (Proportion)	After-Tax Cost	Weighted After-Tax Cost
Debt	20%	3.94%	0.00788
Equity	80%	7.35%	0.05880
		WACC =	.0668 or 6.68%

Therefore, we estimate Champion's WACC to be 6.68%, based on its planned use of debt financing and operating plans.

Taking a Stand on the Issues—Estimating the Firm's Cost of Capital

Our discussion of the estimation of the cost of capital began by enumerating three basic issues that had to be addressed. In the process of reviewing all the ins and outs of the estimation process, it is apparent that analysts must make a lot of decisions that can have a material effect on the cost of capital estimate. Here we briefly recap each of the issues that must be addressed and summarize the procedures that we feel represent the best thinking on each issue.

Figure 4-6 lists each of the basic issues we have addressed in the estimation of the cost of capital to this point. The salient points are as follows:

- Use market value weights to define a firm's capital structure and omit non-interest-bearing debt from the calculations. If the firm plans to change its current use of debt and equity, then the target weights should replace current weights.
- If the cost of capital is used to discount distant future cash flows, use the yield on a long-term bond to estimate the market risk premium, as well as to calculate the excess market returns that are used to estimate the beta.
- When the firm issues investment-grade debt, use the yield to maturity (estimated using current market prices and promised interest and principal payments) to estimate the cost of debt. When the firm's debt is speculative-grade, however, the yield to maturity on the firm's debt (which represents the promised, not expected, yield on the debt) overestimates the cost of debt financing.
- Use multiple methods for estimating the cost of equity capital. This is the single most difficult estimate the firm will make. Using both asset pricing models and discounted cash flow models provides independent estimates of the cost of equity.
- Because the cost of capital is used to discount cash flows that occur in the future, the focus of our analysis should be forward-looking. This does not mean that we ignore historical data. It does mean, however, that historical data are useful only if they help us better understand the future. Indeed, the equity risk premium for the market is typically estimated as an average of past returns, which implies a market risk premium of 6% to 8%. However, a number of studies that utilize the expectations of investment professionals to infer an equity risk premium found it to be much lower. The estimates for the forward-looking market risk premium are in the 3% to 5% range.

Figure 4-6 Issues and Recommendations on the Estimation of a Firm's Cost of Capital

Topic	Issues	Best Practices
(1) Defining the firm's capital structure	What liabilities should be included in defining the firm's capital structure?	Include only those liabilities that have an explicit interest cost associated with them. Specifically, exclude non-interest-bearing liabilities such as accounts payable.
	How should the various sources of capital in the capital structure be weighted?	Weights should reflect the current importance of sources of financing, which, in turn, is reflected in current market values. However, because corporate bonds do not trade often, if at all, and a large component of corporate debt is private debt (i.e., bank loans), which does not have an observable market value, book values are often used.
(2) Choosing the appropriate risk-free rate of interest	What maturity is appropriate for the risk-free government security?	U.S. government debt is the best representation of a risk-free security. However, asset pricing theory provides little guidance as to whether a short-term, intermediate-term, or long-term U.S. Treasury security should be used. Standard practice now is to use a long-term government bond.
(3) Estimating the cost of debt financing	How do you estimate the expected rate of return on investment-grade debt?	Current yields to maturity serve as a reasonable proxy for the expected cost of debt.
	How do you estimate the expected rate of return on speculative or below-investment-grade debt?	Adjustments for the risk of default and recovery rates become important when the prospect of default is significant. The adjustments lead to an estimate of the expected rate of return to the firm's creditors that is based on expected cash flows rather than promised cash flows.
(4) Estimating the cost of equity financing	What model should be used to estimate the cost of equity financing?	Two classes of models are widely used in the estimation of the cost of equity financing: One is based on asset pricing theory, and the other is based on discounted cash flow. Given the inherent difficulties involved in estimating the cost of equity capital, it is wise to use both types of models in an effort to define the potential range of equity capital costs.
	Should historical or forward-looking data be the basis for estimating the cost of common equity?	Historical data are useful only in estimating the cost of capital to the extent that these data are informative about future returns. Thus, in general, forward-looking information is more consistent with the objective of the analysis than are historical data.
	How large is the equity risk premium?	Historical data suggest that the equity risk premium for the market portfolio has averaged 6% to 8% a year over the past 75 years. However, there is good reason to believe that this estimate is far too high. In fact, the equity risk premium according to recent estimates lies in the range of 3% to 4%. We recommend a 5% equity risk premium for the market.

4.4 Summary

The estimation of a firm's WACC involves three fundamental activities: evaluating the composition of the firm's capital structure, estimating the opportunity cost of each source of capital, and calculating a weighted average of the after-tax cost of each source of capital.

The WACC is used extensively throughout the world. Firms use their own WACCs to calculate whether they are under- or overvalued. Hence, a firm's WACC influences how other firms respond to acquisition offers, and because firms are reluctant to issue undervalued securities, the WACC calculation also influences financing choices. As we will discuss in Chapter 7, firms often use their WACC to evaluate the extent to which their managers are able to generate returns that exceed their firms' cost of capital.

The main focus in this text is on how firms evaluate investment opportunities. In this regard, the WACC plays a key role. When firms evaluate opportunities to acquire other firms, they calculate WACC of the acquisition candidate. We will be discussing this in more detail in Chapter 9. When firms evaluate an investment project, they need a discount rate that we will refer to as the project WACC. Discussion of the project WACC is the focus of Chapter 5.

EXERCISES

4-1 THOUGHT QUESTION As a summer intern, you are asked to prepare a spreadsheet calculating the project free cash flow associated with a project your employer is considering. Initially your boss assumes that no debt will be used to fund the project. During your presentation to the committee that evaluates projects, you learn that, in fact, the project will be financed with 25% debt. Determine whether the following statements are true or false, and explain your answer:

a. You need to go back to your office and adjust the project's free cash flows to include the interest on the debt.
b. You need to go back to your office and adjust the project cash flows to update the taxes paid due to the tax shield provided by taking on debt.
c. Your cash flow model does not need to be updated because the financing of the project does not affect the free cash flow calculation.

4-2 THOUGHT QUESTION Describe the difference between a promised cash flow and an expected cash flow. If promised cash flows tend to be higher than expected cash flows, should they be discounted at rates that are higher or lower than the firm's WACC?

4-3 CALCULATING A FIRM'S WACC Nestlé Enterprises is estimating its cost of capital for the first time and has made the following estimates: The firm's debt carries a AAA rating, which is currently yielding 6%; the firm pays taxes at a rate of 30%; the cost of equity is estimated to be 14%; and the firm's debt is equal to 20% of its enterprise value.

a. What is Nestlé's estimated WACC?
b. If Nestlé were to increase its debt level to 40% of enterprise value, the firm's investment banker has told the firm that its credit rating would drop to AA and correspondingly its cost of debt financing would rise to 7%. If the cost of equity corresponding to this new capital structure were to rise to 16%, what would be the firm's estimated WACC?

4-4 CALCULATING THE PROMISED YTM In December of 2005, the Eastman Kodak Corporation (EK) had a straight bond issue outstanding that was due in eight years. The bonds are selling for 108.126%, or $1,081.26, per bond and pay a semiannual interest payment based on a 7.25% (annual) coupon rate of interest. Assume that the bonds remain outstanding until maturity and that the company makes all promised interest and principal payments in a timely basis. What is the YTM to maturity to the bondholders in December of 2005?

4-5 CALCULATING THE COST OF EQUITY Caliber's Burgers and Fries is a rapidly expanding chain of fast-food restaurants, and the firm's management wants to estimate the cost of equity for the firm. As a first approximation, the firm plans to use the beta for McDonalds Corporation (MCD), which equals .56, as a proxy for its beta. In addition, Caliber's financial analyst looked up the current yield on ten-year US Treasury bonds and found that it was 4.2%. The final piece of information needed to estimate the cost of equity using the capital asset pricing model is the market risk premium, which is estimated to be 5%.

a. Estimate the cost of equity for Caliber's using the CAPM and McDonalds Corporation's beta.
b. McDonalds Corporation has an enterprise value of about $80 billion and a debt of $15 billion. If Caliber's has no debt financing, what is your estimate of Caliber's beta coefficient? You can assume that McDonalds' debt has a beta of .20.

4-6 CALCULATING THE COST OF EQUITY Smaltz Enterprises is currently involved in its annual review of the firm's cost of capital. Historically, the firm has relied on the CAPM to estimate its cost of equity capital. The firm estimates that its equity beta is 1.25, and the yield to maturity on long-term US Treasury bonds is 4.28%. The firm's CFO is currently in a debate with one of the firm's advisers at its investment bank about the level of the market risk premium. Historically, Smaltz has used 7% to approximate the market risk premium. However, the investment banker argues that this premium has shrunk dramatically in recent years and is more likely to be in the 3% to 4% range.

a. Estimate Smaltz's cost of equity capital using a market risk premium of 3.5%.
b. Smaltz's capital structure is comprised of 75% equity (based on current market prices) and 25% debt on which the firm pays a yield of 5.125% before taxes at 25%. What is the firm's WACC using both a 3% and 4% market risk premium?

PROBLEMS

4-7 ESTIMATING THE UNLEVERED BETA The CFO of Sterling Chemical is interested in evaluating the cost of equity capital for his firm. However, Sterling uses very little debt in its capital structure (the firm's debt-to-equity capitalization ratio is only 20%), while larger chemical firms use substantially higher amounts of debt. The following table shows the levered equity betas, debt-to-equity ratios, and debt betas for three of the largest chemical firms:

Company Name	Levered Equity Betas	Debt/Equity Capitalization	Assumed Debt Betas
Eastman Chemical Co. (EMN)	1.79	30.77%	0.30
Celanese Corp. (CE)	1.98	23.55%	0.30
Dow Chemical Company (DOW)	1.71	21.60%	0.30

a. Use the information given above to estimate the unlevered equity betas for each of the companies.

b. If Sterling's debt-to-equity capitalization ratio is .20 and its debt beta is .30, what is your estimate of the firm's levered equity beta?

4-8 THREE-STEP PROCESS FOR ESTIMATING A FIRM'S WACC Compano Inc. was founded in 1986 in Baytown, Texas. The firm provides oil-field services to the Texas Gulf Coast region, including the leasing of drilling barges. Its balance sheet for year-end 2014 describes a firm with $830,541,000 in book value assets that has a market value of $1.334 billion.

	December 31, 2014	
Liabilities and Owners' Capital	**Balance Sheet (Book Values)**	**Invested Capital (Market Values)**
Current liabilities		
Accounts payable	$ 8,250,000	
Notes payable	—	—
Other current liabilities	7,266,000	
Total current liabilities	$ 15,516,000	$ —
Long-term debt (8.5% interest paid semiannually, due in 2015)	$420,000,000	$ 434,091,171
Total liabilities	$435,516,000	$ 434,091,171
Owners' capital		
Common stock ($1 par value per share)	$ 40,000,000	
Paid-in-capital	100,025,000	
Accumulated earnings	255,000,000	
Total owners' capital	$395,025,000	$ 900,000,000
Total liabilities and owners' capital	$830,541,000	$1,334,091,171

Compano's executive management team is concerned that its new investments be required to meet an appropriate cost of capital hurdle before capital is committed. Consequently, the firm's CFO has initiated a cost of capital study by one of his senior financial analysts, Jim Tipolli. Jim's first action was to contact the firm's investment banker to get input on current capital costs.

Jim learned that, although the firm's current debt capital required an 8.5% coupon rate of interest (with annual interest payments and no principal repayments until 2025), the current yield on similar debt would decline to 8% if the firm were to raise debt funds today. When he asked about the beta for Compano's debt, Jim was told that it was standard practice to assume a beta of .30 for the corporate debt of firms such as Compano.

a. What are Compano's capital structure weights for debt and equity that should be used to compute its cost of capital?

b. Based on Compano's corporate income tax rate of 40%, the firm's mix of debt and equity financing, and an unlevered beta estimate of .90, what is Compano's levered equity beta? (*Hint:* Compano plans on maintaining the mix of financing over time).

c. Assuming a long-term US Treasury bond yield of 5.42% and an estimated market risk premium of 5%, what should Jim's estimate of Compano's cost of equity be if he uses CAPM?
d. What is your estimate of Compano's WACC?

4-9 CALCULATING THE EXPECTED YTM International Tile Importers Inc. is a rapidly growing firm that imports and markets floor tiles from around the world. The tiles are used in the construction of custom homes and commercial buildings. The firm has grown so fast that its management is considering the issuance of a five-year interest-only note. The notes would have a principal amount of $1,000 and pay 12% interest annually, with the principal amount due at the end of year 5. The firm's investment banker has agreed to help the firm place the notes and has estimated that they can be sold for $800 each under today's market conditions.

a. What is the promised YTM based on the terms suggested by the investment banker?
b. Refer to the appendix to this chapter for this analysis. The firm's management looked with dismay at the YTM estimated in Problem 4-9(a) because it was much higher than the 12% coupon rate, which is much higher than the yield to maturity currently paid on investment-grade debt. The investment banker explained that, for a small firm such as International Tile, the bond rating would probably be in the middle of the speculative grades, which requires a much higher yield to attract investors. The banker even suggested that the firm recalculate the expected YTM on the debt under the following assumptions: The risk of default in years 1 through 5 is 5% per year, and the recovery rate in the event of default is only 50%. What is the expected YTM under these conditions?

4-10 CALCULATING THE PROMISED YTM AND PRICE VOLATILITY On July 15, 2014 the Ford motor company (F) had a $2 billion bond issue outstanding that it issued the previous year. The bonds have a $1,000 par value and pay a fixed coupon of 4.75% paid semiannually on July 15 and January 15. The bonds were due and payable January 15, 2043.

a. What is the promised YTM on the bonds if they are selling for a price equal to par value?
b. Assume now that the Federal Reserve Bank announces a drastic change in monetary policy that results in a 10% in the promised YTM for the bonds (i.e., if the previous YTM was 10%, the new YTM would be 11%). What is the new price for the bond? What is the percent change in bond price compared to the percent change in YTM?
c. Answer part b. where the bond maturity is assumed to be January 15, 2029.
d. What can you observe about the relationship between bond price volatility (i.e., price changes in response to changes in YTM)?

4-11 CALCULATING THE PROMISED YTM Evaluate the promised YTM for the bonds issued by Ford (F) and General Motors (GM). You may assume that interest is paid semiannually. Also, round the number of compounding periods to the nearest six months.

Ford Motor Company	
Coupon:	6.3750%
Maturity:	02/01/2029
Rating:	Baa1/BBB–
Price:	92.7840

General Motors Corporation	
Coupon:	8.375%
Maturity:	07/15/2033
Rating:	Baa2/BBB–
Price:	106.1250

Noting that both these bond issues have similar ratings, comment on the use of the yield to maturity you have just calculated as an estimate of the cost of debt financing to the two firms.

4-12 THREE-STEP PROCESS FOR ESTIMATING A FIRM'S WACC Harriston Electronics builds circuit boards for a variety of applications in industrial equipment. The firm was founded in 1986 by two electrical engineers who left their jobs with General Electric (GE) Corporation. Harriston Electronics' balance sheet for year-end 2014 describes a firm with $1,184,841,000 in assets (book values) and invested capital of approximately $2.2 billion (based on market values):

	December 31, 2014	
Liabilities and Owners' Capital	**Balance Sheet (Book Values)**	**Invested Capital (Market Values)**
Current liabilities		
Accounts payable	$ 17,550,000	
Notes payable	20,000,000	20,000,000
Other current liabilities	22,266,000	
Total current liabilities	$ 59,816,000	$ 20,000,000
Long-term debt (7.5% interest paid semiannually, due in 2020)	$ 650,000,000	$ 624,385,826
Total liabilities	$ 709,816,000	$ 644,385,826
Owners' capital		
Common stock ($1 par value per share)	$ 20,000,000	
Paid-in-capital	200,025,000	
Accumulated earnings	255,000,000	
Total owners' capital	$ 475,025,000	$1,560,000,000
Total liabilities and owners' capital	$1,184,841,000	$2,204,385,826

Harriston's CFO, Margaret L. Hines, is concerned that its new investments be required to meet an appropriate cost of capital hurdle before capital is committed. Consequently, she initiated a cost of capital study by one of her senior financial analysts, Jack Frist. Shortly after receiving the assignment, Frist called the firm's investment banker to get input on current capital costs.

Frist learned that, although the firm's current debt capital required a 7.5% coupon rate of interest (with annual interest payments and no principal repayments until 2020), the current yield to maturity on similar debt had risen to 8.5% so that the current market value of the firm's outstanding bonds had fallen to \$624,385,826. Because the firm's short-term notes were issued within the last thirty days, the 9% contract rate on the notes was the same as the current cost of credit for such notes.

a. What are Harriston's total invested capital and capital structure weights for debt and equity? (*Hint:* The firm has some short-term debt [notes payable] that, like long-term debt, is also interest-bearing debt.)
b. Assuming a long-term US Treasury bond yield of 5.42% and an estimated market risk premium of 5%, what is Harriston's cost of equity based on CAPM if the firm's levered equity beta is 1.2?
c. What is your estimate of Harriston's WACC? The firm's tax rate is 35%.

4-13 UNLEVERING AND RELEVERING EQUITY BETAS In 2006, the major airline carriers, with the principal exception of Southwest Airlines (LUV), continued to be in dire financial condition following the attack on the World Trade Center in 2001.

a. Given the following data for Southwest Airlines and three other airlines (for August 1, 2014), estimate the unlevered equity beta for Southwest Airlines. Use the procedure described in Table 4-1.

Company Name	Levered Equity Beta	Debt/Equity Capitalization	Assumed Debt Beta
American Airlines (AAL)	1.01	.26	0.30
Delta Airlines (DAL)	.96	.22	0.40
Jet Blue (JBLU)	.73	.58	0.30
Southwest Airlines (LUV)	.97	.06	0.20

b. Based on your estimate of Southwest Airlines's unlevered equity beta, relever the beta to get an estimate of the firm's levered beta.

4-14 ESTIMATING THE COST OF EQUITY USING THE FAMA-FRENCH METHOD Telecom services is an industry under rapid transformation because telephone, Internet, and television services are being brought together under a common technology. In fall 2006, the telecom analyst for HML Capital, a private investment company, was trying to evaluate the cost of equity for two giants in the telecom industry: SBC Communications (AT&T) and Verizon Communications. Specifically, he wanted to look at two alternative methods for making the estimate: the CAPM and Fama-French three-factor model. The CAPM utilizes only one risk premium for the market as a whole, whereas the Fama-French model uses three (one for each of three factors). The factors are (1) a market risk premium, (2) a risk premium related to firm size, and (3) a market-to-book risk premium. Data for the risk premium sensitivities (b, s, and h) as well as the beta coefficient for the CAPM are listed in the following table:

	Fama-French (FF) Coefficients			
Company Name	b	s	h	CAPM Beta
SBC Communications (AT&T)	1.0603	−1.4998	1.0776	0.62
Verizon Communications	1.1113	−0.9541	0.639	0.79

The risk premia for each of the risk factors are:

Coefficients	Risk Premia
Market risk premium	5.00%
Size risk premium	3.36%
Market-to-book risk premium	4.40%

a. If the risk-free rate of interest is 3%, what is the estimated cost of equity for the two firms using the CAPM?

b. What is the estimated cost of equity capital for the two firms using the Fama-French three-factor model? Interpret the meaning of the signs ($\pm$) attached to each of the factors (i.e., *b, s,* and *h*).

4-15 CALCULATING THE COST OF CONVERTIBLE DEBT This problem is based on the appendix to this chapter. The Eastman Kodak Corporation had an issue of convertible bonds outstanding in spring 2005 that had a coupon rate of interest and sold for $1,277.20 per bond. The interest payments were made semiannually. The cost of straight debt is 6.05% and the firm's tax rate is 30%. In addition, the cost of new equity raised through the sale of the conversion option was 13.5%, what was the estimated cost of convertible bonds to the company?

4-16 PROMISED VERSUS EXPECTED YTM This problem is based on the appendix to this chapter. In May 2005, the credit rating agencies downgraded the debt of General Motors Corporation (GM) to junk status.

a. Discuss the effect of this drop in credit status on the company's WACC.

b. If you have been using the YTM for the firm's bonds as your estimate of the cost of debt capital and you use the same estimation procedure following the downgrade, has your estimate become more or less reliable? Explain.

4-17 COMPREHENSIVE WACC COMPUTATION On behalf of your firm, you are evaluating a privately held takeover target. The table below contains cost of capital metrics for two comparable publicly traded firms that are in the same general business and are similar in size compared to the acquisition target. You decide to equally weight all the comp data to estimate the correct discount rate to use in valuing the target. The target will be financed with 20% debt, with a pretax cost of debt equal to 4%, and the debt beta is assumed to equal 0. Assume that all of the firms in your analysis are in the 35% tax bracket and that all of the firms have a policy to leave their debt ratio constant. Answer the following questions regarding the correct cost of capital to use in valuing the target. For all parts of this problem, assume a risk-free rate of 3% and a market risk premium of 6%.

Comp Company	Equity Beta	Debt Beta	D/E
Comp 1	1.5	2	15%
Comp 2	2.1	2	30%

a. What is the estimated firm or asset (unlevered equity) beta for the target firm based on the comp data?

b. What is the estimated levered cost of equity for the target based on the comp data and the target's debt/value ratio of 20%?

c. Using the equity cost already calculated and the information on the cost of debt in the problem, what is the WACC to use in discounting the target's projected firm free cash flows?

Extensions and Refinements of WACC Estimation

Our analysis of WACC in this chapter dealt with the basic issues encountered in a simple setting. In this appendix, we address some problems that arise in the analysis of a firm's WACC that are often overlooked in introductory discussions. Specifically, we discuss (1) the estimation of the cost of below-investment-grade debt, where the promised yield to maturity is often much higher than the expected cost of the debt; (2) estimation of the cost of convertible debt, which is a hybrid form of financing that contains both debt and equity elements; and (3) the analysis of *off-balance-sheet* sources of financing, including special-purpose entities.

Estimating the Expected Cost of Below-Investment-Grade Debt Financing

We noted earlier in the chapter that the promised yield to maturity (calculated using the promised principal and interest payments) overstates the cost of debt to the company if the debt is below investment grade. To see why this is so, consider how the stated yield to maturity of a bond is calculated. The yield to maturity, as traditionally defined, is simply the internal rate of return earned by purchasing a bond for its current market price, assuming that you receive all of the bond's promised interest and principal payments over the life of the bond. Because this calculation uses *promised* interest and principal payments and not *expected* cash receipts (which allow for the prospect of default and the recovery of less than 100% of the bond's face value), this computation produces an estimate of the *promised yield to maturity* on the debt,[33] not the *expected yield to maturity*.

We calculate the promised yield to maturity by solving for the discount rate, YTM_{Promised}, which satisfies the following discounted cash flow equation:

$$\begin{aligned}\begin{array}{c}\text{Bond Price}\\\text{Today}\end{array} = \$1{,}000 &= \frac{\text{Promised Principal and Interest in One Year}}{(1 + YTM_{\text{Promised}})^1}\\ &= \frac{\$1{,}100}{(1 + YTM_{\text{Promised}})^1}\end{aligned}$$

[33] In Chapter 2, we used the term *hoped-for cash flows* as optimistic cash flows, contrasted with expected cash flows. In essence, the promised principal and interest payments for bonds that are risky (i.e., have a non-negligible risk of default) are the bondholder's hoped-for cash flows. Thus, the term *promised* cash flow is synonymous with *hoped-for* cash flow.

The YTM_{Promised} is 10% in this instance. This promised yield to maturity is equal to the expected return to the investor only when the promised payment of \$1,100 is made with certainty. In other words, YTM_{Promised} is the investor's expected rate of return (thus, the firm's cost of debt capital) only when there is no risk of default.

When a firm's debt is subject to the risk of default, the promised yield to maturity *overstates* the expected yield to maturity to the debt holder. To see how the prospect of default drives a wedge between the promised and expected yields to maturity on debt, consider the simple case of a bond that matures in one year and pays the holder the \$1,000 face value of the bond plus \$100 in interest. The risky bond has a current price of \$800 and promises to pay the holder \$1,100 in principal and interest in one year. We calculate the promised yield to maturity by solving for the discount rate, YTM_{Promised}, which satisfies the following discounted cash flow equation:

$$\begin{aligned}\begin{matrix}\text{Bond Price}\\ \text{Today}\end{matrix} = \$800 &= \frac{\text{Promised Principal and Interest in One Year}}{(1 + YTM_{\text{Promised}})^1}\\ &= \frac{\$1{,}100}{(1 + YTM_{\text{Promised}})^1}\end{aligned}$$

We estimate the promised yield to maturity to be 37.5%.

Now assume that the likelihood of default by the issuer of the bond is 20% (i.e., there is an 80% probability that the bondholder will receive the full \$1,100). Also, in the event of default, the debt holder will receive 60% of the promised \$1,100 payment, or \$660. The expected cash flow is then $(.80 \times \$1{,}100) + (.2 \times \$660) = \$1{,}012$. We can now calculate the expected yield to maturity using this expected cash flow as follows:

$$\begin{matrix}\text{Bond Price}\\ \text{Today}\end{matrix} = \$800 = \frac{\text{Expected Bond Payment in One Year}}{(1 + YTM_{\text{Expected}})^1} = \frac{\$1{,}012}{(1 + YTM_{\text{Expected}})^1}$$

The estimate of YTM_{Expected} is only 26.5%. This represents the expected cost of the firm's debt capital, not the promised yield to maturity of 37.5% calculated above. The difference between the promised and the expected yield to maturity in this example is quite large because the probability of default is quite high, and the recovery rate is 60%.

Default Rates, Recovery Rates, and Yields on Corporate Debt

To determine the expected return on a debt instrument, one needs estimates of both default rates and recovery rates. Moody's Investors Service provides historical research regarding both these rates and forecasts of future rates as well.

For example, Table 4A-1 summarizes the cumulative default rates on corporate bonds over the period 1983 to 2013. Note that there is a dramatic difference in default risk for investment- versus speculative-grade bonds. In fact, the cumulative default risk for investment-grade bonds is less than 3% even after ten years, whereas the comparable rate for speculative-grade bonds exceeds 35%.

The important detail to note about Table 4A-1 is the following: For firms that issue investment-grade debt, the risk of default is so low that the difference between promised and expected yields is insignificant for practical purposes. However, for speculative-grade debt, issuers' default is much more likely, and it has a significant effect on the cost of debt capital.

What about bondholder recovery rates in the event of default? Estimates of expected recovery rates (like expected default rates) are based on historical experience,

Table 4A-1 Average Cumulative Default Rates for 1 to 10 Years: 1983–2013

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Investment grade	0.10%	0.30%	0.56%	0.86%	1.19%	1.52%	1.86%	2.21%	2.54%	2.89%
Speculative grade	4.67%	9.66%	14.66%	18.69%	22.35%	25.58%	28.43%	30.91%	33.13%	35.13%

Source: Moody's Investors Service, *Corporate Default Study: Corporate Default and Recovery Rates, 1920–2013,* Exhibit 34, p. 34.

and Moody's maintains records on recovery rates. Moody's approximates the recovery rate using the ratio of the market price to the par value of the bond one month after default. The average recovery rate in 2000 was 28.8% of par, a rate that was down from 39.7% a year earlier and the post-1970 average of 42%.[34]

Complicating the prediction process is the fact that recovery rates are inversely correlated with default rates. Very simply, higher default rates are often associated with lower recovery rates. For our purposes in the examples that follow, however, we assume a constant recovery rate.

Estimating the Expected Yield to Maturity for a Long-Term Bond

To illustrate how we might estimate the expected yield to maturity on a bond that faces the risk of default, consider the example posed in Table 4A-2. The bond has a ten-year maturity, a 14% coupon rate, and a $1,000 principal amount. This bond, which has a current price of $829.41, has a promised yield to maturity of 17.76%, which is, of course, substantially higher than the expected yield to maturity of 12.54%. This accounts for the probability of default and less than 100% recovery rate.[35]

To account for the probability of default, we list in the columns the cash flows that the bondholder receives in the event the bond defaults after each year up to ten years. The probability of default for each of these default scenarios is found below each of the Year columns.[36] In addition, we assume that the recovery rate in the event of default is 50%, regardless of the year in which the default occurs. This means that in the event of default, the cash flow to the bondholders is $570 (i.e., the product of the $1,140 in promised interest plus principal multiplied by the estimated recovery rate of 50%).

Estimating the expected yield to maturity for the ten-year bond is a two-step process. The first step entails estimating the yield to maturity for the cash flows in each scenario. For example, if the bond were to default in the first year after its issuance, then the bondholder would receive a return one year later of only $570 (50% of the

[34] D. Hamilton, G. Gupton, and A. Berthault, *Default and Recovery Rates of Corporate Bond Issuers: 2000,* Moody's Investors Service Global Credit Research (February 2001), p. 3.

[35] The 17.76% promised YTM is consistent with the 12.75% spread over the YTM on ten-year Treasury bonds (5.02% YTM) for Caa/CCC bonds reported in Figure 4-3.

[36] The probability of default is equal to the incremental percentage of below-investment-grade debt that defaults each year, as reported in Table 4A-1.

Table 4A-2 Estimating the Expected Cost of Debt on a Long-Term Bond (Rated Caa/CCC)

Coupon	14%	Bond rating Caa/CCC	
Principal	$1,000.00	10-year Treasury yield = 5.02%	
Price	$ 829.41		
Maturity	10 years		
Recovery rate	50%		

	Default Cash Flows										
Year	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Promised Cash Flow**
0	(829.41)	(829.41)	(829.41)	(829.41)	(829.41)	(829.41)	(829.41)	(829.41)	(829.41)	(829.41)	(829.41)
1	570.00	140.00	140.00	140.00	140.00	140.00	140.00	140.00	140.00	140.00	140.00
2		570.00	140.00	140.00	140.00	140.00	140.00	140.00	140.00	140.00	140.00
3			570.00	140.00	140.00	140.00	140.00	140.00	140.00	140.00	140.00
4				570.00	140.00	140.00	140.00	140.00	140.00	140.00	140.00
5					570.00	140.00	140.00	140.00	140.00	140.00	140.00
6						570.00	140.00	140.00	140.00	140.00	140.00
7							570.00	140.00	140.00	140.00	140.00
8								570.00	140.00	140.00	140.00
9									570.00	140.00	140.00
10										570.00	1,140.00
Expected yield to maturity if default occurs in this year	−31.28%	−8.23%	0.98%	5.85%	8.80%	10.76%	12.12%	13.12%	13.87%	14.44%	**17.76%**
Probability of default in each year	4.67%	4.99%	5.00%	4.03%	3.66%	3.23%	2.85%	2.48%	2.22%	2.00%	35.13%
Weighted YTM = E(YTM) × Probability of default	−.96%	−0.41%	0.05%	0.24%	0.32%	0.35%	0.35%	0.33%	0.34%	0.29%	11.52%
Average YTM based on expected cash flows	**11.87%**			**Expected YTM = Cost of debt**				**Promised YTM**			

promised principal plus interest), resulting in a rate of return or yield to maturity of −31.28% on his or her $829.41 investment.

Once the yield to maturity for each of the years in which default might occur (i.e., the default scenarios) is calculated, we can combine all of them to determine the expected yield to maturity for the bond. We consider a total of 11 different default scenarios corresponding to default in years 1 through 10, plus the no-default scenario. The expected yield to maturity of the bond is equal to a weighted average of these possible yields, where the weights are equal to the probability of default in each year plus the probability of not defaulting at all. The resulting expected yield to maturity for this bond is 11.87%, which is substantially less than the promised yield to maturity of 17.76%.

In our example, we assumed a recovery rate of 50%. However, we reported earlier that the average recovery rates have been falling and are now approximately 30%. At this lower recovery rate, the expected YTM is only 8.05%. Consequently, lower recovery rates result in an even more dramatic difference between promised and expected YTM.

Estimating the Cost of Hybrid Sources of Financing—Convertible Bonds

Firms often issue what are referred to as **hybrid securities,** which have the attributes of debt and common equity or of preferred stock and common equity. For example, *convertible bonds* and *convertible preferred stock* represent a very important class of hybrid securities that give the holder the option to exchange, at his or her discretion, the bond or preferred stock for a prescribed number of common shares. Although these securities are not major sources of capital for investment-grade companies, they provide an important source of financing for many emerging high-tech companies and other smaller firms.

The value of a convertible security can be viewed as the value of the bond or preferred share plus the value of the conversion feature, which is technically a call option.[37] To illustrate, consider the case of a convertible bond whose value is defined by Equation 4A.1:

$$\begin{matrix}\text{Convertible}\\ \text{Bond Value}\end{matrix} = \begin{pmatrix}\text{Straight}\\ \text{Bond Value}\end{pmatrix} + \begin{pmatrix}\text{Call}\\ \text{Option Value}\end{pmatrix} \tag{4A.1}$$

This dual source of value means that the cost of financing by issuing convertibles is a function of both the underlying security (bond or preferred stock) and the call option. Consequently, the cost of capital obtained by issuing convertible bonds can be thought of as a weighted average of the cost of issuing straight bonds and the cost of the exchange feature (call option), where the weights equal the relative contributions of the two components to the value of the security.

To illustrate how we might approach the estimation of the cost of convertible debt, consider the convertible debt issued by Computer Associates (CA) that is due March 15, 2013. The bonds sold for $1,066.19 on February 3, 2005, and paid a semiannual coupon

[37] We discuss options and their valuation in some detail beginning in Chapter 10. However, for now it is sufficient that we understand what a call option represents.

payment based on an annual rate of interest equal to 5%. Each bond can be converted into 41.0846 shares of Computer Associates common stock beginning March 21, 2007. The convertible bond issue, like all of the firm's bonds, is rated BB+ by Standard and Poor's.

Before describing how to determine the appropriate cost of capital that should be ascribed to this convertible security, we first note that the promised yield to maturity on the bond, assuming that it is not converted, is only 1.61%. It should also be noted that the promised yield on the firm's straight debt is 4.25%. Clearly, the expected return on the convertible security exceeds the return on the straight debt, but by how much?

To estimate the cost of financing to Computer Associates from the convertible issue, we calculate a weighted average of the cost of straight debt and the cost of raising capital through the sale of the associated call option. We estimate the required rate of return on the convertible bonds using a three-step procedure:

Step 1: *Estimate the component values of the convertible bond issue: straight debt and the conversion call option.* Computer Associates' convertible bonds sold for \$1,066.19 on the date of our analysis, so if we value the straight-debt component, we can calculate the value that the market is assigning to the call option component.

To value the straight-debt component, we need an estimate of the market's yield to maturity for straight debt that Computer Associates could issue today. The firm has a straight-debt issue outstanding with a similar maturity to the convertibles. The straight bond provides a market-based yield to maturity to the bondholders of 4.25%. Consequently, the straight-bond component of the convertible issue can be valued by discounting the promised interest and principal payments using 4.25%:

$$\begin{aligned}\begin{matrix}\text{Straight-}\\ \text{Bond Value}\end{matrix} &= \frac{\$25.00}{(1+.0425/2)} + \frac{\$25.00}{(1+.0425/2)^2} + \frac{\$25.00}{(1+0.425/2)^3} \\ &+ \frac{\$25.00 + \$1{,}000.00}{(1+.0425/2)^4} = \$1{,}014.24\end{aligned}$$

The value of the call option component, therefore, is \$51.95 = \$1,066.19 − 1.014.24.

Step 2: *Estimate the costs of the straight-debt and option components of the convertible bond issue.* We have already estimated the cost of the straight debt to Computer Associates using the yield to maturity on similarly rated bonds issued by the firm that have a similar term to maturity (i.e., 4.25%).[38] However, estimating the cost of the conversion feature (i.e., the conversion call option component) is more difficult and requires an understanding of call options, which we discuss in Chapter 12. Because the call options can be viewed as a levered version of the firm's common equity, we know that the cost of capital associated with the option component of the convertible exceeds the cost of common equity of the issuing firm. In this example, we assume that the cost of capital on the option component is 20%.

[38] Technically, the 4.25% yield to maturity on Computer Associates' straight debt is the *promised* yield; this rate overstates the expected cost of debt financing, as we discussed earlier.

Step 3: *Calculate the cost of convertible debt.* Here we simply calculate a weighted average of debt and equity raised through the conversion feature. The weights attached to each source of financing reflect the relative importance (market values) of each:

	Dollar Value	Percentage of Value
Straight bond	$1,014.24	95.1%
Conversion option	51.95	4.9%
Current bond price	$1,066.19	100.0%

Assuming that the conversion option has a required rate of return of 20% and using the 4.25% cost of straight debt, we estimate the cost of the convertible debt as follows:

	Fraction of Bond Value	Cost of Capital	Product
Straight bond	0.9513	4.25%	0.0404
Equity conversion option	0.0487	20.00%	0.0097
Cost of capital from convertible bonds =			5.01%

Thus, we estimate that the cost of raising capital with convertible bonds is approximately 5%, which is higher than the cost of issuing debt but lower than the cost of issuing equity. This makes sense because convertibles are less risky than equity but more risky than straight debt.

Off-Balance-Sheet Financing and WACC

Following the high-profile financial scandals of the last decade, analysts have been made painfully aware of the importance of off-balance-sheet sources of financing—that is, sources of financing that are not listed among the firm's corporate liabilities but are nevertheless very real liabilities. Here we discuss special-purpose entities (SPEs).

Special-Purpose Entities

The acronym SPE, which stands for special-purpose entity, has become synonymous with the wrongdoing that led to the collapse of Enron Corp. Unfortunately, Enron's use of SPEs has besmirched a very worthwhile concept that has been extremely valuable in a wide range of industries. Specifically, an SPE is an entity created by a sponsoring firm to carry out a specific purpose, activity, or series of transactions that are directly related to its specific purpose.[39]

The issue we want to discuss arises out of the fact that many SPEs are not consolidated with the firm's financial statements; consequently their assets and financial structures are off balance sheet. Should the capital structures of the off-balance-sheet SPEs be incorporated into the estimation of the firm's WACC? In Enron's case, many of the SPEs did not meet the rules prescribed for off-balance-sheet reporting, so the answer to the above question is obviously yes. Where SPEs are truly separate entities (the technical term is *bankruptcy remote*), however, their liabilities do not reach back to the founding firm and consequently are not relevant to the calculation of the firm's WACC.

[39] This discussion relies on Cheryl de Mesa Graziano, "Special Purpose Entities: Understanding the Guidelines," *Issues Alert, Financial Executives International* (January 2002).

CHAPTER 5

Estimating Required Rates of Return for Projects

Chapter Overview

The most widely used approach for choosing the discount rate for new investments is to use the firm's weighted average cost of capital (WACC). However, this approach has some rather severe shortcomings when a firm invests in projects with widely varying risk characteristics. In this chapter, we discuss two methods for customizing or tailoring the discount rate to the specific attributes of the project. We begin by considering the divisional WACC. The divisional WACC approach involves estimating a different cost of capital for each of the firm's operating divisions, using a straightforward extension of the firm WACC approach discussed in Chapter 4. The project-specific WACC is the final approach we consider for identifying the discount rate for new investments. This approach focuses on the specific risk attributes and financing components of individual projects. We consider two variants of the project-specific WACC: (1) projects that have nonrecourse, project debt financing and (2) projects that are financed using general corporate financing.

Although supported in theory, allowing managers to tailor the cost of capital to their divisions or to the specifics of a particular project has its cost. Granting managers discretion in the choice of the discount rate provides them with an opportunity to misuse this discretion to pursue their own pet projects. Consequently, in an effort to constrain this incentive problem, many firms allow their managers no discretion and use the same discount rate for all projects (such as the firm's WACC), while others offer limited discretion (e.g., in the form of a divisional WACC).

We close the chapter with a discussion of the concept of a hurdle rate. Some firms require that their investments have an expected internal rate of return that exceeds a hurdle rate that is higher than the investment's cost of capital.

5.1 Introduction

In Chapter 4, we introduced the concept of a firm's cost of capital (i.e., WACC). The firm's WACC is a key determinant of the value of the firm, as we will discuss in Chapter 8, but it is also widely used as an important element in the evaluation of firm performance, as we will learn in Chapter 7. In addition, a firm's WACC is often used as a starting point for identifying the discount rates used to evaluate new investments that the firm may be considering. Our focus in this chapter is on such investment projects.

The discount rates that firms use to evaluate individual investment projects are not necessarily the same as their WACCs. Most firms are faced with a variety of investment opportunities, and if these investment opportunities have different risks and can be financed in different ways, then it makes sense for them to be evaluated with different discount rates. In particular, investment projects that are less risky and add more to the firm's ability to raise debt capital should require a lower discount rate. In this chapter, we describe how firms can determine what these different discount rates should be.

Before proceeding, we should point out that an investment evaluation policy that allows managers to use different discount rates for different investment opportunities is not necessarily easy to implement. Technical and political issues must be addressed within a firm's organization that can potentially make the use of multiple discount rates more trouble than it is worth. Perhaps because of these issues, more than 50% of the surveyed firms in a 2001 study used a *single, companywide discount rate* to evaluate all investment proposals.[1] However, there can be substantial gains associated with using different discount rates for projects with different risks, and as we show in this chapter, the technical issues can be addressed. Although we are not experts on the politics of organizations, we believe that well-managed corporations can address the political issues once they are made aware of them.

This chapter is organized as follows: Section 5.2 presents the case for addressing differences in project and firm costs of capital when evaluating new investment proposals. Section 5.3 discusses two methods for estimating discount rates that are tailored, to varying degrees, to the specific risks of the projects being evaluated and that also minimize the estimation problems and administrative issues involved in using multiple discount rates. These two methods are the divisional WACC and the project-specific WACC. Section 5.4 discusses hurdle rates and the cost of capital. Finally, Section 5.5 contains summary comments.

5.2 Pros and Cons of Multiple Risk-Adjusted Costs of Capital

The decision to use a single, companywide discount rate versus a more refined estimate that is specifically tailored to the risks of the project being valued is ultimately a matter of managerial judgment. Each approach has its benefits and costs and, as we now discuss, the benefits and costs vary from firm to firm.

The Rationale for Using Multiple Discount Rates

Finance theory is very explicit about the appropriate rate at which the cash flows of investment projects should be discounted. The appropriate discount rate should reflect the opportunity cost of capital, which in turn reflects the risk of the investment. The rationale for this approach is intuitive when one views the appropriate opportunity cost

[1] John Graham and Campbell Harvey, "The Theory and Practice of Corporate Finance: Evidence from the Field," *Journal of Financial Economics* 60 (2001): 187–243.

as the expected rates of return on publicly traded stocks and bonds. One would not initiate investment projects with expected returns that are less than the returns that can be generated from investments in publicly traded stocks and bonds with equivalent risk. Hence, less risky investments whose cash flows resemble the cash flows of a portfolio of bonds have an opportunity cost of capital that is lower than that of more risky investments whose cash flows resemble the cash flows of a portfolio of stock.

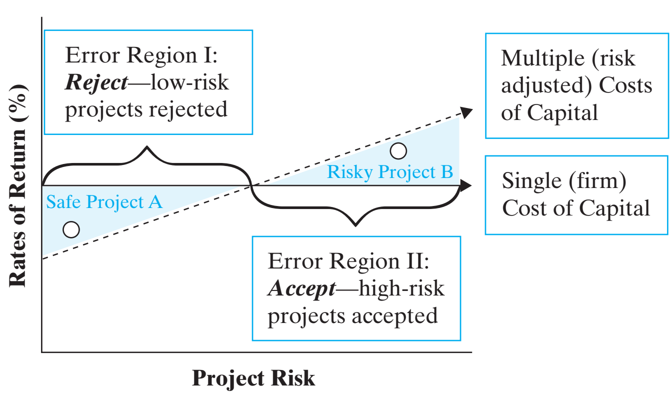
Figure 5-1 illustrates that when a single discount rate (firm WACC) is used, the firm tends to take on investment projects that are relatively risky (project B) and that appear to be attractive because they generate internal rates of return that exceed the firm's WACC. Similarly, the firm tends to pass up investment projects that are relatively safe (project A) but that generate internal rates of return that are less than the firm's WACC. Left unchecked, this bias in favor of high-risk projects will make the firm riskier over time.

Convincing Your Skeptical Boss—Low-Risk Projects Can Be Good Investments

To illustrate the advantages of using multiple discount rates, consider the situation faced by a hypothetical high-tech manufacturing company, Huson Packer Inc. (HPI), which generates most of its revenues from technology-driven products that generate relatively high rates of return. This is a risky business and, as such, the firm is all-equity-financed, with a cost of equity and company cost of capital equal to 12%. Some of the firm's engineers have designed a new laser technology and have proposed that the firm invest \$300 million to launch a line of laser printers to commercialize the technology. Based on an analysis similar to what was described in Chapters 2 and 3, the engineers estimate that the investment will generate an expected internal rate of return of 10.5%. Although the expected return is lower than the firm's WACC of 12%, it should be noted that the project is also less risky than the firm's core business. In particular, the beta for the printer business is only .80, while the beta of HPI's core business is 1.40.

After reviewing the proposal, HPI's CEO responded, "I can't understand how it makes sense to undertake an investment that generates a 10.5% return when our shareholders expect a return on their investment of 12%." How would you convince your

Figure 5-1 Using a Single Cost of Capital Can Bias Investment Decisions Toward Risky Projects



skeptical boss that the investment makes sense? As we explain below, to understand how an investment that returns 10.5% makes sense for a firm with a WACC of 12%, we must understand the distinction between the marginal cost of capital and the average cost of capital.

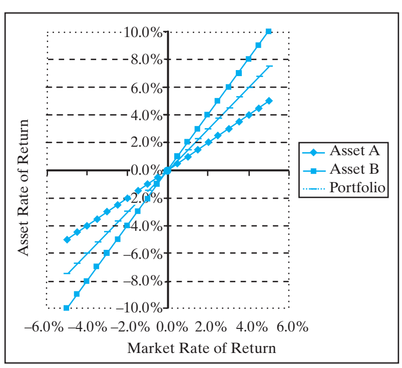
Let's assume that the expected return on the market portfolio is 10% and the risk-free rate is 5%, so that the market risk premium is $10\% - 5\% = 5\%$. Under these conditions, HPI estimates its cost of equity using the capital asset pricing model (CAPM) to be 12% (i.e., $5\% + 1.4 \times 5\%$). Now let's assume that the printer business will constitute 20% of the value of HPI if the investment is undertaken. With the printer business, HPI's new beta will become a weighted average of the beta for the printer business and its core business, which will constitute 80% of the value of the company. Consequently, HPI's beta after investing in the printer business will decline to 1.28 (i.e., $.80 \times 1.4 + .20 \times .8 = 1.28$), and with this lower beta, HPI's required rate of return on its equity (and WACC because the firm is assumed to be all-equity-financed) will decline to $5\% + 1.28 \times 5\% = 11.4\%$. (See the Technical Insight box on portfolio betas.)

One way to assess whether the printer business makes sense is to ask whether HPI, with the addition of the printer business, generates an expected rate of return that exceeds the 11.4% rate of return that will be the firm's cost of capital if it enters the printer business. To calculate whether this is indeed the case, we combine the 10.5% expected

TECHNICAL INSIGHT

Portfolio Betas

The return to a portfolio is simply a weighted average (reflecting the relative investment amounts) of the rates of return earned by the individual assets in the portfolio. It turns out that the risk of a portfolio, measured by its beta, is also a weighted average of the assets in the portfolio. Consider a simple portfolio of two assets, A and B, where each asset constitutes 50% of the value of the portfolio. Asset A has a beta of 1.00 and asset B has a beta of 2.00. The following figure illustrates how the rate of return each asset is expected to earn varies when the market generates rates of return ranging from −5% to +5%. Note that the portfolio return is more volatile than asset A but less volatile than asset B—i.e., the portfolio beta is $1.5 = .5 \times 2 + .5 \times 1$.



rate of return on the printer business (which was based on the cost of entering into the business) with the expected rate of return on the firm's existing business (which is 12% based on the firm's current market value). With the addition of the new project, the firm will generate an expected return of $.80 \times 12\% + .20 \times 10.5\% = 11.7\%$, which exceeds the required rate of return of 11.4%. This implies that the addition of the printer business will cause HPI's stock price to increase enough to drive down its future expected rate of return to its required return of 11.4%. In other words, the printer business is a value-increasing investment.

In practice, valuing an investment project by calculating the firm's WACC, both with and without the evaluated project, would be quite tedious. However, these calculations are not necessary. We can arrive at exactly the same conclusion by evaluating the project in isolation, using a discount rate that reflects the project's beta of .80. Specifically, we should evaluate the project by discounting its expected cash flows at a rate estimated using the CAPM, where the risk-free rate and market risk premium are both equal to 5%—that is, $5\% + .8 \times 5\% = 9\%$.

It should be noted that the preceding example is relatively straightforward because HPI and the printer project are assumed to be all-equity-financed. Debt financing, because of its tax advantage, is assumed to be a less expensive source of capital, so we also have to account for the extent to which the project contributes to the firm's ability to raise debt financing. As our discussion in the rest of the chapter illustrates, the consideration of debt financing definitely adds a few wrinkles to our analysis.

The Benefits of Using a Single Discount Rate

Despite the aforementioned benefits of using multiple discount rates that more nearly reflect project risk, nearly six out of every ten firms use a single, companywide discount rate to evaluate all of their investment projects. One reason is that many firms engage in a very narrow spectrum of activities, and a single discount rate works pretty well for them. A second reason is that using multiple discount rates is difficult and, until recently, the benefits of using different discount rates for different investment projects were not well articulated. Finally, as we will discuss in more detail, the use of multiple discount rates poses an administrative cost that can arise when overly optimistic or opportunistic managers have too much discretion in determining the key parameters that control the valuation of the investment under consideration.

The latter problem arises from the fact that managers have an incentive to get projects approved when the projects benefit them personally. This may, in turn, encourage them to inflate cash flow forecasts and argue for low discount rates for their pet projects. The incentive to inflate cash flow forecasts is mitigated somewhat by the fact that an investment's realized cash flows can later be compared to the forecasts. However, one cannot do an ex post evaluation to determine whether the appropriate discount rate was used when the project was being evaluated. Hence, there is a greater incentive for managers to underestimate project risk (and consequently the cost of capital for the project) than to overestimate the cash flows of the investment projects they propose.

Influence Costs

To get a better understanding of the potential costs associated with using multiple discount rates, it is useful to describe what economists refer to as **influence costs.** (See the Behavioral Insight box on influence costs and managerial discretion.) These added costs include the extra time and effort a project advocate spends trying to justify a lower discount rate, as well as the time spent by the managers charged with evaluating the project who must figure out the extent of the bias.

To understand the problems posed by influence costs, consider the incentives of a manager who is responsible for developing new investment opportunities in Bolivia. Because the manager benefits personally from having the project accepted, he or she has a clear incentive to put the investment proposal in the most favorable light possible.[2] Hence, in addition to providing optimistic cash flow forecasts, the manager has an incentive to *understate risk* in order to justify a lower discount rate that inflates the project's net present value.

The added discretion associated with multiple discount rates can lead to the selection of inferior projects if some managers, because they are either politically better connected within the organization or simply more persuasive, are able to justify lower discount rates for their projects, even when the projects are quite risky. When discount rates are discretionary, it opens up the possibility that favored or more persuasive managers will be able to use artificially low discount rates for their projects, perhaps making it relatively easy for them to meet their benchmarks. Such a perceived lack of fairness can be very costly to a firm and can potentially generate infighting and a general lack of cooperation among workers. (See the Practitioner Insight box on keeping WACC simple). Thus, using a single discount rate for all projects may increase the perception that all workers are evaluated fairly, which in turn improves employee morale because it removes one source of influence cost.

BEHAVIORAL INSIGHT

Limiting Managerial Flexibility to Control Influence Costs

Economists refer to influence costs as costs that arise out of the tendency for employees to spend time and effort attempting to persuade top executives to make choices that are beneficial to themselves and their group or division. The benefits of a firm's capital allocation decisions come in the form of augmenting the scope of employees' power, prestige, visibility, and, of course, their compensation. While some of these choices actually create value, much of the time spent lobbying is likely to waste not only the employee's time but also the time of other employees and top management.[3]

Because of the potential costs associated with influence-seeking behavior, corporations sometimes set rules and procedures that limit managerial flexibility. These rules are often thought of as bureaucratic stumbling blocks that can lead to suboptimal choices. By limiting managerial discretion, however, management's ability to waste time and resources may also be reduced.

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[2] This may be true for many reasons, including (1) the manager's compensation is tied to finding profitable investments, (2) the manager develops special skills associated with the project that could enhance the value of his or her human capital, and (3) the manager simply derives utility from managing large projects.

[3] Influence costs are discussed in detail by Paul Milgrom and John Roberts in their article "Bargaining Costs, Influence Costs, and the Organization of Economic Activity," in *Perspectives in Positive Political Economy,* ed. J. Alt and K. Shepsle (Cambridge: Cambridge University Press, 1990).

PRACTITIONER INSIGHT

The Importance of Keeping WACC Simple and Understandable—A Conversation with Jim Brenn*

Our firm was a pioneer in the adoption and use of a bonus performance measure based on a comparison of the company's return on invested capital to its cost of capital. When we implemented the system, we were very concerned that the rank-and-file employees would trust the system and that it could influence their behavior in ways that contributed to the creation of value for our shareholders. We quickly learned that, to be a trusted performance measure, the measure had to be understandable and verifiable.

The importance of making the performance measure and the standard of firm performance (the cost of capital) transparent and understandable meant that we were willing to sacrifice some technical sophistication. For example, we wanted our employees to be able to replicate our estimate of the firm's cost of capital, so we used book value weights based on our most recent balance sheet to calculate the firm's weighted average cost of capital. Had we used the technically correct market value weights, the cost of capital calculated at any one point in time would reflect current market prices, over which our employees can exercise no control. Therefore, we used book value weights in an effort to provide a stable and easy-to-calculate weighted average cost of capital estimate.

*Jim Brenn is chief financial officer for Briggs and Stratton Corporation, Milwaukee, Wisconsin.

Weighing the Costs and Benefits of Multiple Versus Single Discount Rates

We noted at the outset of this section that there are both pros and cons associated with the use of multiple versus single discount rates that each firm must balance in light of its particular circumstances. The benefits associated with multiple discount rates are most pronounced when the risk attributes of the projects a firm considers vary widely, as is likely to be the case for firms operating in different lines of business or in different countries. For example, firms that operate multiple divisions that face very different risk profiles are obviously better candidates for using multiple discount rates than are firms that operate a single, homogeneous division.

The incentive problems that arise when managers have more discretion to choose discount rates are very real but extremely nebulous and difficult to identify and measure. However, these incentive problems can be mitigated if there is a systematic and verifiable way to estimate the cost of capital. In particular, we recommend that when multiple discount rates are used, the determination of these discount rates should be tied to outside market forces that are not under the control of the managers who may benefit from the investment projects' selection. With this in mind, we now discuss our recommended approaches.

5.3 Choosing a Project Discount Rate

Choosing the appropriate discount rate for an investment project can be a daunting task, and there is no getting around the fact that completing the task entails a substantial amount of judgment on the part of the individuals involved. We now discuss three approaches that can be used to select discount rates that reflect differences in project risk levels. All three methods meet the following criteria: They are consistent with financial theory, they are relatively easy to understand and implement, and they use discount rates based on market returns.

The approaches that are described in Figure 5-2 include: (1) firm WACC (the subject of Chapter 4), (2) divisional WACC, and (3) project-specific WACC. We discuss two variations of a project-specific WACC: one where debt can be paid only from the project's cash flows (project financing) and one where debt can be paid from the firm's total cash flows (corporate financing).

Method 1: Divisional WACC (Industry-Based Divisional Costs of Capital)

Most investments are financed using corporate finance, which means that the debt used to finance the investment comes from corporate debt issues that are guaranteed by the corporation as a whole. Determining the appropriate discount rate for a project under these circumstances can be somewhat more challenging because the cost of financing the project cannot be directly identified. The approach taken by most firms that face this situation is to try to isolate their costs of capital for each of their business units or divisions by estimating divisional WACCs. The idea here is that the divisions take on investment projects with unique levels of risk; consequently, WACC used in each division is potentially unique to that division. Generally, divisions are defined either by geographical regions (e.g., the Latin American division) or industry lines of business. In the discussion that follows, we will assume that the divisions are defined along industry lines and that divisional WACCs can be approximated using average firm WACC within an industry.

The advantages of using a divisional WACC include the following:

- It provides different discount rates that reflect differences in the systematic risk within each of the firm's divisions. The idea is that the individual divisions take on investment projects with common levels of risk that differ across divisions.
- It entails only one cost of capital estimate per division (as opposed to unique discount rates for each project), thereby minimizing the time and effort of estimating the cost of capital.
- The use of a common discount rate throughout the division limits managerial latitude and the attendant influence costs.[4]

To see how firms can estimate divisional WACCs, consider the problem faced by ExxonMobil (XOM), a fully integrated oil company. By "fully integrated," we mean that the company is engaged in every activity associated with its product, beginning with finding and producing oil, up through pumping gasoline into consumers' automobiles. Table 5-1 describes how the firm divides its businesses into three groups: upstream, downstream, and chemicals. Each group has its own special risks, so the opportunity cost of capital for each is likely to be different.

An approach for dealing with differences in the costs of capital for each of ExxonMobil's business units involves identifying what we will call **comparison firms (comps),** which operate in only one of the individual businesses (where possible).

[4] However, we expect that divisional managers may still expend resources to lobby for lower discount rates for their divisions, so the influence costs associated with allowing managers some discretion over what discount rates to use still exist to some extent.

Figure 5-2 Choosing the Right WACC—Discount Rates and Project Risk

Method		Description	Advantages	Disadvantages	When to Use
Firm WACC (discussed in Chapter 4)		Estimate the WACC for the firm as an entity and use it as the discount rate on *all* projects.	• Is a familiar concept to most business executives • Minimizes estimation costs, as there is only one cost of capital calculation for the firm • Does not create influence cost issues	• Does not adjust discount rates for differences in project risk • Does not provide for flexibility in adjusting for differences in project debt capacities	• Projects are similar in risk to the firm as a whole • Using multiple discount rates creates significant influence costs
Method #1: Divisional WACC		Estimate WACC for individual business units or divisions of the firm. Use these estimates as the only discount rates within each division.	• Uses division-level risk to adjust discount rates for individual projects • Entails minimal influence costs within divisions	• Does not capture intra-division risk differences in projects • Does not account for differences in project debt capacities within divisions • Potential influence costs associated with the choice of discount rates across divisions • Difficult to find single-division firms to proxy for divisions	• Individual projects within each division have similar risks and debt capacities • Discount rate discretion creates significant influence costs within divisions but not between divisions
Method #2: Project-specific WACC	Project financing	Estimate WACC for each individual project, using the capital costs associated with the actual financing package for the project.	• Provides a unique discount rate that reflects the risks and financing mix of the project	• Market proxies for project risk may be difficult to find • Creates the potential for high influence costs as managers seek to manipulate to get their pet projects accepted • Capital structure weights are problematic, as equity value of the project is unobservable	• The project is financed with nonrecourse debt • The costs of administering multiple discount rates are not too great
	Corporate financing	Estimate WACC for each individual project, using the capital costs associated with the debt capacity of the project.	• Provides a unique discount rate that reflects the risks and financing mix of the project	• All of the above, plus: • Project debt capacity must be allocated because it is not readily observed	• The project is of such significance that it has a material impact on the firm's debt capacity

Table 5-1 ExxonMobil Divisions (Business Units)—2008 Operating Results

	Upstream—Oil and Gas Exploration and Development	Downstream—Refining Oil and Gas for Energy Use	Chemicals—Conversion of Crude into Plastics and Other Nonenergy Products
Earnings	\$35.402 billion	\$8.151 billion	\$2.957 billion
Return on average capital employed*	53.6%	31.8%	20.4%
Capital expenditures	\$19.734 billion	\$3.529 billion	\$2.819 billion

Source: ExxonMobil 2008 Annual Report.

*Return on average capital employed is a performance measure ratio. From the perspective of the business segments, this return is annual business segment earnings divided by average business segment capital employed (average of beginning and end-of-year amounts). These segment earnings include ExxonMobil's share of segment earnings of equity companies, consistent with our capital employed definition, and exclude the cost of financing.

ExxonMobil can then use the WACCs for these comparison firms to calculate an estimate of the divisional WACC. For example, to estimate the WACC for its upstream business unit, ExxonMobil might use a WACC estimate for firms that operate in the oil and gas extraction industry (SIC 1300). These firms span a wide variety of subindustries related to oil and gas exploration, development, and production. Similarly, analysts could use firms in the petroleum refining and related industries (SIC industry 2900) to estimate the relevant WACC for the downstream business unit; they could use firms in chemicals and allied products (SIC industry 2800) to determine the WACC for the chemicals business unit.

Table 5-2 summarizes the cost of capital for each of these industries using the Ibbotson Associates 2009 *Cost of Capital* quarterly estimates. The procedures used by Ibbotson Associates, which were discussed in Chapter 4, can be briefly described as follows:

- The cost of equity for each firm in the industry is estimated from five different models. We follow Ibbotson Associates and calculate the median value for the industry, using each of the five approaches. For our purposes, we use a simple average of the five estimated costs of equity as our estimate of the cost of equity for the division.
- The cost of debt financing reflects both the current rates of interest and the credit rating of the firm's debt.
- The debt ratio for the industry reflects the book value of the firm's interest-bearing liabilities (both short-term and long-term) divided by the sum of the book value of the firm's debt plus the market value of the firm's equity. For example, in September 2009, Valero Energy Corporation (VLO) had total debt outstanding of \$7.375 billion. The market value of Valero's equity (i.e., its market cap) was \$9.29 billion. Thus, the

Table 5-2 Summary Divisional Costs of Capital Estimates for ExxonMobil

	Upstream—Oil and Gas Exploration and Development (SIC 1300)[a]	Downstream—Refining Oil and Gas for Energy Use (SIC 2900)[b]	Chemicals—Production of Plastics and Other Nonenergy Products (SIC 2800)[c]
Cost of equity[d]	10.17%	7.70%	8.51%
Debt ratio[e]	21.82%	4.93%	18.18%
WACC[f]	10.01%	7.78%	8.68%

Source: Ibbotson Associates, *Cost of Capital: 2009 Yearbook* (data through March 2009).

[a]SIC 1300—oil and gas extraction. This group of firms is primarily engaged in (1) producing crude petroleum and natural gas, (2) extracting oil from oil sands and oil shale, (3) producing natural gasoline and cycle condensate, and (4) producing gas and hydrocarbon liquids from coal at the mine site.

[b]SIC 2900—petroleum refining and related industries. This major group includes firms primarily engaged in petroleum refining, manufacturing paving and roofing materials, and compounding lubricating oils and greases from purchased materials.

[c]SIC 2800—chemicals and allied products. This group includes firms that produce basic chemicals, as well as firms that manufacture products by predominantly chemical processes.

[d]Ibbotson reports five different estimates of the cost of equity, as we discussed in Chapter 4. However, we report the return estimate for the large composite sample, based on CAPM.

[e]The debt ratio is equal to the book value of debt divided by the sum of the book value of debt and the market value of the firm's equity. Again, this ratio reflects an average of the firms in the large-composite category.

[f]We report WACC for the large-composite group within the industry that is calculated using the CAPM-based estimate of the cost of equity.

debt ratio was \$7.375 billion ÷ (\$7.375 billion + 9.29 billion) = 44.25%. The debt ratio provides the weight attached to the firm's after-tax cost of debt, and 1 minus this ratio is the weight attached to the cost of equity to calculate the firm's WACC.

A quick review of Table 5-2 reveals divisional WACCs for ExxonMobil ranging from 10.01% for the upstream division to 7.78% for the downstream division. What this means is that, if the company were to use a single WACC for all divisions, it would tend to overinvest in the upstream division and underinvest in the downstream division.

Divisional WACC—Estimation Issues and Limitations

Although the divisional WACC approach is generally a significant improvement over the single, companywide WACC, the way that it is often implemented using industry-based comparison firms has a number of potential shortcomings:

- *The sample of firms in a given industry may include firms that are not good matches for the firm or one of its divisions.* For example, the ExxonMobil company analyst may be able to select a narrower subset of firms whose risk profiles more nearly match the division being analyzed. In our ExxonMobil example, the comparison firms for the upstream division consisted of the 118 companies in SIC 1300, the comparison firms for the chemicals division included the 312 companies from SIC 2800, and the downstream division comparison firms included the 15 firms from SIC 2900. The firm's management can easily address this problem by selecting appropriate comparison firms. However, the fact that the selection of different comparison firms affects our estimate of the divisional cost of capital implies that if divisional managers participate in the selection process, they have an opportunity to exercise influence over their own cost of capital.

- *The division being analyzed may not have a capital structure that is similar to the sample of firms that are used as comps.* The division may be more or less levered than the firms whose costs of capital are used to proxy for the divisional cost of capital. For example, ExxonMobil raises very little of its capital through debt financing, whereas Valero Energy (VLO) has raised 44.25% of its capital with debt.[5]

  Resolving this problem is more difficult than it may appear at first glance: Multidivision firms do not ordinarily allocate corporate debt to individual divisions, so we really cannot identify divisional capital structures. Therefore, using the capital structures of the comparison firms may be as good as the firm can do when attempting to estimate its divisional WACC.[6] Attempts to allocate debt to the divisions can give rise to an opportunity for divisional managers to lobby for a larger allocation in the hope that it will result in a reduced cost of capital, thus creating yet another instance in which influence costs can enter into the process of estimating the divisional WACC.
- *There may be substantial differences in project risks for investments within a division.* Firms, by definition, are engaged in a variety of activities, and it can be very difficult to identify a group of firms that are predominantly engaged in activities that are truly comparable to a given project. Even within divisions, individual projects can have very different risk profiles. This means that, even if we are able to match divisional risks very closely, there may still be significant differences in risk across projects undertaken within a division. For example, some projects may entail extensions of existing production capabilities, while others involve new-product development. Both types of investments take place within a given division, but they have potentially very different risk profiles.
- *Good matches for comparison firms for a particular division may be difficult to find.* The preponderance of publicly traded firms report multiple lines of business, yet each company is classified into a single industry group. In the case of ExxonMobil, we found three operating divisions (upstream, downstream, and chemicals) and identified an industry proxy for each. However, our downstream industry proxy (petroleum refining and related industries—SIC 2900) actually contained ExxonMobil because this is the firm's dominant industry group.

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[5] This estimate is based on third-quarter 2009 financial statements, using book values of interest-bearing short- and long-term debt and the market value of the firm's equity on November 20, 2009.

[6] Even when the firm can allocate its debt to its individual divisions, there still remains the problem of allocating the market value of the firm's equity to the various divisions. The analyst might use multiples of earnings for the division that reflect current market conditions to estimate equity values. However, this methodology is not without its limitations because it presumes that the multidivision firm is valued by the market as the sum of its divisions (i.e., that there are no synergies to the multidivision firm). The more problematic and complex the estimation procedure, the greater the risk that the divisional WACC becomes a political football for division managers to use in their attempts to gain larger capital allocations for their divisions.

The preceding discussion suggests that, although the use of divisional WACCs to determine project discount rates may represent an improvement over the use of a companywide WACC, this methodology is far from a perfect solution. However, if the firm has investment opportunities with risks that vary principally with industry-risk characteristics, the use of a divisional WACC has some clear advantages over the use of the firm's WACC. It provides a methodology that allows for different discount rates, and it avoids some of the influence costs associated with giving managers complete leeway to select project-specific discount rates.

Method 2: Project-Specific WACCs

We now consider the estimation of an individual project's WACC. The objective here is to fine-tune our estimate of the cost of capital to reflect the specifics of an individual project as opposed to a division or the firm as a whole. A project-specific WACC requires the same inputs as a firm's WACC; that is, it requires estimates for the cost of debt, the cost of equity, and the weights for each source of capital. As we will discuss, there are considerable challenges associated with estimating each of these inputs.

We first consider a situation where the investment is **project financed** using **nonrecourse** debt financing. With nonrecourse debt, the project is the sole source of collateral and the debt holders have no claim to the sponsoring firm's other assets in the event of default. Investments that are project-financed are very similar to an independent firm because lenders loan money based solely on the ability of the project cash flows and assets to repay the loan. A critical feature of project financing and nonrecourse debt relates to something called *bankruptcy remoteness,* which means that if the borrower were to go into bankruptcy, its creditors would not have any claim on the assets of the project-financed asset. Although we do not delve into the legal details, we do want to emphasize that lenders are very cautious when offering nonrecourse financing to a project. Specifically, they want to be assured that the project sponsor's creditors have no claim on the assets of the project in the event the sponsor goes into bankruptcy. Remember that the project lenders have no claim on the sponsor's other assets and, likewise, they want the sponsor's creditors to have no claim on the project assets.

Calculating the appropriate project-specific WACC for a project-financed investment is somewhat more straightforward because the sources of financing are specifically defined for the project and can be observed. In particular, a specific amount of debt is attached to the investment, which is not the case when the project is financed on the firm's balance sheet using corporate financing. Knowing the amount of debt attached to an investment is helpful, but as we will discuss, it is not sufficient for determining the weights on the investment's debt and equity financing because these weights require the market value of equity.

Investments that are financed on the firm's balance sheet add another layer of complexity to the analysis because, in this case, the financing of the project is intermingled with the financing of the firm's other investments. As we will discuss, determining what we will refer to as the debt capacity of a project that is financed on a firm's balance sheet is not completely arbitrary, but it does require some judgment on the part of the manager.

Example: Determining Project-Specific WACC for Project-Financed Projects

To illustrate the estimation of project-specific WACC, we first consider a project-financed investment being evaluated by the independent electric power producer Catalina Inc. As shown in Catalina's balance sheet depicted in panel (a) of Figure 5-3,

Figure 5-3 Project Versus Firm Financing

Panel (a) Pre-Investment Corporation

Catalina Inc.
Balance Sheet
December 31, 2014

Assets $1,200 million		Bonds	$ 600 million
		Equity	600 million
		Total	$1,200 million

Panel (b) Alternative #1—Corporate Finance

Catalina Inc.
Balance Sheet
December 31, 2014

Assets	$1,200 million	Bonds	$ 760 million
Project	200 million	Equity	640 million
Total	$1,400 million	Total	$1,400 million

Panel (c) Alternative #2—Project-Financing Alternative

Catalina Inc.
Balance Sheet
December 31, 2014

Assets	$1,200 million	Debt	$ 600 million
$\text{Equity}_{\text{Project}}$	40 million	Equity	640 million
Total	$1,240 million	Total	$1,240 million

Power Project
Balance Sheet
December 31, 2014

Assets $200 million		Debt	$ 160 million
		Equity	40 million
		Total	$ 200 million

Catalina currently has total assets of $1.2 billion. It is considering the construction and operation of a $200 million major power-production facility in south Texas. The project is substantial and will require Catalina to raise $200 million in additional funds.

Panel (b) of Figure 5-3 highlights the effects of the $200 million investment on the firm's balance sheet if Catalina decides to use corporate financing by borrowing 80% of the funds and raising the remainder using an equity offering. In this case, the total assets of Catalina rise by \$200 million, to \$1.4 billion; the firm's debt rises by \$160 million, to \$760 million; and its equity increases by \$40 million, to \$640 million.

Alternatively, Catalina might use project financing, which entails the creation of a new entity, as depicted in panel (c) of Figure 5-3. The entity is a new company, Power Project, which owns and operates the project. Because the \$40 million in equity financing comes from Catalina, however, Catalina's balance sheet shows an increase of \$40 million in assets (corresponding to the equity in the project) and an increase of the same amount in Catalina's equity account, reflecting the equity issue used to finance the equity portion of the investment.

Estimating Project Equity Value Directly—the Flow-Through-to-Equity Model The focus of project-financed investments is typically on the equity invested in the project, which is valued with the **flow-through-to-equity model.** This approach is simply a discounted cash flow model that focuses directly on the valuation of the equity invested in the project rather than on the value of the project as a whole. Using this approach, we calculate the present value of the equity free cash flows (equity FCFs) using the project's cost of equity capital and compare the estimated equity value with the equity invested in the project.[7] Note that this approach does not require the calculation of the project's WACC but relies on the cost of equity and equity FCFs.

Recall from Chapter 4 that equity free cash flow, or equity FCF, can easily be computed from project FCF by recalling that a project's FCF is equal to the sum of the cash flows available to be paid to the firm's creditors (creditor cash flows) and owners (equity FCF), that is:

$$\begin{matrix}\text{Project} \\ \text{FCF}\end{matrix} = \begin{matrix}\text{Creditor} \\ \text{Cash Flows}\end{matrix} + \begin{matrix}\text{Equity} \\ \text{FCF}\end{matrix}$$

so that

$$\begin{matrix}\text{Equity} \\ \text{FCF}\end{matrix} = \begin{matrix}\text{Project} \\ \text{FCF}\end{matrix} - \begin{matrix}\text{Creditor} \\ \text{Cash Flows}\end{matrix}$$

So what are the cash flows paid to, or received from, the firm's creditors? There are two types of cash flows to consider: interest and principal. Also, because interest expenses are tax-deductible, we adjust interest to reflect the interest tax savings such that after-tax interest equals the firm's interest expense less the tax savings resulting from the deduction of interest from the firm's taxable income. The principal payments can be both cash outflows (to creditors) when the firm initiates new borrowing and cash inflows (to the creditors) when it repays the loan. We can summarize the calculation of creditor cash flows as follows:

$$\begin{matrix}\text{Creditor} \\ \text{Cash Flows}\end{matrix} = \underbrace{\begin{matrix}\text{Interest} \\ \text{Expense}\end{matrix} - \begin{matrix}\text{Interest} \\ \text{Tax Savings}\end{matrix}}_{\text{After-Tax Interest Expenses}} + \underbrace{\begin{matrix}\text{Principal} \\ \text{Payments}\end{matrix} - \begin{matrix}\text{New Debt Issue} \\ \text{Proceeds}\end{matrix}}_{\substack{\text{New Debt Proceeds} \\ \text{(Changes in Principal)}}}$$

We illustrate the calculation of equity FCF in Table 5-3.

We believe that the flow-through-to-equity approach is an appropriate approach for assessing the value of a specific project. However, for the purpose of comparing

[7] Equity free cash flows were defined in Chapter 2.

Table 5-3 Projected Earnings and Cash Flows for the Catalina Power-Generation Project

Panel (a) Assumptions and Forecasts

Initial investment = $200 million in year 0

Depreciable fixed assets = $200 million

Depreciation is straight line on $200 million of capital equipment (no working capital), which is depreciated toward $0.00 in 40 years.

Capital expenditures (CAPEX) = depreciation expense = $5 million per year

Financing mix: $160 million in debt and $40 million in equity

Debt financing terms and conditions:

a. Type of debt—nonrecourse project financing

b. Maturity—infinite

c. Terms—interest only, forever

d. Interest rate—6.52%

e. Beta (debt)—30

Estimated project operating earnings (EBIT) = $20,109,419 per year (year 1 to infinity)

Corporate tax rate = 38%

Capital market estimates and assumptions:

a. Risk-free rate of return on long-term US government bonds = 5.02%

b. Market risk premium = 5.00%

investments across different lines of business, firms may also want to know the appropriate project WACCs for their different investments. Consequently, we extend our analysis of the value of the equity invested in a project to include the value of the project as a whole and the corresponding project-specific WACC, which, for the special case where project finance is used, we refer to as the **project finance WACC.**

Estimating the Cost of Equity and Project Free Cash Flows (FCFs) Panel (a) of Table 5-3 summarizes the assumptions that underlie the cash flow projections for the power-generation project. Of particular note is the fact that a consortium of banks has offered to loan the project $160 million at a rate of 6.52%, which is 52 basis points over the prime rate (currently 6%). Panel (b) contains the pro forma income statements for the project, which, for simplicity, is expected to operate forever, producing a level stream of income. We assume that the entire $200 million investment is comprised of plant and equipment that depreciates straight line over 40 years toward a zero salvage value. In addition, we assume that the firm must spend an amount equal to the depreciation on CAPEX to maintain the plant's productive capacity.

Table 5-3 *continued*

Panel (b) Pro Forma Income Statements and Cash Flow Projections

Pro Forma Income Statements	**Year 1 to Infinity**
Earnings before interest and taxes (EBIT)	$ 20,109,419
Less: Interest expense	(10,432,000)
Earnings before taxes (EBT)	$ 9,677,419
Less: Taxes	(3,677,419)
Net income	$ 6,000,000

Calculation of Project Free Cash Flow (FCF)	**Year 0**	**Year 1 to Infinity**
Earnings before interest and taxes		$ 20,109,419
Less: Taxes		(7,641,579)
Net operating profit after taxes (NOPAT)		$ 12,467,840
Plus: Depreciation expense		5,000,000
Less: CAPEX	$ (200,000,000)	(5,000,000)
Project free cash flow (FCF)	$ (200,000,000)	12,467,840

Calculation of Equity Free Cash Flow	**Year 0**	**Year 1 to Infinity**
Project FCF	$ (200,000,000)	$ 12,467,840
Less: Interest expense	—	(10,432,000)
Plus: Interest tax savings	—	3,964,160
Equals: After-tax interest expense	—	(6,467,840)
Less: Principal payments on debt	—	—
Plus: Proceeds from new debt offerings	$ 160,000,000	—
Equals: Net proceeds from debt financing	$ 160,000,000	—
Equity FCF	$ (40,000,000)	$ 6,000,000

Note: Calculation of Project FCF begins with the firm's EBIT.

Note: No interest or principal payments are considered when computing project FCF.

Note: To get equity FCF, we start with project FCF, then net out cash flows paid to creditors (after-tax interest), subtract principal payments, and add new debt issue proceeds from project FCF.

The project is expected to produce net operating income (i.e., earnings before interest and taxes) of $20,109,419 per year and to pay $10,432,000 in interest expense. Deducting taxes produces an estimated annual net income of $6,000,000 per year in perpetuity. Because CAPEX is assumed to equal the depreciation expense, the project FCFs are equal to $12,467,840 per year.

Estimating the Value of the Equity and the Cost of Equity Capital Using Iteration Until this point, we have followed a simple three-step procedure for implementing discounted cash flow analysis:

Step 1: Estimate future cash flows.
Step 2: Estimate a discount rate.
Step 3: Calculate the present value of the cash flows using the discount rate estimated in step 2.

There is a slight wrinkle in this procedure, however, when the discount rate is not known. The problem that arises when estimating the cost of equity for a project is that the beta of the project, and thus its cost of equity, is determined by the extent to which the project is levered. If the project is more highly levered, the equity beta is higher, which means that the cost of equity is higher and the value of equity is lower. To calculate the leverage of the project, however, one needs to know the value of the equity.

As a first pass, analysts generally use the amount of invested equity in the project (i.e., the book value of the equity investment) to calculate the project's leverage and the firm's cost of equity. For example, in the Catalina project, the analyst would assume an equity value of $40 million and calculate its cost of equity accordingly. As we discuss below, if the value of equity is greater than $40 million, this procedure overestimates the cost of equity and thereby underestimates the value of the project's equity.

The fact that using invested equity rather than the market value of equity can overestimate the risk of a positive NPV project is not a major problem. First, it will not lead one to conclude incorrectly that a positive NPV project really has a negative NPV, or vice versa. Rather, it leads one to understate the NPV of positive NPV investments and understate (make more negative) the NPV of negative NPV investments. Second, as we describe below, a simple iterative procedure can be used to determine the correct NPV.

To understand these issues, we calculate the value of the Catalina project's equity. As we illustrate in Table 5-4, we start with a sample of comparable firms to estimate unlevered equity betas for power-generation projects. You may recall that we used this same process in Table 4-1 to estimate the unlevered equity beta for Pfizer. The process involves first unlevering the equity betas for the proxy firms and then averaging the unlevered betas to use as our estimate of the unlevered equity beta for the Catalina power-generation project. The resulting unlevered equity beta estimate for the project is .4472.

To estimate the cost of equity for Catalina's power-generation project, we must relever this unlevered beta to determine the levered beta and cost of equity for the project. As a first step, we substitute the project's book value debt-to-equity ratio (i.e., $160 million/$40 million = 4) into Equation (1) (found in panel (c) of Table 5-4) to relever the unlevered equity beta. The levered beta estimate is then used to calculate the levered cost of equity, and consequently the value of the project's equity. This analysis generates a cost of equity of 10.2% and an equity value slightly greater than $58 million. Because $58 million is greater than $40 million, we know that the project does create value, and we know that the actual levered beta of the project is lower and the equity value is higher than is indicated by this calculation.

To get a better estimate of both the cost of equity and the value of this equity investment, we can use the estimated value of the equity ($58 million) in place of the invested equity ($40 million) and repeat the above calculations. By doing this, we calculate a slightly lower cost of equity (9.26%) and a slightly higher equity value ($64,806,671). We can then take this new estimate of equity value and again repeat these calculations to determine a new equity value. We can continue this process, iterating between new equity values and levered betas until the value of the project's cost of equity and equity value converge to a fixed amount. A quick review of the results of the iterative process found in panel (b) of Table 5-4 reveals that they converge very quickly. The project's cost of equity capital converges to 9.03% and the value of the equity converges to $66,457,802 in the sixth iteration. We included six iterations to demonstrate that convergence happens quickly.

Table 5-4 Estimating Project Value and the Cost of Equity for a Power-Generation Project

Panel (a) Estimating the Unlevered Project Beta Using Proxy Firms

Company Name	Levered Equity Betas	Debt/Equity Ratio	Assumed Debt Betas	Unlevered Equity Betas
Ameren Corp. (AEE)	0.7600	121.98%	0.30	0.5072
American Electric Power (AEP)	0.6000	102.38%	0.30	0.4482
Dominion Resources (D)	0.5500	76.77%	0.30	0.4414
Duke Energy Corp. (DUK)	0.4600	73.94%	0.30	0.3920
PPL Corp. (PPL)	0.6710	64.19%	0.30	0.5260
			Average	0.4630

Panel (b) Iterative Procedure for Estimating the Cost of Equity, Equity Value, Project Value, and Project Finance WACC

(A) Iteration Steps	(B) Unlevered Equity Beta	(C) Debt/Equity Ratio	(D) Levered Equity Beta	(E) Estimate of the Cost of Equity	(F) Estimated Equity Value
Book weights	0.4472	4.0000	1.0361	10.200%	$58,821,161
Iteration 1	0.4472	2.7201	0.8477	9.258%	$64,806,671
Iteration 2	0.4472	2.4689	0.8107	9.073%	$66,127,493
Iteration 3	0.4472	2.4196	0.8034	9.037%	$66,393,102
Iteration 4	0.4472	2.4099	0.8020	9.030%	$66,445,489
Iteration 5	0.4472	2.4080	0.8017	9.029%	$66,455,782
Iteration 6	0.4472	2.4076	0.8017	9.028%	$66,457,802

Column	Description
(A)	*Iteration steps*—the iteration process begins by substituting the book value debt-to-equity ratio into Equation (1) in panel (c) to solve for the levered equity beta for the project.
(B)	*Unlevered equity beta*—this estimate represents the simple average of the unlevered equity betas found in panel (a).
(C)	*Debt-to-equity ratio*—a key input into the relevering of beta that should represent market values. Because we do not know the market value of the equity invested in the project, we begin our iterative analysis by using the book value of this ratio.
(D)	*Levered equity beta*—the project's levered equity beta, estimated using Equation (1) from panel (c).
(E)	*Estimate of the cost of equity*—calculated using the CAPM found in Equation (2) in panel (c) and the estimate of the levered equity beta from the current iteration.
(F)	*Estimate equity value*—the value of the equity invested in the project, estimated using Equation (3) found in panel (c).

(*Continued*)

Table 5-4 *continued*

Panel (c) Equations Used to Estimate Project Value and the Project's Cost of Equity

(1)

$$\beta_{\text{Equity}_j} = \beta_{\text{Unlevered}_j}\left(1 + \frac{\text{Debt Value}_j}{\text{Equity Value}_j}\right) - \beta_{\text{Debt}_j}\left(\frac{\text{Debt Value}_j}{\text{Equity Value}_j}\right)$$

where β_{Debt} is the estimated debt beta for the project.[8]

(2)

$$\begin{matrix}\text{Levered Cost of}\\ \text{Equity}\,(k_e)\end{matrix} = \begin{matrix}\text{Risk-free}\\ \text{Rate}\,(r_f)\end{matrix} + \left(\begin{matrix}\text{Levered}\\ \text{Equity}\\ \text{Beta}(\beta_{\text{Equity}})\end{matrix}\right)\left(\begin{matrix}\text{Market}\\ \text{Risk Premium}\end{matrix}\right)$$

(3)

$$\begin{matrix}\text{Project}\\ \text{Equity Value}\end{matrix} = \frac{\text{Equity Free Cash Flow}\,(\text{EFCF})_t}{\text{Levered Cost of Equity}\,(k_e)}$$

Calculating Project Value and Project Finance WACC Now that we have calculated the equity value, it is straightforward to value the project by simply adding the estimated value of the project's equity (from the sixth iteration in panel [b] of Table 5-4), $66,457,802, to the project's debt, $160 million, to arrive at a project value that equals $226,457,802. Using this value, we can calculate project finance WACC as the weighted average of the after-tax costs of debt and equity, and we can use as weights the estimated value of the project's equity and the face value of the firm's debt:[9]

	Values	Value Weights	Capital Costs	Product
Debt	$ 160,000,000	0.7065	4.04%	2.85%
Equity	66,457,802	0.2935	9.03%	2.65%
	$ 226,457,802	1.0000		
			Project finance WACC =	5.51%

Project-Specific WACC with Corporate Financing

Firms finance most of their investment projects on their balance sheets, which can make it especially challenging to come up with an approach for estimating project-specific WACCs. This can be a formidable task because one must first determine the amount of debt and

[8] For a discussion of the relationship between the levered firm's equity beta and the unlevered beta, see the Technical Insight box found on page 116 in Chapter 4.

[9] Alternatively, project finance WACC is equal to the discount rate in the following project value equation:

$$\text{Project Value} = \text{Project Equity Value} + \text{Book Value of Project Debt}$$

$$= \frac{\text{Project Free Cash Flow}\ (\text{PFCF})_t}{\text{Project Finance WACC}} = \$226{,}457{,}802 = \frac{\$12{,}467{,}840}{\text{Project Finance WACC}}$$

The project finance WACC is 5.5%. Note that if we had solved for the discount rate that makes the present value equal to the $200 million cost of the project (instead of the $226,457,802 value of the project), the result would have been an estimate of the project's internal rate of return (IRR), which in this case equals 6.23%.

equity that can be attributed to each project and then estimate the costs of these financing sources. As we mentioned earlier, this is more difficult when the investments are financed on the firm's balance sheet because the financing is commingled with the financing of the firm's other investments. As a result, determining the appropriate weight for each source of capital for a particular investment requires the exercise of managerial judgment.

Project Debt Capacity—How Much Debt Will the Project Support? Determining the appropriate weights for a project's sources of financing requires that we first understand the concept of a project's debt capacity. We define the **debt capacity** of a project as the amount of *additional debt* the firm can take on as a result of undertaking the project, without lowering the firm's credit rating. In general, riskier projects have lower debt capacities because they require more equity to offset their higher risk. For example, an investment in new-product development can be quite risky and provides little, if any, debt capacity. However, renovation of the firm's present facilities that is used to support existing product lines is less risky and thus has a higher debt capacity.

Note that the debt capacity of a project is not necessarily the same as the amount of debt that the firm takes on to finance the project. The actual addition to the firm's debt may have more to do with other investment projects that are initiated at about the same time and whether the firm's executives believe that the firm currently has too much or too little debt.

To understand how one can determine the debt capacity of an investment, consider a firm that currently has a BBB+ rating and has an investment opportunity that requires a $100 million investment. Because the investment is expected to generate positive free cash flows, taking the project will enhance the firm's credit rating if it is financed completely with equity. This indicates that the project has at least some debt capacity. Because the investment is risky, however, financing it either completely with debt or, equivalently, by depleting the firm's cash balances would result in a downgrade in the firm's credit rating. For example, if the rating agencies indicate that the firm in the above example will suffer a drop in its rating from BBB+ to BBB if it finances its $100 million investment with more than $45 million in debt, then the project's debt capacity is $45 million.

What determines the debt capacity of a project? Probably the first determinant is the volatility of the project's cash flows. Are the project's cash flows more volatile or less volatile than the firm's total cash flows? If they are more volatile, then the project may have less debt capacity (as a fraction of the value of the project) than the firm. In other words, if the firm has a debt ratio of 30%, then the more risky project may have a debt capacity of only 20%. One should also consider the extent to which the investment project contributes to the firm's diversification. If adding the project reduces the volatility of the firm's total cash flows because of the diversification effect, then the project will have a higher debt capacity. Finally, it is worth noting that investments that can be sold easily with minimal loss of value may also have higher debt capacities. Such projects make firms more attractive to rating agencies because firms can easily convert these assets to cash in the event of financial distress, thereby helping the firm to stave off default and bankruptcy.

It's clear that estimating a project's debt capacity is subjective, but for large investments, firms can get a pretty good idea of the project's

Did You Know?

The History of Bond Ratings

In 1914, John Moody began expanding his published rating coverage to bonds issued by US cities and other municipalities. By 1924, Moody's ratings covered nearly 100% of the US bond market. In 1916, Standard Statistics (a predecessor of the Standard & Poor's Corporation) began assigning debt ratings to corporate bonds. The firm introduced ratings for municipal bonds in 1940.

debt capacity by consulting their investment bankers or by talking directly to credit agencies. (See the Practitioner Insight box describing the interaction between borrowers and the credit rating agencies.) If the project is deemed to be very risky, these outsiders may suggest that the firm use more equity and less debt in the financing package to reduce the potential for a detrimental effect on the firm's credit rating. Alternatively, the bankers and the credit analysts at the credit agencies may suggest that the project can support additional debt. The important point is that individuals outside the firm who do not have a direct stake in whether the project is ultimately accepted can provide an impartial assessment of the project's debt capacity.

What Are the Appropriate Costs of Debt and Equity for an Individual Project? Our recommended process for determining the project's debt capacity provides the appropriate weights for debt and equity that are used in our WACC formula. We now need to determine the relevant costs of debt and equity for the project. Our solution to this problem is very simple: We recommend calculating the project's WACC using estimates of the firm's costs of debt and equity, but using different weights for debt and equity that reflect the debt capacities of the projects. This is obviously a shortcut but, as we will illustrate, if the debt capacities are chosen appropriately and if we use the same costs of debt and equity for each project, we can get a reasonable estimate of the differences between the costs of capital of different projects. Indeed, this approach provides the correct discount rates if differences in debt capacities across projects fully reflect differences in systematic risk across projects (that is, projects with more systematic risk have lower debt capacities).

TECHNICAL INSIGHT

Bond Credit Ratings

Who rates corporate debt? In the U.S. the big three corporate bond rating agencies are Moody's Investors Service, Standard & Poor's, and Fitch Ratings. Although their rating classification symbols differ, all three firms identify high and medium grade investment grade bonds followed by non-investment grade or speculative grade bonds.

Who initiates the rating process? The credit rating process begins when a firm requests that its debt be rated by one of the credit rating agencies. The typical reason for requesting a rating is that it is required by a lender or because the bond issuer wants to sell their debt in the public markets.

Do credit ratings ever change? The quick answer is yes. Rating agencies monitor the firm's credit on an ongoing basis as new information becomes available. The objective is to determine whether the assigned rating is still valid or should be changed.

In addition to regular reviews, the credit rating agency monitors each of the firms whose debt they rate for special events that might trigger a change in default risk. Examples of the type of events that could trigger a reevaluation include the acquisition of another firm or a change in financial policy, such as the initiation of a share repurchase program. The point here is that firms can, and do, take actions that result in a change in their credit rating!

How good are credit rating agencies in predicting default? With each new financial crisis the rating agencies are criticized for not being better predictors of corporate defaults. One possible explanation for this is that the ratings are based on past corporate and market performance. Consequently, they are, by their very nature, lagging indicators of firm performance. The most recent round of criticism came from their ratings of collateralized debt obligations during the 2008 financial crisis.

Although this method is an approximation, it does generate higher project WACC estimates for riskier projects that have lower debt capacities, and it generates lower project WACC estimates for less risky projects that have higher debt capacities. To illustrate, suppose that the firm's cost of equity is 12% and its after-tax cost of debt is 4%. Assume also that project 1 is quite risky and has a debt capacity of only 20%, whereas project 2 is much less risky and has a debt capacity of 60%. Consequently, the WACC for project 1 is

$$(.20 \times 4\%) + (.80 \times 12\%) = 10.4\% \quad \textit{Project \#1 WACC}$$

while the WACC for project 2 is only

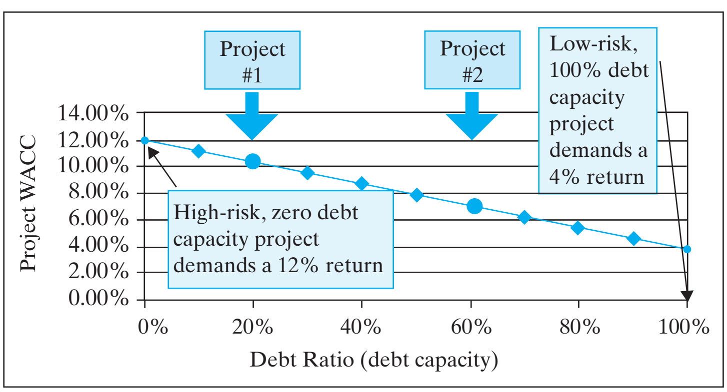
$$(.60 \times 4\%) + (.40 \times 12\%) = 7.2\% \quad \textit{Project \#2 WACC}$$

As this simple example illustrates, the project-specific WACC approach provides a straightforward way to allow project sponsors to argue for different discount rates for different projects, while at the same time putting constraints on the managers' ability to argue for a low discount rate.

Figure 5-4 illustrates the effects of varying debt capacity on the WACCs of projects whose debt capacities range from 0% to 100%. In practice, the range is likely to be much tighter, but the implications are the same. Within these boundaries, the project WACC we calculate is a function of the debt capacity of the project and of the estimated costs of debt and equity financing for the firm (or division).

Summary for Adjusting Project WACC Using Project Debt Capacity The key assumption we make in the approach we have taken in the analysis of the project-specific WACC is that, by accounting for differences in project debt capacity, we are fully accounting for differences in project risk. This is a reasonable assumption for projects that are in the same line of business—and are thus subject to the same risk factors—but have different cost structures and profit margins, and thus different sensitivities to these risk factors.[10] For example, because of improved technology, power plants built with the

Figure 5-4 Debt Capacity and a Project's WACC



[10] Recall from our earlier discussions that firms in the same line of business can have different levels of operating leverage that can cause them to have different levels of risk. In general, firms with higher operating leverage use less financial leverage.

most recent technology are more fuel-efficient and have lower operating costs per kilowatt-hour (kwh) than do plants built using older technology. Thus, new-technology power plants have higher profit margins, which make them less risky and give them higher debt capacities.

To illustrate the higher debt capacity provided by the more efficient new plant technology, consider an example in which a firm wants to construct a power plant with either the newest technology (new plant) or a more traditional (older) technology (old plant). Table 5-5 contains the characteristics of the two plant alternatives. In panel (a), we note that both plants have the capacity to produce 1,100,000 kwh per year; however, new plant incurs total costs of $8,990,000, while old plant incurs costs of $10,200,000 to

Table 5-5 Using Debt Capacity to Adjust for Project Risk—New Plant Versus Old Plant

Panel (a) Operating Costs, Operating Risk, and Debt Capacity

	New Plant	Old Plant
Capacity in kwh per year	1,100,000	1,100,000
Fixed operating costs	$ 8,000,000	$ 8,000,000
Variable operating costs/kwh	$ 0.90	$ 2.00
Total operating costs at capacity	$ 8,990,000	$ 10,200,000

		Net Operating Income (NOI)			% Change NOI	
Price/kwh	Revenues	New Plant	Old Plant	% Change Revenue	New Plant	Old Plant
$10.00	$11,000,000	$2,010,000	$ 800,000			
12.00	13,200,000	4,210,000	3,000,000	20.0%	109%	275%
14.00	15,400,000	6,410,000	5,200,000	16.7%	52%	73%
16.00	17,600,000	8,610,000	7,400,000	14.3%	34%	42%

Panel (b) Debt Capacity and Equity Risk

	New Plant	Old Plant
Debt	$25,125,000	$10,000,000
Interest rate	8.0%	8.0%
Interest expense	$ 2,010,000	$ 800.000
Tax rate	30%	30%

	Net Income	
Price/kwh	New Plant	Old Plant
$10.00	—	—
12.00	1,540,000	1,540,000
14.00	3,080,000	3,080,000
16.00	4,620,000	4,620,000

produce the capacity output.[11] If the per unit price is $12 per kwh, then both plants generate revenues of $13,200,000 per year, with the more efficient, newer plant earning $4,210,000 in operating profits compared to only $3,000,000 for the less efficient, older plant. Other things being the same, new plant is clearly more valuable and will have a greater total debt capacity due to its higher value. In addition, the new plant will have a greater debt capacity as a percentage of its value because its profits are less volatile in response to changes in electric power prices.[12] To see this, consider the effects of a drop in price from $12.00 to $10.00 per kwh (a drop of 16.7%). Assuming that both plants continue to operate at capacity, the new plant's operating profits will drop by 52%, but the old plant's will drop by 73%. This greater sensitivity of the older plant to price changes means that its ability to service debt is less than that of the newer plant.

In panel (b) of Table 5-5, we assume that the old plant is financed with $10 million in debt that carries an 8% rate of interest. Note that if new plant's debt financing is set equal to $25,125,000 of 8% debt, the new plant and old plant will produce the same level of net income regardless of the price of electric power. If this is the case, the equity cash flows to both plants will be the same, which means that the probability of default for both debt issues will be the same and that the appropriate cost of both debt and equity will be the same for both plants. As we discussed earlier, however, the project-specific WACCs for the two plants will be different; the new plant will have a lower WACC because, as a proportion of its value, it is financed with less debt.

The preceding example illustrates that the project-specific WACC approach is likely to work very well for projects that are very similar in all respects other than risk. For projects in very different lines of business, however, the approach is clearly imperfect. For example, differences in the debt capacity of an integrated oil company's refinery business and its chemical business may provide a good indicator of differences in its cost of capital. It should be emphasized, however, that this is only an approximation because there may be inherent differences between the betas of chemical and refinery businesses that are not fully captured by differences in their respective debt capacities.

Before concluding our discussion of this approach, it is worth noting that even for firms in only one line of business, the debt capacity of any individual investment project can look very different from the overall debt ratio of the firm. For example, consider a manufacturing firm with a market value of $2.5 billion that owns a number of factories with an aggregate value of $1.5 billion. Why is the market value of the firm so much higher than the value of its assets? The answer is that the market value of the firm reflects not only the value of the firm's assets but also the cumulative value of all the firm's future opportunities to take on positive NPV investments. In this case, $1 billion of the firm's value is represented by the fact that it has opportunities to take on positive NPV investments in the future.

If the firm has $500 million of debt outstanding, then its debt ratio (in market value terms) is $500 million/$2.5 billion = 20%. When calculating the firm's WACC, we use market value weights of .20 for debt and .80 for equity. However, if each new plant can be financed like the existing plants, with 33% debt, then the project-specific WACC

[11] These computations are based on the assumption that both plants incur $8 million per year in fixed operating costs but that the new plant incurs only $0.90 per kwh to produce power, while the old plant (which is much less fuel-efficient) incurs $2.00 per kwh. Note that we fix output capacity so that the changes in operating profits are driven solely by the price of electric power per kwh (the total costs of producing the 1,100,000 kwh of electric power are fixed for each plant).

[12] Both plants are assumed to continue to operate at their full capacity in the face of changing power prices.

would put more weight on debt and would thus be less than the firm's WACC. Put somewhat differently, the firm's growth opportunities may have zero debt capacity, and the debt capacity of the firm's operating assets may be 33%.

5.4 Hurdle Rates and the Cost of Capital

In this chapter, we have discussed a variety of ways in which firms can determine the cost of capital associated with a given investment project. The traditional theory suggests that to evaluate a project, firms should discount the project's cash flow at the project's cost of capital and then accept the project if the calculated NPV is positive. In practice, however, firms tend to discount cash flows using discount rates, often referred to as *hurdle rates,* which exceed the appropriate cost of capital for the project being evaluated. For example, it's not unusual to see corporate hurdle rates as high as 15% for firms with WACCs, as well as project WACCs as low as 10%. In other words, firms generally require that accepted projects have a substantial *NPV cushion,* or margin of safety. For example, most managers are unwilling to invest in a project with an initial expenditure of $100 million if the project's NPV is only $200,000. In theory, this is a positive NPV project that will add $200,000 to the firm's value. In practice, however, most managers would consider an NPV cushion of 0.2% of the project's initial expenditure to be too small.

Mutually Exclusive Projects

There are a number of reasons why it makes sense to require either an NPV cushion or, equivalently, a hurdle rate that exceeds the project's cost of capital. The first and probably most important reason is that most firms do not believe that their WACC, which is the opportunity cost that we calculate from the capital markets, is the appropriate opportunity cost. The capital markets provide the appropriate opportunity cost for firms that have no constraints and can implement all positive NPV investments. For firms that have constraints that limit the number of projects that can be accepted, however, the opportunity cost of capital reflects the return on alternative investments that may have to be passed up. More precisely, the opportunity cost of capital must reflect the rate of return forgone on the next-best project that must be rejected if the evaluated project is accepted. For example, suppose a firm is choosing between two projects that are of equivalent risk. Further suppose that the first project can generate an expected internal rate of return of 18%. If taking the second project precludes taking the first project, then the appropriate opportunity cost of capital that should be used to evaluate the second project is 18%, not the cost of capital.

High Hurdle Rates May Provide Better Incentives for Project Sponsors

By requiring a high hurdle rate, firms may signal that they have good investment opportunities, which may have the side benefit of motivating project sponsors to find better projects. For example, if top management sets a corporate hurdle rate at 12%, project sponsors may be happy to propose a project with an internal rate of return of 13%. However, with a 15% hurdle rate, the project sponsor will need to put in more effort and negotiate harder with suppliers and strategic partners to come up with an investment plan that meets the higher hurdle. Indeed, we can envision situations where a high hurdle rate actually helps in the negotiation process. For example, suppose that a profitable project requires the participation of two firms that are structuring a deal that, in effect, divides the project's profits. Suppose now that the first firm requires a very high hurdle rate for investment projects, but the second firm does not. In such a situation, the second firm may be willing to make concessions to the first firm to get the project approved.

Accounting for Optimistic Projections and Selection Bias

In general, cash flow forecasts are not very accurate. As a result, if they are unbiased estimates, the process used to select projects can induce an optimistic bias in the cash flow forecasts for those projects that are eventually selected. Hence, it generally makes sense to use a high hurdle rate to offset the optimistic cash flow forecasts.

To understand how these biases can arise, it is useful to consider an investment that a number of firms are competing to acquire. For example, a conglomerate may be selling one of its divisions and plans to sell to the highest bidder. In this situation, we might expect between five and ten firms to evaluate the division and make bids that are somewhat lower than their estimated values. In this situation, the highest bidder is likely to have the most optimistic forecast of the division's future cash flows and thus the highest valuation for the business.

Auction theorists have coined the term *winner's curse* to convey the idea that the winning bidder, being the most optimistic of all the bidders, is likely to be too optimistic and may thus overbid. (See the Behavioral Insight box on the winner's curse.)

BEHAVIORAL INSIGHT

Common Valuation Mistakes: The Winner's Curse

The winner's curse is a thriving part of our culture. This is illustrated in a comment once made by Groucho Marx: "I would never join a club that would have me for a member." Alvy Singer (played by Woody Allen in the movie *Annie Hall*) later applied this same logic to his reluctance to enter a relationship with a woman who would be interested in him. Allen's character considered this tendency to be one of his many neuroses. Economists recognize, however, that it is actually rational to devalue those things that are available and that there is a tendency for firms to fail to recognize the winner's curse and thus overpay for certain investments.

The term *winner's curse* was coined in an article describing competitive bidding in high-risk situations, such as the bidding for drilling rights to areas under the Gulf of Mexico.[13] The authors claimed that oil companies were overpaying for offshore oil leases in Outer Continental Shelf auctions and, as a result, suffered unexpectedly low returns year after year. In these auctions, each firm makes bids based on its estimates of the unknown value of the leases, which means that the most optimistic bidder tends to win the auction. This in turn implies that the winner will overpay for the lease whenever the bidder fails to account for the fact that the bidder tends to be overly optimistic when it places what turns out to be the winning bid.

The winner's curse problem can arise in any opportunity for which firms need to bid either explicitly or implicitly against other firms. Whenever opportunities arise, managers need to think like Groucho Marx and Alvy Singer, and ask whether the opportunity is available because there are flaws that have led better-informed bidders to pass on the opportunity.

[13] E. C. Capen, R. V. Clapp, and W. M. Campbell, "Competitive Bidding in High-Risk Situations," *Journal of Petroleum Technology* 23 (1971): 641–651.

To counteract this tendency to overpay in auctionlike settings, auction theorists recommend that firms shade down their bids to reflect the fact that they are likely to have been overly optimistic if they do win the bid. One way to accomplish this is to require very high hurdle rates when evaluating projects in auctionlike settings. For businesses that are more difficult to value and in situations where there are likely to be more bidders, the winner's curse is more severe. In such situations, an even higher hurdle rate is warranted.

A similar situation arises whenever a firm selects from a set of proposed investment projects. In this situation, the firm is likely to select projects that look the most attractive; in general, these are likely to be the best projects, but they will also be projects that are likely to be not quite as attractive as they may appear. Again, a high hurdle rate is warranted to offset the fact that the cash flow forecasts of selected projects are likely to be optimistic forecasts.

To understand the importance of this selection bias, consider a college that selects only students with very high SAT scores. On average, the students will be very bright, but they may not be quite as bright as their SAT scores would suggest. By selecting students based on high SAT scores, the college will get students that are indeed smarter than average, but they will also be somewhat luckier than average. Students with abilities commensurate with a 1525 SAT score who are unlucky and score only 1450 points will get rejected, while students with abilities commensurate with a 1425 SAT score but who are lucky and score 1500 will get selected. Hence, on average, the students admitted to this college will tend to have SAT scores that exceed their true abilities. For similar reasons, we expect that selected investment projects tend to have cash flow forecasts that exceed their true expected cash flows, which in turn suggests that they should be evaluated using a hurdle rate that exceeds the true cost of capital.

5.5 Summary

Discounted cash flow valuation requires two important inputs: estimates of future cash flows and discount rates. In Chapters 2 and 3, we dealt with cash flows, and in Chapter 4, we focused on discount rates that can be used to value entire firms. This chapter examined the appropriate discount rate that firms should use to value individual investment projects.

In general, project discount rates derived from academic theory deviate substantially from industry practice. Theory suggests that firms should evaluate each investment project with individual discount rates that reflect both the debt capacity and the unique risks of the investment. In practice, firms often use their companywide WACC to evaluate their investments. There are two very practical reasons for this: First, the cost of capital is a subjective concept that is difficult to estimate for publicly traded firms and is even more difficult to estimate for an individual project. Second, providing project advocates with latitude in the selection of the appropriate discount rate may create managerial biases that are worse than those created by using just one discount rate. That is, overly optimistic and/or opportunistic managers may waste time and valuable resources persuading project evaluators to value their projects with lower discount rates, thus making the projects look better than they really are.

In practice, firms use one of three approaches to determine the discount rate to use in valuing investment alternatives. The most common approach involves the use of a single, firmwide WACC for all projects. For firms that operate in multiple divisions whose project risks and financing patterns are unique, a divisional WACC is often used. Finally, some firms estimate a project-specific WACC where the project is of such significance to the firm that developing a customized or tailored estimate of the project WACC is warranted. We discussed two important variants of the project WACC: The first involves projects that are financed using project financing (i.e., nonrecourse debt). The second involves projects that are financed out of corporate sources. In the latter case, the analyst has the added task of estimating the project's debt capacity.

Exercises

5-1 THOUGHT QUESTION Explain how a firm might use the divisional WACC approach to avoid overinvesting in divisions with more risky projects and underinvesting in divisions with less risky projects.

5-2 THOUGHT QUESTION Mango Services Company has a corporate WACC of 10%. You propose investing in a new project that has very little risk with an internal rate of return (IRR) of 8%. Your boss asks, "How can the project possibly have a positive NPV if its IRR is less than our WACC?" What is your answer?

5-3 INVESTOR OPTIMISM AND THE COST OF CAPITAL Investment projects located in Indonesia and other emerging markets frequently have low systematic risk, implying that the appropriate discount rates for the projects are quite low. In practice, most firms (with some notable exceptions) use very high discount rates for these projects. One explanation that has been offered for this practice is that the investing firm uses the high discount rates in an attempt to offset the effects of optimistic cash flow estimates. Is it a good idea to adjust for the risk of overly optimistic cash flow forecasts using changes in discount rates, or should the cash flows themselves be adjusted?

5-4 CALCULATING A FIRM'S WACC AND PROJECT WACC Amgel Manufacturing Company's current capital structure is comprised of 30% debt and 70% equity (based on market values). Amgel's equity beta (based on its current level of debt financing) is 1.20, and its debt beta is 0.29. Also, the risk-free rate of interest is currently 4.5% on long-term government bonds. Amgel's investment banker advised the firm that, according to her estimates, the market risk premium is 5.25%.

- **a.** What is your estimate of the cost of equity capital for Amgel (based on the CAPM)?
- **b.** If Amgel's marginal tax rate is 35%, what is the firm's overall weighted average cost of capital (WACC)?
- **c.** Amgel is considering a major expansion of its current business operations. The firm's investment banker estimates that Amgel will be able to borrow up to 40% of the needed funds and maintain its current credit rating and borrowing cost. Estimate the WACC for this project.

5-5 CONCEPTUAL EXERCISE The term *hurdle rate* is often used in the context of project evaluation and is sometimes used to refer to the risk-adjusted discount rate—i.e., the required rate of return on a project with a given level of risk. The risk-adjusted discount rate refers to the cost of capital or opportunity cost of raising money to finance an investment, and hurdle rates are generally higher than the cost of capital. Why might a firm use hurdle rates that exceed its cost of capital?

PROBLEMS

5-6 CONCEPTUAL EXERCISE Smith Inc. is a public company but is tightly controlled by Joe Smith, the grandson of the founder. Smith is quite confident about his ability to evaluate investments in all aspects of the business. The situation at Smith Inc. is quite different from that at Jones Inc., although they share a similar line of business. Jones Inc. has a much less powerful CEO, who delegates much more control to the heads of the firm's various business units. In fact, Fred Jones, the company's CEO, meets with the heads of the business units, and they make capital allocation choices as a group. Discuss how and why Smith Inc. and Jones Inc. might have different approaches for determining the discount rates used to evaluate their projects.

5-7 DIVISIONAL WACC In 2006, Anheuser-Busch Companies Inc. (BUD) engaged in the production and distribution of beer worldwide, operating through four business segments: domestic beer, international beer, packaging, and entertainment. The domestic beer segment offers beer under Budweiser, Michelob, Busch, and Natural brands in the United States, in addition to a number of specialty beers that include nonalcohol brews, malt liquors, specialty malt beverages, and energy drinks. The international beer segment markets and sells Budweiser and other brands outside the United States and operates breweries in the United Kingdom and China. In addition, the international beer segment negotiates and administers license and contract brewing agreements with various foreign brewers. The packaging segment manufactures beverage cans and can lids for drink customers, buys and sells used aluminum beverage containers, and recycles aluminum containers. The entertainment segment owns and operates theme parks. In 2005, Anheuser-Busch reported the following segment revenues and net income:

Dollar Amount (Millions) for	Domestic Beer	International Beer	Packaging	Entertainment
2005				
Gross sales	$10,121.00	$864.00	$1,831.50	$904.40
Income before income taxes	2,293.40	70.10	120.40	215.10
Equity income	—	147.10	—	—
Net income	$ 1,421.90	$ 433.70	$ 74.60	$133.40

Assume that you have just been charged with the responsibility for evaluating the divisional cost of capital for each of the business segments.

a. Outline the general approach you would take in evaluating the cost of capital for each of the business segments.

b. Should the fact that $1,156 million of the packaging segment's revenues come from internal sales to other Busch segments affect your analysis? If so, how?

5-8 PROJECT-SPECIFIC WACC In 2014, worldwide capacity of wind-powered generators was growing. Wind power still constitutes a small fraction of worldwide electricity use, but in Denmark, wind power provides over 20% of electricity. Moreover, the use of wind power has grown rapidly in recent years. The key feature of wind power is its heavy capital intensity and low ongoing costs (the wind is free). Combined with advances in wind power generation technology, this alternative power source appears to be one of the most promising clean energy sources for the future.

Gusty Power Company (GPC) of Amarillo, Texas, builds and operates wind farms that produce electrical power, which is then sold into the electrical grid. GPC has recently been contacted by the Plains Energy Company of Plainview, Texas, to construct one of the largest wind-power farms ever built. Plains Energy is an independent power producer that normally sells all the electrical power it produces back to the power grid at prevailing market prices. In this instance, however, Plains has arranged to sell all of its production to a consortium of electric power companies in the area for a long-term, contractually set price. Assume that the project generates perpetual cash flows (annual project FCF) of $8,000,000, debt principal is never repaid, capital expenditures (CAPEX) equal depreciation in each period, and the tax rate is 35%.

The project calls for an investment of $100 million, and Plains has arranged for an $80 million project loan that has no recourse to Plains's other assets. The loan carries a 7% rate of interest, which reflects current market conditions for loans of this type. Plains will invest $10 million in the project, and the remainder will be provided by two local power companies that are part of the consortium that will purchase the electrical power the project produces.

a. What is the project-specific WACC, calculated using the book values of debt and equity as a proportion of the $100 million cost of the project? Given this estimate of the WACC, what is the value of the project?

b. Reevaluate the project-specific WACC using your estimate of the value of the project from part a above as the basis for your weights. Use this WACC to reestimate the value of the project, and then recalculate the weights for the project finance WACC using this revised estimate of WACC. Repeat this process until the value of the project converges to a stable value. What is the project's value? What is the project finance WACC?

c. Reevaluate the project-specific WACC and project value where the contract calls for a 2.5% rate of increase in the project free cash flow beginning in the second year of the project's life.

5-9 PROJECT WACC USING CORPORATE FINANCING Pearson Electronics manufactures printed circuit boards used in a wide variety of applications ranging from automobiles to washing machines. In fall 2014, it considered whether to invest in two major projects. The first was a new fabricating plant in Omaha, Nebraska, which would replace a smaller operation in Charleston, South Carolina. The plant would cost $50 million to build and incorporate the most modern fabricating and assembly equipment available. The alternative investment involved expanding the old Charleston plant so that it could match the capacity of the Omaha plant and modernizing some of the handling equipment, at a cost of $30 million. Given the location of the Charleston plant, however, it would not be possible to modernize the plant completely due to space limitations. The end result is that the Charleston modernization alternative cannot match the out-of-pocket operating costs per unit of the fully modernized Omaha alternative.

Pearson's senior financial analyst, Shirley Davies, made extensive forecasts of the cash flows for both alternatives but was puzzling over what discount rate or rates she should use to evaluate them. The firm's WACC was estimated to be 9.12%, based on an estimated cost of equity capital of 12% and an after-tax cost of debt capital of 4.8%. However, this calculation reflected a debt-to-value ratio of 40% for the firm, which she felt was unrealistic for the two plant investments. In fact, conversations with the firm's investment banker indicated that Pearson might be able to borrow as much as $12 million to finance the new plant in Omaha but no more than $5 million to fund the modernization and expansion of the Charleston plant without jeopardizing the firm's current debt rating. Although it was not completely clear what was driving the differences in the borrowing capacities of the two plants, Shirley suspected that a major factor was that the Omaha plant was more cost effective and offered the prospect of much higher cash flows.

a. Assuming that the investment banker is correct, use book value weights to estimate the project-specific costs of capital for the two projects. (*Hint:* The only difference in the WACC calculations relates to the debt capacities for the two projects.)

b. How would your analysis of the project-specific WACCs be affected if Pearson's CEO decided to delever the firm by using equity to finance the better of the two alternatives (i.e., the new Omaha plant or the Charleston plant expansion)?

5-10 PROJECT-SPECIFIC WACC USING CORPORATE FINANCING Lampkin Manufacturing Company has two projects. The first, project A, involves the construction of an addition to the firm's primary manufacturing facility. The plant expansion will add fixed operating costs equal to $200,000 per year and variable costs equal to 20% of sales. Project B, on the other hand, involves outsourcing the added manufacturing to a specialty manufacturing firm in Silicon Valley. Project B has lower fixed costs of only $50,000 per year, and thus lower operating leverage than project A, while its variable costs are much higher, at 40% of sales. Project A has an initial cost of $3.2 million, while project B will cost $3.4 million.

When the question arose as to what discount rates the firm should use to evaluate the two projects, Lampkin's CFO, Paul Keown, called his old friend Arthur Laux, who works for Lampkin's investment banker.

> Art, we're trying to decide which of two major investments we should undertake, and I need your assessment of our firm's capital costs and the debt capacities of both projects. I've asked my assistant to email you descriptions of each. We need to expand the capacity of our manufacturing facility, and these two projects represent very different approaches to accomplishing that task. Project A involves a traditional plant expansion totaling $3.2 million, while project B relies heavily on outsourcing arrangements and will cost us a little more up front, $3.4 million, but will have much lower fixed operating costs each year. What I want to know is, How much debt can we use to finance each project without putting our credit rating in jeopardy? I realize that this is a very subjective thing, but I also know that you have some very bright analysts who can provide us with valuable insight.

Art replied:

> Paul, I don't know the answers to your questions right off the top of my head, but I'll put some of our analysts on it and get back to you tomorrow at the latest.

The next day, Art left the following voice-mail message for Paul:

> Paul, I've got suggestions for you regarding the debt-carrying capacity of your projects and current capital costs for Lampkin. Our guys think that you've probably got room for about $1,200,000 in new borrowing if you do the traditional plant expansion project, in other words, Project A. If you decide on project B, we estimate that you could borrow up to $2,400,000 without realizing serious pressure from the credit rating agencies. If the credit agencies cooperate as expected, we can place that debt for you with a yield of 5%. Our analysts also did a study of your firm's cost of equity and estimate that it is about 10% right now. Give me a call if I can be of additional help to you.

a. Assuming that Lampkin's investment banker is correct, use book value weights to estimate the project-specific costs of capital for the two projects. (*Hint:* The only difference in the WACC calculations relates to the debt capacities for the two projects. Also, the firm's tax rate is 35%.)

b. How would your analysis of project-specific WACCs be affected if Lampkin's CEO decided that he wanted to delever the firm by using equity to finance the better of the two alternatives (i.e., project A or project B)?

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PART III

Financial Statements and Valuation

Part III is a two-chapter review of the use of financial statements in the valuation of both businesses and projects. In Chapter 6, we review the basic elements of financial statement analysis, including the connection between accrual-based financial statements and cash flow. In addition, the chapter demonstrates the use of a firm's financial statements as a tool for making financial forecasts of firm cash flows, which constitutes a critical step in the valuation of any business.

In Chapter 7, we discuss the fact that, in addition to evaluating investment projects based on net present value (NPV) analysis, managers frequently consider how a proposed investment project influences their firm's reported earnings per share. We discuss why managers have an interest in earnings per share as well as long-term value creation, which leads to a discussion of performance assessment. As we discuss, the potential disconnect between long-term value creation and the improvement of earnings per share is recognized by consultants who have used the logic of discounted cash flow (DCF) analysis to design methods to evaluate and compensate managers.

CHAPTER 6

Forecasting Financial Performance

Chapter Overview

Valuing an ongoing business requires the same inputs as any other valuation exercise: (1) a forecast of the investment's free cash flow (FCF) and (2) an estimate of the appropriate risk-adjusted discount rate. With an ongoing business, however, there is an important distinction:

> *Firms typically have a history of past performance that is recorded in their financial statements, whereas proposed projects do not.*

The history presented in a firm's financial statements contains a wealth of information that can be utilized in the valuation process. By using information from the financial statements about how the firm has made money in the past, we can better forecast future free cash flows and future financial performance. Before we can do this, however, we need to understand the relationship between accounting earnings and cash flows. This is a primary objective of this chapter.

6.1 Introduction

In Chapters 2 and 3, our focus was on the valuation of investment projects. This chapter provides our introduction to the problem of valuing an entire firm or business enterprise. Although the process used to value projects and entire firms is very similar, the valuation of a firm is in some ways easier because the firm has a history of past cash flows that can be used as a starting point for estimating future cash flows. But there's a catch. The firm's history is recorded in its financial statements, which are prepared in accordance with a set of accounting rules and guidelines. To uncover the firm's historical cash flows from these statements, we need to understand these accounting rules and guidelines.

Chapter 6 is organized as follows: We first review three of the four financial statements required of every public firm: the income statement, the balance sheet, and the statement of cash flow. The statement of retained earnings is the fourth required statement and is not germane to our purposes here. Next, we use planned, or pro forma, financial statements to model our forecast of future performance. Finally, we extract cash flows from the pro forma financial statements, which are in turn used to value the firm.

6.2 Understanding Financial Statements and Cash Flow

Financial statements are prepared in accordance with a set of reporting guidelines called generally accepted accounting principles (GAAP). These guidelines come from a number of sources, including the accounting profession as well as various government regulatory bodies, such as the Securities and Exchange Commission (SEC) and the Public Company Accounting Oversight Board (PCAOB). These rules and guidelines do not, in general, result in financial statements that provide information in the form that is most conducive for valuing a firm. Even so, as we illustrate in the pages that follow, a firm's financial statements can be recast so that they reveal the firm's cash flows.

The Income Statement

The income statement is the first of three basic financial statements that we will discuss. Panel (a) of Table 6-1 contains the income statements for a hypothetical firm called Better Buys Inc., for 2011 to 2013, as they would be prepared by the firm's financial accountants and reported to the public. For example, in 2013, Better Buys recognized total revenues equal to $37,219,250 and incurred costs of goods sold equal to $24,192,513, leaving a gross profit of $13,026,737. After subtracting operating expenses and depreciation expenses, its operating income is $3,487,380.[1] To arrive at earnings before taxes, we must add the $300,000 in nonoperating income and subtract the $888,841 in interest expense, resulting in earnings before taxes of $2,898,539. Subtracting a tax liability of $1,159,416 produces net income after taxes of $1,739,123 for 2015. Because the firm paid $200,000 in dividends to its common stock holders, $1,539,123 was retained and reinvested in the firm.

Cash Versus Accrual Accounting—Net Income Is Not the Same As Cash Flow

The income statement is prepared using the principles of accrual, as opposed to cash accounting, which means that the entries in the income statement do not necessarily correspond to transfers of cash during the period for which the statement was prepared. This is a very important point, so let's dig a little deeper into what accrual accounting means for the preparation of the income statement.

The accrual-based income statement is constructed using two fundamental principles: the *revenue recognition principle,* to determine which revenues to include in the statement, and the *matching principle,* to determine what expenses to include.

- *The revenue recognition principle and firm revenues.* According to the **revenue recognition principle,** revenue is recognized in the period in which products (goods or services), merchandise, or other assets are exchanged for cash or claims on cash.

[1] Depreciation and amortization expenses are not always identified separately in the income statement but are sometimes combined with operating expenses. When this occurs, one can identify the depreciation expense from the cash flow statement, which we discuss later.

Table 6-1 **Better Buys Inc. Income Statement**

Panel (a) Historical Income Statements

	2011	2012	2013
Revenues	$ 33,125,000	$ 35,112,500	$ 37,219,250
Cost of goods sold	(21,696,875)	(22,472,000)	(24,192,513)
Gross profit	$ 11,428,125	$ 12,640,500	$ 13,026,737
Operating expenses			
Fixed cash operating expenses	(2,000,000)	(2,000,000)	(2,000,000)
Variable cash operating expenses	(5,300,000)	(5,618,000)	(6,029,519)
Depreciation expense	(1,343,750)	(1,424,375)	(1,509,838)
Net operating income	$ 2,784,375	$ 3,598,125	$ 3,487,380
Nonoperating (other) income	300,000	300,000	300,000
Earnings before interest and taxes	3,084,375	3,898,125	3,787,380
Interest expense	$ (974,438)	$ (860,855)	$ (888,841)
Earnings before taxes	$ 2,109,938	$ 3,037,270	$ 2,898,539
Taxes	(843,975)	(1,214,908)	(1,159,416)
Net income	$ 1,265,963	$ 1,822,362	$ 1,739,123
Dividends paid	(200,000)	(200,000)	(200,000)
Addition to retained earnings	$ 1,065,963	$ 1,622,362	$ 1,539,123

Panel (b) Common Size Income Statements

	2011	2012	2013
Revenues	100.0%	100.0%	100.0%
Cost of goods sold	−65.5%	−64.0%	−65.0%
Gross profit	34.5%	36.0%	35.0%
Operating expenses			
Fixed cash operating expenses	−6.0%	−5.7%	−5.4%
Variable cash operating expenses	−16.0%	−16.0%	−16.2%
Depreciation expense	−4.1%	−4.1%	−4.1%
Net operating income	8.4%	10.2%	9.4%
Nonoperating income	0.9%	0.9%	0.8%
Earnings before interest and taxes	9.3%	11.1%	10.2%
Interest expense	−2.9%	−2.5%	−2.4%
Earnings before taxes	6.4%	8.7%	7.8%
Taxes	−2.5%	−3.5%	−3.1%
Net income	3.8%	5.2%	4.7%

The accounting income statement found in panel (a) is prepared in accordance with GAAP and is based on the accrual method of accounting, which recognizes revenues in the period in which they are earned and the expenses incurred when generating those revenues. Panel (b) provides these same accounting numbers expressed as a percentage of sales. These percentages are known collectively as the *common size income statements*. This common size income statement is often used as a tool of financial statement analysis.

This may sound very academic, but revenue recognition is very important and it is sometimes difficult to determine when revenues should be reported as having been earned. For example, suppose a movie studio sells the television rights to a movie it has not yet completed filming. Should the revenue from the sale of the rights be reported when the contract is signed, when the movie is delivered to the television network, when the network actually makes a cash payment to the studio, or when the movie is aired on the network? Most transactions are far less complicated than the sale of movie rights, but this example serves to demonstrate the difficulties that can arise when determining when a particular source of revenue should be reported in the firm's income statement.

- *The matching principle and expenses.* The expenses reported in the firm's income statement are those that were incurred in the process of generating the reported revenues. In other words, expenses are matched to reported revenues. This is the **matching principle.**

In summary, the firm's profits or net income for the period represent the difference in revenues recognized as earned during the period minus the matching expenses the firm incurred in generating those revenues, as shown in Equation (6.1):

$$\begin{matrix}\text{Revenues} \\ \text{for the Period}\end{matrix} - \begin{matrix}\text{Expenses} \\ \text{for the Period}\end{matrix} = \text{Net Income} \tag{6.1}$$

Note that there is no requirement that cash ever change hands during the period. This means that reported net income for the period does not have to equal cash flow. To illustrate, consider the following example involving the purchase and sale of a big-screen television:

- *On December 15, Better Buys Inc. orders and receives a new big-screen television.* The set cost Better Buys $2,500, but the manufacturer gave Better Buys credit terms of net 90, which means that the firm has ninety days to pay for the set with no penalty or interest charged.
- *On December 24, Better Buys Inc. sells the big-screen television for $4,500.* The buyer of the television opens a charge account with Better Buys for the entire purchase price, on which he will not have to make a payment for six months.
- *On December 31, Better Buys closes its books for the fiscal year just ended.* As part of its revenues for the year, Better Buys recognizes $4,500 in revenues from the sale of the television and a corresponding cost of goods sold of $2,500.

Better Buys does not collect any cash for six months nor does the firm pay for the big-screen television for ninety days; however, the firm's income statement for the period will report additional profits before taxes of $2,000!

Operating Versus Nonoperating Income

Another important feature of the way in which the accounting profession presents a firm's income statement is the separation of operating and nonoperating income. **Operating income,** as the name suggests, is the income generated by the firm's core business operations. For Better Buys Inc., this would be the sale of televisions and other electronic appliances that generated an operating profit of $3,487,380 for 2013. **Nonoperating income** is generated by investments the firm has made in assets that are unrelated to the firm's primary business. For example, gains from the sale of investments or the sale of a subsidiary or division would generally be recorded as nonoperating income. Other examples include the costs incurred from restructuring, currency exchange, or the write-off of obsolete inventory. In 2015, Better Buys earned $300,000 in nonoperating income from $3 million it has invested in other businesses.

Common Size Income Statement

Panel (b) of Table 6-1 contains common size income statements for Better Buys Inc. spanning the period from 2011 to 2013. These statements are simply standardized income statements in which each line item is converted to a percentage of revenues for the year. Three line items in the common size income statement entries are highlighted using block arrows: Gross profit/revenues, Net operating income/revenues, and Net income/revenues. These ratios are collectively referred to as **profit margins**—specifically the **gross profit margin, operating profit margin,** and **net profit margin,** respectively.

Analysts pay close attention to a firm's profit margins because they convey important information about the past performance of a firm. For example, in 2013, Better Buys Inc. had 35% of each dollar of revenues left over after paying for the goods and services it sold. The firm also kept 9.4% out of each dollar of sales after paying all the firm's operating expenses. After including the firm's sources of nonoperating income, paying interest expenses, and recognizing the firm's tax liability for the year, we see that Better Buys earned net income equal to 4.7% of revenues.

To evaluate these profit margins, analysts typically compare them to those of similar firms in the industry and examine whether the margins are improving or deteriorating over time. Figure 6-1 contains sample data on profit margins for three consumer electronics firms—Best Buy Inc. (BBY), GameStop Corp. (GME), and Conn's Inc. (CONN)—as well as for retail giant Walmart (WMT). The profit margins are all very similar, suggesting that gross profits are about 25% of firm revenues, operating profits are about 7% of revenues, and net profits are about 4% of revenues. These profit margins reflect the operations of a retail firm. The numbers are somewhat different for automaker Toyota (TM), which has a lower gross profit margin but higher operating and net profit margins. The point we are trying to make is that different types of businesses have unique profitability attributes. So when you analyze the historical performance of a firm, you should look for anomalies that suggest that the firm is a particularly good performer or perhaps a laggard.

Panel (b) of Figure 6-1 presents trailing twelve-month profit margins for Best Buy Inc., the computers and electronics industry, and all firms in the S&P 500 index. Note first that Best Buy has performed very well in the most recent years when compared to others in its industry. However, the profit margins in this industry are much lower than those of the average firm found in the S&P 500. This latter point further emphasizes that comparisons of financial performance must be restricted to firms that operate in similar environments and face similar competitive forces.

The Balance Sheet

The balance sheet provides a snapshot of the firm's financial position at a moment in time and a detailed account of the company's assets, liabilities (debts), and shareholders' equity. The balance sheet equation, shown in Equation (6.2), requires that the sum of the book values of the firm's assets equal the sum of the debts the firm owes to its creditors plus the book value of the stockholders' equity:

$$\text{Assets} = \text{Liabilities} + \begin{matrix}\text{Stockholders'}\\ \text{Equity}\end{matrix} \tag{6.2}$$

Figure 6-1 **Profit Margins for Three Consumer Electronics Firms, Walmart (WMT), and Toyota (TM)**

Panel (a) Profit Margin Data for 2012 to 2013

	Best Buy Inc. (BBY)		GameStop Corp. (GME)		Conn's Inc. (CONN)		Walmart (WMT)	
	2012	2013	2012	2013	2012	2013	2012	2013
Gross profit margin	24.4%	23.9%	27.7%	25.6%	26.8%	25.9%	23.4%	23.2%
Operating profit margin	5.6%	5.4%	6.2%	6.9%	8.0%	7.2%	5.6%	5.8%
Net profit margin	3.8%	3.5%	3.0%	4.1%	5.3%	4.8%	3.3%	3.4%

	Toyota Motor Corp. (TM)	
	2012	2013
Gross profit margin	19.7%	18.1%
Operating profit margin	9.3%	8.6%
Net profit margin	6.9%	6.5%

Panel (b) Best Buy Inc., Industry Average, and S&P 500 Average Profit Margin Ratios

	Best Buy Inc.	Industry Average	S&P 500 Average Profit Margin Ratios
Gross margin (TTM*)	24.14%	1.16%	41.28%
Gross margin—five-year average	24.19%	20.9%	40.68%
Operating margin (TTM)	4.4%	0.19%	—
Net profit margin (TTM)	2.69%	0.1%	9.88%

Source: Reuters (www.reuters.com/finance/stocks/ratios?symbol=BBY.N&rpc=66profitability)

Profit margins for 2012 to 2013 include the following: gross profit margin = gross profit/sales, operating profit margin = net operating income/sales, and net profit margin = net income/sales.

*TTM = trailing twelve months.

The account balances shown in the balance sheet change over time to reflect the actions taken by the firm's management. As such, the balance sheet contains a history of the firm's decisions regarding the specific assets in which the firm has invested, how the firm has financed those assets (debt versus equity), how profitable the firm has been over time (the size of the firm's retained earnings balance), and the mix of the firm's assets (the relative size of the firm's investments in long-term or fixed assets compared to the size of its total assets). The assets of the firm are divided into current assets (cash, receivables, and inventories) and long-term assets (net property, plant, and equipment plus investments), and the financing side of the balance sheet is broken down into liabilities and owners' equity. The liabilities are further divided into current liabilities (that are due and payable within a period of one year or less) and long-term liabilities. Four years of Better Buys Inc.'s historical balance sheets are found in panel (a) of Table 6-2.

Table 6-2 Better Buys Inc. Balance Sheets

Panel (a) Historical Balance Sheets

Balance Sheets	**2010**	**2011**	**2012**	**2013**
Cash and marketable securities	$ 624,000	$ 650,000	$ 702,500	$ 744,385
Accounts receivable	6,651,500	7,102,000	7,408,738	8,113,797
Inventories	10,001,000	10,643,000	11,938,250	12,282,353
Current assets	$ 17,276,500	$ 18,395,000	$ 20,049,488	$ 21,140,534
Net property, plant, and equipment	13,437,500	14,243,750	15,098,375	16,004,278
Investments	3,000,000	3,000,000	3,000,000	3,000,000
Total Assets	$ 33,714,000	$ 35,638,750	$ 38,147,863	$ 40,144,812
Accounts payable	$ 7,812,500	$ 8,281,250	$ 8,778,125	$ 8,800,100
Short-term debt	6,875,000	7,287,500	7,724,750	8,188,235
Current liabilities	$ 14,687,500	$ 15,568,750	$ 16,502,875	$ 16,988,335
Long-term liabilities	4,603,061	4,563,719	4,504,195	4,464,966
Total liabilities	$ 19,290,561	$ 20,132,469	$ 21,007,070	$ 21,453,301
Deferred income taxes	$ 329,749	$ 346,629	$ 358,778	$ 370,372
Common stock	$ 10,000,000	$ 10,000,000	$ 10,000,000	$ 10,000,000
Retained earnings	4,093,690	5,159,653	6,782,015	8,321,139
Total owners' equity	14,093,690	15,159,653	16,782,015	18,321,139
Total liabilities and owners' equity	$ 33,714,000	$ 35,638,750	$ 38,147,863	$ 40,144,812

Panel b. Common Size Balance Sheets (standardized by total assets for each year)

	2010	**2011**	**2012**	**2013**
Cash and marketable securities	2%	2%	2%	2%
Accounts receivable	20%	20%	19%	20%
Inventories	30%	30%	31%	31%
Current assets	51%	52%	53%	53%
Net property, plant, & equipment	40%	40%	40%	40%
Investments	9%	8%	8%	7%
Total Assets	100%	100%	100%	100%
Accounts payable	23%	23%	23%	22%
Short-term debt	20%	20%	20%	20%
Current liabilities	44%	44%	43%	42%
Long-term liabilities	14%	13%	12%	11%
Total liabilities	57%	56%	55%	53%
Deferred income taxes	1%	1%	1%	1%
Common stock	30%	28%	26%	25%
Retained earnings	12%	14%	18%	21%
Total owners' equity	42%	43%	44%	46%
Total liabilities and owners' equity	100%	100%	100%	100%

The balance sheet represents a summary of a company's financial condition at a point in time. The balance sheet equation states that the sum of the firm's assets must equal the sum of the sources of financing used to acquire those assets (stockholders' equity plus the firm's debts). Panel (a) includes historical balance sheet data for 2010 to 2013. Panel (b) contains the common size balance sheet accounts, where each line item in the balance sheet is divided by total assets for the year.

Measurement—Where Do the Numbers Come From?

Historical cost is the primary guiding principle underlying the construction of a firm's balance sheet. Very simply, when a firm acquires an asset or incurs a liability, the amount recorded on its balance sheet is the dollar value of the transaction *at that time.* Following this principle does not mean, however, that the account balance remains equal to the historical cost forever. As Figure 6-2 illustrates, balance sheet entries for some types of accounts are adjusted to current market values on a regular basis using a process called mark-to-market accounting, while others are adjusted only in the event that the market value of the asset declines. Understanding the accounting practices underlying the determination of the account balances is essential to gaining a full appreciation of the firm's financial condition depicted in the balance sheet.

Nonoperating Assets and Investments

Better Buys has a line item titled "investments," which has a $3 million balance. This line item (sometimes referred to as "long-term investments" because they are assets the company intends to hold for longer than one year) can consist of stocks and bonds of other companies, real estate, as well as cash set aside for a specific purpose. Accounting for investments in other companies can be complicated. (See Figure 6-2.) Briefly, an equity investment involving more than 20% but less than 50% of the equity of another firm is recorded as an investment and is titled something like "investments in unconsolidated subsidiaries." If the firm owns more than 50% of a subsidiary, then the rules of accounting call for consolidation of the subsidiary into the firm's balance sheet and income statement. When this occurs, a minority interest account appears between liabilities and owners' equity, representing the value of the minority-owned shares, because 100% of the value of the subsidiary's assets were incorporated into the consolidated balance sheet.

The important thing to note here is that the presence of a long-term investment category on a firm's balance sheet signifies the presence of a potentially significant nonoperating asset that will need to be valued. This means that the analyst will need to dig deeper into the footnotes of the financial statement to determine the exact nature of the investments in order to determine an appropriate approach to valuing them. For example, in 2008, the Starbucks Corporation (SBUX) had the following investments listed on its balance sheet:

Long-term investments—available-for-sale securities	$ 71,400,000
Equity and cost investments	302,600,000
Total investments	$374,000,000

From Note 4 of Starbucks 2008 financial statements, we learn that the long-term available-for-sale investments included $59.8 million of illiquid auction rate securities. The auction market failures that began in mid-February 2008 made these securities illiquid, so they were reclassified as long-term investments (they were previously classified as short-term available-for-sale securities). Note 7 reveals that Starbucks' equity and cost investments totaling $302.6 million were comprised of $267.9 million in equity method investments at the end of 2008 and $34.7 million in cost method investments (see Figure 6-2 for a discussion of these categories). The equity method investments consisted of various limited partnerships (StarCon LLC, which is a joint venture formed in March 2007 with Concord Music Group Inc., and various international Starbucks affiliates from countries around the world). The investments recorded using the cost method represent equity interests in entities to develop and operate Starbucks-licensed retail stores in several global markets including Mexico, Hong Kong, and Greece. Starbucks' equity investments in unrelated businesses equaled only $2.8 million.

Figure 6-2 The Balance Sheet: How Are the Account Balances Determined?

Assets	Definition	Method of Measurement
Cash and cash equivalents	These are the most liquid assets on the firm's balance sheet. They include deposits that mature in ninety days or less.	Fair value equal to the amount of cash held.
Short-term investments	Investments in short-term government bonds, marketable securities, and commercial paper.	Market value.
Receivables	The amount owed to the company by its customers who made credit purchases.	The amount of cash the firm expects to collect from its customers from prior sales.
Inventories	The goods and materials that a firm holds in stock.	Lower of cost or market value.
Long-term tangible assets	Property, plant, and equipment that are used in the firm's principal line of business.	Historical cost less accumulated depreciation unless the fair value of the assets drops below this amount, in which case they are written down and a charge to earnings is taken to reflect the write-down.
Intangible assets	Identifiable nonmonetary assets that cannot be seen, touched, or physically measured. Examples include copyrights, patents, trademarks, and goodwill.	Historical cost. If there is a defined life of the asset, then its value is written off over time. Otherwise, the recorded value is changed only if its market value declines below the recorded or carrying value on the firm's balance sheet.
Goodwill	An intangible asset that arises when a firm purchases another firm and the purchase price exceeds the acquired firm's fair value, where fair value is the amount the firm's assets can be bought or sold in a transaction between willing parties.	Goodwill is recorded at an historical cost. Should the value of the acquired firm's assets decline after the acquisition, then goodwill is written off; otherwise, it remains at historical cost.
Investments—long-term debt securities	Debt securities such as bonds that are held as investments by the firm.	Three categories are used to determine the recorded value: (1) *investments held for active trading*—fair market value with adjustments for unrealized gains and losses (market to market); (2) *investments available for sale* (not for trading but may be sold before maturity)—recorded at fair market value, but unrealized gains and losses do not affect the asset balance (they result instead in adjustments to equity), and interest income is reported in the income statement; and (3) *investments held to maturity*—recorded at historical cost with no adjustment for unrealized gains and losses, but interest income is recorded in the income statement.

Assets	Definition	Method of Measurement
Investments—equity	Equity securities purchased and held by the firm as an investment.	The method for determining the reporting of these investments depends on the fraction of the equity of the shares of the issuing firm that the investing company owns: (1) less than 20% ownership—these investments are classified using the same three categories used to categorize debt security investments and accounted for on the balance sheet in the same way; (2) investments involving more than 20% but less than 50% ownership—recorded at the historical cost of the investment but written up to record the firm's share of the earnings of the investment company and written down for dividends paid or goodwill that is written off (the share of the firm's earnings and write-off of goodwill is also recorded in the firm's income statement); (3) investments involving more than 50% of the equity of another firm—the financial statements of the two firms are consolidated, with a deduction for minority interests in the net assets (on the balance sheet) and net income (on the income statement).
Liabilities	**Definition**	**Method of Measurement**
Payables (short-term)	Liabilities incurred in the normal course of business as a result of the granting of credit. Examples include accounts payable, interest payable, and taxes payable.	Fair value, which equals the amount of cash required to satisfy the obligation.
Short-term debt and long-term debt	Financial obligations arising out of the firm's borrowing money that is to be repaid in a period of one year or less is short-term. Examples include bank loans and lease obligations. Debt obligations that do not mature within a period of one year are long-term.	Fair value, which is equal to the present value of the contractual payment obligations. This represents the market value of the obligations at the time they are recorded; however, as interest rates change over time, the changes in the values of these obligations are not adjusted. However, the debt footnote to the balance sheet typically compares market values of these obligations to their book values.
Accrued and estimated liabilities	Liabilities that arise in the firm's operations, including pension liabilities, warranty liabilities, and estimated restructuring liabilities.	Quasi–fair value, which is estimated using the present value of the expected future financial obligation. The term *quasi* reflects that fact that there are no market values available to use when adjusting the value of these liabilities; thus, the amounts used are estimated. Because the account value is adjusted to an estimated value, this practice is sometimes euphemistically referred to as marked-to-model accounting.

The point we are making is that the "other assets" or "investments" line items on the firm's balance sheet can contain significant assets whose values will not be captured when we calculate the present value of the firm's estimated free cash flow. This happens because "other income" is not included in firm free cash flow. This in turn means that we will need to value these investments independently of the firm's operating assets and add them to our discounted firm free cash flow calculation.

The Common Size Balance Sheet

Panel (b) of Table 6-2 contains **common size balance sheets,** which are constructed by dividing each balance sheet line item by total assets. The common size balance sheet is a popular tool of financial statement analysis because it provides a quick answer to some very basic questions about the firm. For example, on the financing side of the balance sheet, we see that 53% of Better Buys' total assets in 2013 were financed by debt, with 42% of total assets financed with current liabilities that must be repaid in a year or less. This percentage suggests that the firm could find itself unable to repay its debts in a timely fashion and thus be forced into financial insolvency. It is not possible to say that the firm faces an unusual degree of financial risk based on this one ratio alone. However, the analyst might use this indicator as the motivation for exploring firm liquidity and financial risk more fully.

Statement of Cash Flow

The **statement of cash flow** (sometimes referred to as the **cash flow statement**) reports a company's inflows and outflows of cash. This statement converts information from the firm's income statement and balance sheet, which are both prepared using the principles of accrual accounting, into cash flows for the period.

Table 6-3 contains Better Buys' statements of cash flow for 2011–2013. The statement details the sources of cash inflow to the firm and how the firm spent cash for the period, which when combined equals the change in the firm's cash balance for the period. Specifically, the cash flow statement is divided into three parts that represent the firm's cash flows from (1) operating activities, (2) investing activities, and (3) financing activities. Thus, in equation form, the cash flow statement appears in Equation (6.3):

$$\begin{pmatrix}\text{Cash Flows from}\\ \text{Operations}\end{pmatrix} + \begin{pmatrix}\text{Cash Flows from}\\ \text{Investment Expenditures}\end{pmatrix} + \begin{pmatrix}\text{Cash Flows from}\\ \text{Financing}\end{pmatrix} = \begin{matrix}\text{Change in Cash Balance}\\ \text{for the Period}\end{matrix} \tag{6.3}$$

For 2013, Better Buys experienced a $41,885 increase in its cash balance that resulted from a $2,233,369 cash inflow from the firm's operations, a ($2,415,740) cash outflow for investment expenditures, and a $224,256 cash inflow from financing activities. Note that it is conventional in accounting to report negative numbers by including them in parentheses.

Free Cash Flow Computations

Our discussion to this point has focused on the firm's financial statements that are prepared using the rules of GAAP. It is now time to switch gears and focus on the free cash flow (FCF) generated by the firm during 2013. In Chapter 4, we introduced the concept of equity free cash flow, which is the free cash flow earned by the firm that is available for distribution to the firm's common stockholders. Both firm (or project) and equity free cash flow can be computed from information contained in the firm's financial statements.

Table 6-3 Better Buys Inc. Statement of Cash Flow for 2011 to 2013

	2011	2012	2013
Cash Flows from Operations			
Net income	$ 1,265,963	$ 1,822,362	$ 1,739,124
Depreciation	1,343,750	1,424,375	1,509,838
	$ 2,609,713	$ 3,246,737	$ 3,248,962
(Increase) decrease in accounts receivable	(450,500)	(306,738)	(705,059)
(Increase) decrease in inventory	(642,000)	(1,295,250)	(344,103)
	$ (1,092,500)	$ (1,601,988)	$ (1,049,162)
Increase (decrease) in accounts payable	$ 468,750	$ 496,875	$ 21,975
Increase (decrease) in deferred income taxes	16,880	12,149	11,594
Cash provided by operations	$ 2,002,842	$ 2,153,774	$ 2,233,369
Cash Flows from Investing Activities			
(Increase) decrease in net fixed assets	(2,150,000)	(2,279,000)	(2,415,740)
Cash flows from investing activities	(2,150,000)	(2,279,000)	(2,415,740)
Cash Flows from Financing Activities			
Increase (decrease) in short-term debt	$ 412,500	$ 437,250	$ 463,485
Increase (decrease) in long-term liabilities	(39,342)	(59,524)	(39,229)
Increase (decrease) in common stock	—	—	—
Dividends paid	(200,000)	(200,000)	(200,000)
Cash flows from financing activities	$ 173,158	$ 177,726	$ 224,256
Change in Cash	$ 26,000	$ 52,500	$ 41,885

The statement of cash flow explains the change in cash balance for the period. It does so by decomposing firm cash flows into three categories: operating activities, investment activities, and financing activities. For example, Table 6-2 shows that at the end of 2012, Better Buys had a cash balance of $702,500; at the end of 2013, this balance was $744,385. Hence, there was a change in cash balance over the period of $41,885.

Firm (Project) Free Cash Flow

Panel (a) of Table 6-4 contains estimates of the 2013 firm free cash flow (firm FCF) for Better Buys prepared using the direct and indirect methods. The direct method focuses directly on the cash flows generated by the firm's operations, whereas the indirect method focuses on the distribution of those cash flows to the firm's investors.

Calculating Capital Expenditures (CAPEX) for 2013

Better Buys Inc. invested an additional $2,415,740 in new plant and equipment during 2013. We can verify this capital expenditure by examining the change in net property, plant, and equipment between 2013 and 2012:

Net property, plant, and equipment (2012)	$	15,098,375
Less: Depreciation expense (2013)		(1,509,838)
Plus: CAPEX (2013)		**2,415,740**
Net property, plant, and equipment (2013)	$	16,004,278

Direct Method for Calculating Firm Free Cash Flow The direct method is the methodology we have been using throughout the book to calculate free cash flow. It begins

Calculating Operating Net Working Capital for 2015

Better Buys Inc. invests an additional $1,069,072 in 2013, which is calculated as the change in operating net working capital between 2013 and 2012 as follows:

	2012	2013	Change
Cash and marketable securities	$ 702,500	$ 744,385	$ 41,885
Accounts receivable	7,408,738	8,113,797	705,059
Inventories	11,938,250	12,282,353	344,103
Current assets	$ 20,049,488	$ 21,140,534	$ 1,091,047
Less: accounts payable	(8,778,125)	(8,800,100)	$ (21,975)
Equals: operating net working capital	$ 11,271,363	$ 12,340,434	**$ 1,069,072**

Thus, the net new investment in operating net working capital is equal to the change in the firm's levels of operating net working capital for the period.

Note that in this situation, we assume that cash and marketable securities are part of the firm's operating current assets. As such, cash and marketable securities are included in the calculation of operating net working capital. This will not be the case, however, when these accounts are not considered operating assets and are omitted from the working capital calculation.

by calculating net operating profit after tax (NOPAT), adds back noncash expenses such as depreciation for the period plus any adjustment to deferred taxes, then subtracts capital expenditures (CAPEX) and any increase in net operating working capital to get a firm FCF for 2013.

The adjustment to NOPAT for the change in the firm's **deferred tax liability** deserves some explanation because it did not arise earlier when we calculated project free cash flow. Note that the tax liability calculated using the firm's net operating income that we referred to as taxes on operating income is simply the firm's current tax rate(s) applied to the firm's operating income. However, because firms often pay taxes on income computed in a slightly different way than the income they report (e.g., they use accelerated depreciation to calculate their tax liability but use straight-line depreciation for financial reporting), they often pay less in taxes than is reported in the firm's income statement. The difference accumulates in a deferred income tax liability, which will eventually be drawn down as the firm pays the tax it owes in the future. To adjust for the difference in taxes actually paid and the tax liability incurred by the firm during the period, we add back any increase in the deferred income tax liability and subtract any decrease in this account when calculating the firm's free cash flow.

Indirect Method for Calculating Firm Free Cash Flow The indirect method for calculating firm free cash flow focuses on how the firm's cash flow is distributed among its creditors and investors. Our focus has been, and will continue to be, on the direct method; however, the indirect method provides a useful reminder of just what firm FCF represents (i.e., the cash available for distribution to the firm's creditors and investors). For example, in 2013, Better Buys Inc. distributed $533,305 after taxes to its short- and long-term creditors in the form of interest payments, obtained an additional $463,485 from its short-term creditors in the form of added loans, distributed $39,229 to its long-term creditors in principal repayments, and paid $200,000 to its common stockholders in cash dividends.

Other Income and Firm Free Cash Flow Better Buys Inc.'s firm FCF available for distribution to all its investors for 2013 was $309,049. Note that this total includes both the free cash flow from operations and the after-tax nonoperating income. This raises an important point about firm valuation compared to project valuation. Firms often generate income from both operating and nonoperating assets. The first, as we

Table 6-4 Better Buys Inc. Firm and Equity Free Cash Flow Calculations for 2011 to 2013

Panel (a) Firm Free Cash Flow (Firm FCF) Calculation	2011	2012	2013
Direct Method			
Net operating income	$ 2,784,375	$ 3,598,125	$ 3,487,382
Less: taxes on operating income	(1,113,750)	(1,439,250)	(1,394,953)
Net operating profit after taxes (NOPAT)	$ 1,670,625	$ 2,158,875	$ 2,092,429
Increase (decrease) deferred taxes	$ 16,880	$ 12,149	$ 11,594
Plus: depreciation	1,343,750	1,424,375	1,509,838
Less: CAPEX	(2,150,000)	(2,279,000)	(2,415,740)
Less: change in operating net working capital	(649,750)	(1,157,613)	(1,069,072)
Firm free cash flow (from operations)	$ 231,505	$ 158,787	$ 129,049
Nonoperating income after taxes at 40%	180,000	180,000	180,000
Firm free cash flow available for all investors	$ 411,505	$ 338,787	$ 309,049
Indirect Method			
Interest (1 − tax rate)	$ 584,663	$ 516,513	$ 533,305
(Increase) decrease in short-term debt	(412,500)	(437,250)	(463,485)
(Increase) decrease long-term liabilities	39,342	59,524	39,229
Dividends	200,000	200,000	200,000
(Increase) decrease in common stock	—	—	—
Firm free cash flow available for all investors	$ 411,505	$ 338,787	$ 309,049
Panel (b) Equity Free Cash Flow (Equity FCF) Calculation			
Direct Method			
Net income	$ 1,265,963	$ 1,822,362	$ 1,739,124
Plus: depreciation	1,343,750	1,424,375	1,509,838
Increase (decrease) in long-term liabilities	(39,342)	(59,524)	(39,229)
Increase (decrease) in short-term debt	412,500	437,250	463,485
Increase (decrease) in deferred income taxes	16,880	12,149	11,594
Less: change in operating net working capital (NWC)	(649,750)	(1,157,613)	(1,069,072)
Less: capital expenditures (CAPEX)	(2,150,000)	(2,279,000)	(2,415,740)
Equity FCF	$ 200,000	$ 200,000	$ 200,000
Indirect Method			
Dividends	200,000	200,000	200,000
Less: new stock issues	—	—	—
Plus: stock repurchases	—	—	—
Equity free cash flow (Equity FCF)	200,000	200,000	200,000

Firm and equity free cash flows for 2013 to 2015 are calculated using both the direct and indirect methods.

discussed earlier when describing Better Buys' balance sheet, arises out of its core business operations. For example, Better Buys generated a free cash flow of $129,049 from its operations in 2013. In addition, firms often generate other income from investments they have made in unrelated business activities or from interest income on cash and marketable securities. For example, in 2013, Better Buys earned an after-tax amount of $\$180{,}000 = \$300{,}000 \times (1 - .40)$ from such investments. These nonoperating cash flows, like operating cash flows, are a source of value for the firm and must be incorporated into our analysis. Standard practice involves separating these two categories of income and valuing them independently.

Nonoperating income can also be generated from excess capacity in the firm's operating assets. For example, if the firm does not need all its warehouse space to support the projected level of operating income and if its excess capacity can be leased to another firm, then the rental income from leasing the excess capacity provides a source of nonoperating income. Excess capacity can also arise out of the one-time sale of plant and equipment the firm owns but does not need for supporting its operations. This type of other income is often an important motivation for the acquisition of one firm by another.

One final source of other income from excess capacity comes in the form of excess cash and marketable security holdings by the firm. In fact, some valuation analysts consider 100% of a firm's cash holdings as excess in the sense that they are not needed to support the firm's operations. This is an extreme position; a more reasonable position is to assume that the firm needs a small percentage, say, 2%, of its revenues in cash and marketable securities and that any excess is considered a source of other income. For example, if a firm's cash balance were $10 million and 2% of revenues were only $1 million, then an acquiring firm might consider that, by acquiring the firm, it would gain an asset worth $9 million that would need to be added to the value of the firm's operating assets.

Equity Free Cash Flow

Panel (b) of Table 6-4 includes both the direct and indirect methods of estimating equity free cash flow (equity FCF), which equals $200,000 for 2013. Note that the direct method begins with net income, which is then adjusted for the effects of noncash depreciation, changes in the firm's short- and long-term debt, deferred taxes, and net new investments in both capital equipment and operating working capital. The indirect method focuses on the distribution of cash to the firm's shareholders through the payment of cash dividends or share repurchases net of any new equity financing the firm might have obtained from the sale of shares. In 2013, Better Buys Inc. did not repurchase or issue any shares of stock but did pay a cash dividend of $200,000, so the equity FCF for 2013 was $200,000.

Reconciling the Cash Flow Statement with Firm FCF

The firm's cash flow statement in Table 6-3 contains a line item titled "cash provided by operations," which was equal to $2,233,369 for 2013. This term sounds very much like "firm free cash flow (from operations)" that we calculated using the direct method for estimating firm FCF in Table 6-4. These two quantities are obviously not the same because we calculated free cash flow from operations for Better Buys to be only $129,049. Exploring the reasons for the difference in these two quantities gives us an opportunity to develop the link between the firm's cash flow statement and firm free cash flow. This is important because, in this analysis, we demonstrate that the FCF calculation we have been using to value projects in earlier chapters and will use to value the firm in subsequent chapters is consistent with the firm's accounting statements. We will rely on this relationship later when we prepare our financial forecasts using the format of the firm's financial statements to create pro forma statements.

There are three reasons for this difference between the line item in the cash flow statement titled "cash provided by operations" and the firm's free cash flow (from operations). Specifically, cash provided by operations from the cash flow statement:

1. is measured after subtracting after-tax interest expense because interest expense is deducted in the calculation of net income (whereas FCF is calculated before the deduction of interest expense).
2. includes after-tax nonoperating or other income because this source of income is also part of net income (whereas FCF separates cash flow from operations and nonoperating activities).
3. excludes consideration for capital expenditures because these expenditures are included in the cash flow statement in a separate line item called "cash flows from investing activities."

To reconcile the cash provided by operations with firm free cash flow (from operations), we begin with cash provided by operations from the cash flow statement. Next we subtract the increase in cash balance of $41,885, which is included in the estimate of the change in operating net working capital; add back after-tax interest expense; subtract after-tax sources of nonoperating or other income; and finally subtract capital expenditures:

Reconciliation Process	**Data Source or Computation**	**Dollars**
Cash provided by operations	Cash flow statement	$ 2,233,369
Less: increase in cash balance	Cash flow statement	(41,885)
Plus: after-tax interest expense[2]	$888,841 (1 − .40)	533,305
Less: after-tax other income	$300,000 (1 − .40)	(180,000)
Less: capital expenditures (CAPEX)	Cash flow statement	(2,415,740)
Firm free cash flow (from operations)		$ 129,049

So even though the line item found in the firm's cash flow statement called "cash provided by operations" sounds very similar to the "firm free cash flow (from operations)," they are not the same; they *are* related, however, as the above reconciliation demonstrates.

Free Cash Flow and Nonoperating Income

In Chapter 2, we focused our attention on something we referred to simply as firm free cash flow. However, in Table 6-4, where we calculate the firm free cash flow for the Better Buys example, we identify two similar-sounding free cash flow numbers: firm free

[2] Recall that the corporate tax rate was 40% in the Better Buys example.

cash flow (from operations), equal to $129,049 for 2013, and free cash flow available for investors, which equals $309,049. The difference in these two cash flow numbers is equal to the $180,000 that is the after-tax nonoperating income that Better Buys Inc. earned during 2013.

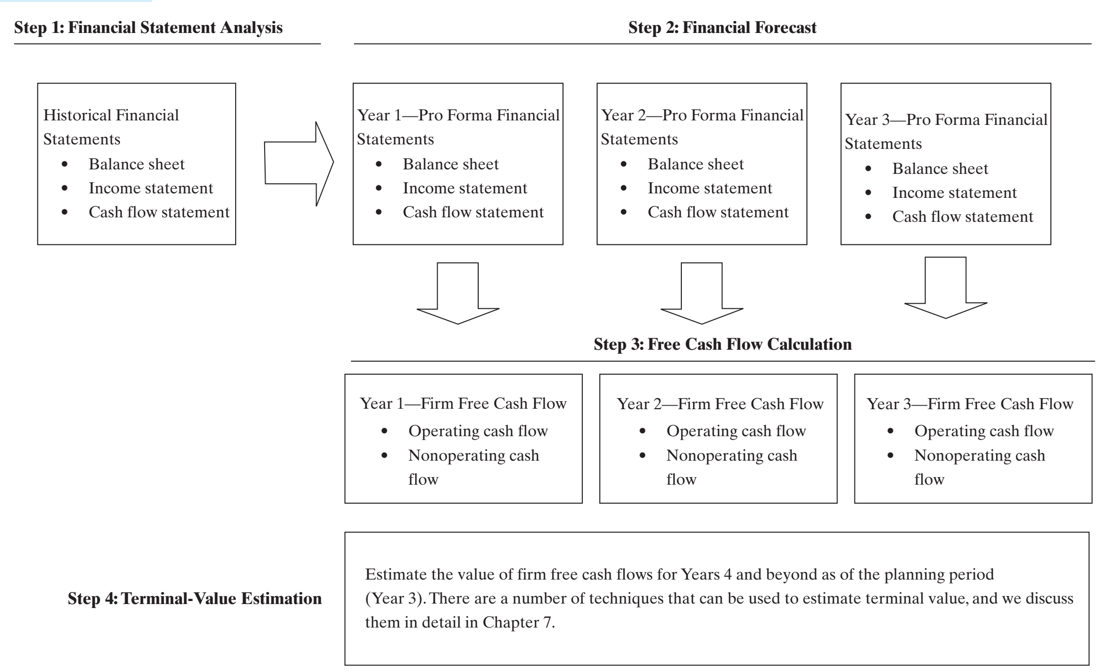
As discussed on p. 202, nonoperating income is income derived from activities that are unrelated to the firm's core business operations. Examples include dividend income, profits and losses from investments, gains and losses from foreign exchange, and capital gains resulting from the sale of real estate investments that were not related to the firm's operations. The amount of nonoperating income varies from one firm to another and over time as well. Because the determinants of operating and nonoperating income are different, standard practice involves making separate analyses and forecasts for each. We return to this point later when we discuss forecasting.

6.3 Forecasting Future Financial Performance

Now that we have reviewed the content of a firm's financial statements and reconciled them to the cash flow estimate, it is time to take a closer look at financial forecasting. We can think of the financial forecast as a four-step process, which we describe below and illustrate in Figure 6-3:

Step 1: *Perform an analysis of the firm's most recent financial statements.* Our ability to develop an understanding of how a firm will make money in the future is greatly enhanced by a thorough understanding of how it has made money in the past.

Figure 6-3 Financial Forecasting and Business Valuation



Step 2: *Construct pro forma financial statements for a three- to five-year planning period.* Accounting financial statements are the standard model used to evaluate a firm's past and projected future performance.

Step 3: *Convert pro forma financial statement forecasts to predictions of the firm's free cash flow from operations and free cash flow from nonoperating income.* As we discussed in the previous section, we can extract the necessary information for a forecast of future cash flow from a firm's income statement and balance sheet.

Step 4: *Forecast the value of cash flows after the end of the planning period using a terminal value.* Although detailed pro forma financial statements can be prepared for an extended period of time (beyond the three to five years noted in step 2), analysts typically condense the valuation of post-planning-period cash flows into a single terminal-value estimate.

Step 1: Perform an Analysis of Historical Financial Statements

There are a number of data sources for financial statements. For publicly held firms, the annual report or 10K filing with the SEC is provided by the SEC at www.sec.gov/edgar.shtml. The data are also available in a form that is somewhat easier to access from Standard & Poor's Compustat data service (www.compustartresources.com/support/index.html). In addition, there are free database sources such as those found at Yahoo (finance.yahoo.com/?u) or Google (google.com/finance). However, the standardization of financial information found in these large common databases has a downside. To develop a common format and eliminate the peculiarities of the reporting formats of individual companies, some data entries have to be combined into general categories such as "other assets" or "other liabilities." This practice can sometimes obscure important assets and liabilities and make them harder to forecast, thereby creating forecasting errors.

Once the historical financial statements have been collected, the next phase in the analysis involves looking for relationships between the individual line items in the statements and firm revenues, which can be used to build our forecast of pro forma financial statements. Good places to start this analysis are the common size income statement and the balance sheet, which we saw earlier in Tables 6-1 and 6-2. If we have multiple years of historical financial statements, then we can use the common size ratios (e.g., cost of goods sold/revenues) to look for stable relationships that can be used to forecast the individual line items in the income statement and balance sheet. For example, look at panel (b) of Table 6-1 and the gross profit margin identified by the top arrow. The gross profit margin, which is the percentage of firm revenues left after paying for cost of goods sold, appears to vary randomly around its average of 35.16%. Thus, in the absence of any information about the size of the firm's cost of goods sold, we might forecast gross profits in the future to equal the average gross profit over the past three years.

The term *financial statement analysis* refers to the process of analyzing a firm's financial statements to learn about how well the firm is being managed and the firm's future performance potential. In the pages that follow, we provide a brief overview of the basic elements of financial statement analysis. Before we embark, however, we first point out some important observations concerning a firm's financial statements that should be kept in mind along the way:

1. *Financial statements are constructed using estimates and assumptions.* GAAP allows considerable room for legitimate reporting differences between firms in similar industries.

2. *Management prepares its own financial statements.* Firms report the results of their activities, and there are considerable opportunities for manipulation. Even if the statements are audited (as all publicly held firms must be), the auditor provides only an opinion about whether the statements were prepared in accordance with GAAP; the auditor does not prepare them.
3. *Alternative reporting options within GAAP provide the basis for reporting differences.* Within GAAP, there are allowances for different methods of reporting a given event or transaction that lead to very different results. For example, inventories can legitimately be accounted for using a last in–first out (LIFO) or a first in–first out (FIFO) method, and fixed assets can be depreciated using one of several methods.
4. *Nonfinancial information contained in the firm's financial statements can be critical.* Firms regularly report information in footnotes and explanatory notes that can be very important when trying to understand and forecast a firm's future performance. For example, assets that are leased with operating leases do not appear in the firm's balance sheet, and future lease payments are not included as liabilities. However, operating lease payments, which can in fact be a significant obligation, are reported in the footnotes to the firm's balance sheet.

Performing a Financial Statement Analysis

For business valuation purposes, financial statement analysis provides a tool for learning about the current state of a firm's operations, which can help us avoid mistakes when we are forecasting the firm's future cash flows. Some examples of the types of forecast errors that we want to avoid are discussed in Figure 6-4.

The set of problems described in Figure 6-4 arises either because of bad luck or ineffective management of the firm's resources. A careful analysis of a firm's financial statements can also help uncover evidence of earnings manipulation by the firm's management. Earnings are sometimes manipulated by managers to paint a rosier picture of firm performance. In some instances, the manipulation is simply designed to smooth out reported earnings, while in others it is designed to fraudulently disguise the firm's true performance. A very suspicious example of the former is the 100 straight quarters of rising earnings per share at General Electric (GE) under the leadership of CEO Jack Welch. An example of the latter is the case of Worldcom, which increased earnings by capitalizing costs that should have been expensed in the current period.

Step 2: Construct Pro Forma Financial Statements for the Planning Period

Our earlier analysis showed how the firm's historical financial statements can be recast to reveal the firm's historical free cash flows. Similarly, we can calculate a firm's forecasted free cash flows from pro forma income statements and pro forma balance sheets.

The Forecast Horizon

The value of a firm reflects cash flows that are expected to be generated over many years in the future. Because forecasting distant cash flows is very difficult, however, the typical practice in industry is to break the future into two segments: (1) a planning period of three to five years and (2) everything after the end of the planning period. Analysts prepare very detailed projections of revenues, expenses, and cash flows for the

Figure 6-4 Problems That Can Be Detected by Financial Statement Analysis

Problem	Financial Statement Analysis—Detecting the Problem
Uncollectible accounts receivable. Just because the firm has an accounts receivable balance outstanding does not mean that the accounts can be collected in a reasonable period of time.	Compare the firm's *average collection period (ACP)* to the ACP of other peer firms and look for trends over time that might suggest deterioration in collection times. An increasing ACP over time is often a red flag that collection problems are growing. An *aging schedule* of accounts receivable tells the analyst what proportion of the firm's accounts pay on time or are late and provides a way to identify slow-paying accounts.
Unsalable inventory. The firm may have items listed in its inventories that are either not salable or salable only at reduced prices.	Compare the firm's *inventory turnover ratio* to the ratio of other peer firms and to itself over time. If the firm's inventory turnover is lower than that of its peers, this could suggest the presence of obsolete or unsalable inventory items. Also, an improving turnover ratio over time may signal that the firm is discounting its merchandise, so a simultaneous review of profit margins is helpful when looking for this problem.
Overstated residual (book) values of property, plant, and equipment. The firm's stock of fixed assets may be outdated or obsolete.	Assess the firm's efficient utilization of fixed assets using the *fixed asset turnover ratio* by making peer firm comparisons as well as time series comparisons for the firm itself. Deterioration in this ratio over time and when compared to peer firms suggests either obsolete equipment or inefficient utilization of existing equipment. If a problem is indicated, then a more thorough investigation (including technical advice) would be necessary before proceeding.
Excessive probability of financial distress. The firm's use of debt financing may be such that the probability of default in the event of an economic downturn is excessive in the eyes of the individual or the firm doing the valuation.	Debt utilization can and should be assessed in terms of the level of debt used in the firm's capital structure (i.e., the ratio of debt to assets and debt to equity) as well as the firm's ability to service debt (i.e., using the times interest earned or fixed charge coverage ratio). These ratios should be compared to the ratios of peer firms and also over time for the same firm to detect any trends. In addition, the debt footnote that accompanies the firm's annual 10K filing with the SEC provides information concerning the rates of interest and maturities of the firm's debt as well as any off-balance-sheet financing it may have outstanding.[3]

planning period. The values of the post-planning-period cash flows are then lumped together into something called the terminal value. We will discuss the valuation of post-planning-period cash flows and the terminal value calculations later in this chapter, and we will discuss alternative approaches in greater detail in Chapter 8.

[3] For example, the debt footnote to Starbucks Corporation's (SBUX) 2013 10K revealed that the firm's long-term debt was comprised of $550 million of 6.25% Senior Notes issued in 2012 that are due in August 2017, with interest paid on February 15 and August 15.

Developing a Revenue Forecast

The key to preparing an unbiased estimate of a firm's future cash flows is an unbiased and informed forecast of the firm's future revenues. Revenue forecasts are typically prepared in one of two ways: top down or bottom up. The top-down approach begins with macro- or market-level data and then focuses on market share to get firm revenue estimates. The bottom-up method begins with the firm's own estimates by product line and customers to formulate an estimate of future revenues. Both approaches have their merits, and using both approaches in concert provides a useful way to cross-check the reasonableness of the revenue forecast. Regardless of which method is used, forecasting is difficult and fraught with error. Consequently, the tools of risk analysis discussed in Chapter 3 are frequently applied to the firm's free cash flow estimates, just as they are applied to project cash flows to evaluate the effect of uncertainty on our estimate of firm value.

For our purposes, we will assume that the revenue forecast for Better Buys Inc. is made using a constant annual growth rate. For the planning period, the predicted rate of growth in revenues is 6%. During the post-planning period, we will assume that the firm's cash flows do not grow but remain equal to the firm free cash flow predicted for the end of the planning period (year 2020).

Forecast Methods Used to Construct Pro Forma Statements

In general, the estimates of the individual entries in the firm's pro forma income statements, balance sheets, and cash flow statements depend on the relationship between each entry and firm revenues. It is common practice to use the common size statements (like those found in Tables 6-1 and 6-2) to construct the pro forma financial statements. However, a blind use of the constant percentage of sales (common size income statement) and percentage of total assets (common size balance sheet) fails to capture any economies of scale effects because the percentages are constant for all sales levels. If the firm being valued is an acquisition target, then the acquiring firm will want to impose its own assumptions about how the firm will be operated in performing the valuation analysis. For example, if the acquirer feels that the inventory policies of the acquired firm are lax and result in larger-than-necessary investments in inventories, then future cash flow forecasts will assume lower inventory levels.

Pro Forma Income Statements

Table 6-5 contains pro forma income statements for Better Buys Inc. spanning the five-year period from 2014 to 2018. In our forecast of Better Buys' pro forma statements, we use four types of forecast methods:

1. *Constant rate of growth.* Sales are assumed to grow at a constant rate of 6% per year over the planning period.
2. *Percentage of sales.* Cost of goods sold and variable operating expenses are estimated to be 64.8% and 16.1% of sales, respectively. These percentages are based on an average of similar ratios calculated over the period from 2011 to 2013 found in Table 6-1.
3. *Percentage of assets, investments, or liabilities for the prior year.* Depreciation expense is 10% of the net property, plant, and equipment balance at the close of the previous year; nonoperating income is 10% of the firm's investments at the close of the prior year; and interest expense is 7% of the sum of the firm's short- and long-term debt for the prior year.

Table 6-5 **Better Buys Inc. Pro Forma Income Statements for 2014 to 2018**

	Forecast Method	Assumption	2014	2015	2016	2017	2018
Revenues	Constant growth rate	6.0%	$ 39,452,405	$ 41,819,549	$ 44,328,722	$ 46,988,446	$ 49,807,752
Cost of goods sold	Percentage of sales	64.8%	(25,578,309)	(27,113,008)	(28,739,788)	(30,464,176)	(32,292,026)
Gross profit	Calculated		$ 13,874,096	$ 14,706,542	$ 15,588,934	$ 16,524,270	$ 17,515,726
Operating expenses							
Fixed cash operating expenses	Constant	2,000,000	(2,000,000)	(2,000,000)	(2,000,000)	(2,000,000)	(2,000,000)
Variable cash operating expenses	Percentage of sales	16.0%	(6,338,686)	(6,719,008)	(7,122,148)	(7,549,477)	(8,002,446)
Depreciation expense	Percentage of fixed assets in period ($t - 1$)	10.0%	(1,600,428)	(1,696,453)	(1,798,241)	(1,906,135)	(2,020,503)
Net operating income	Calculated		$ 3,934,982	$ 4,291,081	$ 4,668,545	$ 5,068,658	$ 5,492,778
Nonoperating income	Percentage of investments in period ($t - 1$)	10.0%	300,000	300,000	300,000	300,000	300,000
Earnings before interest and taxes	Calculated		$ 4,234,982	$ 4,591,081	$ 4,968,545	$ 5,368,658	$ 5,792,778
Interest expense	Percentage of total liabilities in period ($t - 1$)	7%	(885,724)	(877,441)	(859,652)	(832,617)	(795,433)
Earnings before taxes (EBT)	Calculated		$ 3,349,258	$ 3,713,639	$ 4,108,893	$ 4,536,041	$ 4,997,345
Taxes	Tax rate × EBT	40.0%	(1,339,703)	(1,485,456)	(1,643,557)	(1,814,416)	(1,998,938)
Net income	Calculated		$ 2,009,555	$ 2,228,184	$ 2,465,336	$ 2,721,625	$ 2,998,407
Dividends paid	Policy variable—fixed dollar amount	$ 200,000	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)
Addition to retained earnings	Calculated		$ 1,809,555	$ 2,028,184	$ 2,265,336	$ 2,521,625	$ 2,798,407

- $t - 1$ refers to the period just ended or the prior period.
- The pro forma income statement is a forecast of the income statement for a future period, made using assumptions and estimates of the determinants of future revenues and expenses.

4. *Constant.* The fixed cash operating expenses are assumed to remain unchanged over the forecast period. Historically, the firm's fixed cash operating expenses have totaled $2 million, and we forecast a continuance of this amount over the next five years.

The remaining entries in the pro forma income statement are calculated in accordance with the definition of each item (e.g., gross profit = revenues − cost of goods sold).

Pro Forma Balance Sheets

Table 6-6 contains the pro forma balance sheets for 2014 to 2018 and indicates steady growth in the firm's total assets from $42,057,881 in 2014 to $52,309,675 by the end of the final year of the forecast. Two types of forecast methods are used to construct these statements:

1. *Percentage of sales.* For example, all of the current asset accounts as well as net property, plant, and equipment are assumed to be a percentage of firm revenues for the period. The use of the percentage of sales method implies a fixed relationship between firm sales and the line item being forecast. The forecast percentage of sales used to construct the pro forma balance sheets is obtained by averaging the annual percentages for the most recent three years (2011–2013).[4]
2. *Policy variables.* The firm's investments (nonoperating assets), long-term liabilities, and common stock entries are all estimated based on a policy decision. Specifically, the investment account is held constant, as is the common stock account. The long-term liabilities account is used to balance the pro forma balance sheets and is allowed to float up or down in accordance with the firm's needs for financing during the period.

Forecasts of assets and liabilities in the pro forma balance sheet are often made using financial ratios other than the percentage of sales or assets, as we have done here. The primary advantage of using such an approach is the information conveyed by the particular financial ratio used to predict the asset or liability. For example, we can forecast the firm's accounts receivable balance using an estimate of the average collection period:

$$\begin{array}{c}\text{Average Collection}\\ \text{Period (ACP)}\end{array} = \frac{\text{Accounts Receivable}}{\text{Sales} \div 365 \text{ days}}$$

To forecast the accounts receivable balance for a future period for which we have some ideas about the average collection period and have developed a sales estimate, we can simply substitute these estimates into the ACP relationship found above and solve for accounts receivable. However, this is equivalent to using a percentage of sales approach, where we solve the above equation for accounts receivable, as shown in Equation (6.4):

$$\text{Accounts Receivable} = \left(\frac{\begin{array}{c}\text{Average Collection}\\ \text{Period (ACP)}\end{array}}{365 \text{ days}} \right) \times \text{Sales} \tag{6.4}$$

Note that the "percentage of sales" being implicitly used to estimate accounts receivable is simply the ratio of the ACP divided by 365 days!

[4] You may note that we are forecasting the entries in the balance sheet using percentage of revenues rather than the percentage of assets found in the common size balance sheet. These two methods are equivalent as long as the relationship between revenues and assets remains constant over the forecast period. For example, if revenues were twice the firm's total assets, then forecasting accounts payable as 5% of revenues would be equivalent to forecasting them as 10% of assets.

Table 6-6 **Better Buys Inc. Pro Forma Balance Sheets for 2014 to 2018***

Balance Sheets	Forecast Method	Assumption	2014	2015	2016	2017	2018
Cash and marketable securities	Percentage of revenues	2.0%	$ 749,596	$ 794,571	$ 842,246	$ 892,780	$ 946,347
Accounts receivable	Percentage of revenues	21.4%	8,442,815	8,949,384	9,486,347	10,055,527	10,658,859
Inventories	Percentage of revenues	32.7%	12,900,936	13,674,993	14,495,492	15,365,222	16,287,135
Current assets	Calculated		$ 22,093,347	$ 23,418,948	$ 24,824,084	$ 26,313,530	$ 27,892,341
Net property, plant, and equipment	Percentage of revenues	43.0%	16,964,534	17,982,406	19,061,351	20,205,032	21,417,334
Investments	Policy variable	Constant	3,000,000	3,000,000	3,000,000	3,000,000	3,000,000
Total	Calculated		$ 42,057,881	$ 44,401,354	$ 46,885,435	$ 49,518,561	$ 52,309,675
Accounts payable	Percentage of revenues	22.8%	$ 8,995,148	$ 9,534,857	$ 10,106,949	$ 10,713,366	$ 11,356,168
Short-term debt	Perentage of revenues	20.3%	8,008,838	8,489,369	8,998,731	9,538,654	10,110,974
Current liabilities	Calculated		$ 17,003,987	$ 18,024,226	$ 19,105,679	$ 20,252,020	$ 21,467,141
Long-term liabilities	Policy variable	Balancing term	4,526,035	3,791,376	2,895,797	1,824,669	562,276
Total liabilities	Calculated		$ 21,530,022	$ 21,815,602	$ 22,001,476	$ 22,076,689	$ 22,029,417
Deferred income taxes	Percentage of tax liability†	2.0%	$ 397,166	$ 426,875	$ 459,746	$ 496,035	$ 536,013
Common stock	Policy variable	Constant	$ 10,000,000	$ 10,000,000	$ 10,000,000	$ 10,000,000	$ 10,000,000
Retained earnings	Calculated		10,130,693	12,158,877	14,424,213	16,945,838	19,744,245
Total owners' equity	Calculated		$ 20,130,693	$ 22,158,877	$ 24,424,213	$ 26,945,838	$ 29,744,245
Total liabilities and owners' equity	Calculated		$ 42,057,881	$ 44,401,354	$ 46,885,435	$ 49,518,561	$ 52,309,675

*The pro forma balance sheet is an estimate of the balance sheet for a future period based on assumptions and estimates of the determinants of the firm's balance sheet.

†Deferred taxes (2014) = deferred taxes (2013) + .01 × tax liability (2014), and so forth. Note that because deferred taxes increase by 2% of the firm's tax liability for the year, the effective tax rate is 98% of the stated tax rate, or .98 × 40% = 39.2% as long as this relationship holds.

Our point here is not to say that using one method or the other is preferred; they are obviously equivalent. The appropriate focus of the analyst should be on determining a better estimate of the percentage of sales or, equivalently, the ACP.

When the Percentage of Sales Method Should Not Be Used

The percentage of sales method of financial forecasting is not always best, and the analyst should be aware of its limitations. Let's now examine the times when the percentage of sales method does *not* work. We can do this by considering the equation for a percentage of sales forecast such as the one presented in Equation (6.4). Looking at Table 6-6, we see that the net property, plant, and equipment (PPE) balance for Better Buys Inc. is forecast to equal 43% of the firm's predicted revenues.[5] This suggests that if Better Buys Inc. expects $10 million in revenues, the firm would need $4.3 million in PPE, and if the firm were to expect $20 million in revenues, it would need twice this amount of PPE, and so forth. In reality, however, Better Buys probably would not acquire PPE at a constant percentage of revenues from year to year but would, in a growing environment, overbuild PPE in anticipation of its future needs. In other words, PPE expenditures tend to be lumpy, so assuming a constant percentage of revenues for this asset account is not appropriate.

Another problem with the percentage of sales method of forecasting arises when there are economies of scale for a particular asset. For example, Better Buys Inc. may need $10 million in inventories to support a $30 million level of sales, but this inventory level (given the firm's ability to replenish inventories as needed) may support up to $50 million in sales. If this is the case, then the percentage of sales made up of inventories would be expected to decline as firm sales rose from $30 to $50 million.

The key point here is that the percentage of sales method of financial forecasting is appropriate *only* if the asset or liability being forecast does indeed vary as a constant percentage of revenues and the firm plans to make adjustments to the account balance on a regular basis in response to changing sales.

Step 3: Convert Pro Forma Financial Statements to Cash Flow Forecasts

Table 6-7 contains the pro forma cash flow statements for Better Buys spanning the period from 2014 to 2018. The growing amount of cash flow from operations over the period allows the firm to retire more long-term debt (the policy variable chosen to balance the firm's finances). However, the free cash flow forecast that we need to value Better Buys is calculated in Table 6-8. The firm free cash flow (from operations) increases from $669,762 in 2014 to $1,187,334 in 2018, while the after-tax nonoperating income remains constant at $180,000.

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[5] Do not be confused by the fixed $3 million in investments. These investments are unrelated to the firm's operating assets and do not include capital expenditures, which vary as a fixed percentage of sales.

Table 6-7 Better Buys Inc. Pro Forma Statement of Cash Flow for 2014 to 2018

	2014	2015	2016	2017	2018
Cash Flows from Operations					
Net income	$ 2,009,555	$ 2,228,184	$ 2,465,336	$ 2,721,625	$ 2,998,407
Depreciation	1,600,428	1,696,453	1,798,241	1,906,135	2,020,503
	$ 3,609,982	$ 3,924,637	$ 4,263,577	$ 4,627,760	$ 5,018,910
(Increase) decrease in accounts receivable	(329,018)	(506,569)	(536,963)	(569,181)	(603,332)
(Increase) decrease in inventory	(618,584)	(774,056)	(820,500)	(869,730)	(921,913)
	$ (947,602)	$ (1,280,625)	$ (1,357,463)	$ (1,438,910)	$ (1,525,245)
Increase (decrease) in accounts payable	$ 195,048	$ 539,709	$ 572,091	$ 606,417	$ 642,802
Increase (decrease) in deferred income taxes	26,794	29,709	32,871	36,288	39,979
Cash provided by operations	$ 2,884,223	$ 3,213,430	$ 3,511,077	$ 3,831,555	$ 4,176,446
Cash Flows from Investing Activities					
(Increase) decrease in gross fixed assets	$ (2,560,684)	$ (2,714,325)	$ (2,877,185)	$ (3,049,816)	$ (3,232,805)
Cash flows from investing activities	$ (2,560,684)	$ (2,714,325)	$ (2,877,185)	$ (3,049,816)	$ (3,232,805)
Cash Flows from Financing Activities					
Increase (decrease) in short-term debt	$ (179,397)	$ 480,530	$ 509,362	$ 539,924	$ 572,319
Increase (decrease) in long-term liabilities	61,069	(734,659)	(895,579)	(1,071,128)	(1,262,393)
Increase (decrease) in common stock	—	—	—	—	—
Dividends paid	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)
Cash flows from financing activities	$ (318,327)	$ (454,129)	$ (586,217)	$ (731,204)	$ (890,074)
Change in Cash	$ 5,211	$ 44,976	$ 47,674	$ 50,535	$ 53,567

The pro forma statement of cash flow is an estimate of the sources and uses of cash for the firm for a future period based on assumptions and estimates of the determinants of those cash flows. The statement can be estimated using information contained in the current period balance sheet, the pro forma balance sheet for the period, and the pro forma income statement for the period.

Step 4: Estimate the Terminal Value of Firm Free Cash Flows

We estimate the value of the firm's cash flows for all years after the end of the planning period in a lump sum commonly referred to as the terminal value. The terminal value represents the present value of all the firm's free cash flows that are expected to be received beginning with one period after the end of the planning period and extending into the indefinite future.

Table 6-8 Better Buys Inc. Free Cash Flow Forecast for 2014 to 2018

Panel (a) Firm Cash Flow (Firm FCF) Calculation	2014	2015	2016	2017	2018
Net operating income	$ 3,934,982	$ 4,291,081	$ 4,668,545	$ 5,068,658	$ 5,492,778
Less: taxes on operating income	(1,573,993)	(1,716,432)	(1,867,418)	(2,027,463)	(2,197,111)
Net operating profit after taxes (NOPAT)	$ 2,360,989	$ 2,574,648	$ 2,801,127	$ 3,041,195	$ 3,295,667
Increase (decrease) deferred taxes	$ 26,794	$ 29,709	$ 32,871	$ 36,288	$ 39,979
Plus: depreciation	1,600,428	1,696,453	1,798,241	1,906,135	2,020,503
Less: CAPEX	(2,560,684)	(2,714,325)	(2,877,185)	(3,049,816)	(3,232,805)
Less: change in operating net working capital	(757,764)	(785,892)	(833,045)	(883,028)	(936,010)
Firm free cash flow (from operations)	$ 669,762	$ 800,593	$ 922,009	$ 1,050,774	$ 1,187,334
Nonoperating income after taxes	180,000	180,000	180,000	180,000	180,000
Free cash flow available for investors	$ 849,762	$ 980,593	$ 1,102,009	$ 1,230,774	$ 1,367,334

Panel (b) Equity Free Cash Flow (Equity FCF) Calculation	2014	2015	2016	2017	2018
Net income	$ 2,009,555	$ 2,228,184	$ 2,465,336	$ 2,721,625	$ 2,998,407
Plus: depreciation	1,600,428	1,696,453	1,798,241	1,906,135	2,020,503
Increase (decrease) in long-term liabilities	61,069	(734,659)	(895,579)	(1,071,128)	(1,262,393)
Increase (decrease) in short-term debt	(179,397)	480,530	509,362	539,924	572,319
Increase (decrease) in deferred income taxes	26,794	29,709	32,871	36,288	39,979
Less: change in operating NWC	(757,764)	(785,892)	(833,045)	(883,028)	(936,010)
Less: capital expenditures (CAPEX)	(2,560,684)	(2,714,325)	(2,877,185)	(3,049,816)	(3,232,805)
Equity free cash flow (equity FCF)	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000

6.4 Looking Ahead—The Mechanics of Calculating Enterprise Value

Now that we have estimates of the firm's cash flows (both operating and nonoperating), we estimate the enterprise value of the firm as the sum of the present values of its operating cash flows (i.e., the present value of firm free cash flow from operations) plus the present value of nonoperating cash flows, that is:

$$\begin{matrix}\text{Enterprise}\\ \text{Value}\end{matrix} = \begin{matrix}\text{Present Value of}\\ \text{Firm FCF from Operations}\end{matrix} + \begin{matrix}\text{Value of Nonoperating}\\ \text{Cash Flows}\end{matrix} \tag{6.5}$$

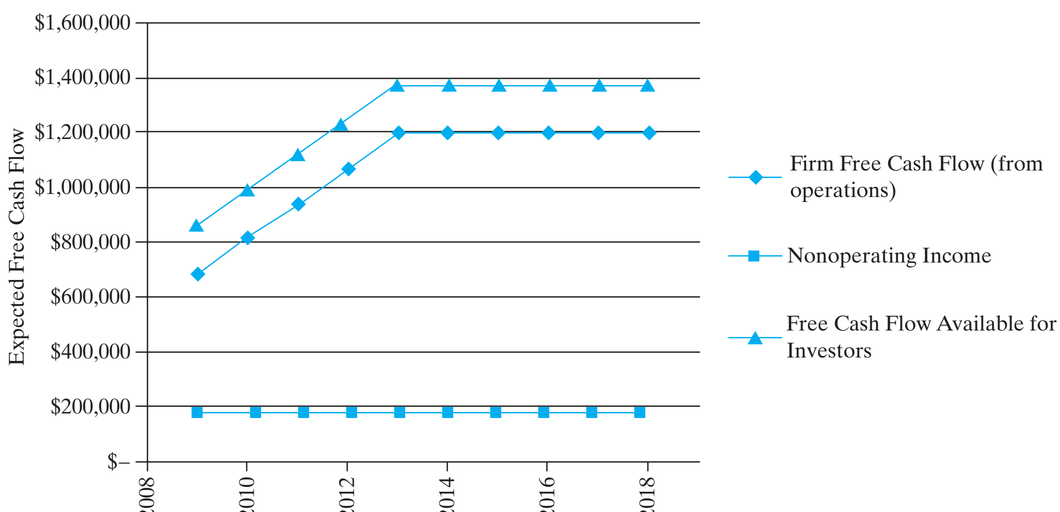
Planning Period and Terminal Value

In our previous discussion of forecasting, we forecast only the next five years of cash flows for Better Buys Inc. even though the firm would typically be expected to survive for many years. In theory, because a business has an indefinite and unpredictable life, the analyst would want to forecast future cash flows over a very long period of time. In practice, however, analysts typically prepare detailed financial forecasts (such as those underlying the preparation of Table 6-8) for a **planning period** of three to five years. The value of the remaining cash flows for all years following the end of the planning period is then estimated as a **terminal value.** The terminal value can be estimated in a number of ways (and we discuss these methods in more detail in Chapter 8); however, for now we estimate the present value of the post-planning-period cash flows for Better Buys Inc. by assuming that these cash flows remain constant after the end of the planning period such that they are a level perpetuity equal to the firm's free cash flow for 2018.

Figure 6-5 describes the time series of cash flows we have estimated for Better Buys spanning the period from 2014 through 2018. Of course, the firm continues to produce cash flows into the indefinite future, which are assumed to be equal to the cash flow realized in 2018.

One final note about nonoperating cash flows is in order. In our Better Buys Inc. example, the nonoperating cash flows are a level perpetuity of $300,000 per year ($180,000 after taxes). In practice, nonoperating income often comes from nonrecurring sources such as the sale of assets arising out of restructuring and other extraordinary sources. These cash flows can be much more difficult to predict and are often a one-time cash flow. Nonetheless, they can potentially be very important sources of value to the firm and must be forecast. But because we segment

Figure 6-5 Better Buys Inc. Free Cash Flow Forecast for 2014 to 2018



Better Buys Inc. is expected to receive a growing stream of free cash flow from its operations, plus a constant after-tax cash flow of $180,000 from its nonoperating income over the period. Although only ten years of cash flow are included in the figure, the cash flows are assumed to remain constant into the indefinite future.

the future into a planning period followed by all subsequent cash flows, we modify Equation (6.5) as follows:

$$\begin{aligned} EV = {} & [PV(\text{FCF from 2014–2018}) + PV(\text{Terminal value of firm FCF from operations})] \\ & + [PV(\text{nonoperating income for 2014–2018}) \\ & + PV(\text{Terminal value of nonoperating income})] \qquad (6.5) \end{aligned}$$

The estimation of enterprise value using Equation 6.5 involves the calculation of the value of the planning period cash flows (operating and nonoperating) and adding this to the value of the terminal values (operating and nonoperating).

If the appropriate discount rate for valuing the operating cash flows is 15% and the corresponding discount rate for nonoperating cash flows is 10%, then we can estimate the enterprise value of Better Buys Inc. using Equation (6.5) as follows:

	Value of Cash Flows		
	Planning Period (2014–2018)	**Terminal Value**	**Total**
Firm free cash flow (from operations)	$ 2,985,100	$ 3,935,431	$ 6,920,530
Nonoperating income	682,341	1,117,658	$ 1,800,000
Total	$ 3,667,441	$ 5,053,089	$ 8,720,530

We estimate the value of Better Buys Inc. at the end of 2018 to be $8,720,530, which represents the value of a stream of free cash flows from operations equal to $6,920,530 and a stream of nonoperating income worth $1,800,000.00.

In Chapter 8, we will explore another approach to the estimation of the value of a business based on market multiples. This methodology is widely used to estimate both enterprise value and project value. Moreover, it is widely used as the basis for estimating terminal values even where it is not used to value planning period cash flows.

6.5 Summary

Firms publish financial statements that document their earnings and financing histories. Because a firm's ability to generate cash flows in the past provides important insights about its ability to generate future cash flows, valuation experts benefit from the skills required to unlock the information in these financial statements. In this chapter, we have reviewed the format of the firm's financial statements and linked them to the firm's free cash flow. This analysis revealed that, although financial statements are prepared in accordance with the rules of accrual accounting, the resulting statements can be readily translated back into cash flows that form the basis for valuing the firm.

Exercises

6-1 CASH FROM OPERATIONS AND FREE CASH FLOW The item called "cash provided by operations" in the cash flow statement sounds a lot like firm free cash flow. Although these two quantities are related, they are not the same. Discuss the three sources of difference between them.

6-2 DEALING WITH NONOPERATING INCOME What is "other" or "nonoperating income," and how should it be incorporated into the valuation of a firm?

6-3 FINANCIAL STATEMENT ANALYSIS Financial statement analysis can be used to identify weaknesses in a firm's operations. Give some examples of the types of problems that can be identified and how the financial analyst might uncover them.

6-4 INCOME VERSUS CASH FLOW The guiding principles underlying the accrual basis of accounting drive a wedge between a firm's reported income and its cash flow. What are some of the reasons for the differences in net income and cash flow?

6-5 FINANCIAL FORECASTING PROCESS Describe the four-step financial forecasting process as it is used in the estimation of the value of a firm. How does the percentage of sales forecasting method fit into this process?

Problems

6-6 ACCRUAL VERSUS CASH ACCOUNTING A firm's net income is calculated as the difference in the revenues it recognizes for the period less the expenses it incurred in the process of generating those revenues. The method used to determine what revenues are earned and what expenses have been incurred is determined in accord with the basic rules of accrual, not cash, accounting. Consider the following situation:

- On March 1, 2015, the Sage Video Store in Tacoma, Washington, placed an order for 10 52-inch Sony liquid crystal display (LCD) televisions. The vendor they ordered from gave the firm sixty days to pay the $1,200 cost per television.
- On April 12, 2015, Mary Griggs came into the Sage Video Store and purchased one of the Sony televisions for $1,950. Part of Mary's motivation for making the purchase was that she did not have to make a payment for the purchase for six months and did not have to make a down payment either.
    - **a.** If Sage ends its first quarter on May 1, how does the sale of the television to Mary affect the firm's gross profits for the quarter? What is the impact of the sale on the firm's cash flow?
    - **b.** If Mary were to make a 10% cash down payment at the time of the purchase and then not begin making payments for six months, what is the impact of the sale on the firm's gross profit and cash flow?

6-7 COMMON SIZE FINANCIAL STATEMENTS The balance sheet and income statement for Webb Enterprises Inc. are found below:

Balance Sheet	**2015**
Cash and marketable securities	$ 500
Accounts receivable	6,000
Inventories	9,500
Current assets	$ 16,000
Net property, plant, and equipment	17,000
Total	$ 33,000
Accounts payable	$ 7,200
Short-term debt	6,800
Current liabilities	$ 14,000
Long-term debt	7,000
Total liabilities	$ 21,000
Total owners' equity	12,000
Total liabilities and owners' equity	$ 33,000

Income Statement	**2015**
Revenues	$ 30,000
Cost of goods sold	(20,000)
Gross profit	$ 10,000
Operating expenses	(8,000)
Net operating income	$ 2,000
Interest expense	(900)
Earnings before taxes	$ 1,100
Taxes	(400)
Net income	$ 700

a. Prepare a common size balance sheet for Webb Enterprises.

b. Prepare a common size income statement for Webb Enterprises.

c. Use your common size financial statements to respond to your boss' request that you write an assessment of the firm's financial condition. Specifically, write a brief narrative that responds to the following questions:

1. How much cash does Webb have on hand relative to its total assets?
2. What proportion of Webb's assets has the firm financed using short-term debt? Long-term debt?
3. What percentage of Webb's revenues does the firm have left over after paying all of its expenses (including taxes)?
4. Describe the relative importance of Webb's major expense categories, including cost of goods sold, operating expenses, and interest expenses.

6-8 USING COMMON-SIZE FINANCIAL STATEMENTS The B&G Construction Company expects to have total sales next year of $15,000,000. In addition, the firm pays taxes at 35% and will owe $300,000 in interest expense. Based on last year's operations, the firm's management predicts that its cost of goods sold will be 60% of sales and operating expenses will total 30% of sales. What is your estimate of the firm's net income (after taxes) for the coming year? What else would you need to know in order to be able to calculate the firm's free cash flow for next year?

6-9 STATEMENT OF CASH FLOWS The statements of cash flow for Walmart (WMT) are found below for the years 2010 through 2013:

In Millions of USD (Except for Per-Share Items)	Twelve Months Ended			
	1/31/2013	1/31/2012	1/31/2011	1/31/2010
Net income	12,731.00	11,284.00	11,231.00	10,267.00
Depreciation and noncash items	6,470.00	6,308.00	4,720.00	4,265.00
Deferred taxes	(8.00)	89.00	(129.00)	263.00
Changes in working capital	1,161.00	2,271.00	2,419.00	249.00
Cash from operating activities	**20,354.00**	**19,952.00**	**18,241.00**	**15,044.00**
Capital investment expenditures	(15,670.00)	(14,463.00)	(14,186.00)	(12,351.00)
Cash from investing activities	**(15,670.00)**	**(14,463.00)**	**(14,186.00)**	**(12,351.00)**
Interest and financing cash flows	(334.00)	(227.00)	(349.00)	113.00
Total cash dividends paid	(3,586.00)	(2,802.00)	(2,511.00)	(2,214.00)
Issuance (retirement) of stock, net	(7,691.00)	(1,718.00)	(3,580.00)	(4,549.00)
Issuance (retirement) of debt, net	4,477.00	(92.00)	4,018.00	4,041.00
Cash from financing activities	**(7,134.00)**	**(4,839.00)**	**(2,422.00)**	**(2,609.00)**
Foreign exchange effects	252.00	97.00	(101.00)	205.00
Net change in cash	**(2,198.00)**	**747.00**	**1,532.00**	**289.00**

a. Describe Walmart's cash flows from operations for the period. Is the firm generating positive cash flow? How has this cash flow changed over time?
b. Is Walmart investing cash in its business? How has Walmart been financing its operations?
c. How would you describe Walmart's pattern of net cash flows for the period?

6-10 ESTIMATING CAPITAL EXPENDITURES At the end of fiscal year 2014, Emerson Electric Co. (EMR) had net property, plant, and equipment equal to $3.5 billion. The ending balance for 2013 was $3.507 billion, and the firm had depreciation expense during 2014 equal to $0.727 billion. How much did the company spend on new property, plant, and equipment during 2014?

6-11 CALCULATING OPERATING NET WORKING CAPITAL Hildebrand Corp. had the following current asset and current liability account balances for 2012 through 2015:

In Millions of Dollars	**2015**	**2014**	**2013**	**2012**
Cash and equivalents	$ 807,926	$ 560,960	$ 617,866	$ 658,255
Short-term investments	178,994	197,408	182,442	614,513
Cash and short-term investments	986,920	758,368	800,308	1,272,768
Accounts receivable	2,028,060	2,365,823	2,341,609	2,302,447
Inventories	1,456,271	1,441,024	1,450,258	1,262,308
Total current assets	4,471,251	4,565,215	4,592,175	4,837,523
Accounts payable	1,138,770	1,601,413	1,584,959	1,416,367
Accrued expenses	878,454	901,546	902,164	863,683
Notes payable/short-term debt	1,038,633	789,285	979,675	821,126
Current portion of long-term debt	531,635	386,879	303,214	248,028
Total current liabilities	$ 3,587,492	$ 3,679,123	$ 3,770,012	$ 3,349,204

a. Compute Hildebrand's operating net working capital for 2012 to 2015.
b. What are the annual changes in operating net working capital for 2013–2015?
c. Analyze the firm's needs for additional capital to support its need for operating working capital.

6-12 FORECASTING PRO FORMA FINANCIAL STATEMENTS Prepare a pro forma income statement and balance sheet for Webb Enterprises (see Problem 6-7), where revenues are expected to grow by 20% in 2016. Make the following assumptions in making your forecast of the firm's balance sheet for 2016:

- The income statement expenses are a constant percentage of revenues except for interest, which remains equal in dollar amount to the 2015 level, and taxes, which equal 40% of earnings before taxes.
- The cash and marketable securities balance remains equal to $500, and the remaining current asset accounts increase in proportion to revenues for 2015.
- Net property, plant, and equipment increase in proportion to the increase in revenues and depreciation expenses for 2016 is $2,000.
- Accounts payable increases in proportion to firm revenues.
- Owners' equity increases by the amount of firm net income for 2011 (no cash dividends are paid).
- Long-term debt remains unchanged, and short-term debt changes in an amount that balances the balance sheet.

6-13 FORECASTING FIRM FCF Using your pro forma financial statements from Problem 6-12, estimate the firm's FCF for 2016.

6-14 ENTERPRISE VALUE An analyst at the Starr Corp. has estimated that the firm's future cash flows for the next five years will equal $80 million per year.

a. If the cost of capital for Starr is 12%, what is the value of Starr Corp.'s planning period cash flows spanning the next five years?
b. It is extremely difficult to estimate cash flows in the distant future, so it is standard practice to lump all the firm's cash flows for years beyond a planning period of, say, five years into something called a terminal value. If companies in Starr's industry are currently selling for five times their annual cash flow, what would you estimate the terminal value of Starr to be in year 5?
c. Apply the same discount rate to the terminal value as to the planning period cash flows, and estimate the enterprise value of Starr today.

Detecting Financial Fraud

Figure 6A-1 provides a list of seven financial shenanigans identified by noted forensic accountant Howard Schilit. The details related to the identification of these shenanigans are beyond the scope of this text; however, the analyst must always be aware of the possibility that the numbers being reported by the firm's management have been massaged. Let the user beware!

Figure 6A-1 Earnings Manipulation and Fraud—Howard Schilit's Financial Shenanigans

Type of Manipulation	Techniques Used to Achieve
Shenanigan 1: Recording revenue too soon or of questionable quality.	Aggressive Accounting Practices **1.** Recording revenues even though future services must still be provided. **2.** Recording revenues before goods are shipped or customer has accepted shipment. **3.** Recording revenues where the customer is not obligated to pay. Recording Revenues of Questionable Quality **4.** Related party transactions. **5.** Providing a "bribe" to the customer to encourage the purchase. **6.** Grossing up revenue.
Shenanigan 2: Recording bogus revenue.	**1.** Recording sales that lack economic substance. **2.** Recording cash received in lending transactions as revenue. **3.** Recording investment income as revenue. **4.** Recording supplier rebates tied to future required purchases as revenues. **5.** Releasing revenue that was improperly held back before a merger.

(*Continued*)

Figure 6A-1 *continued*

Shenanigan 3: Boosting income with one-time gains.	**1.** Boosting profits by selling undervalued assets. **2.** Including investment income or gains as part of revenue. **3.** Reporting investment income or gains as a reduction in operating expenses. **4.** Creating income by reclassifying balance sheet accounts.
Shenanigan 4: Shifting current expenses to a later period (increases current-period earnings and reduces future earnings).	**1.** Capitalizing normal operating costs rather than expensing them. **2.** Changing accounting policies and shifting current expenses to an earlier period. **3.** Amortizing costs too slowly. **4.** Failing to write down or write off assets whose value is impaired. **5.** Reducing asset reserve account balances.
Shenanigan 5: Failing to record or improperly reducing liabilities.	**1.** Failing to record expenses and related liabilities when future obligations remain. **2.** Reducing liabilities by changing accounting assumptions. **3.** Releasing questionable reserves into income. **4.** Creating sham rebates. **5.** Recording revenue when cash is received, even though future obligations remain.
Shenanigan 6: Shifting current-period revenue to a later period (reduces current-period earnings and increases future earnings).	**1.** Creating reserve accounts and releasing them into income in a later period. **2.** Holding back revenue just before an acquisition closes.
Shenanigan 7: Shifting future expenses to the current period as a special charge (decreases current-period earnings and increases future-period earnings).	**1.** Inflating the amount included in a special charge. **2.** Writing off in-process R&D costs from an acquisition. **3.** Accelerating discretionary expenses into the current period.

Source: Adapted from Howard Schilit, *Financial Shenanigans: How to Detect Accounting Gimmicks & Fraud in Financial Reports,* 2nd ed. (New York: McGraw Hill, 2002). Table compiled by authors.

CHAPTER 7

Earnings Dilution, Incentive Compensation, and Project Selection

Chapter Overview

In the long run, firms create value by implementing investment projects that have positive net present values (NPVs). At least in the short run, however, management decisions are influenced by the performance numbers that firms report to their stockholders. Indeed, in practice, managers tend to calculate the accounting implications of their investments as well as their NPVs, and it is not unusual for managers to pass up positive NPV investments that would temporarily reduce their firm's earnings. Although there are important reasons for this focus on earnings, it tends to have a negative influence on investment choices. To counter this tendency, firms have devised alternative performance measures and compensation programs that mitigate some of these biases.

7.1 Introduction

Up to this point, the focus of our valuation approach has been on the cash flows that are expected to be generated by the investment being evaluated. We have ignored the influence of the investment on the firm's reported earnings. In reality, managers take their firm's earnings numbers very seriously and are generally very aware of how a major investment influences their reported earnings in the short run as well as the long run. For example, CFO responses to a recent survey suggest that the pressures of the capital markets encourage decisions that sometimes sacrifice long-term value to meet earnings targets.[1] A startling 80% of the respondents indicated that they would reduce spending on research and development, advertising, maintenance, and hiring that was value-enhancing in order to meet earnings benchmarks. Another indication of the importance of earnings numbers can be found in the growing evidence regarding the extremes to which some firms "manage" their reported earnings. The corporate scandals at Adelphia, Enron, Global Crossing, HealthSouth, Qwest, Rite Aide, Sunbeam, Waste Management, and WorldCom exemplify situations in which earnings management became earnings *manipulation* and even fraud. For the managers of these firms, it appears that reporting favorable earnings was sufficiently important that they were willing to

[1] John R. Graham, Campbell R. Harvey, and Shiva Rajgopal, "The Economic Implications of Corporate Financial Reporting," *Journal of Accounting and Economics* 40, nos. 1–3 (December 1, 2005): 3–73.

risk criminal prosecution. Surely, if this is the case, concern about reported earnings will influence management's investment choices.

We start the chapter by explaining why positive NPV investments sometimes reduce a firm's expected earnings per share (EPS) and why negative NPV investments sometimes increase expected EPS. We first note that when managers evaluate investments by considering their effect on EPS, they are effectively basing their decision on an incorrect cost of capital. The effective cost of capital that is implicitly used with the EPS criterion is the return on cash for those projects financed with cash, the firm's cost of debt for those projects financed with debt, and the ratio of the firm's earnings to price for those projects financed with equity. For projects financed with internally generated cash or debt, the EPS criteria generally leads to the acceptance of too many investment projects. For projects financed with equity, the EPS criteria can lead to the acceptance of either too many or too few investment projects, depending on the firm's earnings–price ratio.

We then describe a second problem that arises because the cash flows of an investment are generally not evenly distributed over the life of a project. Many positive NPV investments generate very little in the way of cash flows in their first few years and, as a result, these projects initially reduce or dilute earnings. In addition, many negative NPV projects have very high initial cash flows and, as a result, temporarily boost EPS.

If the EPS criteria can lead managers astray, why don't managers simply ignore earnings when making investment choices? Perhaps they should, but unfortunately the world is not so simple. As we will explain, the concern about earnings is an inevitable by-product of the practical realities of an environment in which the quality of a firm and its management is judged from quarter to quarter. While managers ideally would *like* to manage for the long term, it is also important that they appear to be doing well now, which means that it is important that they report favorable earnings. As Jack Welch, ex-CEO of General Electric Corporation, so aptly put it:

> "You can't grow long-term if you can't eat short-term."
>
> "Anybody can manage short. Anybody can manage long. Balancing those two things is what management is." (Source: http://www.businessweek.com/1998/23/b3581001.htm)

Unfortunately, there are no simple formulas that will help managers determine the optimal trade-off between NPV, which measures the long-term influence of an investment on firm value, and EPS, which influences short-term value. However, this chapter should provide a framework that will help managers consider this trade-off more thoughtfully. We will also discuss alternative performance measures that have been designed to mitigate this disconnect between earnings and NPV. Arguably, the most prominent of these financial metrics is Economic Value Added (EVA®), developed by Joel Stern and Bennett Stewart.[2]

The chapter is organized as follows: In Section 7.2, we begin by establishing the underlying rationale for managerial sensitivity to the firm's reported earnings. Next, in Section 7.3, we demonstrate how managerial concern for earnings affects project selection. We present examples that illustrate two shortcomings of earnings as an indicator of wealth creation. Section 7.4 reviews economic profit as an alternative to EPS when evaluating new investment proposals. We show that, in many cases, economic profit does provide signals that are consistent with the NPV criteria, but not always. Section 7.5 discusses the effective use of economic profit, and Section 7.6 summarizes the chapter.

[2] G. Bennett Stewart III, 2013, *Best-Practice EVA* (Hoboken, NJ: John Wiley & Sons, Inc.).

7.2 Are Reported Earnings Important?

An investment project that reduces the firm's earnings in the current or following year is referred to as **earnings dilutive.** Likewise, an investment that increases near-term earnings is referred to as **earnings accretive.** These concepts are often used to describe an investment's influence on the firm's total earnings, but for major investments that require the firm to issue new shares, managers are generally more interested in whether the investment is dilutive or accretive to the firm's earnings per share. In addition, there can be a time element to this concept. Managers may refer to projects that are dilutive in the first few years but accretive thereafter. What this means is that the project has a negative effect on earnings in the first few years, but by taking the project, the firm is likely to have higher long-term earnings.

Why Managers Care About Earnings

There are a number of reasons why managers care about reported earnings. The most direct reason is that managers are often paid to care about earnings. Very simply, companies frequently tie short-term bonuses either directly or indirectly to the firm's operating performance, as reflected in its earnings.[3] In addition, long-term incentive compensation frequently involves the use of stock options and equity grants whose value, at least in the short run, is affected by corporate earnings. Finally, earnings (and their effect on share price) may affect the CEO's ability to operate without too much scrutiny from the board of directors, and perhaps even to keep his or her job.

Although it is easy to come up with selfish reasons for why managers care about earnings, earnings are also important to a selfless manager who is simply trying to do what is best for the shareholders. Because earnings communicate the financial viability of the firm to the external capital markets, favorable earnings numbers positively influence a firm's stock price as well as its credit ratings. This is clearly important to a firm that plans to raise external capital in the near future, but may also be important even for firms with no need to raise capital because earnings numbers also communicate information to a firm's nonfinancial stakeholders, such as its customers, employees, and suppliers. A negative earnings surprise and the resulting stock price reaction could have a negative effect on the firm's relation with these stakeholders, while positive earnings and a growing stock price could be critical in determining how these stakeholders view working for and partnering with the firm. In short, it's natural to want to do business with a winner, and in the corporate world, earnings and stock prices are how one keeps score. What this means is that both good and bad earnings can in a sense "snowball," harming the future prospects of firms that report bad earnings and helping the future prospects of firms that report good earnings.

The above discussion (see also the Practitioner Insight box) suggests that the focus on earnings in the corporate world is not something that is likely to change soon. The issues we now address are how this focus on earnings influences managerial investment decisions and whether it is possible to change the way in which firms compensate their managers and communicate to shareholders so that this influence is mitigated.

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[3] Kevin Murphy, of the University of Southern California (USC), surveyed a broad sample of firms using proprietary data from Towers-Perrin and found that, for industrial firms, thirty-two of fifty in his sample used earnings as their primary performance metric; eight of eleven finance and insurance firms and six of seven utilities did likewise.

7.3 Project Analysis—Earnings per Share and Project Selection

The valuation analysis we discussed in previous chapters is typically a major part of the analysis of large investments at most major US corporations. However, as the above discussion suggests, for publicly held firms considering major investments, managers also calculate how the project affects the firm's financial statements over the following two to five years and evaluate whether the project is earnings accretive or earnings dilutive. To illustrate how this is done in practice, we will evaluate hypothetical investment opportunities by considering both their NPVs and their influence on earnings, with a particular focus on how these criteria can provide contradictory conclusions.

Our first example, which illustrates this contradiction, shows that the earnings criterion implicitly uses the wrong cost of equity capital to evaluate an investment. We refer to this as the **equity-cost problem.** Our second example considers a project whose

Practitioner Insight

Earnings and Future Cash Flows: An Interview with Trevor Harris*

Question: In valuing a company, investors are primarily interested in the company's ability to produce future cash flows. In practice, companies can't report what they think their cash flow is going to be for the next ten years. Instead, they report their earnings for the quarter and year just ended. This begs the question as to whether the reported earnings number should aim to provide a measure of current corporate performance that helps investors predict future cash flows. Should investors focus their attention on operating cash flow to get a better sense of a company's future cash-generating capacity?

Trevor: As any corporate or Wall Street analyst will tell you, forecasting future earnings is very difficult. But what most people don't understand is that it's even harder to predict actual cash flows. Moreover, I would argue that reported operating cash flow is far easier for managers to manipulate than earnings. All you have to do is securitize some receivables one minute before your quarter ends, and you can significantly increase your reported operating cash flow. Or you can put off paying for trade receivables by one day—and unless you draw attention to these things, no one will have any idea what you've done. But neither of these things will affect operating earnings.

Question: Is there a better way of calculating earnings—one that would provide investors with a better sense of the company's future cash-generating capacity and provide a reliable measure of wealth creation?

Trevor: I believe that any single-period, flow-based summary statistic—regardless of whether you call it earnings, cash flow, or something else—is going to be a flawed, or at least an incomplete, measure of corporate value creation. Managers are making decisions today that will affect not only this year's results but results for many years going forward. And there's no way that an accounting system can capture the effects on long-run value of these decisions in one number. If your business resembles a savings account where you put money in on schedule and accumulate value at a specified rate of interest, then I could come up with a measure of earnings that can be capitalized at a certain multiple to give you the right value. But, again, for virtually all companies with any degree of complexity, there is no single-period accounting measure that can serve that purpose in a reliable way.

*Former managing director at Morgan Stanley, where his main job was to help the firm's business units and clients with accounting and valuation problems. He is currently a professor at the Columbia University School of Business.

earnings (and cash flows) are back-loaded, which means that the earnings (and cash flows) that the project produces are negative in the early years of the project's life and increase over time. This situation is frequently encountered when a firm undertakes a *strategic investment* in new products or services that requires heavy promotional expenditures in the early years of the project's life. We will refer to this as the **back-loaded earnings problem.**

Example 1—Bad Project with Good Earnings Prospects: The Equity-Cost Problem

To illustrate the *equity-cost problem,* we will consider the case of Beck Electronics, which is evaluating an investment of $6,000,000 in the project described in panel (a) of Table 7-1. The project is to be financed by drawing down $4,000,000 of the firm's cash reserves (the equity component) which were earning a risk-free return of 4% and $2,000,000 in new debt, requiring a 5% interest rate.

To calculate the net impact of this project on the firm's EPS, managers first forecast the firm's EPS by assuming that the project is not undertaken and then compare this EPS forecast to the pro forma projections of EPS under the assumption that the project is taken. Panel (b) of Table 7-1 provides these estimates of the firm's EPS with and without the project. Note that, to keep the example as simple as possible, we assume that both the firm and the new project have indefinite lives and that the firm and the project's revenues, expenses, and earnings are all level perpetuities.

Beck's management anticipates that, without the new project, the firm will realize net income for the coming year of $2,928,000, which is $1.46 a share given the 2 million shares outstanding. The analysis of Beck's post-project EPS (in panel [b] of Table 7-1) reveals that the project is expected to generate earnings equal to $0.16 per share. However, because Beck will no longer have the $4,000,000 cash reserve that generated $160,000 or 4% in pretax interest income, the net gain in the firm's EPS is reduced by $0.064 per share, and the earnings attributable to the project is only $0.096 per share. Even so, the project increases the firm's EPS and thus passes the EPS accretion test.

In general, we can express the effect on earnings or net income attributable to a new project as follows:

$$\begin{matrix}\text{Change in}\\ \text{Net Income}\end{matrix} = \left(\begin{matrix}\text{Project}\\ \text{Operating}\\ \text{Income}\end{matrix} - \begin{matrix}\text{Interest}\\ \text{Expense on}\\ \text{New Debt}\end{matrix} - \begin{matrix}\text{Lost Interest Income}\\ \text{on Cash Used to Fund}\\ \text{the Project's Cost}\end{matrix}\right)(1 - \text{Tax Rate}) \qquad (7.1)$$

It is useful to rearrange the terms as follows:

$$\begin{matrix}\text{Change in}\\ \text{Net Income}\end{matrix} = \underbrace{\left[\left(\begin{matrix}\text{Project}\\ \text{Operating Income}\end{matrix}\right)(1 - \text{Tax Rate})\right]}_{\textbf{Term \#1}} - \underbrace{\left[\left(\begin{matrix}\text{Interest Expense}\\ \text{on New Debt}\end{matrix}\right)(1 - \text{Tax Rate})\right]}_{\textbf{Term \#2}}$$

$$- \underbrace{\left[\left(\begin{matrix}\text{Lost Interest Income}\\ \text{on Cash Used to Fund}\\ \text{the Project's Cost}\end{matrix}\right)(1 - \text{Tax Rate})\right]}_{\textbf{Term \#3}} \qquad (7.1a)$$

The first term on the right-hand side of Equation (7.1a) represents the project's net operating profit after taxes (NOPAT). The second term represents the after-tax cost of the debt used to finance the project, and the final term represents the after-tax opportunity cost of lost interest income on the cash used to fund the project. Substituting the values for each of these variables in the Beck project, we get the following estimate of the impact of the project on net income for the firm:

$$\begin{aligned}\begin{matrix}\text{Change in}\\ \text{Net Income}\end{matrix} &= \$500{,}000(1-.20) - \$2{,}000{,}000 \times .05(1-.20)\\ &\quad -\$4{,}000{,}000 \times .04(1-.20) = \$192{,}000\end{aligned}$$

where the tax rate is 20%, the cost of debt is 5%, and the rate of interest earned on the firm's marketable securities (i.e., cash) is 4%.

Having established that the project is accretive, we now consider whether it has a positive NPV. The new investment is expected to contribute additional operating earnings (i.e., earnings before interest and taxes [EBIT]) of $500,000 per year. To simplify the example we assume the project has an infinite life. This means it does not depreciate nor does it require additional CAPEX. Thus, the project's after-tax free cash flows are estimated to be $400,000 per year:

Earnings before interest and taxes (EBIT)	$500,000
Less: taxes (20%)	(100,000)
Equals: net operating profit (NOPAT)	$400,000
Plus: depreciation expense	0
Less: capital expenditures (CAPEX)	(0)
Equals: project free cash flow (FCF)	$400,000

Assuming that the project's weighted average cost of capital (WACC) is 8% (the same as that of the firm), the value of the project and its NPV can be calculated as follows:

$$\begin{aligned}\text{NPV} &= \begin{pmatrix}\text{Present Value}\\ \text{of the Project's}\\ \text{Free Cash Flow}\end{pmatrix} - \begin{matrix}\text{Investment}\\ \text{in the Project}\end{matrix}\\ &= \frac{\$400{,}000}{.08} - \$6{,}000{,}000 = \$5{,}000{,}000 - \$6{,}000{,}000 = (\$1{,}000{,}000)\end{aligned}$$

Note that the present value of the perpetual stream of free cash flows of $400,000 per year, discounted at the project's 8% cost of capital, is $5,000,000, while the initial investment in the project is $6,000,000. This implies that the NPV is negative at −$1,000,000. Similarly, the internal rate of return (IRR) for the project is defined as follows:

$$\begin{aligned}\text{NPV} &= \begin{pmatrix}\text{Present Value}\\ \text{of the Project's}\\ \text{Free Cash Flow}\end{pmatrix} - \begin{matrix}\text{Investment}\\ \text{in the Project}\end{matrix} = 0\\ &= \frac{\$400{,}000}{\text{IRR}} - \$6{,}000{,}000 = \$0\\ \text{IRR} &= \frac{\$400{,}000}{\$6{,}000{,}000} = .0667 = 6.67\%\end{aligned}$$

Table 7-1 Example 1: Bad Project with Good Earnings for Beck Electronics

Panel (a) Project Characteristics and Assumptions		
Investment outlay	$6,000,000	One-time expenditure
Project life	Infinite	Perpetual life asset
CAPEX = depreciation expense (for project)	—	
Debt financing	2,000,000	Perpetual debt (never matures)
Equity (from retained earnings)	4,000,000	Raised using excess cash
Additional EBIT per year	500,000	Per year (level perpetuity)
Tax rate	20.0%	
Treasury bill yield	4.0%	
Borrowing rate (before tax)	5.0%	
Cost of equity	10.0%	
Cost of capital (WACC)	8.0%	WACC is the same for the firm and the project

Panel (b) Pro Forma Income Statements	Pre-Project Firm	Project	Firm + Project
EBIT	$4,000,000	$ 500,000	$4,500,000
Less: interest expense	(500,000)	(100,000)	(600,000)
Plus: interest income (equity financing)	160,000	0	0
EBT	$3,660,000	$ 400,000	$3,900,000
Less: taxes	(732,000)	(80,000)	(780,000)
Net income	$2,928,000	$ 320,000	$3,120,000
Earnings per share	$ 1.464	$ 0.160	$ 1.560

Note: EPS increases if the project is accepted!

Panel (c) Cash Flow Analysis	Pre-Project Firm	Project	Firm + Project
EBIT	$4,000,000	$ 500,000	$4,500,000
Less: taxes	(800,000)	(100,000)	(900,000)
NOPAT	$3,200,000	$ 400,000	$3,600,000
Plus: depreciation	2,400,000	0	2,400,000

Less: CAPEX	(2,400,000)	(0)	(2,400,000)
FFCF	$ 3,200,000	$ 400,000	$ 3,600,000

Panel (d) Firm and Project Valuation Analysis	**Project**	**Firm + Project**
Value of pre-project firm		$40,000,000
Less: investment outlay	$(6,000,000)	
Plus: value of project cash flows	5,000,000	
Value of firm plus project		39,000,000
Net present value		$ (1,000,000)

Note: The NPV of the project is negative!

Legend:

EBIT = earnings before interest and taxes
EBT = earnings before taxes
NOPAT = net operating profit after taxes
CAPEX = capital expenditures
FFCF = firm free cash flow

Clearly, this is an unacceptable project because it earns a return of only 6.67%, while the cost of capital for the project is 8%.

How Can Projects with Negative NPVs Increase EPS?

How can it be that an investment is accretive to the firm's earnings but has a negative NPV? To understand this, it is useful to remember that the discount rate that is used in the DCF analysis should be viewed as the opportunity cost of capital. This is the rate of return that the firm could earn on an alternative investment that has the same risk as the investment project under evaluation. In contrast, when we examined whether the Beck investment was accretive or dilutive, we were, in effect, assuming that the opportunity cost equaled the rate earned on the cash used to finance the project. In other words, we used a risk-free rate as the opportunity cost of equity capital and thus ignored the fact that the investment project was risky. To better understand what we will refer to as the **equity-cost problem,** let's look more closely at Equation (7.1a):

$$\begin{array}{c}\text{Change in}\\ \text{Net Income}\end{array} = \underbrace{\left[\left(\begin{array}{c}\text{Project}\\ \text{Operating Income}\end{array}\right)(1-\text{Tax Rate})\right]}_{\textbf{NOPAT}}$$

$$\underbrace{-\left[\left(\begin{array}{c}\text{Interest}\\ \text{Expense on}\\ \text{New Debt}\end{array}\right)(1-\text{Tax Rate}) + \left(\begin{array}{c}\text{Lost Interest Income}\\ \text{on Cash Used to Fund}\\ \text{the Equity}\end{array}\right)(1-\text{Tax Rate})\right]}_{\textbf{Capital Cost}}$$

$$= \text{NOPAT} - \text{Capital Cost} \tag{7.1b}$$

The previous expression decomposes into two components the equation for the change in net income resulting from the acceptance of a project. The first term in brackets is net operating profit after taxes (NOPAT). The second term in brackets represents the dollar cost per year (after taxes) of the capital used to finance the project; this is the annual *capital cost* for the project.

An examination of the second term reveals that the only opportunity cost we include for the equity capital component of the employed capital is the lost after-tax income from the cash used to fund the equity in the project. In the Beck example, this was the 4% yield (3.2% after taxes) on short-term Treasury bills, which substantially understates the true opportunity cost of equity capital for the project.

The investment was accretive in this example because its internal rate of return of 6.67% exceeds the 4% risk-free return (3.2% after taxes). However, the project has a negative NPV because its IRR does not exceed the risk-adjusted opportunity cost of capital for the project, which is 8%.

Issuing New Equity: EPS Accretion/Dilution and the Price-to-Earnings Ratio

Up to this point, we have assumed that the firm has sufficient cash from the retention of prior earnings to finance the equity component of its investments. Let's now consider how EPS is affected if Beck must finance the project by issuing new shares of stock. As the following discussion indicates, when firms finance projects by issuing equity, a key factor that determines whether the project is accretive or dilutive is the firm's price-to-earnings (P/E) ratio.

To illustrate the importance of the P/E ratio, we will provide some additional information about Beck Electronics and consider a new investment opportunity that provides a 10% rate of return and requires the issuance of 375,000 shares at $16/share. The investment provides added EBIT of $750,000 per year in perpetuity, which implies that the project is expected to produce an after-tax cash flow of $600,000 in perpetuity. The cost of this investment is $6,000,000, which implies a 10% IRR.

Specifically, as described in case A of Table 7-2, we now assume that both Beck and the new project are all-equity-financed, the cost of equity capital is 10%, and Beck's P/E multiple is 10. The 10% cost of equity capital and P/E ratio of 10 reflect the fact that Beck pays out all of its earnings in dividends and that the equity holders anticipate no growth in the value of the firm's shares. (That is, the cost of equity is equal to the ratio of dividends to share price, which is the same as earnings to share price.) Note too that the project offers a zero NPV because the IRR is exactly equal to the cost of capital.

In this particular example, the project has *no effect* on the firm's EPS (it is neither accretive nor dilutive) and has an NPV equal to 0. Thus, EPS and NPV provide the same signal. As we will show, this occurs because the cost of equity capital in this example is equal to the reciprocal of the P/E ratio. In general, the cost of equity will not exactly equal $E \div P$ (the reciprocal of $P \div E$), which means that there are potential conflicts between the EPS and NPV criteria.

To illustrate, let's alter the example and assume that Beck has significant growth prospects, as in case B of Table 7-2, and that, as a result, its stock price is twice as high and its P/E ratio is 20 instead of 10. With the higher stock price, Beck can fund the project by selling half as many shares of stock as before. The project itself has not changed; however, because Beck's P/E ratio is now higher, initiating the investment dramatically increases the firm's EPS. Indeed, as long as the project returns more than 5% (the current earnings yield when P/E = 20), it will be EPS accretive.[4]

Generalizing the Earnings Accretion/Dilution Analysis

We can generalize the effects of project selection on a firm's EPS by analyzing the expected change in the firm's EPS that will result from the acceptance of a project or investment. *The key consideration in determining whether an equity-financed investment is accretive or dilutive is the relationship between the rate of return earned on the equity*

[4] The following numerical example may help illustrate this point: Without the project, the firm's EPS is $1.60 for each of the 2 million shareholders. Based on a P/E ratio equal to 10, the share price is $16.00. Consequently, raising the $6 million needed to fund the investment in the project will require the issue of $\$6\text{million}/\$16 = 375{,}000$ additional shares. Based on the total shares outstanding after the issuance (2 million plus 375,000), the project's $600,000 annual earnings will increase EPS by $0.253. However, because the cost of equity is equal to $E \div P$, or 10%, the combination of the firm and the project has an EPS of $1.60—exactly the same EPS the firm has without the project. Suppose now that the P/E ratio is 20; the firm's share price would be $\$32\,(20 \times \$1.60)$, which means that fewer shares (half, to be exact) would have to be issued to raise the $6 million needed to finance the project. The EPS of the project turns out to be $0.274, and the EPS of the combination is $1.737.

Table 7-2 Financing the Project by Issuing New Shares of Stock: EPS and NPV

Case A: ROE $= 10\% = 1/_{P/E} = E/P = 10\%$; *No-Growth Firm* (Cost of Equity $= E/P = 10\%$)

Panel (a) Pro Forma Income Statements	**Pre-Project Firm**	**Project**	**Firm + Project**
EBIT	$ 4,000,000	$ 750,000	$ 4,750,000
Less: interest expense	0	0	0
Plus: interest income (equity financing)	0	0	0
EBT	$ 4,000,000	$ 750,000	$ 4,750,000
Less: taxes	(800,000)	(150,000)	(950,000)
Net income	$ 3,200,000	$ 600,000	$ 3,800,000
Shares	2,000,000	375,000	2,375,000
	(Total pre-project shares)	(New shares issued)	(Total post-project shares)
EPS	$ 1.60	$ 1.60	$ 1.60
Panel (b) Cash Flow Analysis	**Pre-Project Firm**	**Project**	**Firm + Project**
EBIT	$ 4,000,000	$ 750,000	$ 4,750,000
Less: taxes	(800,000)	(150,000)	(950,000)
NOPAT	$ 3,200,000	$ 600,000	$ 3,800,000
Plus: depreciation	2,400,000	600,000	3,000,000
Less: CAPEX	(2,400,000)	(600,000)	(3,000,000)
FCF	$ 3,200,000	$ 600,000	$ 3,800,000
Panel (c) Firm and Project Valuation Analysis		**Project**	**Firm + Project**
Value of pre-project firm			$ 32,000,000
Less: investment outlay		$ (6,000,000)	
Plus: value of project cash flows		6,000,000	
Value of firm plus project			32,000,000
Net present value			$ 0

In case A of the table, the firm's EPS is unchanged by the project's acceptance and the project has a zero NPV. In case B, however, where the cost of equity capital is not equal to the reciprocal of the P/E ratio (i.e., the E/P ratio), the project's NPV is still zero but EPS increases.

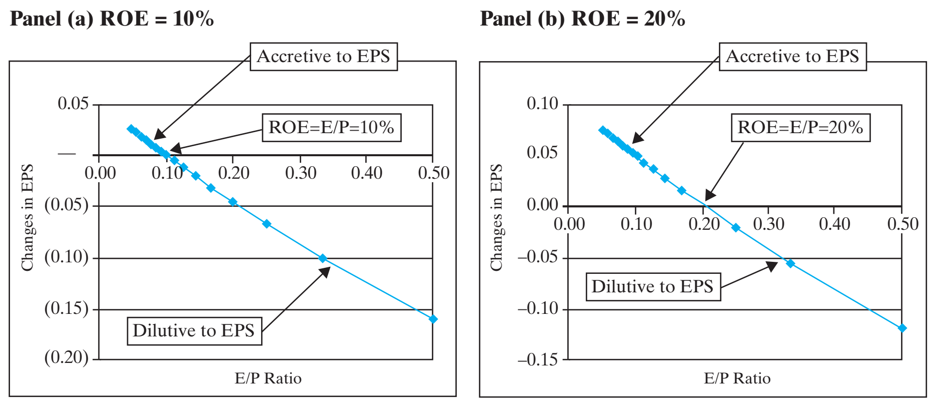
capital invested in the project (return on equity [ROE]) and the earnings-to-price ratio (i.e., E ÷ P or the reciprocal of the P/E ratio). If the project's ROE is greater than the E/P ratio, then it will be accretive to the firm's EPS. Similarly, if the ROE is less than the E/P ratio, the project will be dilutive to EPS.

Case B: ROE $= 10\% > 1/_{P/E} = 5\%$; *Growth Firm* (Cost of Equity $= 10\% > 1/_{P/E} = 5\%$)

Panel (a) Pro Forma Income Statements	**Pre-Project Firm**	**Project**	**Firm + Project**
EBIT	$ 4,000,000	$ 750,000	$ 4,750,000
Less: interest expense	0	0	0
Plus: interest income (equity financing)	0	0	0
EBT	$ 4,000,000	$ 750,000	$ 4,750,000
Less: taxes	(800,000)	(150,000)	(950,000)
Net income	$ 3,200,000	$ 600,000	$ 3,800,000
Shares	2,000,000	187,500	2,187,500
	(Total pre-project shares)	(New shares issued)	(Total post-project shares)
EPS	$ 1.60	$ 3.20	$ 1.737
Panel (b) Cash Flow Analysis	**Pre-Project Firm**	**Project**	**Firm + Project**
EBIT	$ 4,000,000	$ 750,000	$ 4,750,000
Less: taxes	(800,000)	(150,000)	(950,000)
NOPAT	$ 3,200,000	$ 600,000	$ 3,800,000
Plus: depreciation	2,400,000	600,000	3,000,000
Less: CAPEX	(2,400,000)	(600,000)	(3,000,000)
FCF	$ 3,200,000	$ 600,000	$ 3,800,000
Panel (c) Firm and Project Valuation Analysis		**Project**	**Firm + Project**
Value of pre-project firm			$ 32,000,000
Less: investment outlay		$ (6,000,000)	
Plus: value of project cash flows		6,000,000	
Value of firm plus project			32,000,000
Net present value			$ —

Figure 7-1 generalizes the relationship between the change in the firm's earnings, the project's ROE, and the E/P ratio. In panel (a), the project's ROE is 10%, and this return produces earnings accretion as long as the E/P ratio is below 10%. In panel (b), the project provides an ROE of 20%; as long as the E/P ratio is below 20%, the project

Figure 7-1 ROE Versus the E/P Ratio and EPS Accretion/Dilution



Accretive to earnings per share (EPS)—the change in EPS is positive when the ROE exceeds the E/P ratio. When ROE is 10% (panel [a]), the project is accretive when the E/P ratio is 10% or less. Similarly, when ROE is 20% (panel [b]), the project increases firm earnings when the E/P ratio is 20% or less.

Dilutive to earnings per share (EPS)—the change in EPS is negative if the ROE is less than the E/P ratio.

is accretive. In essence, holding new investments to the earnings accretion standard is equivalent to comparing the project's return on equity to the E/P ratio. This standard is appropriate only when the cost of equity for the project is equal to E ÷ P, which generally is not the case.

Which firms are most apt to take negative NPV projects when using EPS accretion as a decision tool for project analysis? The answer, of course, is firms for which the E/P ratio most underestimates their true cost of equity financing. In general, these will be growth firms, which have high P/E ratios, because their earnings are likely to grow in the future.

Debt Financing and Earnings Dilution

The preceding example illustrates how the firm's P/E ratio influences whether the project is accretive or dilutive. However, this is only the case when the project is financed with new equity. When the project is financed with debt, a comparison of the project's IRR and the after-tax cost of the debt determines whether the project is accretive or dilutive. For example, in the Beck example, the project is accretive if it is financed with debt with an after-tax cost that is less than 10%.

Suppose that you are recommending a positive NPV project that has an IRR of 8% and suggest that it be financed by issuing equity. Your firm's current P/E ratio is 10, which implies that this equity-financed project will be dilutive. Depending on the situation, your CEO may not like the idea of initiating a project that dilutes the firm's current EPS. What are your alternatives?

One alternative is to simply abandon the project. A second alternative is to use sufficient debt financing so that the project is accretive rather than dilutive. Which is the preferred alternative? That depends on the NPV of the project and on the firm's ability to raise debt capital without jeopardizing its credit rating.

Example 2—Good Project with Back-Loaded Earnings Prospects

The second issue we discuss that can cause earnings dilution is the **back-loaded earnings problem.** By *back-loaded,* we simply mean that the project generates little if any earnings in its early years, with most of its earnings occurring toward the end of the project's life.

Consider the situation faced by Dowser Chemical, which is about to launch a new product that involves an initial investment of $33,750,000 and is expected to generate revenues and earnings over a period of ten years. In addition to the cost of plant and equipment, the new-product launch requires aggressive pricing and substantial expenditures for product promotion, which will severely reduce profits in the initial years. As the new product gains acceptance in the marketplace, it will require a less generous promotional budget, and prices can be raised. The combined effects of these changes will boost both project cash flows and the firm's EPS.

Table 7-3 contains the accounting consequences of Dowser's investment project. Panel (a) contains pro forma balance sheets corresponding to the initial formation of the project in year 0 and for years 1 through 10. The initial balance sheet for year 0 reveals an initial investment of $3,750,000 in current assets and an additional investment of $30,000,000 in property, plant, and equipment, for total assets of $33,750,000. Dowser finances a portion of the firm's current assets with $1,250,000 in payables. The remainder of the project's financing needs is raised using long-term debt or bonds equal to $10,833,333 and $21,666,700 in equity, which total $32,500,000 in invested capital. Panel (b) contains pro forma income statements indicating that the project is expected to lose money in year 1 of its operations but will be profitable in each year thereafter.

To estimate the NPV of the project, we convert the accounting pro forma income statements into estimates of the project's free cash flow as shown in Table 7-4. This exercise reveals that the project will not produce positive cash flows until year 5. Nonetheless, based on the project's ten years of estimated cash flows and a discount rate of 12% (the project's weighted average cost of capital), we estimate the NPV of the project to be $5,718,850. Consequently, based on the NPV estimate, we conclude that the project is a good prospect for the firm.

But what is the effect of the project's acceptance on the firm's earnings per share?

Earnings Effects—Accretion Versus Dilution

Major projects like the one Dowser Chemical is considering can have a significant effect on the firm's reported earnings. To measure how the project affects EPS, we will again estimate the firm's EPS both with and without the project. In this case, we will not only look at how EPS is affected by the project in one year, we will also examine how EPS is affected over the next ten years. These projections, shown in Table 7-5, reveal that the project takes several years before it is accretive to EPS. As a result, during the first year, the project reduces the firm's earnings by $758,000, thereby lowering EPS by ($0.42) in year 1. The project continues to be dilutive for the next four years and finally becomes accretive in year 6 by $0.12 per share.

The dilemma faced by the manager, then, is the following: Should the firm adopt the project and suffer the earnings-dilution effects over the next four years or avoid the project even though it has a positive NPV?

Table 7-3 Pro Forma Financial Statements for a Proposed New Business by Dowser Chemical

Panel (a) Pro Forma Balance Sheets ($ Thousands)

	Years				
	0	**1**	**2**	**3**	**4**
Current assets	$ 3,750.00	$ 4,500.00	$ 5,400.00	$ 6,480.00	$ 7,776.00
Property, plant, and equipment	30,000.00	32,000.00	34,400.00	37,280.00	40,736.00
Total	$ 33,750.00	$ 36,500.00	$ 39,800.00	$ 43,760.00	$ 48,512.00
Accruals and payables	$ 1,250.00	$ 1,500.00	$ 1,800.00	$ 2,160.00	$ 2,592.00
Long-term debt	10,833.33	11,666.67	12,666.67	13,866.67	15,306.67
Equity	21,666.67	23,333.33	25,333.33	27,733.33	30,613.33
Total	$ 33,750.00	$ 36,500.00	$ 39,800.00	$ 43,760.00	$ 48,512.00
Invested capital	$ 32,500.00	$ 35,000.00	$ 38,000.00	$ 41,600.00	$ 45,920.00

Panel (b) Pro Forma Income Statements ($ Thousands)

	Years			
	1	**2**	**3**	**4**
Sales	$ 30,000	$ 36,000	$ 43,200	$ 51,840
Cost of goods sold	(12,000)	(14,400)	(17,280)	(20,736)
Gross profit	$ 18,000	$ 21,600	$ 25,920	$ 31,104
Operating expenses (excluding depreciation)	(15,000)	(16,800)	(18,960)	(21,552)
Depreciation expense	(3,000)	(3,200)	(3,440)	(3,728)
Net operating income	$ —	$ 1,600	$ 3,520	$ 5,824
Less: interest expense	(1,083)	(1,167)	(1,267)	(1,387)
Earnings before taxes	$ (1,083)	$ 433	$ 2,253	$ 4,437
Less: taxes	325	(130)	(676)	(1,331)
Net income	$ (758)	$ 303	$ 1,577	$ 3,106

7.4 Economic Profit and the Disconnect Between EPS and NPV

In the preceding section, we demonstrated that two fundamental problems arise when earnings accretion is used as a criterion for project selection. The first is the equity-cost problem, whereby the opportunity cost of equity is not properly accounted for in the

Years					
5	6	7	8	9	10
$ 9,331.20	$ 11,197.44	$ 13,436.93	$ 16,124.31	$ 19,349.18	$ 23,219.01
44,883.20	49,859.84	55,831.81	62,998.17	71,597.80	81,917.36
$ 54,214.40	$ 61,057.28	$ 69,268.74	$ 79,122.48	$ 90,946.98	$ 105,136.37
$ 3,110.40	$ 3,732.48	$ 4,478.98	$ 5,374.77	$ 6,449.73	$ 7,739.67
17,034.67	19,108.27	21,596.59	24,582.57	28,165.75	32,465.57
34,069.33	38,216.53	43,193.17	49,165.14	56,331.50	64,931.14
$ 54,214.40	$ 61,057.28	$ 69,268.74	$ 79,122.48	$ 90,946.98	$ 105,136.38
$ 51,104.00	$ 57,324.80	$ 64,789.76	$ 73,747.71	$ 84,497.25	$ 97,396.71

Years					
5	6	7	8	9	10
$ 62,208	$ 74,650	$ 89,580	$ 107,495	$ 128,995	$ 154,793
(24,883)	(29,860)	(35,832)	(42,998)	(51,598)	(61,917)
$ 37,325	$ 44,790	$ 53,748	$ 64,497	$ 77,397	$ 92,876
(24,662)	(28,395)	(32,874)	(38,249)	(44,698)	(52,438)
(4,074)	(4,488)	(4,986)	(5,583)	(6,300)	(7,160)
$ 8,589	$ 11,907	$ 15,888	$ 20,665	$ 26,399	$ 33,278
(1,531)	(1,703)	(1,911)	(2,160)	(2,458)	(2,817)
$ 7,058	$ 10,203	$ 13,977	$ 18,506	$ 23,940	$ 30,462
(2,117)	(3,061)	(4,193)	(5,552)	(7,182)	(9,139)
$ 4,941	$ 7,142	$ 9,784	$ 12,954	$ 16,758	$ 21,323

calculation of EPS. The second is the back-loaded earnings problem, whereby projects produce a disproportionate amount of their earnings in the latter half of their lives, which makes even positive NPV projects' earnings dilutive in their early years. In both cases, EPS accretion/dilution analysis can provide a faulty signal concerning the NPV of the project.

Table 7-4 Analysis of Project Cash Flow and NPV for Dowser Chemical ($ Thousands)

	Years			
	1	2	3	4
Sales	$ 30,000	$ 36,000	$ 43,200	$ 51,840
Net operating income	0	1,600	3,520	5,824
Less cash tax payments	0	(480)	(1,056)	(1,747)
Net operating profits after taxes (NOPAT)	$ 0	$ 1,120	$ 2,464	$ 4,077
Plus: depreciation expense	3,000	3,200	3,440	3,728
Less: investments:				
In net working capital	(500)	(600)	(720)	(864)
In new capital (CAPEX)	(5,000)	(5,600)	(6,320)	(7,184)
Total net investment for the period	$ (5,500)	$ (6,200)	$ (7,040)	$ (8,048)
Free cash flow (FCF)	$ (2,500)	$ (1,880)	$ (1,136)	$ (243)

Project Valuation	
Present value of invested capital, year 10	$ 6,859.73
Terminal value of free cash flows (12% cost of capital)	31,359.13
Present value of project cash flows	$ 38,218.85
Less: initial invested capital in year 0	(32,500.00)
Net present value	$ 5,718.86

In the 1980s, financial consultants began recommending alternative performance measures and executive compensation programs to address the bias associated with the influence that EPS accretion/dilution analysis was having on management choices. The best known of these alternative "economic profit" measures was Economic Value Added (EVA)®.

Economic Profit (EVA®)

The accounting profession has long advocated the use of a modified accounting profit measure called residual income or economic profit to measure periodic firm performance. Stern Stewart and Company define economic profit, or EVA®, as follows:

$$\text{EVA}^{\circledR}_t = \begin{matrix}\text{Net Operating}\\ \text{Profit after}\\ \text{Taxes (NOPAT)}_t\end{matrix} - \begin{matrix}\text{Capital}\\ \text{Charge}_t\end{matrix} \tag{7.2}$$

Years					
5	6	7	8	9	10
$ 62,208	$ 74,650	$ 89,580	$ 107,495	$ 128,995	$ 154,793
8,589	11,907	15,888	20,665	26,399	33,278
(2,577)	(3,572)	(4,766)	(6,200)	(7,920)	(9,983)
$ 6,012	$ 8,335	$ 11,122	$ 14,466	$ 18,479	$ 23,295
4,074	4,488	4,986	5,583	6,300	$ 7,160
(1,037)	(1,244)	(1,493)	(1,792)	(2,150)	$ (2,580)
(8,221)	(9,465)	(10,958)	(12,750)	(14,899)	$ (17,479)
$ (9,258)	$ (10,709)	$ (12,451)	$ (14,541)	$ (17,049)	$ (20,059)
$ 828	$ 2,114	$ 3,657	$ 5,508	$ 7,729	$ 10,395

where

$$\text{NOPAT}_t = \begin{pmatrix}\text{Earnings Before}\\ \text{Interest and Taxes}\\ (\text{EBIT})_t\end{pmatrix} \times \left(1 - \begin{matrix}\text{Corporate}\\ \text{Tax Rate}\end{matrix}\right)$$

and

$$\begin{matrix}\text{Capital}\\ \text{Charge}_t\end{matrix} = \begin{matrix}\text{Invested}\\ \text{Capital}_{t-1}\end{matrix} \times \begin{matrix}\text{Weighted Average}\\ \text{Cost of}\\ \text{Capital (WACC)}\end{matrix}$$

Equation (7.2) looks very similar to Equation (7.1b), defined earlier in our discussion of the Beck example. However, the capital charge found in Equation (7.2) incorporates the true opportunity cost of equity, which is 8% in the Beck example,

Table 7-5 **Analysis of Earnings Dilution Effects for Dowser Chemical ($ Thousands Except for Per-Share Information)**

Analysis of Earnings Dilution Effects	**1**	**2**	**3**	**4**
Project net income	$ (758)	$ 303	$ 1,577	$ 3,106
Firm net income without the project	53,750	57,781	62,115	66,773
Total firm net income with the project	$ 52,992	$ 58,085	$ 63,692	$ 69,880
Total shares outstanding with the project	10,688.33	10,736.81	10,760.31	10,760.31
Combined firm and project earnings per share	$ 4.96	$ 5.41	$ 5.92	$ 6.49
Total shares outstanding without the project	10,000	10,000	10,000	10,000
Firm earnings per share without the project	$ 5.38	$ 5.78	$ 6.21	$ 6.68
Earnings (dilution)/accretion per share	**$ (0.42)**	**$ (0.37)**	**$ (0.29)**	**$ (0.18)**

rather than the after-tax yield on Treasury bills that is reflected in Equation (7.1b) (4% yield, or 3.2% after taxes).[5] Because the appropriate risk-adjusted capital charge is higher than the risk-free rate that is implicit in the analysis of earnings, the economic profits associated with this project will be much lower than the earnings attributable to the project.

Using Economic Profit to Evaluate the Equity-Cost Problem

In Table 7-6, we apply the economic profit concept to the evaluation of the Beck investment introduced earlier in Table 7-1. The economic profit analysis found in Table 7-6 reveals that Beck's economic profit drops to $720,000, reflecting the ($80,000) economic profit of the project. This negative economic profit reflects the fact that the project is not a value-creating investment (which is consistent with the negative NPV of −$1,000,000 that we calculated in panel [d] of Table 7-1).

[5] To see why this is the case, we can rewrite the capital charge (cost) in Equation (7.1b) as follows:

$$\begin{aligned}\text{Capital Charge} &= \left[\begin{pmatrix}\text{Interest Expense}\\\text{on New Debt}\end{pmatrix}(1-\text{Tax Rate}) + \begin{pmatrix}\text{Lost Interest Income}\\\text{on Cash Used to Fund}\\\text{the Equity}\end{pmatrix}(1-\text{Tax Rate})\right]\\&= \left[\frac{\left[\begin{pmatrix}\text{Interest Rate}\\\text{on New Debt}\end{pmatrix}\times\text{Debt}\times\left(1-\begin{matrix}\text{Tax}\\\text{Rate}\end{matrix}\right)+\begin{pmatrix}\text{T-Bill}\\\text{Rate}\end{pmatrix}\times\begin{pmatrix}\text{Cash Used to Fund}\\\text{Equity}\end{pmatrix}\times\left(1-\begin{matrix}\text{Tax}\\\text{Rate}\end{matrix}\right)\right]}{\text{Debt}+\text{Equity}}\right]\times(\text{Debt}+\text{Equity})\\&= \begin{pmatrix}\text{Weighted Average}\\\text{of After-Tax Borrowing Rate}\\\text{and the T-Bill Rate}\end{pmatrix}\times(\text{Debt}+\text{Equity})\end{aligned}$$

5	6	7	8	9	10
$ 4,941	$ 7,142	$ 9,784	$ 12,954	$ 16,758	$ 21,323
71,781	77,165	82,952	89,174	95,862	103,052
$ 76,722	$ 84,307	$ 92,736	$ 102,128	$ 112,620	$ 124,375
10,760.31	10,760.31	10,760.31	10,760.31	10,760.31	10,760.31
$ 7.13	$ 7.84	$ 8.62	$ 9.49	$ 10.47	$ 11.56
10,000	10,000	10,000	10,000	10,000	10,000
$ 7.18	$ 7.72	$ 8.30	$ 8.92	$ 9.59	$ 10.31
$ (0.05)	**$ 0.12**	**$ 0.32**	**$ 0.57**	**$ 0.88**	**$ 1.25**

A further indication that economic profit provides the correct signal of the project's potential for creating shareholder value lies in the fact that the present value of all future economic profits is equal to the project's NPV. In the Beck Electronics investment example, where economic profit is a constant amount for all future years and the project is assumed to have an infinite life (i.e., the future economic profits are a level perpetuity), we can calculate the present value of all future economic profits as follows:

$$\begin{array}{c}\text{Present Value}\\ \text{of All Future}\\ \text{Economic Profits}\end{array} = \frac{\text{Economic Profit}}{\text{Cost of Capital}} = \frac{(\$80{,}000)}{.08} = (\$1{,}000{,}000)$$

The present value of all future economic profits is equal to what Stern Stewart refers to as the market value added (MVA) for the project (or firm), which is simply the project NPV. We should point out, however, that the MVA used to rank company performance

Table 7-6 Using Economic Profit to Solve the Equity-Cost Problem for Beck Electronics Inc.

	Pre-Project Firm	Project	Firm + Project
EBIT	$ 4,000,000	$ 500,000	$ 4,500,000
Less: taxes	(800,000)	(100,000)	(900,000)
NOPAT	$ 3,200,000	$ 400,000	$ 3,600,000
Less: capital charge	(2,400,000)	(480,000)	(2,880,000)
Economic profit	$ 800,000	$ (80,000)	$ 720,000

EBIT = earnings before interest and taxes; NOPAT = net operating profit after taxes; capital charge = invested capital times the weighted average cost of capital; equity capital charge = equity capital times the cost of equity capital; economic profit = NOPAT less the capital charge.

TECHNICAL INSIGHT

MVA and NPV

Market value added (MVA) has been calculated as the difference in the market value of the firm (share price times number of shares plus liabilities—often measured using book values) less an estimate of the capital invested in the firm at a particular point in time. The latter is basically an adjusted book value of the firm's assets taken from the most recent balance sheet. In this estimation of MVA, future economic profits are not estimated and discounted, and the estimate of invested capital is not equal to replacement cost or the dollar amount that would be required to replicate the asset portfolio of the firm. Consequently, MVA as reported in the financial press (e.g., Stephen Taub, "MVPs of MVA," *CFO Magazine,* July 1, 2003) is not technically equal to the NPV of the firm but is an approximation based on a comparison of the market value of the firm's outstanding securities (debt and equity) and the book value of the firm's assets (after making some key adjustments). See Chapter 5 in G. Bennett Stewart III, *The Quest for Value* (HarperBusiness, 1991).

and reported in the popular financial press is not calculated as the present value of expected future economic profits (see the Technical Insight box).

In this particular example, economic profit, or EVA®, provides a very useful tool for evaluating periodic performance in a way that is completely consistent with the NPV criterion. That is, because the project produces a constant stream of earnings and economic profit, a positive economic profit means that the project has a positive NPV, and a negative economic profit signals a negative NPV.

As we demonstrate using the Dowser Chemical example, however, economic profit does not automatically address the problems that arise when an investment's earnings are not stable or evenly distributed over the life of the project. Specifically, we consider two settings in which the distribution of earnings over the life of a project poses a problem. The first arises when earnings are concentrated in the latter years of a project's life; we have referred to this as the *back-loaded earnings problem.* In this case, the project can have negative economic profits for one or more of the early years of its life and still provide a positive expected NPV for the project's entire life. The second occurs when project earnings are concentrated in the early years of a project's life; we refer to this as the *front-loaded earnings problem.* In this situation, the project may initially produce positive economic profits for one or more years and then turn sufficiently negative in the latter years resulting in a negative NPV over the project's entire life.

Using Economic Profit to Evaluate the Back- and Front-Loaded Earnings Problems

As we noted in the Beck Electronics example, the use of economic profit in place of EPS corrects a project-selection error that can arise when EPS accretion or dilution is a critical decision variable. The Beck example illustrates that the EPS criterion implicitly uses the incorrect discount rate. To correct the problem, one uses an alternative performance measure that uses the correct discount rate. Unfortunately, economic profit does not directly address the issues associated with the back-loaded earnings problem illustrated in the Dowser Chemical example.

Back-Loaded Earnings

Panel (a) of Table 7-7 includes the economic profit calculations for each year of the Dowser Chemical problem introduced earlier. Although the project has a positive NPV, it has negative economic profits in years 1 through 4 before becoming positive in year 5.[6] As we mentioned earlier, the present value of all the years' economic profits of an investment is equal to its NPV (see panel [b] of Table 7-7). However, the fact that the sum of the present values of the annual economic profit measures is equal to NPV does not say that *any particular year's* economic profit reveals whether the project has a positive, negative, or zero NPV!

Front-Loaded Earnings

Table 7-8 contains an investment project that is similar to the Dowser example except that the pattern of earnings is reversed. In this example, the project earns more in the early years and less in the later years of its life, implying that NOPAT as well as economic profits are higher in year 1 than in any subsequent year.[7] The result is that, for the front-loaded project, economic profits are positive for the first four years before switching to negative in years 5 through 10. In this example, the project has a negative NPV (see panel [b] of Table 7-8), even though the EVA®s in the initial years are positive.

Summing Up

The value of a multiyear project is a function of multiple cash flows or, analogously, multiple years of economic profit, and any one year's performance is generally not sufficient to evaluate the overall value of an investment project. This fact poses a very serious dilemma for the financial manager who would like to select positive NPV investments but is evaluated and paid based on the firm's year-to-year performance. The problem is most serious when project value creation is uneven from year to year and takes place over many years.

7.5 Practical Solutions—Using Economic Profit Effectively

We have demonstrated that if the cash flows of a positive NPV project are back-loaded, the project can dilute economic profit as well as EPS in the early years. Similarly, a front-loaded project may initially be accretive to both economic profits and earnings even when its NPV is negative. In either case, there is a *horizon problem* that biases managers away from back-loaded projects, even though they may have positive NPVs, and toward front-loaded projects that may have negative NPVs.

Two approaches can be taken to resolve the horizon problem. The first involves refining how we calculate the performance measure. This means making adjustments to how the

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[6] Note that two equivalent methods are used to calculate economic profit in panel (a) of Table 7-7. The first is the conventional method defined in Equation (7.2). The second simply recognizes the fact that return on invested capital (ROIC) is equal to the ratio of NOPAT to invested capital and calculates economic profit by multiplying the difference in the ROIC and weighted average cost of capital (k_{WACC}) by invested capital.

[7] Although we do not report it in Table 7-8, the project is also accretive to earnings in the first two years of its life before becoming dilutive in years 3 through 10.

Table 7-7 Using Economic Profit (or EVA®) to Evaluate the Dowser Chemical Example Introduced in Table 7-3

Panel (a) Calculating Economic Profit ($000)				
Method 1		Years		
	1	2	3	4
Sales	$ 30,000	$ 36,000	$ 43,200	$ 51,840
Operating income	0	1,600	3,520	5,824
Less: cash tax payments	0	(480)	(1,056)	(1,747)
Net operating profits after taxes (NOPAT)	$ 0	$ 1,120	$ 2,464	$ 4,077
Less: capital cost = invested capital × k_{WACC}	(3,900)	(4,200)	(4,560)	(4,992)
Economic profit = NOPAT − capital cost	$ (3,900)	$ (3,080)	$ (2,096)	$ (915)
Method 2				
Return on invested capital (ROIC)	0.00%	3.20%	6.48%	9.80%
Cost of capital (k_{WACC})	12%	12%	12%	12%
Invested capital ($t - 1$)	$ 32,500	$ 35,000	$ 38,000	$ 41,600
Economic profit = (ROIC − k_{WACC}) × invested capital ($t - 1$)	$ (3,900)	$ (3,080)	$ (2,096)	$ (915)

Panel (b) Market Value Added (MVA) and Project NPV ($000)	
MVA = present value of economic profits	$ 5,719
Plus: invested capital	32,500
Project value	$38,219
NPV = project value − invested capital	$ 5,719

depreciation expense is calculated so that it follows more closely the actual changes in the value of the property, plant, and equipment over the life of the project rather than following an accounting rule such as straight-line depreciation. The second entails refinements to how managers are compensated. An example of the latter is something called a *bonus bank,* which effectively allows bonuses to reflect performance over longer time periods.

Modifying the Calculation of Economic Profit

When calculating economic profit, we typically use an accounting method for depreciating the cost of plant and equipment over the life of the investment. For example, using straight-line depreciation and no salvage value, we see that a $100,000 piece of equipment with a five-year depreciable life produces $20,000 per year in depreciation expenses. This means that the invested capital we assign to this equipment in year 0 is $100,000; in year 1, it is $80,000; and so forth. It would be highly unlikely that the actual

Years					
5	6	7	8	9	10
$ 62,208	$ 74,650	$ 89,580	$ 107,495	$ 128,995	$ 154,793
8,589	11,907	15,888	20,665	26,399	33,278
(2,577)	(3,572)	(4,766)	(6,200)	(7,920)	(9,983)
$ 6,012	$ 8,335	$ 11,122	$ 14,466	$ 18,479	$ 23,295
(5,510)	(6,132)	(6,879)	(7,775)	(8,850)	(10,140)
$ 502	$ 2,202	$ 4,243	$ 6,691	$ 9,629	$ 13,155
13.09%	16.31%	19.40%	22.33%	25.06%	27.57%
12%	12%	12%	12%	12%	12%
$ 45,920	$ 51,104	$ 57,325	$ 64,790	$ 73,748	$ 84,497
$ 502	$ 2,202	$ 4,243	$ 6,691	$ 9,629	$ 13,155

value of the equipment would decline in exactly this manner over time. In fact, for projects that have back-loaded earnings and cash flows, the value of the invested capital may actually increase during the early years of the project's life when the investment is being put in place. Similarly, for front-loaded projects, the value of the invested capital may decline very rapidly in the early years when the earnings are the greatest. This mismatch between standard methods of accounting for invested capital in depreciable assets and the actual pattern of change in value of those assets leads to the problems we noted in the previous section with regard to both earnings and economic profit.

Harold Bierman suggests a technical fix to this problem that utilizes what he refers to as either present value or economic depreciation to determine invested capital.[8] The key to Bierman's adjustment to the calculation of economic profit lies in the estimation

[8] Harold Bierman, "Beyond Cash Flow ROI," *Midland Corporate Finance Journal* 5, no. 4 (Winter 1988): 36–39.

Table 7-8 Using Economic Profit (or EVA®) to Evaluate an Investment with Front-Loaded Earnings

Panel (a) Calculating Economic Profit ($000)				
Method 1	Years			
	1	2	3	4
Sales	$ 80,000	$ 76,000	$ 72,200	$ 68,590
Operating income	12,632	11,600	10,620	9,689
Less: cash tax payments	(3,789)	(3,480)	(3,186)	(2,907)
Net operating profits after taxes (NOPAT)	$ 8,842	$ 8,120	$ 7,434	$ 6,782
Less: capital charge = invested capital × k_{WACC}	(7,453)	(7,200)	(6,960)	(6,732)
Economic profit	$ 1,389	$ 920	$ 474	$ 50
Method 2				
Return on invested capital (ROIC)	14.24%	13.53%	12.82%	12.09%
Cost of capital (k_{WACC})	12%	12%	12%	12%
Invested capital	$ 62,105	$ 60,000	$ 58,000	$ 56,100
Economic profit	$ 1,389	$ 920	$ 474	$ 50

Panel (b) Market Value Added (MVA) and Project NPV ($000)	
MVA = present value of economic profits	$ (617)
Plus: invested capital	62,105
Project value	$ 61,488
NPV = project value − invested capital	$ (617)

of economic depreciation. Economic depreciation is simply the change in the present value of a project's expected future cash flows from year to year. To illustrate how this is done, panel (a) of Table 7-9 presents an analysis of the back-loaded earnings investment faced by Dowser Chemical (this was introduced in Table 7-3 and its economic profits were analyzed in Table 7-7). The first step in the analysis involves estimating the IRR for the investment project, which is 13.73%. Next, we estimate the value of the project at the beginning of each year based on the present value of the project's future cash flows from that year forward, using the IRR as the discount rate. Thus, the value of the project's future cash flows in year 0 equals the $32,500,000 invested in the project. In year 1, the value of the invested capital equals the present value of the expected cash flows for years 2 through 10, or $39,462,080, and so forth. The economic depreciation, then, is simply the change in value of the project from year to year, so that, for year 1, the project depreciation is actually a positive $6,962,080, reflecting appreciation in the value of the project. This is because the early period cash flows are actually negative, and as we move out further in time, the future cash flows consist of more positive (back-loaded) cash flows.

		Years			
5	6	7	8	9	10
$ 65,161	$ 61,902	$ 58,807	$ 55,867	$ 53,074	$ 50,420
8,805	7,964	7,166	6,408	5,687	5,003
(2,641)	(2,389)	(2,150)	(1,922)	(1,706)	(1,501)
$ 6,163	$ 5,575	$ 5,016	$ 4,485	$ 3,981	$ 3,502
(6,515)	(6,310)	(6,114)	(5,928)	(5,752)	(5,584)
$ (352)	$ (735)	$ (1,098)	$ (1,443)	$ (1,771)	$ (2,082)
11.35%	10.60%	9.85%	9.08%	8.31%	7.53%
12%	12%	12%	12%	12%	12%
$ 54,295	$ 52,580	$ 50,951	$ 49,404	$ 47,933	$ 46,537
$ 352	$ (735)	$ (1,098)	$ (1,443)	$ (1,771)	$ (2,082)

Our revised economic profit measure now reflects a revised NOPAT estimated as the sum of the project's original free cash flow (project FCF) plus the economic depreciation for the year. For year 1, the revised NOPAT is equal to ($2,500,000) + $6,962,080, or $4,462,080. The capital charge for year 1 (and all subsequent years) is also revised to reflect the economic value of the invested capital based on the present value of future cash flows for each year. Thus, for year 1, the capital charge is equal to the invested capital of $32,500,000 × 12%, or $3,900,000. Subtracting the revised estimate of the capital charge from the revised NOPAT produces our revised economic profit for year 1 of $562,080.

Recall that this example has a positive NPV of $5,719,000, but with the back-loaded earnings, it produced negative economic profits in the early years of the project when we calculated economic profits in the conventional way in Table 7-7. Note that the revised economic profit measures are all positive if we use economic depreciation, which implies that this is a value-enhancing project.

Panel (b) of Table 7-9 provides an analysis of the front-loaded earnings project introduced earlier in Table 7-8. Remember that this project had a negative NPV of ($617,100), but with front-loaded earnings, the economic profits for the early years of

Table 7-9 Revising Economic Profit to Reflect Economic Depreciation

Panel (a) Back-Loaded Earnings Example ($ Thousands)

	0	1	2	3	4
Project free cash flows	$ (32,500.00)	$ (2,500.00)	$ (1,880.00)	$ (1,136.00)	$ (243.20)
Internal rate of return on the investment	13.73%				
Present value of future cash flows (estimated invested capital)	$ 32,500.00	$ 39,462.08	$ 46,760.02	$ 54,315.93	$ 62,016.42
Economic depreciation = change in present value of future cash flows		6,962.08	7,297.94	7,555.91	7,700.49
Revised NOPAT = project FCF + economic depreciation		$ 4,462.08	$ 5,417.94	$ 6,419.91	$ 7,457.29
Revised capital charge = revised invested capital $(t-1)\times$ cost of capital		(3,900.00)	(4,735.45)	(5,611.20)	(6,517.91)
Revised estimate of economic profit		$ 562.08	$ 682.49	$ 808.71	$ 939.38
NPV = MVA = present value of all future economic profits (revised)	$ 5,718.85				

Panel (b) Front-Loaded Earnings Example ($000)

	0	1	2	3	4
Project free cash flows	$ (62,105.26)	$ 10,947.37	$ 10,120.00	$ 9,334.00	$ 8,587.30
Internal rate of return on the investment	11.79%				
Present value of future cash flows	$ 62,105.26	$ 58,481.68	$ 55,258.16	$ 52,440.50	$ 50,037.27
Economic depreciation		(3,623.58)	(3,223.52)	(2,817.66)	(2,403.23)
Revised NOPAT = project FCF + economic depreciation		$ 7,323.79	$ 6,896.48	$ 6,516.34	$ 6,184.07
Less: revised capital charge		$ (7,452.63)	$ (7,017.80)	$ (6,630.98)	$ (6,292.86)
Revised estimate of economic profit		$ (128.84)	$ (121.33)	$ (114.64)	$ (108.79)
MVA = present value of all future economic profits (revised)	$ (617.10)				

the project were positive. However, applying economic depreciation to the problem revises the economic profit measures, making them all negative for years 1 through 10, which is consistent with the notion that the project destroys rather than creates wealth.

Stern Stewart offers additional recommendations that may mitigate the horizon problem. For example, it suggests that firms capitalize their R&D and advertising expenditures rather than expense them in the period in which the funds are spent. In addition, it recommends that firms account for investment expenditures more slowly

5	6	7	8	9	10
$ 828.16	$ 2,113.79	$ 3,656.55	$ 5,507.86	$ 7,729.43	$107,792.02
$ 69,702.79	$ 77,158.83	$ 84,095.79	$ 90,133.84	$ 94,779.32	$ 0.00
7,686.37	7,456.04	6,936.96	6,038.05	4,645.48	(94,779.32)
$ 8,514.53	$ 9,569.83	$ 10,593.51	$ 11,545.91	$ 12,374.91	$ 13,012.71
(7,441.97)	(8,364.34)	(9,259.06)	(10,091.49)	(10,816.06)	(11,373.52)
$ 1,072.56	$ 1,205.50	$ 1,334.45	$ 1,454.42	$ 1,558.85	$ 1,639.19

5	6	7	8	9	10
$ 7,877.94	$ 7,204.04	$ 6,563.84	$ 5,955.64	$ 5,377.86	$ 50,038.95
$ 48,060.00	$ 46,523.46	$ 45,445.92	$ 44,849.51	$ 44,760.54	$ 0.00
(1,977.27)	(1,536.54)	(1,077.54)	(596.42)	(88.97)	(44,760.54)
$ 5,900.67	$ 5,667.50	$ 5,486.30	$ 5,359.23	$ 5,288.90	$ 5,278.41
(6,004.47)	(5,767.20)	(5,582.82)	(5,453.51)	(5,381.94)	(5,371.26)
$ (103.81)	$ (99.70)	$ (96.52)	$ (94.28)	$ (93.04)	$ (92.86)

over time as the project comes on line and becomes productive (i.e., expensing the cost of capital equipment over time as the project starts to produce revenues). In this way, firms reduce the size of the capital charge in the early years of the project's life. These changes have the effect of making measured economic profits flow more evenly over time in the same way that switching to economic depreciation does.

Although these changes make sense, there is a real challenge in communicating any economic profit measure to the financial markets. Any profit measure that deviates from

INDUSTRY INSIGHT

An Interview with Bennett Stewart, Jr.*

Question:
What should managers do when the NPV and earnings criteria come into conflict? Are managers sufficiently credible that investors will believe them when they say that earnings are temporarily lower because the firm has taken on investments that have positive NPVs but are temporarily dilutive?

Bennett:
Management can always communicate more information, such as the fact that a project has a ramp-up phase, or that an increase in research or marketing expense will temporarily depress earnings. When this occurs, EVA® is a good framework for making such disclosures. However, I think that, although all this is necessary, it is not a sufficient solution. The question for investors is: Why should we believe management? How do we know they are not manipulators just like Enron?

The best communication mechanism for a firm's management is this: They put their money where their mouth is. This can be accomplished using a combination of the following company policies: a bonus plan that is based on sharing the EVA® improvement over time, bonuses paid through the use of an *at risk* bonus bank, a requirement that managers hold significant illiquid equity in the company, a company share repurchase plan that times share repurchases to coincide with management's view of the market valuation of company stock, and restricting manager stock sales to programmatic sales (i.e., planned sales following a stated program).

*Founding partner of Stern Stewart and Company, in New York City. CEO of EVA Dimensions LLC, Locust Valley, New York.

generally accepted accounting principles (GAAP) calculations is likely to be viewed as less credible because management has the discretion to make those choices that describe the firm's performance in the best possible light. What this means is that the firm will need a compelling argument, as well as credibility with the markets, to justify its economic profit calculations. Bennett Stewart, who is interviewed in the Industry Insight box, indicates that managers in these situations are most likely to be credible in the financial markets if they can show that they are personally invested in their firms' long-term outcomes.

Modifying the Method Used to Pay Bonuses Based on Economic Profit

Stern Stewart recommends a number of practices that should lengthen the investment horizon of managers.[9] In particular, they recommend that, performance bonuses be banked and paid out over time. The "bonus bank" extends a manager's decision horizon

[9] The discussion in this section is based on J. Stern, B. Stewart III, and D. Chew, "The EVA® Financial Management System," *Journal of Applied Corporate Finance* 8, no. 2 (Summer 1995): 32–46.

because money placed in the bonus bank is considered "at risk." The firm's performance over the term of the bonus bank influences the payout from the bank.

The typical bonus bank plan works as follows: Bonuses for the current year are determined based on firm performance (e.g., Stern Stewart recommends that bonuses be based on improvements in the firm's EVA®). One-third of the earned bonus is paid to the employees, while two-thirds is *banked* for later distribution. In the second year of the plan, the firm's performance is used to determine employee bonuses again. If the firm's performance deteriorates, however, the bonus is actually negative and is deducted from the employees' bonus bank account. If firm performance warrants the payment of a bonus in the second year, then the total bonus is equal to one-third of year 1's bonus (from the bonus bank) plus one-third of the bonus earned in year 2. The key factor here is that, because the bonus bank is at risk, employees are discouraged from taking a very short-term view in their decisions. Taking actions in the current year to boost current-period performance at the expense of performance in the next two years (in a three-year plan) will come back to haunt the employee.

7.6 Summary

In the classroom, financial economists drive home the notion that cash flows determine value and that reported earnings should not be a matter of concern to investors. In reality, though, managers *do* care about the earnings their firms report each quarter, and this concern has an effect on the investment projects that are chosen.

Are students being misinformed in the classroom when they are taught to focus on cash flow and disregard earnings? The answer is a qualified no. Value is a function of cash flows received by investors. If they ignore reported earnings, however, the firm's management team subjects itself to the perils of misinterpretation by investors in the capital market. For this reason, corporate executives look not only at wealth-creation estimates for new projects based on net present value but also at whether the project is accretive to earnings. Unfortunately, these competing investment criteria are not always consistent. As this chapter has demonstrated, projects that are accretive in their early years can produce negative NPVs, and projects that are initially dilutive can have positive NPVs.

Table 7-10 summarizes the performance measurement problems that arise when managerial performance is assessed periodically using earnings and when new projects are evaluated based on whether they are accretive or dilutive to firm earnings. The first is the *equity-cost problem,* which reflects the fact that EPS does not consider the appropriate opportunity cost of equity capital. Switching from earnings to economic profit resolves this problem by accounting for the opportunity cost of invested equity capital. The second problem relates to the timing of project earnings and cash flow. Specifically, projects that have *back-loaded earnings* can often be dilutive in their early years and still have positive NPVs. Similarly, bad projects that have *front-loaded earnings* can be accretive to earnings in the early years of project life and have negative NPVs. In both these cases, the simplistic application of economic profit can lead to what we refer to as a "horizon problem." That is, managers who are paid bonuses based on annual earnings or economic profits have incentives to avoid back-loaded earnings projects and to undertake front-loaded earnings projects.

Table 7-10 Summary of the Managerial Horizon Problem: Solving the Measurement Problem

Distribution of Project Earnings/Cash Flows over Time	Source of Financing	Problem	Solution
I. Stable (i.e., neither front- nor back-loaded)	Internal equity	Economic profit assigns the proper equity cost to the project, whereas EPS assigns a cost for equity capital equal to the forgone interest income earned by the firm on excess cash.	Evaluate periodic performance using economic profit.
	External equity (sale of common stock)	If the cost of equity is not equal to the E/P ratio, then the EPS dilution (accretion) criterion is not consistent with NPV $< 0 (>0)$.	Evaluate periodic performance using economic profit.
	Debt financing	Economic profit assigns the proper cost of equity. However, projects financed with debt will be accretive as long as they earn more than the after-tax cost of debt.	Evaluate periodic performance using economic profit.
II. Back-loaded	Any	The annual economic profit in the early years of the project's life will be negative, even for positive NPV projects.	Revise economic profit metric to reflect economic depreciation. Capitalize R&D and advertising expenses and amortize over the project's life. Use a bonus bank compensation plan to extend management's horizon.
III. Front-loaded	Any	The annual economic profit in the early years of the project's life can be positive, even for negative NPV projects.	Revise economic profit metric to reflect economic depreciation. Capitalize R&D and advertising expenses and amortize over the project's life. Use a bonus bank compensation plan to extend management's horizon.

To address this horizon problem, firms need to compensate managers appropriately and communicate the long-term value of their investments to the capital markets. In other words, firms should compensate managers in a way that provides incentives to take long-horizon projects with positive NPVs and design economic profit measures that increase when firms undertake positive NPV investments that have long horizons. While the solutions to the managerial horizon problem summarized in Table 7-10 make sense if the economic profit measures are used internally for compensation purposes, the real challenge lies in convincing the capital markets to believe that the numbers really capture the firm's true performance. This is because capital markets realize that managers always have an incentive to claim that their current earnings are low because they are making great investments that will pay off in the future. Essentially, the problem that a firm's management faces in this situation is one of trust and credibility with the outside investor community. There are no magic or ready-made formulas that are available to create credibility. The real key involves taking the long view, where value-enhancing choices trump short-term earnings consequences.

Exercises

7-1 EPS ACCRETION AND NPV This chapter demonstrated that the requirement that new projects be accretive to firm EPS sometimes results in accepting negative NPV projects and rejecting positive NPV projects. Under more restrictive circumstances, however, requiring that new investments be accretive to earnings may be consistent with the NPV criteria. Are the following statements true or false? Defend your answers.

a. If project earnings are expected to grow at the same rate as the firm's earnings, an EPS-accretive project is a positive NPV project.

b. The earnings-accretive criterion worked for conglomerates in the 1960s because they were able to take over low-P/E stocks that were earnings-accretive.

7-2 ANALYZING A PROJECT WITH BACK-LOADED EARNINGS Hospital Services Inc. provides health care services primarily in the western part of the United States. The firm operates psychiatric hospitals that provide mental health care services using inpatient, partial hospitalization, and outpatient settings. In spring 2015, the firm is considering an investment in a new patient-monitoring system that costs \$6 million per hospital to install. The new system is expected to contribute to the firm's earnings before interest, taxes, depreciation, and amortization (EBITDA) via annual savings of \$2.4 million in years 1 and 2, plus \$4.25 million in year 3.

The firm's CFO is interested in investing in the new system but is concerned that the savings from the system are such that the immediate impact of the project may be to dilute the firm's earnings. The firm has just moved to an economic profit–based bonus system, and the CFO fears that the project may also make the individual economic profits of the hospitals look bad—a development that would generate resistance from the various hospital managers if they saw their bonuses being decreased.

a. Assume that the cost of capital for the project is 15%, the firm faces a 30% marginal tax rate, it uses straight-line depreciation over a three-year life for the new investment, and it has a zero salvage value. Calculate the project's expected NPV and IRR.

b. Calculate the annual economic profits for the investment for years 1 through 3. What is the present value of the annual economic profit measures discounted using the project's cost of capital? What potential problems do you see for the project?

c. Calculate the economic depreciation for the project, and use it to calculate a revised economic profit measure following the procedure laid out in Table 7-8. What is the present value of all the revised economic profit measures when discounted using the project's cost of capital? (*Hint:* First, revise the initial NOPAT estimate from your answer to Exercise 7-2a by subtracting the economic depreciation estimate from project free cash flow calculated in Exercise 7-2a. Next, calculate the capital charge for each year based on invested capital less economic depreciation.)

d. Using your analysis from Exercise 7-2b and c, calculate the return on invested capital (ROIC) for years 1 through 3 as the ratio of NOPAT for year t to invested capital for year $t - 1$. Compare the two sets of calculations and discuss how the use of economic depreciation affects the ROIC estimate for the project.

7-3 ANALYZING A PROJECT WITH FRONT-LOADED EARNINGS Wind Power Inc. builds and operates wind farms that generate electrical power using wind turbines. The firm has wind farms throughout the Southwest, including Texas, New Mexico, and Oklahoma. In spring 2015, the firm was considering an investment in a new monitoring system that costs $6 million per wind farm to install. The new system is expected to contribute to firm EBITDA via annual savings of $4.25 million in year 1, $2.9 million in year 2, and $1 million in year 3.

Wind Power's CFO is interested in investing in the new system but is concerned that the savings from the system are such that the immediate impact of the project is so accretive to the firm's earnings that the individual unit managers will adopt the investment even though it may not be expected to earn a positive NPV. The firm has just moved to an economic profit–based bonus system, and the CFO fears that the project may also make the individual economic profits improve dramatically in the short term—a development that would provide an added incentive for the wind-farm managers to take on the project.

a. Calculate the project's expected NPV and IRR, assuming that the cost of capital for the project is 15%, the firm faces a 30% marginal tax rate, it uses straight-line depreciation for the new investment over a three-year project life, and it has a zero salvage value.

b. Calculate the annual economic profits for the investment for years 1 through 3. What is the present value of the annual economic profit measures discounted using the project's cost of capital? What potential problems do you see for the project?

c. Calculate the economic depreciation for the project and use it to calculate a revised economic profit measure following the procedure laid out in Table 7-8. What is the present value of all the revised economic profit measures when discounted using the project's cost of capital? (*Hint:* First, revise the initial NOPAT estimate from your answer to Exercise 7-3a by subtracting the economic depreciation estimate from project free cash flow calculated in Exercise 7-3a. Next, calculate the capital charge for each year based on invested capital less economic depreciation.)

d. Using your analysis in answering Exercises 7-3b and c, calculate the return on invested capital (ROIC) for years 1 through 3 as the ratio of NOPAT for year t to invested capital for year $t - 1$. Compare the two sets of calculations and discuss how the use of economic depreciation affects the ROIC estimate for the project.

Problems

7-4 EPS VERSUS ECONOMIC PROFIT Let's modify the Beck Electronics example found on page 230 as follows. First, we assume that *all* of the project's $6 million cost is funded through the use of excess cash (i.e., from equity, funded out of retained earnings). We also assume that the market rate of interest earned on the $6 million in cash that will be invested in the project equals 12.5%. Note that the after-tax rate of return (given the 20% tax rate) is 10%, which is the cost of equity capital.

a. Evaluate the investment's impact on Beck's EPS.
b. What is the project's NPV?
c. What is the annual economic profit for the project?
d. What do your calculations tell you about the project? Is it one that Beck should pursue? Explain your answer.

7-5 ECONOMIC PROFIT AND NPV Steele Electronics is considering investing in a new component that requires a $100,000 investment in new capital equipment, as well as additional net working capital. The investment is expected to provide cash flows over the next five years. The anticipated earnings and project free cash flows for the investment are found in the table below.

a. Assuming a project cost of capital of 11.24%, calculate the project's NPV and IRR.
b. Steele is considering the adoption of economic profit as a performance evaluation tool. Calculate the project's annual economic profit using the invested capital figures found in the table. How are your economic profit estimates related to the project's NPV?
c. How would your assessment of the project's worth be affected if the economic profits in 2016 and 2017 were both negative? (No calculations required.)

Project Pro Forma Income Statements

	2016	2017	2018	2019	2020
Revenues	$100,000	$105,000	$110,250	$115,763	$121,551
Less: cost of goods sold	(40,000)	(42,000)	(44,100)	(46,305)	(48,620)
Gross profit	$ 60,000	$ 63,000	$ 66,150	$ 69,458	$ 72,930
Less: operating expenses	(20,000)	(21,000)	(22,050)	(23,153)	(24,310)
Less: depreciation expense	(20,000)	(20,000)	(20,000)	(20,000)	(20,000)
Net operating income	$ 20,000	$ 22,000	$ 24,100	$ 26,305	$ 28,620
Less: interest expense	(3,200)	(3,200)	(3,200)	(3,200)	(3,200)
Earnings before taxes	$ 16,800	$ 18,800	$ 20,900	$ 23,105	$ 25,420
Less: taxes	(5,040)	(5,640)	(6,270)	(6,932)	(7,626)
Net income	$ 11,760	$ 13,160	$ 14,630	$ 16,173	$ 17,794

(*Continued*)

Project Free Cash Flows

	2015	2016	2017	2018	2019	2020
Net operating income		$ 20,000	$ 22,000	$ 24,100	$ 26,305	$ 28,620
Less: taxes		(6,000)	(6,600)	(7,230)	(7,892)	(8,586)
NOPAT		$ 14,000	$ 15,400	$ 16,870	$ 18,414	$ 20,034
Plus: depreciation		20,000	20,000	20,000	20,000	20,000
Less: CAPEX	$ (100,000)	—	—	—	—	—
Less: change in net working capital (NWC)	(5,000)	(250)	(263)	(276)	(289)	6,078
Project free cash flow	$ (105,000)	$ 33,750	$ 35,138	$ 36,594	$ 38,124	$ 46,112
Invested capital		$ 105,000	$ 85,250	$ 65,513	$ 45,788	$ 26,078

PART IV

Enterprise Valuation

Estimation of the value of an ongoing business enterprise can be more challenging than the valuation of a single project for at least two reasons: First, businesses do not do just one thing. They might start out with a single product or service, but invariably their business strategy becomes more complex. This means that, when valuing a business, we have to be particularly attentive to strategic considerations because multiple product lines and service offerings create a portfolio effect that provides both opportunities and challenges. Second, businesses have histories that can provide valuable information about the firm's ability to generate future cash flows. These histories are recorded in the firms' financial statements, which are prepared using accrual rather than cash accounting. As we learned earlier in Chapter 6, the analyst needs to be equipped with an understanding of the differences between cash and accrual accounting to understand fully the firm's past performance and what it implies about its future potential.

In Part IV of this book, we apply a combination of market-based multiples (Chapter 8) and the discounted cash flow (DCF) methodology (Chapter 9), developed in earlier chapters, to estimate enterprise value. In Chapter 10, we look at business valuation through the eyes of the private equity investor. This includes venture capitalists who are trying to structure a deal with an entrepreneur for capital in exchange for a share of the business, as well as leveraged buyout firms who use substantial amounts of borrowed money in combination with relatively little equity to acquire entire business units. Although there are important differences among all these approaches, the rationale for each is based on the traditional DCF methodology.

CHAPTER 8

Relative Valuation Using Market Comparables

Chapter Overview

In this chapter, we discuss *relative valuation,* or valuation using *market comparables*—a technique that is often used to value businesses, business units, and other major investments. We introduce the use of relative valuation in the context of a valuation problem faced by almost everyone—the valuation of residential real estate. Although this illustration is quite simple, it illustrates the basic tenets of the use of relative valuation. Relative valuation criteria are often viewed as substitutes for the discounted cash flow (DCF) analysis we described in earlier chapters. As the discussion in this chapter illustrates, the DCF approach can be viewed as the conceptual basis for most relative valuation criteria, and the two approaches should be seen as complements.

8.1 Introduction

Relative valuation uses market prices from observed transactions to impute the value of a firm or investment opportunity. If you are considering the sale of your home, you might estimate the appropriate asking price by looking at **market comparables.** For example, you might calculate the ratio of prices from recent sales in the neighborhood to the square footage of the homes to calculate a price per square foot and then multiply this number by the number of square feet in your house to get an estimate of what the home should sell for. For income-producing investments, analysts consider additional ratios, which include market values relative to earnings, cash flow, sales, or the book value of recent transactions.

Up to this point, we have estimated the value of an investment by discounting cash flows, which requires that the analyst develop a forecast of expected future cash flows as well as an appropriate discount rate. As we will illustrate in this chapter, valuing investments using *market comparables* (or *comps*) essentially solves the same problem using different information. Specifically, instead of trying to estimate future cash flows, this approach uses information from the market prices of comparable transactions. The critical assumption that underlies this approach to valuation is that the "comparable" transactions are truly comparable to the investment being evaluated.

Even though the science behind relative valuation is relatively easy to grasp, the successful application of this valuation methodology requires considerable skill. To help you develop that skill, we have organized the chapter as follows: In Section 8.2, we introduce relative valuation using examples from both residential and commercial real estate. Here we present the essential elements of the comparables valuation process, and we demonstrate the link between relative valuation multiples and DCF valuation. In Section 8.3, we discuss the use of comparables to value an entire business or enterprise. We learn that one of the most popular valuation ratios is the ratio of enterprise value to earnings before interest, taxes, depreciation, and amortization (EBITDA). In Section 8.4, we illustrate the use of the price–earnings multiple to value a firm's common equity, which is arguably the most common use of relative valuation. Section 8.5 discusses the valuation of a firm's equity when company shares are sold to the public for the first time (i.e., an initial public offering [IPO]). In Section 8.6, we discuss a number of critical issues that arise in the use of relative valuation using market-based comparables. Section 8.7 contains summary comments.

8.2 Valuation Using Comparables

Relative valuation using market comparables involves a four-step process. To illustrate the steps, consider the valuation of a service station in Tulsa, Oklahoma.

Step 1: Identify similar or comparable investments and recent market prices for each. This is the most critical step in the process; the quality of the resulting estimate of value depends on how carefully matched the comparables are to the investment being valued.

Example: Within the last six months, two other service stations in Tulsa have sold. Sales prices and other pertinent information for the sales are available for analysis.

Step 2: Calculate a valuation metric for use in valuing the asset. This involves identifying a key attribute of the investment being valued and dividing it into the market prices of the comparables to compute a valuation ratio. Examples of commonly used attributes include earnings per share (when valuing common stock); the number of square feet (when valuing a home or building); and earnings before interest, taxes, depreciation, and amortization (when valuing a business enterprise). Once we have calculated the valuation ratios for the market comps, we typically average them to calculate the *valuation ratio* used in valuing the asset.

Example: The valuation of businesses like a Tulsa service station typically uses a valuation ratio based on some definition of earnings. For illustration purposes, we will use the operating earnings and define the valuation ratio as the sale or transaction price divided by the station's net operating earnings. For the two service stations that we have identified as market comps, we have the following information:

Station	Sale Price	Net Operating Earnings	Valuation Ratio
A	$ 900,000	$450,000	2
B	$1,200,000	$100,000	12
		Average valuation ratio	7

Step 3: Calculate an initial estimate of value. Multiply the valuation ratio (typically the average of a set of market comps) by the key attribute of the investment whose value is being estimated.

Example: The operating earnings of the Tulsa service station were $150,000 for the most recent year. Applying the average valuation ratio of 7 to these earnings produces an initial value estimate of $1,050,000.

Step 4: Refine or tailor your initial valuation estimate to the specific characteristics of the investment. In refining the estimate, we analyze and, if need be, adjust the valuation ratio to reflect the peculiarities of the investment being valued.

Example: The immediate concern we have about the initial estimate for the Tulsa service station relates to the dramatic disparity in valuation ratios for the two comparable sales. Why did station B sell for a multiple of 12 times operating earnings, while station A commanded a multiple of only 2? In cases where there are large disparities in the valuation ratios, we want to ensure that the numbers used in arriving at the comparable valuation ratios are reasonable. For example, maybe station B actually generated operating earnings of only $100,000 in the year of the analysis; however, in the year of the sale, the station's earnings were depressed by the partial closure of its main entrance for six months due to road improvements. If we normalized the firm's operating earnings to reflect our estimate of what operating earnings would have been without the construction, station B would have had operating earnings of $200,000. With the normalized earnings figure, the valuation ratio for station B would have been only 6 (not 12). Using the revised valuation ratio for station B and assuming that station A was not similarly affected, we get an average valuation ratio of 4.0 and a value estimate for the station being analyzed of only $600,000 $(4.0 \times \$150,000)$, which is dramatically lower than the initial estimate.

To gain additional perspective on the issues raised in the service station valuation example, we include two real estate valuation examples. The first entails an analysis of a residence, and the second is a more complicated commercial real estate example.

Valuing Residential Real Estate Using Comparables

Anyone who has ever sold or bought a house through a real estate agent has experienced the use of relative valuation based on the method of comparables. The standard valuation approach for residential housing is to look for the price per square foot at which similar properties have recently sold. Just like our service station example, the valuation of a house begins by looking for comparable sale transactions. Perhaps the best way to gain an appreciation for the nuances of this methodology is by the use of a simple example.

Consider the valuation of a home with 3,581 square feet of floor space, located in McGregor, Texas (five miles east of former president George W. Bush's ranch in Crawford, Texas). The house is only one year old, is situated on an oversized lot, and has a swimming pool. The owner has set an asking price of $385,000 but has indicated a willingness to be flexible. Our problem is to estimate what the house should sell for, given the information on two recent market transactions in the same neighborhood.

The home is located in a popular area where recent sales have been recorded. The subdivision in which the home sits is less than five years old, so all the homes are of approximately the same age and condition. Two sales have occurred in the immediate neighborhood over the previous six months. Details on these sales are found below:

	Comp 1	Comp 2
Sale price	$330,000	$323,000
Square footage	3,556	4,143
Selling price/sq. ft.	$ 92.80	$ 77.96
Time on the market	97 days	32 days

We can use the selling price per square foot for the two comps to estimate the value of the home by multiplying the home's square footage of 3,581 by the corresponding selling prices per square foot for the comps.

Valuation Using Comps	Comp 1	Comp 2	Average
Comparable sq. ft. selling price	$ 92.80	$ 77.96	$ 85.38
Square footage of house being valued	3,581	3,581	3,581
Estimated value	$332,317	$279,175	$305,746

The estimates of the value of the home range from $279,175, based on the sale price of comp 2, to $332,317, based on the sale price of Comp 1. The average of the two price estimates is $305,746.

Up to now, we have not taken into account two distinctive features of the house we are valuing. Specifically, it is located on a lot that is somewhat larger than the average lot in the subdivision, which may be worth $15,000 to $20,000 more than the average lot. In addition, the home has a new swimming pool, which cost about $30,000 to build.

Valuation Using Comps	Comp 1	Comp 2	Average
Estimated value	$332,317	$279,175	$305,746
Adjustments			
Plus lot premium	20,000	20,000	20,000
Plus pool	15,000	15,000	15,000
Estimated market value	$367,317	$314,175	$340,746

To adjust for these two differences, we add a lot-size premium of $20,000 plus half the cost of installing the pool, or $15,000. (Not everyone wants a swimming pool, and typically pools increase the price of the home by about half their cost when the home is sold.) This raises our average estimated value of the house to $340,746.

Is the house worth the estimated $340,746? The answer is an emphatic *maybe.* The reason for hesitating is that there are always intangibles that influence the value of a house (or a company, for that matter) that are not captured in the pricing of similar properties (comps). For example, it is not uncommon for houses that are built on premium lots to have special amenities or premium features. Although we do not know whether this is the case here, it is important that we consider the unique attributes of the house before arriving at our final estimate of its value.

This simple housing valuation example illustrates three key points concerning the use of the method of comparables:

- Point 1: *Identification of appropriate comps is paramount.* The valuation estimate is only as good as the set of comparables selected to determine the valuation multiple. Consequently, a real effort should be made to identify appropriate comparables.
- Point 2: *The initial estimate must be tailored to the investment's specific attributes.* The initial value estimate is only the beginning of the analysis. Even carefully selected comparables are almost always imperfect replicas of the investment being evaluated. As a result, the method of comparables requires that the analyst make a number of adjustments. In this case, we were able to make adjustments for known differences between the house we are valuing and the comparison homes. Even after this process is complete, however, other intangible differences can often lead to differences of opinion about the actual value of the house. When a business or a large investment project is valued, these types of adjustments can be extremely important.
- Point 3: *The specific metric used as the basis for the valuation can vary from one application to another.* In our residential real estate valuation example, we used square footage as the comparable feature, yet we used operating earnings in the service station example. In general, analysts use multiples of cash flows or some measure of earnings when reliable measures are available, but they rely on less direct measures of an investment's earnings potential in other cases. In the case of a residential home, the owner receives housing services, which can be viewed as his or her earnings from the property. When we use square footage (as opposed to cash flows) as the basis for comparing houses, we are assuming that the flow of housing services is directly related to the size of the house. Similarly, when valuing cable companies, analysts often use the number of cable subscribers as the key valuation metric. The important thing is that we select a valuation metric that is closely related to the investment's ability to generate cash flows or other benefits.

Valuing Commercial Real Estate

The residential real estate example involving the house in McGregor, Texas, should provide some feel for how to use the market comparables approach. Let's now consider commercial real estate. Although commercial real estate is often valued with the same multiples or comparables as residential real estate, analysts generally value commercial real estate by evaluating cash flow ratios as well as prices per square foot. As we show below, the cash flow valuation multiples that are used in practice have a direct relationship to the DCF approach that we discussed in the earlier chapters.

Valuation Ratios (Multiples) and DCF Valuation

To illustrate the connection between DCF valuation and relative valuation, let's consider the problem of valuing a perpetual cash flow stream of $100 per year, where the rate used to discount the cash flows is 20%. In Chapter 2, we noted that the present value of this cash flow stream is calculated as follows:[1]

$$\text{Value} = \frac{\text{Cash Flows}}{\text{Discount Rate}\,(k)} \tag{8.1}$$

Substituting into Equation (8.1), we estimate a value of \$500, that is:

$$\text{Value} = \frac{\$100}{.20} = \$500$$

With a slight rearrangement of terms, we can express the DCF valuation as the product of the annual cash flow of \$100 and a multiple, that is:

$$\text{Value} = \$100 \times \left(\frac{1}{.20}\right) = \$100 \times 5 = \$500$$

In this form, we recognize that the multiplier used to value the stream of \$100 cash flows is $(1/.20) = 5$. It is customary when valuing commercial real estate to define what is known as a capitalization or "cap" rate. The **capitalization rate** is the reciprocal of the multiple used to value the property. In this instance, the cap rate is $1/5 = .20$, which in this example (a level perpetuity cash flow stream) is simply the discount rate. However, the cap rate is not always the discount rate; indeed, it is somewhat less than the discount rate when cash flows are expected to grow, and it exceeds the discount rate when cash flows are expected to shrink or decline over time.

To illustrate how the cap rate can differ from the discount rate, let's consider the case where the \$100 cash flow grows at a rate of 5% per year forever and the discount rate is 20%. Recall from our earlier discussions in Chapters 2 and 4 that the DCF valuation equation (Equation [8.2]) used in this situation is known as the **Gordon growth model,** that is:[2]

$$\text{Value} = \frac{\text{Cash Flow}_0[1 + \text{Growth Rate}\,(g)]}{\text{Discount Rate}\,(k) - \text{Growth Rate}\,(g)} \tag{8.2}$$

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[1] The present value of a level perpetuity with periodic cash flow X and discount rate k can be shown to be equal to X/k. This result is well known in finance and constitutes the sum of the following geometric progression:

$$\sum_{t=1}^{\infty} \frac{X}{(1+k)^t} = X \sum_{t=1}^{\infty} \frac{1}{(1+k)^t} = X\left(\frac{1}{k}\right)$$

This analytical expression has a very intuitive basis. Think of the following situation: You want to generate a cash flow of X each year forever. How much would you have to put in a bank if the interest rate paid is k? The answer is X/k because the interest you earn each year is $k(X/k)$—exactly X. Thus, investing an amount X/k is equivalent to generating a cash flow of X each year forever.

[2] Recall from our discussion in Chapter 2 that the Gordon growth model is simply the sum of the following geometric progression:

$$\sum_{t=1}^{\infty} \frac{X_0(1+g)^t}{(1+k)^t} = X_0 \sum_{t=1}^{\infty} \frac{(1+g)^t}{(1+k)^t},$$

which can be reduced to

$$X_0\left(\frac{1+g}{k-g}\right) \text{ or } X_1\left(\frac{1}{k-g}\right)$$

where $k > g$ and X_1 is equal to $X_0(1 + g)$.

Substituting into Equation (8.2) produces an estimate of value equal to \$700, that is:

$$\text{Value} = \frac{\$100\,(1 + .05)}{.20 - .05} = \$700$$

Once again, we can restate the above DCF formula in terms of a multiple of firm cash flows, that is:

$$\text{Value} = \text{Cash Flow}_0 \times \left(\frac{[1 + \text{Growth Rate}\,(g)]}{\text{Discount Rate}\,(k) - \text{Growth Rate}\,(g)}\right) \tag{8.3}$$

where the term in parentheses is the valuation multiple that reflects a growing stream of cash flows. Again, substituting into Equation (8.3), we get the following:

$$\text{Value} = \$100 \times \left(\frac{1 + .05}{.20 - .05}\right) = \$100 \times 7 = \$700$$

The valuation multiple in this example is equal to the ratio of one plus the growth rate in future cash flows, divided by the difference between the discount rate and the anticipated rate of growth in future cash flows. In the example of the growing perpetuity calculated above, the valuation multiple is 7. Because the multiple is equal to 7, the cap rate is 1/7 or 14.29%, which is less than the 20% discount rate.

Using the cap rate, we value the growing cash flow stream as follows:

$$\begin{aligned}\text{Value} &= \text{Cash Flow}_0 \times \left(\frac{[1 + \text{Growth Rate}\,(g)]}{\text{Discount Rate}\,(k) - \text{Growth Rate}\,(g)}\right)\\ &= \text{Cash Flow}_0\left(\frac{1}{\text{Cap Rate}}\right) = \$100 \times \left(\frac{1}{.1429}\right) = \$700\end{aligned}$$

The difference between the discount rate and the capitalization rate increases with the growth rate anticipated in future cash flows. Table 8-1 illustrates this situation. Panel (a) includes the valuation multiples corresponding to discount rates ranging from 5% to 22.5% and growth rates ranging from 0% to 5%.[3] Note that only when there is zero anticipated growth in future cash flows (as seen in the first column) are the discount rate and the capitalization rate equal to one another. As the rate of growth increases, the divergence between the cap rate and discount rate widens. In fact, the cap rate is approximately equal to the difference between the discount rate (k) and the growth rate (g), but not quite, because the growth rate also appears in the numerator of the valuation multiple, that is, $(1 + g)/(k - g)$.[4]

[3] We include only one case where the discount rate of 5% is equal to the growth rate of 5%. For this case, and whenever the growth rate exceeds the discount rate, the Gordon model "blows up" and indicates an infinite value for the investment opportunity. The Gordon model cannot be applied because the growth rate in cash flows would dominate the effects of discounting. Clearly, this makes little economic sense. In practice, while growth rates may exceed discount rates for temporary periods of very high growth, they will never be greater than the discount rate on a permanent basis because such a growth rate is not sustainable. The investment would attract new capital, and competition among new entrants would drive down profit margins and consequently growth rates in cash flows.

[4] It is also common to define the Gordon growth model using the projected cash flow for the end of the first period [that is, Cash flow$_1$ = cash flow$_0(1 + g)$], in which case the valuation multiple becomes $\left(\frac{1}{k - g}\right)$ and the capitalization, or cap, rate equals $(k - g)$.

Table 8-1 Capitalization Rates, Discount Rates, Growth Rates, and Valuation Multiples

Panel (a) Valuation Multiple $= \left(\frac{1+g}{k-g}\right)$

	Growth Rates (g)					
Discount Rates (k)	**0%**	**1%**	**2%**	**3%**	**4%**	**5%**
5.0%	20.00	25.25	34.00	51.50	104.00	Infinite
7.5%	13.33	15.54	18.55	22.89	29.71	42.00
10.0%	10.00	11.22	12.75	14.71	17.33	21.00
12.5%	8.00	8.78	9.71	10.84	12.24	14.00
15.0%	6.67	7.21	7.85	8.58	9.45	10.50
17.5%	5.71	6.12	6.58	7.10	7.70	8.40
20.0%	5.00	5.32	5.67	6.06	6.50	7.00
22.5%	4.44	4.70	4.98	5.28	5.62	6.00

Panel (b) Implied Capitalization Rate $= 1 \Big/ \left(\frac{1+g}{k-g}\right) = \left(\frac{k-g}{1+g}\right)$

	Growth Rates (g)					
Discount Rates (k)	**0%**	**1%**	**2%**	**3%**	**4%**	**5%**
5.0%	5.00%	3.96%	2.94%	1.94%	0.96%	NM
7.5%	7.50%	6.44%	5.39%	4.37%	3.37%	2.38%
10.0%	10.00%	8.91%	7.84%	6.80%	5.77%	4.76%
12.5%	12.50%	11.39%	10.29%	9.22%	8.17%	7.14%
15.0%	15.00%	13.86%	12.75%	11.65%	10.58%	9.52%
17.5%	17.50%	16.34%	15.20%	14.08%	12.98%	11.90%
20.0%	20.00%	18.81%	17.65%	16.50%	15.38%	14.29%
22.5%	22.50%	21.29%	20.10%	18.93%	17.79%	16.67%

Note: NM = not meaningful

Office-Building Example

To demonstrate the valuation of an investment with market multiples, let's consider an office building that is currently generating cash flows of \$3 million per year. To value the building using the DCF approach, you need estimates of both the expected growth rates of the cash flows (g) as well as the appropriate discount rate (k), neither of which is readily observable. In contrast, the cash flow multiples approach requires only one input, which can be inferred from previous transactions. For example, if a similar office building that generated \$4 million per year recently sold for \$40 million, one could say that the market multiple is 10 and the cap rate is 10%. If the office building in question is truly comparable, you might then say that its value is \$3 million times 10, or \$30 million. This, of course, is a trivial exercise if the buildings really are directly comparable. The challenge lies in determining the extent to which the buildings are really comparable and in then assessing how their differences should influence the appropriate multiples.

Valuation When the Buildings Are Not Identical In practice, no two investments are identical, so you must assess the extent to which the differences are likely to have a material effect on the valuation multiples. To see how small differences between the comps and the investment being valued can be very important, consider the valuation of the two office buildings described below:

Valuation Analysis				
	Per Square Foot		Total Building	
	Building A	Building B	Building A	Building B
Building size	—	—	50,000 sq. ft.	50,000 sq. ft.
Rent	$ 30/sq. ft.	$ 21/sq. ft.	$ 1,500,000	$ 1,050,000
Maintenance	(10.00)/sq. ft.	(10.00)/sq. ft.	(500,000)	(500,000)
Net operating income	$ 20.00/sq. ft.	$ 11.00/sq. ft.	$ 1,000,000	$ 550,000
Selling price information				
Sales multiple for net operating income (NOI)	10/sq. ft.	?/sq. ft.	10	?
Cap rate = 1/sales multiple	10%/sq. ft.	?/sq. ft.	10%	?
Estimated property value	$ 200/sq. ft.	?/sq. ft.	$ 10,000,000	?

Building A sold for $200 per square foot, or $10,000,000, which reflects a sales multiple of 10 times the building's $1,000,000 annual net operating income (NOI) and a capitalization rate of 10%. The two buildings are identical in size (50,000 square feet) and maintenance costs ($10/sq. ft., or $500,000 per year), but there is one very important difference. The rental rates ($30 versus $21 per square foot) are very different, reflecting their different locations. Building A is in the heart of the downtown business district; building B is not. However, the local economic factors that drive rental rates affect the two buildings in a similar fashion. Thus, the rental income of each building is similar with respect to *risk and expected growth rates.* This is an important assumption, which we use later.

The two buildings and their operating costs are nearly identical. Because the tenants pay their own utilities and day-to-day operating expenses, the maintenance costs of each building's owner do not vary over time or with swings in occupancy and rental rates. It is tempting to simply apply building A's NOI multiple (of 10) to building B, which would produce a valuation of $110 per square foot, or $5,500,000 for the building. But is this valuation correct? Should building B sell for the same multiple and consequently have the same cap rate as building A?

At first glance, it does appear that the two buildings are very similar; they are the same size, their rental incomes are determined by the same local economic fluctuations, and both have identical maintenance costs. But, as we now discuss, the different locations of the buildings and the impact of these locations on rental rates have a significant effect on the operating risk characteristics of the two buildings. Specifically, because the rents (revenues) are lower for building B, it has more **operating leverage,** which means that its cash flows are more sensitive to changes in revenue. As a result, the risks and the growth rates of the cash flows of the two buildings are not the same, which in turn implies that the buildings should sell for different multiples of their cash flows.

Operating Leverage and Investment Risk To understand the differences in operating leverage between the two buildings, note that building A rents for \$30 per square foot and has maintenance costs of \$10 per square foot, while building B is much closer to breakeven and rents for only \$21 per square foot and has the same \$10-per-square-foot maintenance costs as building A. What this means is that building B has higher fixed costs relative to revenues, meaning that it has substantially higher operating leverage than building A. To illustrate how operating leverage affects risk, look at what happens to the NOI for building A when its rental revenues increase or decrease by 20%:

Building A			
% change in revenues	−20%	0%	20%
Revenues	\$1,200,000	\$1,500,000	\$1,800,000
Maintenance (fixed cost)	(500,000)	(500,000)	(500,000)
Net operating income	\$ 700,000	\$1,000,000	\$1,300,000
% change in revenues	**−20%**	**0%**	**20%**
% change in NOI	**−30%**	**0%**	**30%**

A decrease in revenues of 20% results in a 30% drop in building A's NOI. Similarly, when revenues rise by 20%, building A's NOI rises by 30%. This dynamic reflects the fact that, for building A, the ratio of the percentage change in NOI divided by the percentage change in revenues is 1.5. Moreover, this particular relationship between the percentage change in operating income and revenues is not constant for a particular investment but varies with the level of firm revenues and NOI. In fact, the closer the revenue level is to breakeven (i.e., NOI equal to zero), the larger is this multiple. The fact that the percentage changes in NOI are greater than the corresponding percentage changes in revenues is due to the fact that building maintenance costs do not rise proportionately with revenues. Indeed, in this particular case, the maintenance costs are constant.

Now let's look at the relationship between revenues and NOI for building B. For building B, a 20% decrease in revenues leads to a 38.18% decrease in its NOI; when revenues rise by 20%, the NOI increases by 38.18%. Hence, building B's operating income is more sensitive to changes in rental revenues than is building A's. In short, building B has higher operating leverage than building A and, as a result, we expect its operating income to be more volatile in response to changes in rental revenues.

Building B			
% change in revenues	−20%	0%	20%
Revenues	\$840,000	\$1,050,000	\$1,260,000
Maintenance (fixed cost)	(500,000)	(500,000)	(500,000)
Net operating income	\$340,000	\$ 550,000	\$ 760,000
% change in revenues	**−20.00%**	**0.00%**	**20.00%**
% change in NOI	**−30.18%**	**0.00%**	**38.18%**

Investigating the Determinants of Cash Flows Even though we have established that the two buildings are *not* perfectly comparable, it is still possible to use an adjusted comparable analysis, based on the sale price of building A, to value building B. To do this, we need to first get a better feel for what determines the values of the two buildings by digging a bit more deeply into the determinants of their cash flows. Specifically, we can decompose each building's NOI into rental revenues and maintenance costs. In addition, we can think of distinct *revenue multipliers* and *maintenance-cost multipliers* instead of a composite NOI multiplier. This decomposition helps us analyze how each component of NOI influences the values of the two buildings. Equation (8.4a) defines building value based on NOI as the difference between the value of the building's rental revenues and the value of its maintenance costs:

$$\begin{aligned}\begin{array}{c}\text{Building}\\ \text{Value}\end{array} &= \left(\text{NOI} \times \begin{array}{c}\text{NOI}\\ \text{Multiple}\end{array}\right) = \left(\begin{array}{c}\text{Rental}\\ \text{Revenues}\end{array} \times \begin{array}{c}\text{Revenue}\\ \text{Multiple}\end{array}\right)\\ &\quad - \left(\begin{array}{c}\text{Maintenance}\\ \text{Costs}\end{array} \times \begin{array}{c}\text{Maintenance}\\ \text{Multiple}\end{array}\right) \qquad (8.4a)\end{aligned}$$

or, using capitalization rates:

$$\begin{aligned}\begin{array}{c}\text{Building}\\ \text{Value}\end{array} &= \left(\frac{\text{NOI}}{\text{NOI Cap Rate}}\right) = \left(\frac{\text{Rental Revenues}}{\text{Revenue Cap Rate}}\right)\\ &\quad - \left(\frac{\text{Maintenance Costs}}{\text{Maintenance Cap Rate}}\right) \qquad (8.4b)\end{aligned}$$

We use the cap-rate formulation in our analysis and assume that the rates applicable to building A's maintenance and revenues are also appropriate for building B. Because both buildings cost the same to maintain, it seems reasonable to use identical cap rates for the maintenance costs. Moreover, because we have assumed that rent revenues for each building are similar in terms of both growth and risk, a single revenue cap rate is reasonable to apply to the rents from both buildings.

If the ratio of rents to expenses were the same for both buildings (resulting in identical operating leverage), then these assumptions would imply that cap rates for each building would also be identical. However, as we will show, when two buildings differ in their operating leverage, they generally differ in their overall cap rates, even when they have the same revenue and maintenance cap rates. The decomposition method we illustrate here allows the analyst to compare buildings that differ only in their operating leverage. If buildings A and B differ on more than this dimension, additional analysis is required.

Because we assume that the maintenance costs are fixed, they are somewhat easier to value and are a logical starting point of our analysis. Recall that the cap rate and the discount rate are the same for the case of a constant perpetuity. We assume that the discount rate (and cap rate) for maintenance, which is assumed to be certain, is the borrowing rate associated with building A, which is 8%. Thus, the present value of building A's maintenance costs using Equation (8.1) is as follows:

$$\begin{array}{c}\text{Value of}\\ \text{Building A's}\\ \text{Maintenance Costs}\end{array} = \frac{\$500{,}000}{.08} = \$6{,}250{,}000$$

Given the $10,000,000 value of building A and the above present value of its maintenance costs, the value of the building's revenues must equal $16,250,000. This amount is the value of the building plus the value of the maintenance costs. This implies a capitalization rate for building A's annual rental revenues of 9.23% after rounding (because $1,500,000/.0923 = $16,250,000).

We now use the capitalization rates from building A to value building B. Specifically, we will use the 9.23% cap rate inferred from the valuation of building A's revenues to value the revenues of building B as follows:

$$\frac{\$1{,}050{,}000}{.0923} = \$11{,}375{,}000$$

We use the 8% cap rate on building A's maintenance costs to value the costs for building B as follows:

$$\frac{\$500{,}000}{.08} = \$6{,}250{,}000$$

The resulting valuation of building B is $5,125,000 (which we calculate as $11,375,000 − $6,250,000). The details of our analysis of building B are summarized in the table below:

	Per Square Foot		**Total**	
	Building A	**Building B**	**Building A**	**Building B**
Borrowing rate	8%	8%	8%	8%
Value of maintenance costs	$ (125.00)	$ (125.00)	$ (6,250,000)	$ (6,250,000)
Implied revenue value	$ 325.00	$ 227.50	$ 16,250,000	$ 11,375,000
Implied revenue multiple	10.833	10.833	10.833	10.833
Implied revenue cap rate	9.23%	9.23%	9.23%	9.23%
Property value	$ 200.00	$ 102.50	$ 10,000,000	$ 5,125,000
Implied multiple of NOI	10.000	9.318	10.000	9.318
Implied cap rate of NOI	10.0%	10.732%	10.0%	10.732%

Based on this analysis, we estimate that building B is actually worth only $5,125,000 rather than the earlier estimate of $5,500,000, which was based on a more naïve application of multiples. The lower value reflects the fact that building B has more operating leverage and is thus riskier, which in turn implies that it must have a higher cap rate.

Key Learning Points We can draw two important learning points from the commercial real estate valuation exercise that generalize to almost any investment. The first point is that investments that look very similar on the surface can generate cash flows with very different risks and growth rates, and should thus sell for different multiples. As this example illustrates, operating leverage is an important determinant of value and must be accounted for in choosing comps, and when operating leverage is different, it is important to adjust comps for these differences. Finally, the example illustrates the importance of exercising great care and using creative ways to apply the method of market comparables properly. It is very tempting to assume that because the use of market comparables as a valuation tool appears very simple, the analysis *is* simple. The fact is that valuation using market comparables requires the same diligence and care as discounted cash flow analysis.

8.3 Enterprise Valuation Using EBITDA Multiples

The most popular approach used by business professionals to estimate a firm's enterprise value involves the use of a multiple of an accounting earnings number commonly called EBITDA, which refers to earnings before interest, taxes, depreciation, and amortization. Analysts generally view EBITDA as a crude measure of a firm's cash flow and thus view EBITDA multiples as roughly analogous to the cash flow multiples used in real estate. As our discussion in this section indicates, sometimes the analogy is good and sometimes it is not.

Enterprise Value Versus Firm Value

You may recall from our discussion of the firm's cost of capital in Chapter 4 that the enterprise value of a firm is defined as the sum of the values of the firm's interest-bearing debt and its equity minus the firm's cash balance on the date of the valuation. For example, on March 18, 2014, Airgas Inc. (ARG)[5] had an enterprise value of $10.454 billion, which can be computed as follows:

Elements of the Firm's Balance Sheet	**Values (000)**
Non-interest-bearing debt	$ 2,335
Interest-bearing debt (short and long term)	2,607.82
Common equity (market value = price per share × shares outstanding)	7,930.00
Firm value	$ 12,873
Less: non-interest-bearing debt	(2,335.14)
Less: cash and equivalents	(83.39)
Equals: enterprise value	$ 10,454

We can calculate the equity value of Airgas Inc. from enterprise value as follows:

$$\begin{aligned}\text{Owner's Equity} &= \text{Enterprise Value} - (\text{Interest-Bearing Debt} - \text{Cash}) \quad (8.5a)\\ &= \text{Enterprise Value} - \text{Net Debt}\\ \$7.930 \text{ billion} &= \$20.454 \text{ billion} - 2.524 \text{ billion} \quad (8.5b)\end{aligned}$$

where the term *net debt* refers to the firm's interest-bearing liabilities less cash.

[5] Airgas Inc. and its subsidiaries distribute industrial, medical, and specialty gases and welding, safety, and related products in the United States.

The Airgas EBITDA Multiple

To calculate the Airgas EBITDA multiple, we solve the following equation:

$$\begin{matrix}\text{Enterprise} \\ \text{Value}_{\text{Airgas 2014}}\end{matrix} = \text{EBITDA}_{\text{Airgas 2014}} \times \begin{matrix}\text{EBITDA} \\ \text{Multiple}\end{matrix} \tag{8.6}$$

For example, on March 18, 2014, Airgas' EBITDA was \$943 million and its enterprise value was \$10,454 billion; this results in an EBITDA multiple for Airgas of 11.09. In the next section, we look at how the Airgas EBITDA multiple, along with multiples of similar firms, can be used to value a privately held company.

Example: Valuing a Privately Held Firm

To explore the use of an EBITDA multiple, we consider the valuation of Helix Corporation, a privately owned company operating out of Phoenix, Arizona, that is a potential acquisition candidate. Because it is privately owned, a potential acquirer cannot observe its market value. However, the acquirer can use similar firms that *are* publicly traded to infer a value for Helix by using the appropriate EBITDA valuation ratio.

EBITDA	\$ 10,000,000
Enterprise value = 11.66 × \$10,000,000	116,600,000
Plus: cash	2,400,000
Less: interest-bearing debt	(21,000,000)
Equity value	\$ 98,000,000

We first identify comparable firms from which to calculate an appropriate EBITDA multiple and then apply this multiple to Helix's EBITDA to arrive at an initial estimate of the enterprise value of the firm.[6] The second step in the process involves refining our estimates of both the EBITDA multiple and the firm's EBITDA. This step constitutes a careful assessment of the basic elements of the valuation (EBITDA and the EBITDA multiple or valuation ratio) to tailor the analysis to the specific firm that is being valued. We consider each step in the analysis over the next few pages.

Helix is a regional supplier of specialty gases including nitrogen, oxygen, argon, helium, acetylene, carbon dioxide, nitrous oxide, hydrogen, welding gases, purity grades, and application blends. We identify four national firms that constitute Helix's primary competitors: Air Products (APD), Airgas (ARG), Praxair (PX), and Applied Industrial Technologies (AIT). Consequently, we begin by identifying the most recent EBITDA multiples for these firms.

Table 8-2, which describes financial information about the four public firms that are engaged in a business similar to Helix, reveals that the average EBITDA multiple for comparable firms is 11.66. If Helix anticipates earning \$10 million in EBITDA this year, then our initial estimate of the firm's enterprise value is \$10 million × 11.66 = \$116.6 million. Helix has a cash balance of \$2.4 million and owes interest-bearing debt totaling \$21 million. Consequently, we estimate the value of Helix's equity to be \$98 million.

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[6] We are assuming that Helix's EBITDA for the year just ended is known. This would be the case if Helix and Airgas had entered into negotiations.

Table 8-2 Comparable-Firm EBITDA Multiples for Helix Corporation ($ Millions)

($ millions)	Air Products (APD)	Praxair, Inc. (PRAX)	Applied Industrial Technologies, Inc (AIT)	AirGas (ARG)	Average
Enterprise Value	31,140	47,400	2,010	10,454	
EBITDA	2,481	3,703	197	943	
Multiples	12.55	12.80	10.20	11.09	11.66

Just as we did earlier with our real estate valuation exercises, we must now engage in the second phase of the valuation process, which involves tailoring the analysis to Helix. In other words, we consider the need to make adjustments to both the EBITDA and the EBITDA multiple used in step 1. To gain some perspective on the issues that arise in the second step of the valuation process, we must first take a detour and review the relationship between EBITDA and free cash flow.

EBITDA and Firm Free Cash Flow

When we opened our discussion of the EBITDA enterprise-valuation approach, we noted that analysts often think of EBITDA as a rough estimate of cash flow. Although the two measures are related, EBITDA is not the same as free cash flow (FCF). Figure 8-1 illustrates the difference between EBITDA and a firm's free cash flow, which can help us understand when the EBITDA valuation approach works well and when it does not. The figure shows that EBITDA falls short of the firm's free cash flow by the sum at the bottom of the rightmost column of Figure 8-1. Specifically, EBITDA is a before-tax measure and does not include expenditures for new capital equipment (CAPEX) and does not account for changes in net working capital (NWC). Summarizing Figure 8-1, we see that all the items listed here make EBITDA overstate Firm FCF.

$$\text{EBITDA} = \text{FCF} + (\text{T} \times \text{EBIT} + \text{CAPEX} + \text{NWC}) \qquad (8.7a)$$

Similarly, solving for FCF:

$$\text{FCF} = \text{EBITDA} - (\text{T} \times \text{EBIT} + \text{CAPEX} + \text{NWC}) \qquad (8.7b)$$

What this last expression illustrates is that FCF is often more volatile than EBITDA. The reason is that FCF accounts for new investments in CAPEX and NWC, which are discretionary to varying degrees[7] and vary over the business cycle, rising in good times and contracting in bad times. Thus, in those years when large capital investments are being made, EBITDA significantly exceeds the firm's free cash flow, and vice versa.

[7] For example, to the extent that capital expenditures can be delayed or sped up and credit terms allow the firm some discretion over when to pay for short-term credit, these expenditures are under the control of management.

Figure 8-1 EBITDA and Cash Flow

Comparing the Calculation of FCF and EBITDA		Difference
Firm free cash flow (FCF)	**EBITDA**	**FCF − EBITDA**
EBIT (earnings before interest and taxes)	EBIT	0
Less: taxes = T × EBIT	NA	−T × EBIT
Plus: depreciation and amortization	Plus: Depreciation and amortization	0
Less: capital expenditures (CAPEX)	NA	−CAPEX
Less: change in net working capital (NWC)	NA	−NWC
Sum: FCF	EBITDA	**−T × EBIT −CAPEX −NWC**

Why Use EBITDA Multiples Rather than Cash Flow Multiples?

Although EBITDA provides a crude estimate of a firm's cash flows, it does provide a relatively good measure of the before-tax cash flows that are generated by the firm's existing assets. To see this, reexamine Equation (8.7) and assume that the firm will not be paying taxes and will not be investing and growing. Because the firm will not be growing, it will not experience any changes in working capital. Under these assumptions, FCF will be equal to EBITDA, as you can see from Equation (8.7b). We can value these cash flows using Gordon's growth model (Equation [8.2]), but we must recognize that without new investment, the cash flows from the firm's existing business are likely to diminish over time, as competitors enter the firm's market and as its plant and equipment become obsolete.

Remember, however, that because EBITDA measures only the earnings of the firm's assets already in place, it ignores the value of the firm's new investments. This is clearly a disadvantage of this valuation tool. One might think that it would be better to value the earnings potential of the entire firm using an FCF multiple than to value just its assets in place using an EBITDA multiple. However, as we noted earlier, FCF for most firms is very volatile because it reflects discretionary expenditures for capital investments and working capital that can change dramatically from year to year. In fact, FCF is frequently negative because capital expenditures often exceed internally generated capital. As a result, FCF multiples are unlikely to be as reliable as multiples based on EBITDA, and for this reason they are not used as often in practice.

One may ask, however, whether it is reasonable to simply ignore the firm's capital expenditures, which is implicitly being done when using EBITDA multiples. The answer is that we can ignore capital expenditures if we believe that the firm's investments have zero net present values on average. While this might be a reasonable assumption for many mature firms, one certainly does not want to ignore growth opportunities that have positive net present values (NPVs). Given this, in any valuation that utilizes EBITDA multiples, it is important to take into account differences between the value of the growth opportunities of the firm being valued (that is, the extent to which the firm has positive NPV investments) and the growth opportunities of the comparison firms.

In summary, EBITDA multiples provide a good valuation tool for businesses in which most of the value comes from a firm's existing assets. For this reason, we see EBITDA multiples being used in practice primarily for the valuation of stable, mature businesses. EBITDA multiples are much less useful for evaluating businesses whose values reflect significant future growth opportunities.

The Effects of Risk and Growth Potential on EBITDA Multiples

As just mentioned, EBITDA reflects the cash flows generated by the assets the firm currently owns and operates and, in general, these cash flows are likely to decline over time. However, the decline is likely to be less for some businesses than others, and in some businesses we expect to see increases rather than decreases in cash flows. Consequently, when using an EBITDA multiple, one must consider the growth potential of the firm being valued and select a set of comparable firms to estimate the EBITDA valuation ratio that share similar prospects. In addition, one must consider the risk differences between the firm being evaluated and the comparison firms, and determine how these risk differences should be reflected in discount rates and hence in multiples.

It is common practice to select firms within the same industry as market comparables because these are likely to be the most similar to the firm being evaluated. However, there can be substantial differences in risk characteristics and growth opportunities among firms within an industry, and EBITDA multiples should be adjusted to reflect these differences. To a large extent, differences in firm risk arise because of variations in operating leverage across firms, and as our commercial real estate example illustrated, differences in operating leverage can arise because of differences in profit margins. In addition, differences can arise because of differences between fixed and variable operating costs. Firms that incur higher levels of fixed operating costs but lower variable costs experience more volatile swings in profits as their sales rise and fall over the business cycle. Differences in expected growth rates tend to be somewhat more subjective; however, analysts can consider past growth rates as indicators of future growth rates.

Although it is generally quite difficult to make objective adjustments to EBITDA multiples to allow for differences in risk and growth opportunities, it is critical that these considerations enter into the selection of comparable firms. Let's return to our earlier analysis of the appropriate EBITDA multiple for the valuation of Helix Corporation to see how we might make such adjustments. We might, for example, want to compare Helix's growth opportunities and risk with each of the firms in Table 8-2. The relatively low EBITDA multiple for Airgas may reflect the fact that its risk (as reflected in the firm's cost of capital) is high and/or its growth opportunities are low when compared to those of the other firms. This begs the question, "Is Helix more like Airgas or the remaining comparison firms?" Although we cannot answer this question without more information about Helix and the comparison firms, this analysis is exactly what is required to get the best possible estimate of the EBITDA valuation multiple for valuing Helix.

Normalizing EBITDA

We argued earlier that the appeal of EBITDA over cash flow relates to its relative stability when compared to FCF. However, EBITDA does vary over time, and any given year's EBITDA may be influenced by idiosyncratic effects that need to be accounted for when using the EBITDA valuation model. In the Helix Corporation example, we used the firm's most recent year's EBITDA of $10 million to value the firm. The presumption we made was that this EBITDA was not influenced by any nonrecurring special event during the past year. If the EBITDA was affected by any such event, it would lead us to place a value on Helix that is not reflective of the firm's future earning power. For example, if the 2005 EBITDA for Helix reflected the results of a one-time transaction with a customer that contributed $500,000 to EBITDA but is not likely to be repeated in future years, we might want to make a downward adjustment to EBITDA to $9,500,000. Similarly, if the 2005 EBITDA reflects extraordinary write-offs of $250,000, then we might want to make an upward adjustment of EBITDA to $10,250,000.

Adjusting the Valuation Ratio for Liquidity Discounts and Control Premiums

It should be noted that the value calculated in the preceding section is not necessarily the price a buyer is willing to pay. The price the buyer will pay can vary depending on the type of buyer. Specifically, financial buyers tend to determine the price they are willing to pay based on an analysis of the acquisition in isolation. That is, they look at the business as a single entity. They then forecast the cash flows they think the business can earn and place a value on them. Strategic buyers, in contrast, tend to think of the value of the business in the context of other businesses they own or are thinking of acquiring. These buyers tend to consider potential synergies as well as the stand-alone value of the business. As a consequence, strategic buyers often pay more for a business than a purely financial buyer does.

The rationale for the possible discount is that Helix is a privately held firm, and the market-based EBITDA multiples we used in our first-pass valuation were based on a sample of publicly held firms. Private companies often sell at a discount to their publicly traded counterparts because they cannot be sold as easily. A discount of 20% to 30% is not unusual in these circumstances, and the discount is typically attributed to the fact that the shares of privately held firms are less liquid (i.e., harder to sell) than those of public firms. Hence, if we apply a 30% discount, our estimate of the enterprise value of Helix is reduced to $\$81{,}620{,}000 = 11.66 \times \$10{,}000{,}000(1 - .3)$. In this case, the estimated value of Helix's equity equals $63,020,000, that is:

Enterprise value (revised)	$81,620,000
Plus: cash	2,400,000
Less: interest-bearing debt	(21,000,000)
Equity value	$63,020,000

If Helix is being acquired by Airgas, which is a publicly traded firm, is the liquidity discount likely to be an issue? Because Airgas is itself a public firm and is unlikely to want to sell Helix, the relevance of a liquidity discount is subject to debate. The actual price that will be paid on this transaction depends on the relative bargaining strengths of the buyer and seller (i.e., how motivated Airgas is to make the acquisition and how motivated Helix's owners are to sell). This in turn depends on the synergies and improvements Airgas expects to achieve when it takes control of Helix.

The Airgas acquisition of Helix might be considered a strategic acquisition, which is a fancy way of saying that there are benefits (or synergies) from control. In contrast to purely financial acquisitions, which often require liquidity discounts, strategic acquisitions often feature control premiums, which can enhance the value of an acquisition target by 30% or more. Once again, when acquiring a private firm such as Helix, the amount of any control premium paid depends on the relative strength of the bargaining positions of the buyer and seller. The point here is that adjustments for liquidity discounts and control premiums vary from one situation to another.

8.4 Equity Valuation Using the Price-to-Earnings Multiple

Up to this point, our focus has been on the valuation of either major investment projects or the enterprise value of an entire firm. For these applications, it is common for financial analysts to use EBITDA multiples along with the DCF approach. In this section, we explore how analysts value a firm's equity.

One approach would be to use EBITDA multiples to estimate enterprise value, as described in the last section, and then subtract the firm's interest-bearing debt to determine the value of its equity. While this approach is used in practice, it is not the main approach used when valuing a firm's equity. Instead, equity analysts tend to focus their attention on estimating the earnings of the firms they evaluate and then use the **price-to-earnings (P/E) ratio** to evaluate the price of the common stock.

The price-to-earnings (P/E) multiple valuation approach is defined in Equation 8.8:

$$\left(\frac{\text{Price per Share for a Comparable Firm}}{\text{Earnings per Share for a Comparable Firm}}\right) \times \begin{matrix}\text{Earnings per Share}\\ \text{for the Firm Being Valued}\end{matrix} = \begin{matrix}\text{Estimated Value}\\ \text{of the Firm's Equity}\end{matrix} \tag{8.8}$$

As we just mentioned, the P/E valuation approach is used to estimate the value of the *firm's equity*. It is not used to find the enterprise value, as we did using the EBITDA valuation method.

Example—Valuing ExxonMobil's Chemical Division Using the P/E Method

To illustrate the use of the P/E ratio valuation approach, let's suppose that ExxonMobil (XOM) is considering the sale of its chemical division. Although this is a hypothetical case, it provides a realistic setting in which the P/E multiple valuation approach might prove useful. If the chemical division is sold as an independent company to the public, ExxonMobil could use an IPO to sell the new company's shares. As an alternative, the

Table 8-3 Chemical Company Price/Earnings Ratios (August 16, 2005)

	Share Price	÷	EPS	=	P/E Ratio
BASF AG (BF)	\$ 70.47		\$ 5.243		13.44
Bayer AG (BAY)	35.64		1.511		23.59
Dow Chemical (DOW)	47.40		4.401		10.77
E I DuPont (DD)	41.00		2.572		15.94
Eastman Chemical (EMN)	51.69		5.75		8.99
FMC (FMC)	59.52		5.729		10.39
Rohm & Hass (ROH)	45.02		2.678		16.81
			Average		14.28

division could be sold to another company. In either instance, ExxonMobil needs to place a value on the division.

The chemical division of ExxonMobil is one of the largest chemical companies in the world.[8] The chemical division earned \$3.428 billion in 2004, compared to \$1.432 billion in 2003 and \$830 million in 2002. If the company were to consider selling the division via an IPO, a key question it would want to answer would be, "How much can we expect to receive for the sale of the equity?" We can get a quick glimpse at the magnitude of this equity value by applying an average P/E ratio of similar firms to the chemical division's earnings. Table 8-3 contains P/E ratios for seven of the largest chemical companies in the world. They have an average P/E multiple of 14.28, which implies that, as a first approximation, ExxonMobil's chemical division is likely to be worth about \$48.94 billion $=$ 14.28 $\times$ \$3.428 billion.

To refine our estimate of the value of ExxonMobil's (XOM's) chemical division, we want to scrutinize more closely the market comparables and evaluate the extent to which they are really similar to ExxonMobil's chemical division. For example, we noted above that the revenues of ExxonMobil's chemical division make it the third largest chemical company in the world. If firm size is an important determinant of P/E ratios, then the appropriate comparison group would consist of the very largest firms from the industry. Based on their market capitalizations, which is equal to price per share multiplied by the number of shares of common stock outstanding (found in Table 8-4), the four largest firms include BASF AG, Bayer AG, Dow Chemical, and E I DuPont. The average P/E multiple for these four firms is 15.935, and if we apply this multiple to the valuation of ExxonMobil's equity in the chemical division, the estimate is \$54.63 billion. This is a number that ExxonMobil's management would find much more to their liking!

[8] Not every firm makes its divisional reporting available in its public filings. When no divisional reporting is available, this type of analysis would be very difficult to carry out by an outside analyst. As we propose here, however, the company could perform the analysis internally as long as it maintains divisional financial reports.

Table 8-4 Market Capitalization and P/E Ratios for the Chemical Industry Comps

	P/E Ratio	Market Capitalization (Billions)
BASF AG (BF)	13.44	$38.25
Bayer AG (BAY)	23.59	25.63
Dow Chemical (DOW)	10.77	45.25
E I DuPont (DD)	15.94	40.61
Eastman Chemical (EMN)	8.99	4.10
FMC (FMC)	10.39	2.20
Rohm & Hass (ROH)	16.81	10.01
Average for the big 4	15.94	$37.44
Average for the smallest 3	12.06	5.44

There is substantial dispersion, however, in the P/E ratios in this industry. Hence, to value the ExxonMobil chemical division, we must ask whether its risk and growth potential are more like those of Bayer AG, which has a P/E ratio of 23.59, or more like Dow, which has a P/E ratio of only 10.77. A complete answer to this question would require more in-depth analysis of differences and similarities between ExxonMobil's chemical division and those of the comparable firms, which would certainly include an analysis of the growth prospects and the operating leverage of the different firms.

The remainder of our P/E discussion delves into the impact of a firm's growth prospects on its P/E ratio, both in the context of a stable firm that grows at a steady rate forever and that of a high-growth-rate firm that enjoys a period of high rates of growth followed by a reduction to a sustainable but lower rate of growth.

P/E Multiples for Stable-Growth Firms

A stable-growth firm is one that is expected to grow indefinitely at a constant rate. The P/E multiple of such a firm is determined by its constant rate of growth and can be calculated by solving the Gordon growth model applied to the valuation of a firm's equity, as in Equation (8.9):[9]

$$P_0 = \frac{\text{Dividend per Share}_0(1+g)}{k-g} = \frac{\text{Earnings per Share}_0(1-b)(1+g)}{k-g} \tag{8.9}$$

where

$b =$ the retention ratio, or the fraction of firm earnings that the firm retains, implying that $(1-b)$ is the fraction of firm earnings paid in dividends

$g =$ the growth rate of these dividends

k is the required rate of return on the firm's equity

[9] Note that this equation is simply Equation (8.2) applied to the firm's equity rather than to its enterprise value.

TECHNICAL INSIGHT

Current Versus Forward Earnings and the P/E Ratio

The price-to-earnings (P/E) ratio is a simple concept: The current market price of a firm's common stock is divided by the firm's annual earnings per share. Although the current market price is an unambiguous variable, earnings are not. For example, the earnings variable sometimes represents earnings per share for the most recent year. In that case, the P/E ratio is referred to as the *current P/E ratio* or *trailing P/E ratio.* There is yet another commonly used definition of the P/E ratio that defines earnings per share by using analysts' forecasts of the next year's earnings. This is the *forward P/E ratio.*

To illustrate, let's consider the sample of chemical companies used in the valuation example of the ExxonMobil chemical division. The current (trailing) and forward P/E ratios for these firms are found below:

	Share Price	Current EPS	Current/ Trailing P/E Ratio	Forecast EPS	Forward P/E Ratio
BASF AG (BF)	$ 70.47	$ 5.243	13.44	$ 7.27	9.69
Bayer AG (BAY)	35.64	1.511	23.59	2.69	13.27
Dow Chemical (DOW)	47.40	4.401	10.77	5.71	8.30
E I DuPont (DD)	41.00	2.572	15.94	3.04	13.48
Eastman Chemical (EMN)	51.69	5.75	8.99	5.93	8.71
FMC (FMC)	59.52	5.729	10.39	5.66	10.51
Rohm & Hass (ROH)	45.02	2.678	16.81	3.12	14.44
		Average	14.28		11.20

Forward P/E ratios are lower than the current (trailing) P/E ratios in the six instances where earnings are expected to grow and are higher in the one instance (FMC) in which earnings per share is expected to decline. Although the differences in P/E are not dramatic for these sample firms, they can be dramatic in turnaround situations or in the case of firms that are facing large changes in their earnings prospects for the future. For these cases, it is important for the analyst to look beyond the current or trailing P/E when trying to compare the market's current valuation of a share of stock to that of comparable firms.

By rearranging the terms in this equation, we can express the P/E ratio as follows:

$$\text{P/E Ratio} = \frac{(1-b)(1+g)}{k-g} \tag{8.10a}$$

To look more deeply into the determination of P/E ratios, we first observe that firms are able to grow their earnings by reinvesting retained earnings in positive NPV projects. We assume that these positive NPV investments earn a rate of return, which we denote as r, that exceeds the firm's required rate of return, k. Well-positioned firms with competitive advantages, intellectual property, patents, and managerial expertise can generate both higher rates of return on new investment as well as opportunities to reinvest more of their earnings. It is the combination of the amount by which r exceeds k and the fraction of firm earnings that can be profitably reinvested each year $(1 - b)$ that determines the firm's P/E ratio.

To illustrate, suppose that a firm with \$100 million of invested capital generates returns on invested capital of 20% per year. If the firm pays out 100% of its earnings each year, then the dividend will be \$20 million each year. In this case, the growth rate of the firm's dividends, g, is zero. Now suppose that the firm pays only 40% of its earnings in dividends and reinvests the remaining 60% in its operations. In this case, the first dividend will be $D_1 = \$100\text{M} \times (.2) \times (.4) = \$8$ million, leaving the firm with a capital base of \$112 million. If the firm continues to generate the same 20% return on the larger capital base, and if it continues to pay out 40% of its earnings and retain 60%, its second-year dividend will be $D_2 = \$112\text{M} \times (.2) \times (.4) = \$8.96$ million. Dividends will continue to grow at $(\$8.96 - \$8.00)/\$8.00 = 12\%$ annually as long as the dividend payout policy continues and the firm's return on capital remains equal to 20%.

Under these assumptions, we can express a firm's dividend growth rate as the product of its retention rate, b, and the rate of return it can provide on newly invested capital, r. We can now restate the P/E multiple from Equation (8.10a) as follows:

$$\text{P/E Multiple} = \frac{(1 - b)(1 + g)}{k - g} = \frac{(1 - b)(1 + br)}{k - br} \tag{8.10b}$$

Using Equation (8.10b), we see that for a stable-growth firm, the P/E multiple is determined by the firm's dividend payout policy (i.e., 1 minus the retention ratio, or $1 - b$); the required rate of return of the stockholders, k; and the rate of return the firm expects to earn on reinvested earnings, r. Thus, we can use Equation (8.10b) to explore the relationship between the P/E multiple and each of these key variables.

To illustrate the effect of differences in anticipated rates of growth and retention ratios on the P/E ratio, let's consider the two firms (A and B) described in Table 8-5. Firm A has the opportunity to create value for shareholders by retaining and reinvesting its earnings. This is reflected in the fact that the firm's return on invested capital, r, is 10%, which is greater than the stockholders' required rate of return, k, of 8%. Firm B, on the other hand, hurts its shareholders if it reinvests because its return on invested capital (10%) is less than the stockholders' required rate of return (12%).

Note that for firm A, the P/E multiple rises as the fraction of its earnings that can be retained and profitably invested rises. This reflects the creation of shareholder wealth that occurs when a firm with an 8% required rate of return earns 10% on its new investment. The P/E multiple found in Equation (8.10b) becomes infinite, however, when the retention ratio hits 80%. At an 80% retention ratio, the firm's growth rate (which equals the product of b and r) equals 8%. A quick glance at Equation (8.10b) tells us why this happens: The growth rate and required rate of return on equity are both 8%; thus, the value of the firm's equity is undefined. The situation with firm B is the inverse of that of firm A: The P/E multiple decreases as the firm retains a larger fraction of its earnings (i.e., as b increases). This, of course, reflects the fact that the firm is able to earn only 10% by reinvesting the earnings when its stockholders demand a 12% return.

Table 8-5 The P/E Multiple and Dividend Policy for a Stable-Growth Firm

Firm A: $r = 10\%, k = 8\%$			Firm B: $r = 10\%, k = 12\%$		
Retention Ratio (b)	**Growth Rate (g)**	**P/E Multiple**	**Retention Ratio (b)**	**Growth Rate (g)**	**P/E Multiple**
0%	0%	12.50	0%	0%	8.33
10%	1%	12.99	10%	1%	8.26
20%	2%	13.60	20%	2%	8.16
30%	3%	14.42	30%	3%	8.01
40%	4%	15.60	40%	4%	7.80
50%	5%	17.50	50%	5%	7.50
60%	6%	21.20	60%	6%	7.07
70%	7%	32.10	70%	7%	6.42
80%	8%	Undefined*	80%	8%	5.40
90%	9%	Undefined*	90%	9%	3.63
100%	10%	Undefined*	100%	10%	0.00

$r =$ return on reinvested earnings

$k =$ stockholders' required rate of return

*These cells have negative P/E multiples. Here the formula for P/E multiple $(1 - b)(1 + g)/(k - g)$ does not apply because, for $k < g$, the series (perpetuity) does not converge. Intuitively, this situation implies that the earnings are growing faster than the cost of capital forever. This situation cannot arise in a competitive economy, where free entry will drive down high growth rates to the feasible range (where $k < g$).

P/E Multiple for a High-Growth Firm

We can relate the P/E multiple for a high-growth firm to company fundamentals in much the same way as we did for a stable-growth firm—with one important difference. Because we do not expect a firm to be able to achieve high growth forever, describing the firm's growth prospects requires two growth periods. We assume that the firm experiences very high growth lasting for a period of n years, followed by a period of much lower but stable growth.[10] Equation (8.11) captures the valuation of the equity of such a firm:

$$P_0 = \frac{\text{EPS}_0(1 + g_1)(1 - b_1)}{k - g_1}\left(1 - \frac{(1 + g_1)^n}{(1 + k)^n}\right) + \frac{\text{EPS}_0(1 + g_1)^n(1 - b_2)(1 + g_2)}{k - g_2}\left(\frac{1}{(1 + k)^n}\right) \tag{8.11}$$

[10] Recall that we are describing a two-stage growth model similar to our discussion in Chapter 4. The difference here is that we define equity value as the present value of expected future dividends (not equity free cash flow).

In this equation we abbreviate earnings per share$_0$ as EPS_0, and both the retention ratio (b) and the growth rate (g) are now subscripted to reflect the fact that the firm's dividend policy and its growth prospects can be different for the two growth periods.[11]

We can interpret Equation (8.11) as follows: The first term on the right-hand side expresses the present value of a stream of dividends received over the next n years. For the high-growth firm, dividends grow at a rapid rate equal to g_1 for n years, after which the dividends grow at a constant (and lower) rate g_2 forever.

We can now solve for the P/E multiple simply by dividing both sides of Equation (8.11) by EPS_0. The result is found below:

$$\frac{P_0}{EPS_0} = \frac{(1-b_1)(1+g_1)}{k-g_1}\left(1-\frac{(1+g_1)^n}{(1+k)^n}\right) + \frac{(1-b_2)(1+g_1)^n(1+g_2)}{k-g_2}\left(\frac{1}{(1+k)^n}\right) \tag{8.12}$$

Let's analyze the determinants of the P/E multiple for the high-growth firm. Recalling that $g_1 = b_1 r_1$ and $g_2 = b_2 r_2$, we see that the firm's P/E multiple is a function of the firm's dividend policy in the two periods (i.e., b_1 and b_2), the return on equity that the firm earns on its invested capital (r_1 and r_2), and the stockholders' required rate of return (k). Again, the relationship between r (both r_1 and r_2) and k—the return on reinvested earnings and the stockholders' required rate of return, respectively—is the key determinant of the P/E multiple. If $r > k$, the firm's P/E multiple increases, and the amount of the increase is determined by its retention ratio, b.

To illustrate the use of the P/E ratio for a high-growth firm, consider Google Inc., which was formed in 1998 and went public in 2004. On July 3, 2014, its share price was \$582.87, giving the firm a P/E multiple of 30.54 based on trailing twelve month (TTM) earnings of \$19.09 per share. To evaluate whether this high P/E ratio can be justified, we will use Equation (8.12), which provides for two growth periods: a finite period of high growth followed by a stable-growth period.

To analyze Google's P/E ratio using Equation (8.12), we use information found in panel (a) of Table 8-6, along with three estimates of the duration of the high-growth period (n in Equation [8.12]), the dividend payout ratio after year n (i.e., $1 - b_2$), and

[11] Earnings would grow at g_1 for n years and at g_2 immediately thereafter. In contrast, dividends would grow at g_1 for n years and at a lower g_2 after $(n + 1)$ years. But in the intervening period, $(n, n + 1)$, there would be a discontinuity in dividend growth, as shown below:

Year	Earnings	Imputed Earnings Growth	Dividends	Imputed Rate of Dividend Growth
$(n-1, n)$	$EPS_0(1+g_1)^n$	g_1	$EPS_0(1+g_1)^n(1-b_1)$	g_1
$(n, n+1)$	$EPS_0(1+g_1)^n(1+g_2)$	g_2	$EPS_0(1+g_1)^n(1+g_2)(1-b_2)$	$[(1+g_2)(1-b_2)]/(1-b_1) - 1$
$(n+1, n+2)$	$EPS_0(1+g_1)^n(1+g_2)^2$	g_2	$EPS_0(1+g_1)^n(1+g_2)^2(1-b_2)$	g_2

Table 8-6 Analyzing the P/E Ratio of a High-Growth Firm: Google Inc.

Panel (a) Current Stock Price and Earnings Information (July 3, 2014)

Stock Price	\$582.87
EPS (TTM)	\$19.09
P-E Ratio	30.54
Earnings Retention Ratio (b_1)	100.0%
Return on Equity (r_1)	14.76%
Earnings Growth Rate ($g_1 = b_1 \times r_1$)	14.76%
Estimate of Google's Cost of Equity	
Beta	1.14
Risk free rate	3.00%
Market Risk Premium	5.00%
Cost of Equity	8.70%

Panel (b) Scenario Analysis

	Current Data (July 3, 2014)		Growth Period				Post Growth Period		
	P-E Ratio	Share Price	Length of Period (n)	Return on Equity (r_1)	Dividend Payout, ($1 - b_1$)	Growth Rate (g_1)	Return on Equity (r_2)	Dividend Payout, ($1 - b_2$)	Growth Rate (g_2)
Scenario #1	**30.54**	**\$582.87**	15	14.76%	0%	14.76%	5.14%	80.00%	1.03%
Scenario #2	**30.54**	**\$582.87**	10	14.76%	0%	14.76%	19.50%	80.00%	3.90%
Scenario #3	**30.54**	**\$582.87**	5	14.76%	0%	14.76%	26.56%	80.00%	5.31%

the anticipated rate of growth in earnings (g_2) after year *n.* Recall that the growth rate in earnings after year *n* can be estimated as the product of the fraction of the firm's earnings that are retained (i.e., that are not paid out in dividends) and the rate of return earned on reinvested earnings, or the return on equity. Thus, the key determinants of Google's P/E are the length of the high-growth period (n), in combination with the dividend payout ratio (1 – b), and the return on equity during the post-high-growth period (r). Table 8-6 contains three scenarios that include sets of these key parameters, each of which produces the observed P/E of 30.54 and a current share price of $582.87 for Google's shares. Of course, these are not the only possible combinations of these parameters that will produce a P/E ratio of 30.54 for Google. However, they do illustrate the feasibility of obtaining a P/E ratio that is consistent with its observed market P/E.

To determine how one might evaluate the plausibility of these scenarios, let's consider scenario 1 in more depth. Scenario 1 assumes that Google will be able to reinvest 100% of its earnings for the next fifteen (15) years at its current return on equity of 14.76%. Because the firm retains all of its earnings, the rate of growth in earnings is also 14.76% (recall that the rate of growth is equal to the product of the return on equity and the retention ratio). Thus, in 15 years, Google's estimated earnings per share will be $\$150.54 = \$19.09(1 + .1476)^{15}$. At this future date, the firm's P/E ratio will be 10.536, which is much lower than its current P/E ratio of 30.54. The reason for the decline in the P/E ratio is that Google's growth rate in this later period drops from 14.76% to only 1.03%.

Is it really likely that Google will be able to maintain a 14.76% return on its reinvested earnings for 15 years? If Google can indeed accomplish this, it will earn more than $100 billion in the fifteenth year. One might decide that this particular set of assumptions is overly optimistic and conclude that Google's stock is overpriced. Alternatively, one might consider whether scenarios 2 and 3 are more plausible. These scenarios make less optimistic assumptions about the duration of the high-growth-rate period but justify Google's current P/E multiple by assuming a higher long-term return on equity (r) and consequently a higher growth rate. Note that we assume a dividend payout of 80% for all three scenarios. For example, in scenario 2 where the high growth period is only 10 years, Google must earn a return on equity of 19.5% per year forever in order to justify a share price of $582.87 (while paying out 80% of its earnings in dividends).[12]

As this Google example illustrates, the use of P/E multiples, like all of the approaches we consider, provides equity valuations that are only as good as the judgment of the equity analyst who performs the analysis. The P/E multiples approach provides a useful tool for taking a set of assumptions and translating them into an estimate of stock price. When carrying out a valuation analysis, one should consider a variety of plausible scenarios and determine how sensitive the valuation model's output is to the duration of the period of high growth as well as to the reinvestment rate and return on equity that will prevail after the period of high growth.

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[12] In scenario 2, Google's EPSs are assumed to grow at 14.76% for only ten years and then at 3.9% thereafter in perpetuity.

8.5 Pricing an Initial Public Offering

When a firm sells its shares in the public market for the first time, the process of offering those shares is commonly referred to as an *initial public offering (IPO).* As we will briefly discuss in this section, the market comparables approach used in this chapter plays an important role in the pricing of IPOs.

As a first step in the IPO process, the lead underwriter (that is, the investment banker who manages the IPO process for the company that is going public) determines an initial estimate of a range of values for the issuer's shares. The estimate is typically the result of a comparables valuation analysis that utilizes several valuation ratios such as the ones discussed in this chapter. For example, the underwriter may estimate enterprise value using an EBITDA multiple and then subtract the firm's net debt (i.e., interest-bearing debt less the firm's cash reserves) to get an estimate of the issuer's equity value. The price per share, then, is simply equity value divided by the number of shares the firm is issuing. Given the variety of comparables and valuation ratios typically used in this analysis, this exercise will result in a range of equity prices (say, $10 to $15 per share) for the new issue, not a single offering price.

After setting the initial price range, the underwriters go through what is known as a book-building process, where they gauge the level of investor interest. Specifically, over the weeks leading up to the offering date, the lead underwriter and company executives travel around the country meeting with potential investors. These visits are known as the road show. During these visits, the underwriter's sales force collects information from potential institutional investors about their interest in purchasing shares at various prices within the initial valuation range. This information forms the basis for the book, which contains nonbinding expressions of interest in buying shares of the IPO at various prices, generally within the initial price range.

During the pricing meeting on the eve of the IPO, the investment banker and company executives meet to decide on the initial offering price. Narrowing the range of prices down to a single price is a result of the judgment of company executives and the following considerations:

- An updated valuation analysis based on that day's pricing information for comparable companies and recent IPO transactions in combination with the most up-to-date measures of company performance (i.e., EBITDA).
- An analysis of the level of interest in the new offering that is determined in the book-building process. Obviously, high expressions of interest encourage the firm to move the offering price toward the upper end of the initial pricing range, and vice versa.
- The underwriters like to price the IPO at a discount, typically 10% to 25%, based on the price at which the shares are likely to trade on the market. Underwriters argue that this helps generate good after-market support for the offering.

8.6 Other Practical Considerations

In this section, we close our discussion of relative valuation by delving into some practical issues that arise when performing a valuation exercise using multiples. Specifically, the first two steps of the four-step procedure are the most critical to the overall success of the effort. These steps involve choices that the analyst must make regarding the set of comparable firms and the particular valuation metric used to determine relative value. In addition, we open a discussion, which will continue into Chapter 9, dealing with the use of multiples valuation and DCF valuation.

Selecting Comparable Firms

We now circle back to step 1—choosing comparable firms—to explore it in more detail. Although it is the first task facing the analyst, it is perhaps the most difficult. Comparable firms share similar operating and financial characteristics. In particular, comparable firms should share similar growth prospects and operating cost structures as well as similar capital structures.

The typical approach taken when selecting comparable firms entails using firms from the same industry group. This makes sense for a number of reasons. First, firms within a given industry tend to utilize similar accounting conventions, which allows the analyst to compare the various accounting ratios directly. Second, firms in the same industry tend to have similar risks and growth prospects.[13] As we have discussed, however, different firms in the same industry often have very different management philosophies, which leads to very different risk and growth profiles. In addition, firms often do business in multiple industries, making it difficult to determine to which industry group a firm belongs. For example, in our earlier analysis of ExxonMobil (XOM), we found that it had three operating divisions located in different industries.[14] When this occurs, the analyst may find it necessary to utilize an average of the industry valuation ratios corresponding to each of the firm's operating business units.

Choosing the Valuation Ratio

Although earnings and EBITDA valuation ratios tend to be the most commonly used, some firms have either zero or negative earnings. When this is the case, analysts tend to look to other valuation ratios for guidance. For example, as we discussed earlier, real estate valuations generally include an analysis of the price per square foot of comparable properties. For some businesses, analysts use valuation ratios based on firm sales or book value. Table 8-7 provides a summary list of some of the most popular valuation ratios. Panel (a) focuses on equity valuation ratios, and panel (b) lists some popular enterprise-valuation ratios.

Maintaining Consistency When Selecting a Valuation Ratio

A simple but important guide for using valuation ratios is that the numerator and denominator of the ratio should be consistent. By "consistent," we mean that if the price or value metric in the numerator is based on equity value (e.g., price per share), then

[13] These results are based on a comparison of observed prices to estimated prices (based on the various ways of forming groups of comparable firms and assessing the significance of the absolute deviation, measured as a percent of the observed price). See A. Alford, "The Effect of the Set of Comparable Firms on the Accuracy of the Price–Earnings Valuation Method," *Journal of Accounting Research* (Spring 1992): 94–108.

[14] These divisions include Upstream (oil and gas exploration and development), Downstream (refining oil and gas for energy use), and Chemicals (conversion of crude into plastics and other nonenergy products).

PRACTITIONER INSIGHT

The Pricing of New Shares in an Initial Public Offering (IPO): An Interview with J. Douglas Ramsey, Ph.D.*

In 2006, we took EXCO Resources (NYSE: XCO) public with an initial public offering. EXCO had only been a privately held firm since 2003, when we were taken private with the help of the private equity firm Cerberus Capital Management LP. The motivation for going public at this time was to raise capital needed to fund some major acquisitions of oil and gas properties and reduce the amount of debt on the balance sheet. This followed on the heels of an equity buyout several months earlier, where certain private equity investors from the 2003 going-private transaction were cashed out. The equity buyout was funded with a combination of debt and new private equity.

The pricing of the new shares is done by the lead investment bank (J.P. Morgan in our case), using market price comparables for similar firms. Specifically, our banker looked at six different ratios equal to enterprise value divided by one of six different valuation metrics that are commonly used in our industry.† This analysis, in combination with the values of EXCO's own valuation metrics, gave us an idea of what type of enterprise value we could expect once the IPO was complete. From this valuation and the number of shares we planned to sell, we could then impute a price for our shares.

The actual price at which the new shares were offered was not determined until the night before the IPO in a pricing meeting. In this meeting, our investment banker brought an updated analysis of market comparables along with "the book." The latter is comprised of a listing of the indications of interest in acquiring our shares in the initial offering. This book is built over the weeks prior to the IPO, during what is typically referred to as the "road show," where company management and representatives of the joint book runners—in our case, J.P. Morgan, Bear Stearns, and Goldman Sachs—barnstorm the country, talking to potential institutional investors about the offering.

*Director of Strategic Planning and Special Projects for EXCO Resources Inc., Dallas, Texas.

†The valuation metrics include company-specific attributes that are believed to be important indicators of the firm's enterprise value. In the case of an oil and gas company, these typically include things such as the current year's production, proved reserves of oil and natural gas, current-year free cash flow, and estimates of earnings before interest, taxes, depreciation, and amortization plus development and maintenance expenses (EBITDAX) for the next two years.

the denominator should reflect an attribute of the firm that is directly related to share price. For example, net income per share or earnings per share can be linked directly to share price because earnings represent the income that is available for distribution to shareholders or reinvested on their behalf. However, on occasion we have seen analysts report share price relative to EBITDA and share price relative to sales ratios (i.e., price per share divided by sales per share), which are inconsistent ratios because EBITDA and sales are generated by the entire assets of the firm, not just the equity portion of the firm's balance sheet. Consequently, if one does want to compare firms on the basis of a ratio that involves a variable such as sales per share, one must be careful to select comparable firms that share similar operating leverage and financial leverage with the evaluated firm.

Table 8-7 Alternative Valuation Ratios

Panel (a) Equity Valuation Ratios

Valuation Ratio	Definition	Measurement Issues	When to Use	Valuation Model
Price to earnings (P/E)	$\frac{\text{Price per Share}}{\text{Earnings per Share}}$ *Price per share* = market price per share of common stock *Earnings per share* = annual net income ÷ shares outstanding	*Price per share*—typically, the most recent share price is used. However, if share price is very volatile, a normalized price (e.g., an average of beginning and ending prices for the month) may be used. *Earnings per share*—although current-year or annualized current-quarter (trailing) earnings can be used, it is not uncommon to use analysts' expectations of future (leading) earnings. Moreover, earnings are typically measured before extraordinary items and may include only earnings from the firm's primary operations.	Firms with an established record of positive earnings that do not have significant noncash expenditures.	$\text{Estimated Stock Price} = (\text{EPS})_{\text{Firm}} \times \left(\text{P/E Ratio}\right)_{\text{Industry}}$
Price to earnings to growth (PEG)	$\frac{\text{Price per Share}}{\text{Earnings per Share (EPS)} \div \text{Growth rate in EPS}}$ *Growth rate in EPS* = expected rate of growth in EPS over the next year	*Growth rate in EPS*—estimates of growth rates can be made from historical earnings estimates or can be obtained from analysts' estimates.	Firms that face stable prospects for future growth in EPS as well as similar capital structures and similar industry risk attributes.	$\text{Estimated Stock Price} = \left(\frac{\text{Growth Rate in EPS}}{\text{EPS}}\right)_{\text{Firm}} \times \left(\text{PEG Ratio}\right)_{\text{Industry}}$

Market to book value of equity	$\frac{\text{Market Value of Equity}}{\text{Book Value of Equity}}$ *Market value of equity* = price per share × shares outstanding *Book value of equity* = total assets − total liabilities	*Market value of equity*—the same issues that arise in selecting a price per share apply here. *Book value of equity*—although the book value of equity is easy to pull from the firm's balance sheet, differences in the ages of firm assets (when acquired and rates of depreciation) as well as other differences in how various assets are accounted for (fair market value—marked to market—or cost) and the conservatism employed in accounting practices can lead to variation across firms.	Firms whose balance sheets are reasonable reflections of the market values of their assets. Financial institutions are the classic case.	$\text{Estimated Equity Value} = \begin{pmatrix}\text{Book Value}\\ \text{of Equity}\end{pmatrix}_{\text{Firm}} \times \begin{pmatrix}\text{Market to}\\ \text{Book Ratio}\end{pmatrix}_{\text{Industry}}$
Panel (b) Enterprise-Valuation Ratios				
Enterprise value (EV) to EBITDA	$\frac{\text{Enterprise Value}}{\text{EBITDA}}$ *Enterprise value* = price per share × shares outstanding + interest-bearing (short- and long-term) debt less cash *EBITDA* = earnings before interest, taxes, depreciation, and amortization	*Enterprise value*—EV is typically estimated as the market value of the firm's equity (price per share times shares outstanding) plus the book value of the firm's interest-bearing debt. Consequently, the problems that arise in determining which stock price to use (most recent versus normalized) arise here too. *EBITDA*—this earnings figure is easily accessed from the firm's income statement. However, cyclical variations in earnings and unusual variations in firm revenues may require some normalization to better reflect the firm's future earnings potential.	Firms that have significant noncash expenses (i.e., depreciation and amortization). Examples include industries with large investments in fixed assets, including health care, oil and gas equipment services, and telecommunications.	$\text{Estimated Enterprise Value} = (\text{EBITDA})_{\text{Firm}} \times \begin{pmatrix}\text{EV to EBITDA}\\ \text{Ratio}\end{pmatrix}_{\text{Industry}}$

(*Continued*)

Table 8-7 *continued*

Valuation Ratio	Definition	Measurement Issues	When to Use	Valuation Model
Enterprise value (EV) to cash flow	$\frac{\text{Enterprise Value}}{\text{Cash Flow per Share}}$ *Enterprise value* = Equity value plus Interest-bearing debt *Cashflow* = firm free cash flow (FCF)	*Cash flow*—FCF adjusts EBITDA to consider taxes and additional investment required in capital equipment (CAPEX) and working capital. Consequently, the issues that arise with FCF include those applicable to EBITDA, plus any normalization of CAPEX required to adjust for extraordinary circumstances in any given year.	Firms with stable growth and thus predictable capital expenditures. Examples include chemicals, paper products, forestry, and industrial metals.	Estimated Enterprise Value = $(\text{FCF})_{\text{Firm}} \times \left(\begin{array}{c}\text{EV to FCF}\\ \text{Ratio}\end{array}\right)_{\text{Industry}}$
Enterprise value (EV) to sales	$\frac{\text{Enterprise Value}}{\text{Sales}}$ *Sales* = firm annual revenues	*Sales*—firm revenues sit at the top of the firm's income statement. However, they too may not be reflective of the firm's earning potential if they are abnormally large or depressed due to nonrecurring factors.	Young firms and startups that do not have an established history of earnings.	Estimated Enterprise Value = $(\text{Sales})_{\text{Firm}} \times \left(\begin{array}{c}\text{EV to Sales}\\ \text{Ratio}\end{array}\right)_{\text{Industry}}$

Dealing with Unreliable Financial Information

In any given year, a firm's reported earnings often provide an imperfect measure of the business's ability to generate future cash flows. This is particularly true for young firms that are very far from reaching their potential (i.e., have significant growth potential) or, for that matter, almost any firm going through a transition. Under these circumstances, EBITDA or earnings per share are often negative, making it impossible to rely on ratios based on earnings. In other cases, either the accounting is suspect or the business is able to generate value to its owners, perhaps by paying high salaries, in ways that do not show up in the firm's income statements.

For situations like these, the firm's reported earnings are unreliable indicators of the firm's value. In these circumstances, the analyst can take one of two possible courses of action. The first involves the use of other valuation ratios that may utilize more reliable measures of the firm's ability to generate future cash flows. Most of these alternatives are measures of the size of the business and are thus analogous to valuing real estate on a price-per-square-foot basis. The most popular size measure is firm revenues or sales, followed closely by the book value of the firm's assets. For example, in panel (a) of Table 8-7, the market to book value of equity ratio might be used if the objective is estimating a firm's equity value, or the enterprise value to sales ratio might be used to estimate enterprise value. There are also commonly used measures of size that are unique to particular industries. For example, newspapers, magazines, and cable companies are often valued relative to their number of subscribers, and money management firms and other financial institutions are often valued relative to the amount of assets they manage.

The second course of action open to the analyst who finds that corporate earnings are not reflective of the firm's earning potential involves adjusting or normalizing reported earnings so that they provide a more reasonable reflection of the firm's earning potential. For example, when valuing small family-run businesses, it is not uncommon for the owner to pay him- or herself a noncompetitive salary or to take special perquisites such as a company car, as a way of extracting additional tax-deductible value out of the business. When faced with the prospect of valuing such a business, the analyst must make appropriate adjustments to the firm's earnings before using them to value the enterprise. We will not delve into this process in any detail because there are many excellent books on financial statement analysis that detail the circumstances giving rise to a need to normalize earnings and how to do it.

Valuation Ratios Versus DCF Analysis

When valuing major investments, it often makes sense to do both a DCF analysis (which we discuss in detail in Chapter 9) as well as a valuation that employs a number of different comparables-based multiples. Once the analysis is complete, the analyst is still left with the problem of sorting out the various value estimates and using his or her professional judgment to arrive at a final valuation. This judgment depends in part on the quality of information that is available and in part on the purpose of the valuation.

To understand what we mean by the purpose of the valuation, let's consider an investor with an interest in acquiring coal-fired power plants. Suppose that this particular investor is considering the purchase of a specific plant that is quite similar both in age and technology to five other plants that were sold in the last three months, and two others that are currently for sale. In this situation, the quality of the comparables market data is quite good, which means that the acquirer should compare the plants based on valuation ratios rather than projecting future plant cash flows, estimating an appropriate discount rate, and then performing a DCF analysis. Again, we are assuming that the technologies and the ages of the plants are similar so that their values—relative to their earnings, cash flows, or electricity-generating capacities—should be very similar. In a sense, the question being answered in this valuation is: "What should I expect to have to pay for the coal-fired power plant under today's market conditions?"

Although the comparables approach provides the appropriate methodology for evaluating whether a particular power plant is favorably priced, it is much less useful for a firm that wants to evaluate whether or not it makes sense to acquire power plants in general. The basic question in this case is: "What should a coal-fired power plant be worth today in absolute terms?" Note that we are asking a much more basic question here. We no longer want to know just how one coal-fired plant is valued relative to others, but whether coal-fired plants in general are good investments. To answer this question, we can still envision comparing EBITDA ratios of power plants and oil refineries as a starting point in the evaluation of which type of investment is likely to be more attractive. However, for this more general question, the analyst should rely much more heavily on DCF analysis, which involves making forecasts of future power output, electricity prices, and costs of generation.[15]

8.7 Summary

In this chapter, we introduced market-based valuation ratios as an alternative to the discounted cash flow (DCF) method for valuing an investment. Although the DCF approach is generally emphasized by academics, practitioners prefer to use market-based multiples based on comparable firms or transactions for valuing businesses. An important advantage of using valuation ratios is that they provide the analyst with methods for estimating the value of an investment without making explicit estimates of either the investment's future cash flows or the discount rate. However, an even more important reason for using the comparables approach is that it makes direct use of observed market pricing information. Intuitively, it does not make sense to use rough estimates of the discount rate and future cash flows to come up with an estimate of the market value of an investment if you can directly observe how the market values such an investment with comparable transactions.

The reality, however, is that using comparable transactions is not as easy as it might seem at first. There are two important steps to the application, and each is critical:

- First, the analyst must identify a set of comparable transactions for which market pricing data is available. The principal weakness of market-based comparables valuation is that we almost never have truly comparable transactions. Investments typically have unique attributes and, in most cases, the investments that are used as comparables are somewhat of a stretch. For this reason, it is critical that we think carefully when determining the appropriate multiples to use. For example, we should use higher multiples when the cash flows of an investment are likely to

[15] If the company also mines the coal it needs for the plant, the health care liability related to black lung disease can be a very important consideration.

grow faster than those of the comparable investments, and we should use lower multiples when the risk of the investment is higher. In other words, you should use the insights learned from DCF valuation to augment your implementation of the multiples approach.

- The second critical step in using market comparables entails the selection of an appropriate valuation ratio or metric. By "appropriate," we mean that the value of the investment can be thought of simply as a scaled value of the metric where the investment attribute (e.g., earnings, cash flow, square footage) is the scaling variable. For example, when the P/E ratio is used as the valuation metric, we are assuming that the value of the firm's equity is equal to firm earnings scaled by the ratio of share price to earnings. Or if we're valuing an entire firm, we might use the enterprise value to EBITDA multiple, whereby we scale the firm's EBITDA by the multiple to get an estimate of enterprise value.

Exercises

8-1 VALUING RESIDENTIAL REAL ESTATE Sarah Fluggel is considering the purchase of a home located at 2121 Tarter Circle in Frisco, Texas. The home has 3,000 square feet of heated and cooled living area, and the current owners are asking a price of $375,000 for it.

a. Use the information provided in the following table to determine an initial estimate of the value of the home Sarah is considering:

	Comp 1	Comp 2
Sale price	$240,000	$265,000
Square footage	2,240	2,145
Selling price/sq. ft.	$ 107.14	$ 123.54
Time on the market	61 days	32 days

b. After making her initial estimate of the value of the home, Sarah decided to investigate whether the owner's asking price of $375,000 might be justified based on unique attributes of the home. What types of details might you recommend Sarah look for in trying to justify the price of the home?

c. What if the house Sarah is considering had an asking price of $315,000? What would you recommend Sarah do then?

8-2 VALUING EQUITY USING THE PRICE–EARNINGS MULTIPLE Garrett Simpson Investments is evaluating a firm (Garp, Inc.) for recommendation to its clients and trying to evaluate the firm's current stock price. The firm is about to offer its shares to the public and had earnings last year of $2.50 a share, which the analysts believe is expected to grow by 20% next year. Similar firms in the industry are currently selling for price–earnings ratios ranging from ten to fifteen times current period earnings. However, these competitor firms are already public entities and have relatively low growth expectations for their earnings. What is your estimate of an appropriate price range for the shares of Garp? Defend your answer.

8-3 THOUGHT QUESTIONS

a. Parry Electronics is a regional electronics wholesaler and distributor that earned $1,250,000 in EBITDA this year based on revenues of $4,000,000. The enterprise values of publicly traded firms that operate in the same industry currently are valued at five to six times their current EBITDA. What is your estimate of the enterprise value of Parry Electronics? If Parry is small relative to the size of the comparison firms, with assets only one-tenth the size of the largest firm in the industry, how would this influence your valuation estimate? Explain.

b. Suppose we have two companies, A and B, that produce identical products using slightly different production processes. The process used by company A requires more capital equipment, which is already paid for, and can produce the product at lower per-unit costs. Now assume that you have been asked to value company B, which is privately held, and that you want to use company A, which is publicly traded, as the basis for your valuation. Discuss how differences in the production processes of these firms affect both their multiples and discount rates. Relate your answer to the discussion of the valuation of the two office buildings discussed in the chapter.

c. In the tech sector, the price of an IPO is often stated as a multiple of its sales, which is then compared to the price/sales ratio of comparable firms. Why do you think that analysts use price/sales ratios in this setting rather than price/earnings ratios?

PROBLEMS

8-4 VALUING COMMERCIAL REAL ESTATE BuildingOne Properties is a limited partnership formed with the express purpose of investing in commercial real estate. The firm is currently considering the acquisition of an office building that we refer to simply as building B. Building B is very similar to building A, which recently sold for $36,960,000. BuildingOne has gathered general information about the two buildings, including valuation information for building A:

	Per Square Foot		Total Square Footage	
	A	**B**	**A**	**B**
Building size (sq. ft.)			80,000	90,000
Rent	$100/sq. ft.	$120/sq. ft.	$8,000,000	$10,800,000
Maintenance (fixed cost)	(23)/sq. ft.	(30)/sq. ft.	(1,840,000)	(2,700,000)
Net operating income	$ 77/sq. ft.	$ 90/sq. ft.	$6,160,000	$ 8,100,000

Buildings A and B are similar in size (80,000 and 90,000 square feet, respectively). However, the two buildings differ both in maintenance costs ($23 and $30 per square foot) and rental rates ($100 versus $120 per square foot). At this point, we do not know why these differences exist. Nonetheless, the differences are real and should somehow be accounted for in the analysis of the value of building B using data based on the sale of building A. Building A sold for $462 per square foot, or $36,960,000. This reflects a sales multiple of six times the building's net operating income (NOI) of $6,160,000 per year and a capitalization rate of 16.67%.

a. Using the multiple of operating income, determine what value BuildingOne should place on building B.

b. If the risk-free rate of interest is 5.5% and the building maintenance costs are known with a high degree of certainty, what value should BuildingOne place on building B's maintenance costs? How much value should BuildingOne place on building B's revenues and, consequently, on the firm?

8-5 VALUING A PRIVATELY HELD FIRM The auto parts business has three large publicly held firms: O'Reilly Automotive Inc. (Orly), Advance Auto Parts Inc. (AAP), and Auto Zone Inc. (AZO). In addition to these publicly held firms, Carquest is the largest privately held firm in the industry. Assume that in summer 2010, your investment banking firm is considering whether to approach the top management of O'Reilly with a proposal that they consider acquiring Carquest, which owns over 4,000 auto parts outlets in the United States. As a preliminary step in the evaluation of the possible acquisition, you have assembled a team of analysts to prepare a preliminary analysis of acquisition price multiples that might be warranted based on current market conditions. The analyst team went to work immediately and compiled the following set of financial information and potential valuation ratios:

Financial Information (Millions)	**O'Reilly**	**Advance**	**Auto Zone**
Revenues	$ 2,120.00	$ 4,400.00	$ 5,890.00
EBITDA	321.86	544.38	1,130.00
Net income	171.62	240.16	562.44
Earnings per share	1.507	2.183	7.301
Interest-bearing debt	120.00	560.00	1,720.00
Common equity	1,145.77	939.51	641.16
Total assets	1,713.90	2,615.73	4,401.85
Financial Ratios			
Debt to equity	10.5%	59.6%	269.3%
Gross margins	44.0%	47.3%	49.1%
Operating margins	12.47%	9.42%	16.77%
Expected growth in EPS (5 yrs.)	18.5%	16.0%	13.0%
Market Valuations (Millions)			
Market capitalization	$ 3,240	$ 3,040	$ 6,290
Enterprise value	3,360	3,600	8,010
Valuation Ratios			
Enterprise value/EBITDA	10.44	6.61	7.09
P/E ratio (trailing)	19.42	13.30	11.56
P/E ratio (forward)	15.24	11.21	10.21
Beta	1.24	1.79	1.25

a. How would you use this information to evaluate a potential offer to acquire Carquest's equity?
b. What do you think is driving the rather dramatic differences in the valuation ratios of the three firms?

8-6 NORMALIZING EBITDA Jason Kidwell is considering whether to acquire a local toy manufacturing company, Toys 'n' Things Inc. The company's annual income statements for three years are as follows:

	2014	2013	2012
Revenues	$ 2,243,155	$ 2,001,501	$ 2,115,002
Cost of goods sold	(1,458,051)	(1,300,976)	(1,374,751)
Gross profits	$ 785,104	$ 700,525	$ 740,251
Depreciation and administrative expenses	(574,316)	(550,150)	(561,500)
Net operating income	$ 210,798	$ 150,375	$ 178,751

a. Jason has learned that small private companies such as this one typically sell for EBITDA multiples of three to four times. Depreciation expense equals $50,000 per year. What value would you recommend Jason put on the company?
b. The current owner of Toys'n' Things indicated to Jason that he would not take less than five times 2014 EBITDA to sell out. Jason decides that, based on what he knows about the company, the price could not be justified. However, upon further investigation, Jason learns that the owner's wife is paid $100,000 a year for administrative services that Jason thinks could be done by a $50,000-per-year assistant. Moreover, the owner pays himself a salary of $250,000 per year to run the business, which Jason thinks is at least $50,000 too high based on the demands of the business. In addition, Jason thinks that, by outsourcing raw materials to Asia, he can reduce the firm's cost of goods sold by 10%. After making adjustments for excessive salaries, what value should Jason place on the business? Can Jason justify the value the owner is placing on the business?

8-7 OPERATING LEVERAGE AND FLUCTUATIONS IN OPERATING EARNINGS Assume that Jason Kidwell (from Problem 8-6) is able to purchase Toys 'n' Things Inc. for $2.2 million. Jason estimates that after initiating his changes in the company's operations (i.e., the salary savings plus outsourcing savings described in Problem 8-6), the firm's cost of goods sold are 55% of firm revenues, and operating expenses are equal to a fixed component of $250,000 plus a variable cost component equal to 10% of revenues.

a. Under these circumstances, estimate the firm's net operating income for revenue levels of $1 million, $2 million, and $4 million. What is the percentage change in operating income if revenues go from $2 million to $4 million? What is the percentage change in operating income if revenues change from $2 million to $1 million?

b. Assume now that Jason is able to modify the firm's cost structure such that the fixed component of operating expenses declines to $50,000 per year but the variable cost rises to 30% of firm revenues. Answer Problem 8-7(a) under this revised cost structure. Which of the two cost structures generates the highest level of operating leverage? What should be the effect of the change in cost structure on the firm's equity beta?

8-8 VALUING THE EQUITY OF A STABLE-GROWTH FIRM The Emerson Electric Company (EMR) was founded in 1890 and is located in St. Louis, Missouri. The firm provides product technologies and engineering services for industrial, commercial, and consumer markets worldwide. The firm operates in five business segments: process management, industrial automation, network power, climate technologies, and appliance and tools.

The company has a lengthy history of dividend payments and steady growth. In recent years, the firm's dividend payout has averaged 40% of earnings. For 2007, firm earnings were estimated to be $5.69 a share, and on December 7, 2006, Emerson's shares were trading for $86.01, and has a price–earnings ratio of 19.26. Data for the industry, sector, Emerson, and four competitor firms are shown on page 300.

a. Is Emerson's current stock price reasonable in light of its sector, industry, and comparison firms?

b. Emerson's beta coefficient is 1.27. Assuming a risk-free rate of 5.02% and a market risk premium of 5%, what is your estimate of the required rate of return for Emerson's stock using the capital asset pricing model (CAPM)? What rate of growth in earnings is consistent with Emerson's policy of paying out 40% of earnings in dividends and the firm's historical return on equity? Using your estimated growth rate, what is the value of Emerson's shares using the Gordon (single-stage) growth model? Analyze the reasonableness of your estimated value per share using the Gordon model.

c. Based on your analysis in Problem 8-8(b), what growth rate is consistent with Emerson's current share price of $86.01?

8-9 HIGH-GROWTH OR STABLE-GROWTH FIRM? Intel Corporation is a leading manufacturer of semiconductor chips. The firm was incorporated in 1968 in Santa Clara, California, and represents one of the greatest success stories of the computer age. Although Intel continues to grow, the industry in which it operates has matured, so there is some question whether the firm should be evaluated as a high-growth company or stable-growth company from now on. For example, in December 2007, the firm's shares were trading for $20.88, and has a price–earnings ratio of 17.622. Compared to Google Inc.'s price–earnings ratio of 53.71 on the same date, it would appear that the decision has already been made by the market.

Intel's expected earnings for 2007 were $1.13 per share, and its payout ratio was 48%. Furthermore, selected financial data for the sector, industry, and seven of the largest firms (including Intel) are found in Exhibit P8-9.1 on page 301.

a. Is Intel's current stock price of $20.88 reasonable in light of its sector, industry, and comparison firms?

Comparable Firms								
Description	**Market Cap**	**P/E**	**Return on Equity %**	**Dividend Yield %**	**Long-Term Debt to Equity**	**Price to Book Value**	**Net Profit Margin**	**Price to Free Cash Flow**
Sector: industrial goods		16.606	14.94%	1.48%	0.87	50.471	5.40%	75.481
Industry: industrial equipment and components		15.900	18.40%	1.41%	0.649	10.11	7.90%	−134.9
Emerson Electric Co.	$34.61B	19.276	23.72%	2.40%	0.494	4.257	9.54%	65.156
Parker-Hannifin Corp.	9.81B	14.150	18.16%	1.20%	0.308	2.298	8.25%	34.392
Roper Industries Inc.	4.44B	24.685	14.27%	0.50%	0.603	3.122	11.89%	232.735
Pentair Inc.	3.23B	17.943	11.56%	1.70%	0.485	1.974	4.48%	147.667
Walter Industries Inc.	2.19B	23.537	15.70%	0.30%	4.036	2.731	7.38%	−10.682

Exhibit P8-9.1 Industry Comparables for Intel Corporation

Description	Market Cap	P/E	Return on Equity %	Dividend Yield %	Long-Term Debt to Equity	Price to Book Value	Net Profit Margin	Price to Free Cash Flow
Sector: technology	5,344.81B	27.716	14.77%	1.90%	0.691	5.588	10.39%	55.435
Industry: semiconductor —broad line	252.89B	19.9	16.20%	1.30%	0.096	3.42	15.50%	193.3
Intel Corp.	120.51B	17.622	19.63%	1.90%	0.064	3.437	18.72%	121.039
Texas Instruments Inc.	44.62B	11.08	22.94%	0.50%	0.004	3.71	18.67%	−5,577.55
STMicroelectronics NV	16.35B	24.959	7.81%	0.70%	0.209	1.764	8.24%	−11.219
Advanced Micro Devices Inc.	11.79B	21.152	12.61%	0.00%	0.138	2.088	10.13%	−58.916
Analog Devices Inc.	11.48B	22.667	15.42%	1.90%	NA	3.342	21.48%	311.392
Maxim Integrated Products Inc.	10.28B	23.025	16.93%	1.90%	NA	3.681	21.39%	NA
National Semiconductor Corp.	8.04B	18.49	25.67%	0.60%	0.012	4.481	22.18%	154.483

b. Intel has a beta coefficient equal to 1.66. If we assume a risk-free rate of 5.02% and a market risk premium of 5%, what is your estimate of the required rate of return for Intel's stock using CAPM? What rate of growth in earnings is consistent with Intel's policy of paying out 48% of earnings in dividends and the firm's historical return on equity? Using your estimated growth rate, what is the value of Intel's shares using the Gordon (single-stage) growth model? Analyze the reasonableness of your estimated value per share using the Gordon model.

c. Using your analysis in Problem 8-9(b), what growth rate is consistent with Intel's current share price of $20.88?

d. Analysts expect Intel's earnings to grow at a rate of 12% per year over the next five years. What rate of growth from year 6 forward (forever) is needed to warrant Intel's current stock price (use your CAPM estimate of the required rate of return on equity)? (*Hint:* Use a two-stage growth model where Intel's earnings grow for five years at 12% and from year 6 forward at a constant rate.)

8-10 VALUATION MULTIPLES AND CHANGES IN INTEREST RATES—THOUGHT QUESTION

Both EBITDA to enterprise value and P/E ratios can be linked to interest rates through the discount rate used in discounted cash flow valuation. Holding all else equal, when discount rates are higher, valuation ratios are lower. Perhaps because of this, we tend to see stock prices as well as the value of private business transactions decline when interest rates increase.

Macroeconomists like to describe interest rates as consisting of two components: the real interest rate component and an expected inflation component. In some situations, increases in interest rates are the result of an increasing real interest rate; in other situations, the cause of an interest rate increase is an increase in expected inflation. How might valuation ratios be expected to respond to an interest rate increase generated by an increase in expected inflation versus an interest rate increase that represents an increase in real interest rates?

PROBLEM 8-11 MINI-CASE PRICING SHARES FOR THE FRAMCO RESOURCES IPO

Framco Resources is an independent oil and natural gas company that engages in the acquisition, development, and exploitation of onshore North American oil and natural gas properties. The company has followed a strategy of growth through the development of its inventory of drilling locations and exploitation projects, and selectively pursuing acquisitions. The firm's current management team first purchased a significant ownership interest in Framco (which was a public entity) in December 1997 and since then has achieved substantial growth in reserves and production. In 2003, the company was taken private through a buyout financed using debt capital and equity capital provided by a private equity partner. Late in 2005, Framco's board decided that the time was right for the firm to become once again a public entity by doing an IPO of its shares.

Framco's board selected an investment banker, who prepared a preliminary analysis of possible offering prices for Framco's shares, found in Exhibits P8-11.1 and P8-11.2.

Exhibit P8-11.1 **Industry Comparables Used in Framco Resources IPO Pricing Analysis**

	Firm Characteristics (millions)					Firm Valuation Ratios			
Company	Enterprise Value	2005E Reserves	2006E EBIT-DAX	2007E EBIT-DAX	Firm Free Cash Flow*	2005E Reserves	2006 EBIT-DAX	2007 EBIT-DAX	Firm Free Cash Flow*
Company 1	$20,547	7,311	$3,210	$2,873	$2,940	$2.81	6.40	7.15	6.99
Company 2	21,280	7,220	3,806	3,299	3,502	2.95	5.59	6.45	6.08
Company 3	4,781	1,411	601	602	450	3.39	7.96	7.94	10.62
Company 4	2,508	1,222	380	342	252	2.05	6.60	7.33	9.95
Company 5	2,355	798	460	399	241	2.95	5.12	5.90	9.77
					Mean	**2.83**	**6.33**	**6.96**	**8.68**
					Median	**2.95**	**6.40**	**7.15**	**9.77**

*Firm free cash flow is calculated in the usual way and includes company estimates of maintenance capital expenditures.

Exhibit P8-11.2 **Enterprise Value Estimates for Framco Based on Alternative IPO Share Prices**

	Expected IPO Share Price					
	$20.00	**$22.00**	**$24.00**	**$26.00**	**$28.00**	**$30.00**
Diluted shares outstanding (millions)	51.60	51.60	51.60	51.60	51.60	51.60
Equity value (millions)	$1,032	$1,135	$1,238	$1,342	$1,445	$1,548
Plus: net debt (millions)*	740	688	637	585	534	482
Enterprise value (millions)	$1,772	$1,824	$1,875	$1,927	$1,978	$2,030

*Net debt equals interest-bearing debt less cash ($250,000). The interest-bearing debt total declines with increasing IPO share prices because half the additional proceeds resulting from a higher price are used to retire Framco's debt.

The valuation analysis utilizes valuation ratios based on the current enterprise values of five independent oil and gas companies and three key valuation metrics that are commonly used in the industry: estimated reserves; estimated earnings before interest, taxes, depreciation, amortization, and maintenance capital expenditures (EBITDAX); and firm free cash flow.

Exhibit P8-11.2 contains estimates of Framco's equity and enterprise valuation that would correspond to different IPO share prices. This analysis is based on the assumption that Framco will sell 51.6 million shares of stock for a price of $20 to $30 per share. To complete the comparative analysis, Framco's CFO provided the investment banker with the necessary estimates of his firm's proved reserves for 2005, EBITDAX for 2006 and 2007, and free cash flow:

Valuation Metric	Framco Estimates
2005E proved reserves	$700 million
2006E EBITDAX	$302 million
2007E EBITDAX	$280 million
Firm free cash flow	$191 million

a. Calculate the valuation ratios found in Exhibit P8-11.1 using Framco's valuation metrics for each of the alternative IPO prices found in Exhibit P8-11.2.

b. Based on your calculations (and assuming the valuation metrics are used by investors to make value comparisons among independent oil and gas firms), what price do you think Framco's shares will command at the time of the IPO?

c. The actual offering price for Framco's shares is not set until the pricing meeting with the investment banker the night before the offering date. At this meeting, the investment banker has not only updated comparables data such as that found in Exhibit P8-11.1 but also has indications of interest for purchasing the new shares (the book). In addition, Framco's investment banker reviewed Framco's most recent estimates of the valuation metrics, which were virtually identical to the estimates found in Exhibit P8-11.1. However, the book was quite strong, indicating an oversubscription for the 51.6 million shares at prices at the upper end of the range of prices found in Exhibit P8-11.2. Should Framco try to raise the offering price outside the original range set forth in Exhibit P8-11.2? Explain your answer.

PROBLEM 8-12 **MINI-CASE** VALUING GOOGLE IPO SHARE PRICE[16]

Google Inc. of Mountain View, California, operates the most popular and powerful search engine on the Web. The company went public using an unconventional Dutch auction method on August 19, 2004. The resulting IPO was the largest

[16] © 2010 Betty Simkins, Williams Companies Professor of Business and Professor of Finance, Oklahoma State University. All Rights Reserved. Reprinted with permission.

Exhibit P8-12.1

Financial Information	Earthlink (ELINK)	Yahoo! (YHOO)	eBay (EBAY)	Microsoft (MSFT)
2003 shares outstanding	159,399,000	655,602,000	646,819,000	10,800,000,000
2003 fiscal close stock price	$ 10.00	$ 45.03	$ 64.61	$ 25.64
Market capitalization	$1,593,990,000	$29,521,758,060	$41,790,975,590	$276,912,000,000
Short-term debt	$ 900,000	$ 0	$ 2,800,000	$ 0
Long-term debt	$ 0	$ 750,000,000	$ 124,500,000	$ 0
Cash and equivalents	$ 349,740,000	$ 713,539,000	$ 1,381,513,000	$ 6,438,000,000
Short-term investments	$ 89,088,000	$ 595,975,000	$ 340,576,000	$ 42,610,000,000
EBITDA	$ 218,100,000	$ 455,300,000	$ 818,200,000	$ 14,656,000,000
Net income	$ (62,200,000)	$ 237,900,000	$ 441,800,000	$ 9,993,000,000
Calculated EPS	(0.39)	0.36	0.68	0.93

Internet IPO ever, raising $1.67 billion and leaving the firm with 271,219,643 shares of common stock.

While Google commands a wide lead over its competitors in the search engine market, it is witnessing increased pressure from well-funded rival entities. Yahoo! Inc., with a market cap of approximately $38.43 billion, is generally regarded as following a business model very similar to Google's.

a. Use the data found in Exhibit P8-12.1 for the following companies as comparables in your analysis: Earthlink, Yahoo!, eBay, and Microsoft. Compute the IPO value of Google: shares using each of the comparable firms separately, and then use an average "multiple" of the comparable firms. Use the year-end 2003 balance sheets and income statements of the comparable firms to do the analysis. Assume that Google's forecasted values at the time of the IPO are as follows: Net income is $400 million, EBITDA is approximately $800 million, cash and equivalents are $430 million, and interest-bearing debt (total short-term and long-term) equals only $10 million.[17]

b. Which of the four comparable firms do you think is the best comparison firm for Google? Why?

c. How has the stock performed after the IPO? Do you believe that Google is currently correctly valued in the stock market? Explain your answer.

[17] These estimates for Google are approximate and are based on the company's prospectus.

PROBLEM 8-13 MINI-CASE VALUING CONOCOPHILLIPS' ACQUISITION OF BURLINGTON RESOURCES[18]

Suppose that you were working as an equity analyst in 2005 and were assigned the task of valuing the proposed acquisition, which is described in the following press release:

> Houston, Texas (December 12, 2005)—ConocoPhillips (NYSE: COP) and Burlington Resources Inc. (NYSE: BR) announced today they have signed a definitive agreement under which ConocoPhillips will acquire Burlington Resources in a transaction valued at $33.9 billion. The transaction, upon approval by Burlington Resources shareholders, will provide ConocoPhillips with extensive, high-quality natural gas exploration and production assets, primarily located in North America. The Burlington Resources portfolio provides a strong complement to ConocoPhillips' global portfolio of integrated exploration, production, refining, and energy transportation operations, thereby positioning the combined company for future growth. (Source: http://www.conocophillips.com/NR/rdonlyres/86E7B7A6-B953-4D0D-9B45-E4F1016DD8FD/0/cop_burlington pressrelease.pdf)

In his letter to ConocoPhillips shareholders contained in the company's 2005 annual report, CEO Jim Mulva described the rationale for the proposed Burlington acquisition as follows:

> Burlington's near-term production profile is robust and growing, plus Burlington possesses an extensive inventory of prospects and significant land positions in the most promising basins in North America, primarily onshore. With this access to high-quality, long-life reserves, the acquisition enhances our production growth from both conventional and unconventional gas resources.
>
> Specifically, our portfolio will be bolstered by opportunities to enhance production and gain operating synergies in the San Juan Basin of the United States and by an expanded presence and better utilization of our assets in Western Canada. In addition to growth possibilities, these assets also provide significant cash generation potential well into the future.
>
> Beyond adding to production and reserves, Burlington also brings well-recognized technical expertise that, together with ConocoPhillips' existing upstream capabilities, will create a superior organization to capitalize on the expanded asset base. We do not anticipate that the $33.9 billion acquisition will require asset sales within either ConocoPhillips or Burlington, nor should it change our organic growth plans for the company. We expect to achieve synergies and pretax cost savings of approximately $375 million annually, after the operations of the two companies are fully integrated.
>
> We anticipate immediate and future cash generation from this transaction that will aid in the rapid reduction of debt incurred for the acquisition and go toward the redeployment of cash into strategic areas of growth. Burlington shareholders will vote on the proposed transaction at a meeting on March 30, 2006. (Source: http://wh.conocophillips.com/about/reports/ar05/letter.htm)

[18]

Exhibit P8-13.1 Income Statement and Balance Sheet Values ($ Thousands)

	XTO Energy	Chesapeake Energy	Devon Energy	Apache	Burlington Resources
Ticker	XTO	CHK	DVN	APA	BR
Period ending	31-Dec-04	31-Dec-04	31-Dec-04	31-Dec-04	31-Dec-04
Income statement ($000)					
Total revenue	**1,947,601**	**2,709,268**	**9,189,000**	**5,332,577**	**5,618,000**
Cost of revenue	436,998	204,821	1,535,000	946,639	1,040,000
Gross profit	**1,510,603**	**2,504,447**	**7,654,000**	**4,385,938**	**4,578,000**
Operating expenses					
Selling, general, and administrative	165,092	896,290	1,616,000	173,194	215,000
Depreciation, depleletion, and amortization	414,341	615,822	2,334,000	1,270,683	1,137,000
Others	11,830	—	—	162,493	640,000
Operating income or loss	**919,290**	**992,335**	**3,704,000**	**2,779,568**	**2,586,000**
Income from continuing operations					
Total other income/expenses (net)	—	−20,081	64,000	857	—
Earnings before interest and taxes	919,281	972,254	3,768,000	2,780,425	2,586,000
Interest expense	93,661	167,328	475,000	117,342	282,000
Income before tax	825,620	804,926	3,293,000	2,663,083	2,304,000
Income tax expense	317,738	289,771	1,107,000	993,012	777,000
Net income from continuing operations	**507,882**	**515,155**	**2,186,000**	**1,670,071**	**1,527,000**
Nonrecurring events					
Effect of accounting changes	—	—	—	−1,317	—
Net income	**507,882**	**515,155**	**2,186,000**	**1,668,757**	**1,527,000**
Preferred stock and other adjustments	—	—	−10,000	−5,680	—
Net income applicable to common shares	**$ 507,882**	**$ 515,155**	**$2,176,000**	**1,663,074**	**$1,527,000**

(*Continued*)

Exhibit P8-13.1 *continued*

Balance sheet ($000)					
Assets					
Current assets					
Cash and cash equivalents	9,700	6,896	1,152,000	111,093	217,900
Short-term investments	14,713	51,061	968,000	—	—
Net receivables	364,836	477,436	1,320,000	1,022,625	994,000
Inventory	—	32,147	—	157,293	124,000
Other current assets	47,716	—	143,000	57,771	158,000
Total current assets	**436,965**	**567,540**	**3,583,000**	**1,348,782**	**3,455,000**
Long-term investments	—	136,912	753,000	—	—
Property, plant, and equipment	5,624,378	7,444,384	19,346,000	13,860,359	1,103,300
Goodwill	—	—	5,637,000	189,252	105,400
Other assets	49,029	95,673	417,000	—	202,000
Deferred long-term asset charges	—	—	—	104,087	—
Total assets	**6,110,372**	**8,244,509**	**29,736,000**	**15,502,480**	**15,744,000**
Liabilities					
Current liabilities					
Accounts payable	425,173	872,539	1,722,000	1,158,181	118,200
Short/current long-term debt	75,534	91,414	1,378,000	21,273	2,000
Other current liabilities	259	—	—	103,487	41,500
Total current liabilities	**500,966**	**963,953**	**3,100,000**	**1,282,891**	**1,599,000**
Long-term debt	2,053,911	3,076,405	7,796,000	2,619,807	3,887,000
Other liabilities	199,753	107,395	366,000	1,022,880	851,000
Deferred long-term liability charges	756,369	933,873	4,800,000	2,372,481	2,396,000
Total liabilities	**3,510,999**	**5,081,626**	**16,062,000**	**7,298,059**	**8,733,000**

Ticker	XTO	CHK	DVN	APA	BR
Period ending	31-Dec-04	31-Dec-04	31-Dec-04	31-Dec-04	31-Dec-04
Stockholders' equity					
Preferred stock	—	490,906	1,000	98,387	—
Common stock	3,484	3,169	48,000	209,320	5,000
Retained earnings	1,239,553	262,987	3,693,000	4,017,339	4,163,000
Treasury stock	−24,917	−22,091	—	−97,325	−2,208,000
Capital surplus	1,410,135	2,440,105	9,087,000	4,106,182	3,973,000
Other stockholders' equity	−28,882	−12,193	845,000	−129,482	1,078,000
Total stockholders' equity	**2,599,373**	**3,162,883**	**13,674,000**	**8,204,421**	**7,011,000**
Total liabilities and stockholders' equity	**6,110,372**	**8,244,509**	**29,736,000**	**15,502,480**	**15,744,000**
Other financial data					
Exploration expenses (millions)	$599.5	$184.3	$279.0	$ 2,300.0	$258.0
Shares outstanding (millions)	332.9	253.2	482.0	327.5	392.0
Year-end 2004 closing price	$35.38	$16.50	$38.92	$50.57	
Market capitalization (millions)	$11,778.00	$4,177.80	$18,759.44	$16,561.68	

Brief Company Descriptions

XTO Energy

XTO Energy Inc. (and its subsidiaries) engages in the acquisition, development, exploitation, and exploration of producing oil and gas properties in the United States. The company also produces, processes, markets, and transports oil and natural gas. Its proved reserves are principally located in the Eastern Region, including the East Texas Basin and northwestern Louisiana; Barnett Shale of North Texas; San Juan and Raton Basins of New Mexico and Colorado; Permian and South Texas Region; Mid-Continent and Rocky Mountain Region in Wyoming, Kansas, Oklahoma, and Arkansas; and Middle Ground Shoal Field of Alaska's Cook Inlet. As of December 31, 2005, the company had estimated proved reserves of 6.09 trillion cubic feet of natural gas, 47.4 million barrels of natural gas liquids, and 208.7 million barrels of oil.

Chesapeake Energy

Chesapeake Energy Corporation engages in the development, acquisition, production, exploration, and marketing of onshore oil and natural gas properties in the United States. Its properties are located in Oklahoma, Texas, Arkansas, Louisiana, Kansas, Montana, Colorado, North Dakota, New Mexico, West Virginia, Kentucky, Ohio, New York, Maryland, Michigan, Pennsylvania, Tennessee, and Virginia. As of December 31, 2005, the company had proved developed and

(*Continued*)

Exhibit P8-13.1 *continued*

undeveloped reserves of approximately 7,520,690 million cubic feet of gas equivalent, including approximately 103,323 thousand barrels of oil and approximately 6,900,754 million cubic feet of natural gas. It also owned interests in approximately 30,600 producing oil and gas wells, as of the above date.

Devon Energy

Devon Energy Corporation engages primarily in the exploration, development, and production of oil and gas. It owns oil and gas properties located principally in the United States and Canada. The company's US operations are focused in the Permian Basin, the Mid-Continent, the Rocky Mountains, and onshore and offshore Gulf Coast regions; Canadian properties are focused in the western Canadian sedimentary basin in Alberta and British Columbia. Devon Energy also owns properties located in Azerbaijan, China, and Egypt, as well as areas in West Africa, including Equatorial Guinea, Gabon, and Côte d'Ivoire. In addition, the company markets and transports oil, gas, and natural gas liquids; it constructs and operates pipelines, storage and treating facilities, and gas processing plants. As of December 31, 2005, its estimated proved reserves were 2,112 million barrels of oil equivalent. Devon Energy sells its gas production to various customers, including pipelines, utilities, gas marketing firms, industrial users, and local distribution companies.

Apache

Apache Corporation engages in the exploration, development, and production of natural gas, crude oil, and natural gas liquids, primarily in North America. It has exploration and production interests in the Gulf of Mexico, the Gulf Coast, east Texas, the Permian Basin, and the western Sedimentary Basin of Canada. The company also holds exploration and production interests onshore in Egypt, offshore in Western Australia, offshore in the United Kingdom in the North Sea, offshore in the People's Republic of China, and onshore in Argentina. As of December 31, 2005, it had total estimated proved reserves of 976 million barrels of crude oil, condensate, and natural gas liquids, as well as 6.8 trillion cubic feet of natural gas.

However, at an analysts' meeting, CEO Mulva hinted that the price ConocoPhillips paid for Burlington might be viewed as high by some:

> In terms of mergers and acquisitions, it really becomes more and more of a seller's market, and terms and conditions are not that attractive to buyers. (Source: http://news.softpedia.com/news/ConocoPhillips-Plans-To-Acquire-Burlington-14628.shtml)

Your task is to answer the following basic question: "Is Burlington Resources worth the $35.6 billion offered by ConocoPhillips?" Although you are new to the exploration and production (E&P) industry, you have quickly learned that the method of multiples, or market-based comparables, and specifically the ratio of enterprise value (EV) to EBITDAX are typically used as benchmarks to value E&P companies. In this context, EBITDAX stands for "earnings before interest, taxes, depreciation and amortization, and exploration expenses." EBITDAX differs from EBITDA in that it adds back exploration expenses in addition to depreciation and amortization—hence the term *EBITDAX*.

a. Using the method of multiples based on enterprise value to EBITDAX, the P/E ratio, and the enterprise value to EBITDA ratio, what should the acquisition price be for Burlington Resources shares? Use the following companies as comparables for your analysis: Chesapeake Energy, XTO Energy, Devon Energy, and Apache. Year-end 2004 balance sheets and income statement summary information as well as market capitalization data are provided in Exhibit P8-13.1 (pp. 307–310) for Burlington Resources and each of the comparable firms.

b. Which of the four firms used as comparables do you think is the best comparison firm for Burlington Resources? Why?

c. Based on your analysis of comparables, did ConocoPhillips pay too much or find a bargain? Explain your answer.

d. What additional information would help you with this analysis?

PROBLEM 8-14 **MINI-CASE** DICK'S SPORTING GOODS IPO[19]

Setting: It is early in October 2002, and your investment bank has been hired by the management team at Dick's Sporting Goods (DKS) to determine a valuation/offering price for their stock's IPO.

About Dick's Sporting Goods: DKS, headquartered in Pittsburgh, Pennsylvania, was founded when Dick Stack opened his first store in 1948 with $300 from his grandmother's cookie jar. This company is growing rapidly and plans to use the IPO proceeds for store openings and acquisitions. DKS operates more than 130 stores in twenty-five states, primarily in the eastern United States. The store format is a large big-box store containing smaller shops featuring sporting goods, apparel, and footwear for activities ranging from football and golf to hunting and camping. Besides brands such as Nike and Adidas, Dick's carries Ativa, Walter Hagen, and others exclusive to the company. At the time of the IPO, the DKS management team included the founder's son, Ed, who holds 37% ownership in the company, and the investment firm Vulcan Ventures (founded by

[19]

Exhibit P8-14.1 **Twelve-Month Indexed Stock Performance of Sporting Goods Retailers**

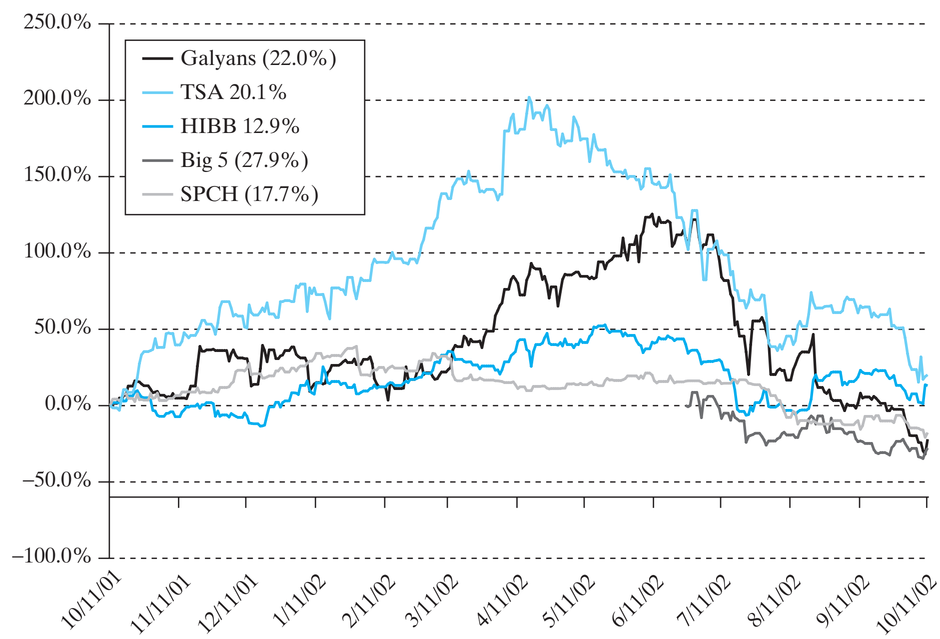

Exhibit P8-14.2 **Twelve-Month Indexed Stock Performance for Sporting Goods Retailer Market Comparable Group Versus the Major Indices**

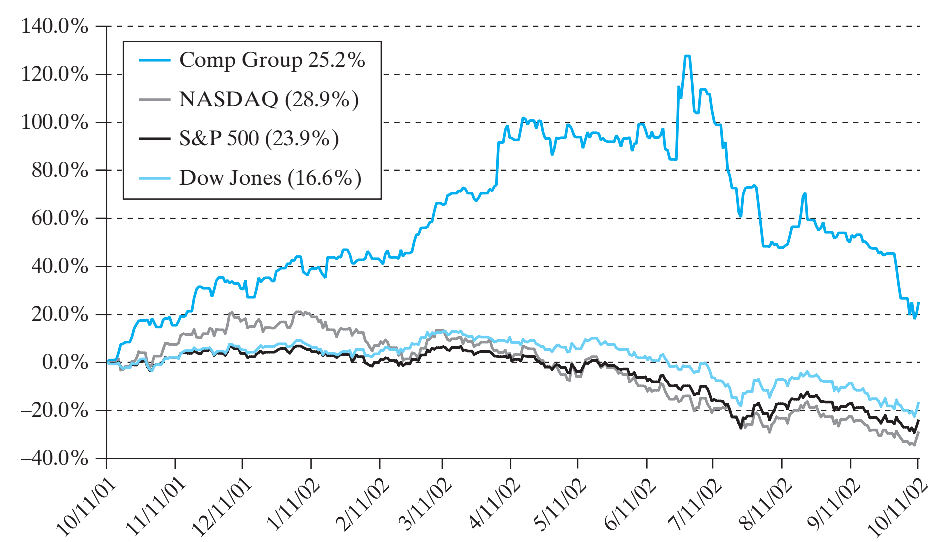

Exhibit P8-14.3 Dick's Sporting Goods Twelve-Month Performance

Dick's Sporting Goods financial data ($ millions)	
Revenues	$1,173.794
Gross profit	$ 298.453
EBIT	$ 55.899
Depreciation and amortization	$ 13.499
EBITDA	$ 69.398
Balance sheet data 8/3/02	
Checks drawn	$ 33.584
Current portion of long-term debt	$ 0.211
Revolving bank line of credit	$ 90.299
Long-term debt and capital leases	$ 3.466
Total debt	$ 127.560
Cash	$ 13.874
Stockholders' equity	$ 78.984

former Microsoft executive Paul Allen), which owns 12% of DKS as a result of a private equity investment.

Industry/Market Overview: With the rise of big-box retailers, sporting goods retailers were consolidating. In 1997 and 2001, Gart Sports Company (GRTS) acquired Sport Mart Inc. and OSH Sporting Goods, respectively. Private equity and venture capital firms held equity investments within the industry. DKS was the first retailer to launch an IPO in three months; from the beginning of July 2002 until the time of offering, it had been the lowest combined IPO tally since the second quarter of 1978. In 2002, other retail IPOs had mixed success. Big 5 Sporting Goods' stock price had declined by 23% because its private equity investor, Leonard Green & Partners LP, raised $105 million in June 2002. Market conditions for equity capital raises were unfavorable, and during the DKS road show, many of the institutional investors expressed concerns that the suggested IPO range of $15 to $18 per share was too high.

VALUATION ASSIGNMENT

a. Based on the DKS financial data (Exhibit P8-14.3) and sporting goods retailer market comparables valuation (Exhibit P8-14.4), estimate an implied equity valuation for the firm for its initial public offering. Calculate an implied equity valuation range based on the comparable enterprise-valuation multiples (EV/Revenue, EV/EBIT, EV/EBITDA). Determine an IPO price range for an estimated 9.47 million shares of equity outstanding.

b. In your opinion, are the selected publicly traded sporting goods companies shown in Exhibit P8-14.4 good choices for market comparables for DKS? Why or why not?

Exhibit P8-14.4 **Sporting Goods Retailer Market Comparables Valuation**[20, 21]

Sporting Goods Retailers	Ticker	Stock Price 10/9/2002	% Change from 12-Month Low	% Change from 12-Month High	Calendar EPS[a] 2002E	Calendar EPS[a] 2003E	Secular Growth Rate[a]	Calendar P/E Multiples 2002E	Calendar P/E Multiples 2003E
Galyan's Trading Co.	GLYN	$ 7.25	0.0%	(68.8%)	$1.06	$1.32	23%	6.8×	5.5×
Gart Sports Co.	GRTS	$14.64	20.8%	(61.2%)	$1.80	$2.10	18%	8.1×	7.0×
Hibbett Sporting Goods	HIBB	$18.89	17.1%	(33.7%)	$1.35	$1.62	20%	14.0×	11.7×
Sport Chalet	SPCH	$ 6.12	0.0%	(43.1%)	$0.71	$0.87	14%	8.6×	7.0×
The Sports Authority	TSA	$ 4.15	1.7%	(71.9%)	$0.66	$0.76	13%	6.3×	5.5×
Big 5 Sporting Goods	BGFV	$ 8.60	0.0%	(39.8%)	$1.09	$1.25	15%	7.9×	6.9×
Average			**6.6%**	**(53.1%)**			**17%**	**8.6×**	**7.2×**
Median			**0.9%**	**(52.1%)**			**16%**	**8.0×**	**6.9×**

Sporting Goods Retailers	LTM Ended	Market Value	Enterprise Value	Enterprise Value/LTM Revenue	Enterprise Value/LTM EBITDA	Enterprise Value/LTM EBIT	Debt/ Total Cap	LTM Margins Gross	LTM Margins EBITDA	LTM Margins EBIT
Galyan's Trading Co.	7/02	$123.50	$123.50	0.2×	3.0×	4.6×	6%	30%	8%	5%
Gart Sports Co.	7/02	$178.50	$313.00	0.3×	6.2×	9.4×	44%	26%	5%	3%
Hibbett Sporting Goods	7/02	$189.90	$191.70	0.7×	7.0×	9.2×	6%	31%	10%	8%
Sport Chalet	6/02	$ 40.40	$ 45.60	0.2×	4.0×	7.3×	14%	28%	5%	3%
The Sports Authority	7/02	$136.20	$331.90	0.2×	4.9×	12.4×	59%	2%	5%	2%
Big 5 Sporting Goods	6/02	$186.40	$327.40	0.5×	5.8×	7.0×	105%	35%	9%	7%
Average				**0.37×**	**5.2×**	**8.3×**	**39%**	**25%**	**7%**	**5%**
Median				**0.27×**	**5.4×**	**8.3×**	**29%**	**29%**	**7%**	**4%**

[a]Annualized three-year EPS growth rate.

LTM = latest twelve months, gross (LTM) margin = gross profit/revenues, EBITDA (LTM) margin = EBITDA/revenues, EBIT (LTM) margin = EBIT/revenues.

[20] Twelve-month valuation for the company as of 10/9/02; EPS and growth forecast per First Call analyst consensus.

[21] Financial data has been normalized for unusual and nonrecurring items.

CHAPTER 9

Enterprise Valuation

Chapter Overview

In this chapter, we review the basics of business, or enterprise, valuation. Our focus is on the *hybrid valuation approach* that combines discounted cash flow (DCF) analysis (discussed in Chapters 2–5) with relative valuation (introduced in Chapter 8). We decompose the enterprise-valuation problem into two steps: The first step involves the valuation of a business's planning period cash flows spanning a three- to ten-year period, and the second step involves the calculation of the *terminal value,* which is the value of all cash flows that follow the planning period. Pure DCF valuation models use DCF analysis to analyze the value of the planning period and terminal-value cash flows, whereas the hybrid valuation model we discuss utilizes DCF analysis to value the planning period cash flows and an earnings before interest, taxes, depreciation, and amortization (EBITDA) multiple to estimate the terminal value.

9.1 Introduction

In this chapter, we focus our attention on what is generally referred to as enterprise valuation, which is the valuation of a business or going concern. An important distinction between a business and an individual project is that, while projects may have finite lives, a business can conceivably last forever. The approach that we recommend, which we refer to as the hybrid approach, recognizes that forecasting cash flows into the foreseeable future poses a unique challenge. To deal with this forecasting problem, analysts typically make explicit and detailed forecasts of firm cash flows for only a limited number of years (often referred to as the *planning period*) and estimate the value of all remaining cash flows as a *terminal value,* at the end of the planning period.

The terminal value can be estimated in one of two ways. The first method is a straightforward application of DCF analysis using the Gordon growth model. As we discussed in earlier chapters, this approach requires an estimate of both a growth rate and a discount rate. The second method applies the multiples approach we discussed in the last chapter; typically, the terminal value is determined as a multiple of the projected end-of-planning-period EBITDA. When this latter approach is used to evaluate the terminal value, and DCF is used to evaluate the planning period cash flows, the model is no longer a pure DCF model but becomes a hybrid approach to enterprise valuation.

The enterprise-valuation approach described in this chapter is used in a number of applications, including acquisitions, which we consider in the example highlighted in this chapter; initial public offerings, where firms go public and issue equity for the first time (which we described in the previous chapter); "going private" transactions (which we will consider in the next chapter); spin-offs and carve-outs, where the division of a firm becomes a legally separate entity; and, finally, the valuation of a firm's equity for investment purposes.

In most applications, analysts use a single discount rate—the weighted average cost of capital (WACC) of the investment—to discount both the planning period cash flows and the terminal value. This approach makes sense if the financial structure and the risk of the investment are relatively stable over time. However, analysts frequently need to estimate the enterprise value of a firm that is experiencing some sort of transition, and in these cases the firm's capital structure is often expected to change over time. Indeed, firms are often acquired using a high proportion of debt, which is then paid down over time until the firm reaches what is considered a target capital structure. In these cases, the assumption of a fixed WACC is inappropriate, and we recommend the use of a variant of the DCF model known as the *adjusted present value model,* which we describe later in this chapter.

It should be noted that when firms acquire existing businesses, they typically plan on making changes in the business's operating strategy. This requires that the potential acquirer value the business given both its current strategy as well as the proposed new strategy. Valuing a publicly traded firm based on its current strategy can be viewed as a way to validate the valuation model—if the estimated value does not equal the firm's actual value, then the analyst may want to re-evaluate the model. When the model passes this reality check, value scenarios where the firm's operating strategy is changed following the acquisition can then be evaluated to determine whether the new strategy creates additional value. To help answer this question, sensitivity analysis can be deployed to determine the situations in which this additional value is indeed realized.

The chapter is organized as follows: Section 9.2 introduces the notion of estimating a firm's or business unit's enterprise value using the hybrid/multiples approach. Section 9.3 introduces the adjusted present value (APV) model, which is an alternative model that does not require that the firm's capital structure remain constant over the foreseeable future. We close our discussion of enterprise valuation with summary comments in Section 9.4.

9.2 Using a Two-Step Approach to Estimate Enterprise Value

We noted in the chapter introduction that forecasting firm cash flows into the foreseeable future is a challenging task; for that reason, analysts typically break the future into two segments: a finite number of years, known as the planning period, and all years thereafter. (See the Practitioner Insight box titled Enterprise-Valuation Methods Used on Wall Street.) Consequently, the application of the DCF model to the estimation of enterprise value can best be thought of as the sum of the two terms

PRACTITIONER INSIGHT

Enterprise-Valuation Methods Used on Wall Street: An Interview with Jeffrey Rabel*

In broad brush terms there are three basic valuation methodologies used throughout the investment banking industry: trading or comparable company multiples, transaction multiples, and discounted cash flows. Emphasis on a particular methodology varies depending on the particular setting or type of transaction. For equity transactions such as the pricing of an initial public offering (IPO), relative valuation based on multiples of market comparables (firms in the same or related industries, as well as firms that have been involved in recent similar transactions) is the preferred approach. The reason for the emphasis on this type of valuation is that the company will have publicly traded equity and thus investors will be able to choose whether to buy said company or any of the other companies that are "peers."

A key consideration in relative valuation analysis is the selection of a set of comparable firms. For example in the Hertz IPO, we not only looked at the relative prices of car rental firms (Avis, Budget, etc.) but also considered industrial equipment leasing companies (United Rental, RSC Equipment, etc.) because this was a growing piece of Hertz's business model. We also looked at travel-related companies, as a large part of the Hertz rental car business is driven by airline travel. Some also believed that Hertz, because of its strong brand name recognition, should be compared to valuation multiples of a set of companies with strong brand recognition, including firms such as Nike or Coke. Obviously, selection of a comparable group of firms and transactions is critical when carrying out a relative valuation because different comparable sets trade at different multiples and this affects the valuation estimate.

In merger and acquisition (M&A) analysis involving a strategic buyer (typically another firm in the same or a related industry) or a financial buyer such as a private equity firm (see Chapter 10 for further discussion), the second type of relative valuation method—transaction multiples—is used in combination with discounted cash flows (DCFs). The reason for the focus on a transaction multiple is the fact that transaction multiples represent what other buyers have been willing to pay for similar companies or companies with related lines of business. The transaction multiples are used in combination with the DCF approach, as DCF allows the buyers to value the acquisition based on their forecast of its performance under their assumptions about how the business will be run.

DCF valuation methods vary slightly from one investment bank to another; however, the typical approach to enterprise valuation is a hybrid approach consisting of forecasting cash flows to evaluate near-term projections and relative valuation to estimate a terminal value. The analysis typically involves a five-year forecast of the firm's cash flows, which are discounted using an estimate of the firm's weighted average cost of capital. Then the value of cash flows that extend beyond the end of the planning period are estimated using a terminal value that is calculated based on a multiple of a key firm performance attribute such as EBITDA. The terminal-value estimate is frequently stress-tested using a constant growth rate with the Gordon growth model to assess the reasonableness of the implied growth rate reflected in the terminal-value multiple.

The final valuation approach we use [is] a variant of the DCF approach that is used where an M&A transaction involves a financial sponsor (generally a private equity firm such as Blackstone, Cerberus, or KKR). Financial buyers are primarily driven by the rate of return they earn on their investor's money, so the valuation approach they use focuses on the IRR [internal rate of return] of the transaction. The basic idea is to arrive at a set of short-term cash flow forecasts that the buyer is comfortable with, estimate a terminal value at the end of the forecast period (typically 5 years), and then determining IRRs by varying the acquisition price.

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found in Equation (9.1). The first term represents the present value of a set of cash flows spanning a finite number of years, referred to as the *planning period (PP)*.

$$\begin{matrix}\text{Enterprise}\\ \text{Value}\end{matrix} = \begin{matrix}\text{Present Value}\\ \text{of the Planning}\\ \text{Period (PP) Cash Flows}\end{matrix} + \begin{matrix}\text{Present Value}\\ \text{of the Terminal}\\ \text{Value}\end{matrix} \tag{9.1}$$

The second term is the present value of the estimated terminal value (TV_{PP}) of the firm at the end of the planning period. As such, the terminal value represents the present value of all the cash flows that are expected to be received beyond the end of the planning period. As the Technical Insight box illustrates, the terminal-value estimate is generally quite important and can often represent over 50% of the value of the enterprise.

Example: Immersion Chemical Corporation Acquires Genetic Research Corporation

To illustrate our enterprise-valuation approach, consider the valuation problem faced by the Immersion Chemical Corporation at the end of 2014. Immersion provides products and services worldwide to the life sciences industry and operates in four businesses: human health, biosciences, animal health/agriculture, and specialty and fine chemicals. The company's overall strategy is to focus on niche markets that have global opportunities, develop its strong customer relations, and enhance its new-products pipeline. In an effort to expand into biopharmaceuticals, Immersion is considering the acquisition of Genetics Research Corporation (GRC), which will be integrated into Immersion's Specialty and Fine Chemicals division.

TECHNICAL INSIGHT

Do We Want a Long or Short Planning Period?

In practice, valuation analysts use planning periods anywhere from three to ten years in length. The length of the planning period is influenced by the answers to two questions: First, what is the quality of available valuation comps? If the analyst has comps that are very similar to the investment being valued, a shorter planning period is generally recommended. By using a shorter planning horizon, the analyst puts more weight on the continuing value, which in our hybrid model means that the comp is given more weight in the valuation process. Second, are the cash flows in the planning period likely to be different than the cash flows of the comp, and can they be estimated accurately? An ideal application of the hybrid method is one where there is a three-year transition period and where the investment may generate cash flows that are very different than the comp, but after the three-year transition, the valued investment and the comp are likely to generate very similar cash flows. In such a case, the analyst would use a three-year planning period. On the other hand, if the business being valued does not have good comps, then it might be necessary to forecast out ten or more years before applying a multiple to the valuation of the firm's continuing value.

Immersion can acquire GRC for a cash payment of $100 million, which is equal to a multiple of six times GRC's 2014 EBITDA. Immersion will also be assuming GRC's accounts payable and accrued expenses, which total $9,825,826, so the book value of the GRC acquisition would be $109,825,826 (see Table 9-1). To finance the GRC acquisition, Immersion will borrow $40 million in nonrecourse debt and will need to raise $60 million in equity.[1] Based on conversations with its investment banker, Immersion's management has learned that the $100 million acquisition cost is well within the range of five to seven times EBITDA that has recently been paid for similar firms. As the analysis below indicates, this price is also in line with

Table 9-1 Pre- and Postacquisition Balance Sheets for GRC

	Preacquisition 2014	Postacquisition 2014
Current assets	$ 41,865,867	$ 41,865,867
Gross property, plant, and equipment	88,164,876	88,164,876
Less: accumulated depreciation	(41,024,785)	(41,024,785)
Net property, plant, and equipment	$ 47,140,092	$ 47,140,092
Goodwill	—	20,819,867
Total	$ 89,005,959	$ 109,825,826
Current liabilities	$ 9,825,826	$ 9,825,826
Long-term debt	36,839,923	40,000,000
Total liabilities	$ 46,665,749	$ 49,825,826
Common stock (par)	290,353	400,000
Paid-in capital	20,712,517	59,600,000
Retained earnings	21,337,340	—
Common equity	$ 42,340,210	$ 60,000,000
Total	$ 89,005,959	$ 109,825,826
Acquisition financing—		
Assumed payables and accrued expenses	$ 9,825,826	
Long-term debt (40% of enterprise value)	40,000,000	
Sale of common stock	60,000,000	
Total	$ 109,825,826	
Shares issued ($1.00 par value)	400,000	
Net proceeds	$ 60,000,000	
Price per share	$ 150.00	

[1] The remaining $9,825,826 represents the value of GRC's accounts payable and accrued expenses, which will be assumed by Immersion.

Immersion's own DCF analysis of GRC, given cash flow projections based on its current operating strategy.

Table 9-1 contains the pre- and postacquisition balance sheets for GRC, which indicate that Immersion is paying just over $20 million more than GRC's book value for the business. Note that the $20,819,867 difference between the purchase price and GRC's preacquisition (book value) total assets is recorded as goodwill on the revised balance sheet.[2] GRC's postacquisition balance sheet contains $40 million in long-term debt (on which it pays 6.5% interest) plus $60 million in common equity (common stock at par plus paid-in capital). The remainder of the right-hand side of the balance sheet consists of current liabilities that consist entirely of payables and accrued expenses, which are non-interest-bearing liabilities. Thus, after it is acquired by Immersion, GRC will have a total of $100 million in invested capital, of which 40% is debt and 60% is equity.

Valuing GRC Using DCF Analysis

In Chapter 2, we laid out the following three-step process for using DCF analysis, which we will now apply to the valuation of GRC:

Step 1: Estimate the amount and timing of the expected cash flows.
Step 2: Estimate a risk-appropriate discount rate.
Step 3: Calculate the present value of the expected cash flows, or enterprise value.

Table 9-2 details our analysis of the DCF evaluation of the enterprise value of GRC under the assumption that the firm's operations continue as they have in the past. We refer to this as the *status quo strategy.*

In the following discussion, we expand on each of the three steps of the DCF analysis.

Step 1: *Estimate the amount and timing of the expected cash flows.* In panels (a) and (b) of Table 9-2, we present the pro forma financial statements and cash flow projections for GRC that are required to complete step 1 of a DCF analysis. The cash flow projections consist of planning period cash flows spanning the period from 2015 to 2020 and terminal-value estimates based on cash flow projections for 2021 and beyond. In addition, panel (a) contains the pro forma financial statements on which these projections are built. The pro forma income statements assume that GRC maintains its operations as it has in the past (i.e., under a status quo strategy) and reflect an assumed rate of growth in revenues of 4% per year during the planning period.

The asset levels found in the pro forma balance sheets reflect the assets that GRC needs to support the projected revenues. The initial financing for the acquisition was presented earlier in Table 9-1. Any additional financing requirements are assumed to be raised by first retaining 80% of GRC's earnings and then raising any additional funds the firm requires using long-term debt. A quick review of the pro forma balance sheets found in panel (a) of Table 9-2, however, indicates that, under the status quo strategy, GRC's long-term debt actually declines from $40 million at the end of 2014 to $23,608,049 by 2020. This decrease reflects the fact that, given our projections, the firm's retention of future earnings is more

[2] By including all the purchase premium as goodwill, we are assuming that the appraised value of GRC's assets is equal to its book value.

Table 9-2 Estimating GRC's Enterprise Value Using DCF Analysis (Status Quo Strategy)

Panel (a) Step 1: Estimate the Amount and Timing of the Planning Period Future Cash Flows

Planning Period Pro Forma Financial Statements

	Preacquisition	Postacquisition	Pro Forma Income Statements					
	2014	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Revenues	$ 80,000,000	$ 80,000,000	$ 83,200,000	$ 86,528,000	$ 89,989,120	$ 93,588,685	$ 97,332,232	$ 101,225,521
Cost of goods sold	(45,733,270)	(45,733,270)	(50,932,000)	(52,629,280)	(54,394,451)	(56,230,229)	(58,139,438)	(60,125,016)
Gross profit	$ 34,266,730	$ 34,266,730	$ 32,268,000	$ 33,898,720	$ 35,594,669	$ 37,358,456	$ 39,192,794	$ 41,100,506
General and administrative expense	(17,600,000)	(17,600,000)	(17,984,000)	(18,383,360)	(18,798,694)	(19,230,642)	(19,679,868)	(20,147,063)
Depreciation expense	(6,500,000)	(6,500,000)	(7,856,682)	(7,856,682)	(7,856,682)	(7,856,682)	(7,856,682)	(7,856,682)
Net operating income	$ 10,166,730	$ 10,166,730	$ 6,427,318	$ 7,658,678	$ 8,939,292	$ 10,271,131	$ 11,656,244	$ 13,096,761
Interest expense	(2,523,020)	(2,523,020)	(2,600,000)	(2,549,847)	(2,453,680)	(2,307,941)	(2,108,865)	(1,852,465)
Earnings before taxes	$ 7,643,710	$ 7,643,710	$ 3,827,318	$ 5,108,831	$ 6,485,612	$ 7,963,190	$ 9,547,379	$ 11,244,296
Taxes	(1,910,928)	(1,910,928)	(956,830)	(1,277,208)	(1,621,403)	(1,990,798)	(2,386,845)	(2,811,074)
Net income	$ 5,732,783	$ 5,732,783	$ 2,870,489	$ 3,831,623	$ 4,864,209	$ 5,972,393	$ 7,160,534	$ 8,433,222

	Preacquisition	Postacquisition	Pro Forma Balance Sheets					
	2014	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Current assets	$ 41,865,867	$ 41,865,867	43,540,502	45,282,122	47,093,407	48,977,143	50,936,229	52,973,678
Gross property, plant, and equipment	88,164,876	88,164,876	96,021,558	103,878,240	111,734,922	119,591,604	127,448,286	135,304,968
Less: accumulated depreciation	(41,024,785)	(41,024,785)	(48,881,467)	(56,738,149)	(64,594,831)	(72,451,513)	(80,308,194)	(88,164,876)
Net property, plant, and equipment	$ 47,140,092	$ 47,140,092	$ 47,140,092	$ 47,140,092	$ 47,140,092	$ 47,140,092	$ 47,140,092	$ 47,140,092
Goodwill	—	20,819,867	20,819,867	20,819,867	20,819,867	20,819,867	20,819,867	20,819,867
Total	$ 89,005,959	$ 109,825,826	$ 111,500,461	$ 113,242,081	$ 115,053,366	$ 116,937,102	$ 118,896,188	$ 120,933,637

(*Continued*)

Table 9-2 *continued*

Current liabilities	$ 9,825,826	$ 9,825,826	$ 9,975,651	$ 10,131,469	$ 10,293,520	$ 10,462,053	$ 10,637,327	$ 10,819,613
Long-term debt	36,839,923	40,000,000	39,228,419	37,748,922	35,506,789	32,444,078	28,499,462	23,608,049
Total liabilities	$ 46,665,749	$ 49,825,826	$ 49,204,070	$ 47,880,392	$ 45,800,309	$ 42,906,131	$ 39,136,790	$ 34,427,661
Common stock (par)	290,353	400,000	400,000	400,000	400,000	400,000	400,000	400,000
Paid-in capital	20,712,517	59,600,000	59,600,000	59,600,000	59,600,000	59,600,000	59,600,000	59,600,000
Retained earnings	21,337,340	—	2,296,391	5,361,689	9,253,057	14,030,971	19,759,398	26,505,976
Common equity	$ 42,340,210	$ 60,000,000	$ 62,296,391	$ 65,361,689	$ 69,253,057	$ 74,030,971	$ 79,759,398	$ 86,505,976
Total	$ 89,005,959	$ 109,825,826	$ 111,500,461	$ 113,242,081	$ 115,053,366	$ 116,937,102	$ 118,896,188	$ 120,933,637

Planning Period Cash Flow Estimates

	Projected Firm FCFs					
	2015	2016	2017	2018	2019	2020
Net operating income	$ 6,427,318	7,658,678	$ 8,939,292	$ 10,271,131	$ 11,656,244	$ 13,096,761
Less: taxes	(1,606,830)	(1,914,670)	(2,234,823)	(2,567,783)	(2,914,061)	(3,274,190)
Net operating profit after taxes (NOPAT)	$ 4,820,489	$ 5,744,009	$ 6,704,469	$ 7,703,349	$ 8,742,183	$ 9,822,571
Plus: depreciation	7,856,682	7,856,682	7,856,682	7,856,682	7,856,682	7,856,682
Less: capital expenditures (CAPEX)	(7,856,682)	(7,856,682)	(7,856,682)	(7,856,682)	(7,856,682)	(7,856,682)
Less: changes in net working capital	(1,281,602)	(1,332,866)	(1,386,180)	(1,441,628)	(1,499,293)	(1,559,264)
Equals firm FCF	$ 3,538,887	$ 4,411,143	$ 5,318,289	$ 6,261,721	$ 7,242,890	$ 8,263,306

Panel (b) Step 1 (continued): Terminal-Value Cash Flow Estimate

Method 1—DCF Using the Gordon Growth Model

Terminal-Value Multiples from the Gordon Model

	Growth Rates (g)			
Discount Rates	**0%**	**1%**	**2%**	**3%**
8.3%	12.05	13.84	16.19	19.43
8.8%	11.36	12.95	15.00	17.76
9.3%	10.75	12.17	13.97	16.35
9.8%	10.20	11.48	13.08	15.15

Terminal-Value Estimates (for FCFs Received in 2021 and Beyond)

	Growth Rates (g)			
Discount Rates	**0%**	**1%**	**2%**	**3%**
8.3%	$ 99,557,908	$ 114,327,938	$ 133,786,865	$ 160,588,784
8.8%	$ 93,901,209	$ 106,999,224	$ 123,949,596	$ 146,744,924
9.3%	$ 88,852,757	$ 100,553,487	$ 115,459,897	$ 135,098,501
9.8%	$ 84,319,453	$ 94,840,221	$ 108,058,622	$ 125,164,788

Method 2—Multiples Using Enterprise-Value to EBITDA Ratio

Terminal-Value Estimates

Enterprise Value / EBITDA	Terminal Value
5.00	$104,767,215
5.50	115,243,936
6.00	125,720,658
6.50	136,197,379
7.00	146,674,101

Panel (c) Step 2: Estimate a Risk-Appropriate Discount Rate

- *Cost of debt*—The estimated borrowing rate is 6.5% with a marginal tax of 25%, resulting in an after-tax cost of debt of 4.875%.
- *Cost of equity*—An average industry unlevered equity beta of .89 implies a levered equity beta for GRC of 1.28, assuming a target debt ratio of 40% and a debt beta of .30. Using the capital asset pricing model (CAPM) with a ten-year Treasury bond yield of 5.02% and a market risk premium of 5% produces an estimate of the levered cost of equity of 11.42%.
- *Weighted average cost of capital* (WACC)—Using the target debt-to-value ratio of 40%, the WACC is approximately 8.8%.

Panel (d) Step 3: Calculate the Present Value of Future Cash Flows

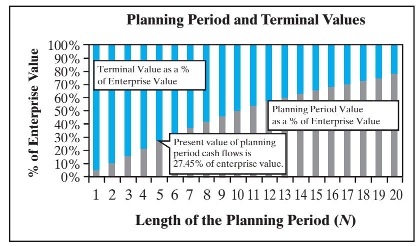
	Present Values of Expected Future Cash Flows				
		Terminal Value		Enterprise Value	
Discount Rate	**Planning Period FCF**	**Method 1**	**Method 2**	**Method 1**	**Method 2**
7.8%	$26,201,884	$78,986,073	$80,112,266	$105,187,958	$106,314,150
8.8%	**$25,309,857**	**$74,729,086**	**$75,794,582**	**$100,038,943**	**$101,104,439**
9.8%	$24,461,738	$70,737,378	$71,745,960	$ 95,199,116	$ 96,207,698

TECHNICAL INSIGHT

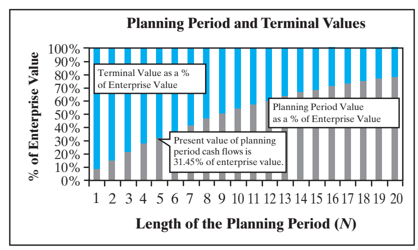
Terminal Values, Expected Growth Rates, and the Cost of Capital

When estimating value using a planning period and a terminal value, how much of the value can be attributed to each of these components? To answer this question, consider the situation where a firm's FCFs are expected to grow at a rate of 12% per year for a period of five years, followed by a 2% rate of growth thereafter. If the cost of capital for the firm is 10%, then the relative importance of the planning period cash flows and the terminal-value cash flows for different planning periods is captured in the following figure.

If the analyst uses a five-year planning period, then the present value of the planning period cash flows in this example constitutes 18.90% of the value of the enterprise, leaving over 81.10% of enterprise value in the terminal value. Similarly, if a three-year planning period is used, then the terminal value constitutes 83.77% of the enterprise-value estimate, leaving only 16.23% for the planning period. The key observation we can make from this analysis is that the terminal value is at least 50% of the value of the firm for all commonly used planning periods (i.e., three to ten years).



The previous example was obviously a very high-growth firm. It stands to reason, then, that the terminal value may be less important for more stable (low-growth) firms. It turns out (as the figure found below indicates) that even for a very low- and stable-growth firm whose cash flows grow at 2% per year forever, the terminal value is still the dominant component of the enterprise-value estimate for the typical three- to ten-year planning period. In this case, if the firm has a constant rate of growth of 2% per year for all years, a five-year planning period results in 31.45% of the enterprise value coming from the cash flows in the planning period, which leaves 68.55% of enterprise value in the terminal value.



The message is very clear: The analyst must spend significant time estimating the firm's terminal value. In fact, even for a long (by industry standards) planning period of ten years, the terminal value for the slow-growth firm above is still roughly half (47%) of the firm's enterprise value.

How important should the terminal value be to the enterprise value of your firm? As the examples we've used above suggest, the answer varies with the firm's growth prospects and the length of the planning period used in the analysis. In general, terminal value increases in importance with the growth rate of firm cash flows and decreases with the length of the planning period.

than adequate to meet its financing needs, which allows the firm to retire its long-term debt. Finally, GRC's estimated cash flows, also found in panel (a), indicate that, from 2015 through 2020, cash flows are expected to grow from \$3,538,887 to \$8,263,306.

Following the planning period cash flows, panel (b) includes two methods to estimate the terminal value of GRC, undertaken in 2020. The first method (Method 1) uses the Gordon growth model (introduced in Chapter 2) to estimate the present value of the firm's free cash flows (FCFs) beginning in 2021 and continuing indefinitely. Specifically, we estimate the terminal value in 2020 using Equation (9.2):

$$\begin{matrix}\text{Terminal}\\ \text{Value}_{2020}\end{matrix} = \frac{\text{FCF}_{2020}\left(1 + \begin{matrix}\text{Terminal}\\ \text{Growth Rate}(g)\end{matrix}\right)}{\left(\begin{matrix}\text{Cost of Capital}\\ (k_{\text{WACC}})\end{matrix} - \begin{matrix}\text{Terminal}\\ \text{Growth Rate}(g)\end{matrix}\right)} \tag{9.2}$$

To estimate the terminal value using this method, we assume that the cash flows the firm generates after the end of the planning period grows at a constant rate (g), which is less than the cost of capital (k_{WACC}). Recall from our discussion of multiples in Chapter 8 that Equation (9.2) can be interpreted as a multiple of firm FCF_{2020}, where the multiple is equal to the ratio of 1 plus the terminal growth rate divided by the difference in the cost of capital and the growth rate, that is:

$$\begin{matrix}\text{Terminal}\\ \text{Value}_{2020}\end{matrix} = \text{FCF}_{2020}\left(\frac{1+g}{k_{\text{WACC}} - g}\right) = \text{FCF}_{2020} \times \left(\begin{matrix}\text{Gordon Growth}\\ \text{Model Multiple}\end{matrix}\right)$$

In panel (b) of Table 9-2, we report a panel of Gordon growth model multiples that correspond to what Immersion's management thinks is a reasonable range of values for the discount rate and rate of growth in future cash flows. For example, for an 8.8% cost of capital and a 2% terminal growth rate, the multiple for a terminal value based on the Gordon growth model, $\left(\frac{1+g}{k_{\text{WACC}}-g}\right)$, is 15. Based on the estimated FCF_{2020} of \$8,263,306, this produces an estimate of the terminal value at the end of 2020 of \$123,949,596.

In addition to the DCF analysis of the terminal value, panel (b) of Table 9-2 provides an analysis that uses EBITDA multiples (method 2), as shown in Equation 9.3:

$$\begin{matrix}\text{Terminal}\\ \text{Value}_{2020}\end{matrix} = \text{EBITDA}_{2020} \times \begin{matrix}\text{EBITDA}\\ \text{Multiple}\end{matrix} \tag{9.3}$$

Multiples ranging from five to seven are reported in panel (b) of Table 9-2. Using a multiple of six (which is the multiple reflected in the asking price for GRC) times EBITDA_{2020} (i.e., the sum of net operating income and depreciation expense for 2020, which equals \$20,953,443) produces an estimated terminal value for GRC in 2020 of $\$125{,}720{,}658 = 6 \times (\$13{,}096{,}761 + 7{,}856{,}682)$. It should be noted that the EBITDA multiple and the free cash flow multiple generate very similar terminal-value estimates when there are no extraordinary capital expenditures or investments in net working capital. If this were not the case, the analyst would want to double-check his or her assumptions and attempt to reconcile the conflicting terminal-value estimates.

Step 2: *Estimate a risk-appropriate discount rate.* Because the debt financing for GRC is nonrecourse to Immersion, Immersion's finance staff members analyzed the cost of capital using the project financing method described in Chapter 5. Details supporting the calculation are provided in panel (c) of Table 9-2. The analysis resulted in an estimated cost of capital for GRC of 8.8%.

Step 3: *Calculate the present value of the expected cash flows, or enterprise value.* In panel (d) of Table 9-2, we estimate the enterprise value of GRC using the cash flow estimates from panel (a) and discounting them at the estimated cost of capital for GRC from panel (c), plus or minus 1%—8.8% (the estimated WACC), 7.8%, and 9.8%. The result is an array of enterprise-value estimates reflecting each of the methods used to estimate the terminal value and the range of cost of capital estimates. With the 8.8% cost of capital, the estimate of enterprise value is just slightly higher than $100 million. Indeed, based on the $100 million investment, and the cash flow forecast found in panel (a) of Table 9-2, the internal rate of return for the acquisition is 9.02%, using a relatively conservative EBITDA multiple (6) to compute the terminal value of the cash flows.

Based on this analysis, we can see that the acquisition is fairly priced, with an enterprise value very nearly equal to the $100 million in invested capital. In other words, this is essentially a zero net present value (NPV) investment. Given the uncertainties that naturally underlie the cash flow and discount rate estimates, we would not expect Immersion's managers to proceed with this acquisition unless they expect to make changes in the operating strategy of the business that will make the investment look more attractive. As we discuss below, Immersion's management does, in fact, wish to consider implementing changes.

Typically, a new owner considers changes in operating strategies following an acquisition. In this case, Immersion's management is considering a proposal that includes additional expenditures on capital equipment and marketing, with the hope of expanding GRC's market share. Given the economies of scale associated with manufacturing in this industry, the higher market share will lead to higher operating margins and an enhanced value for the acquired business. The question we need to answer then is, "Will these anticipated changes in fact increase the NPV of the investment?"

Valuing GRC Under the Growth Strategy

To evaluate the GRC acquisition under the assumed growth strategy, Immersion's analysts carefully revised GRC's projected cash flows and repeated the valuation analysis carried out for the status quo case. The results of this analysis are contained in Table 9-3. Panel (a) of the table presents GRC's most recent year's financial statements (for 2014, both pre- and postacquisition) and pro forma financial statements for the six-year planning period that spans 2015 through 2020.

The growth strategy involves increased expenditures on marketing as well as the addition of new manufacturing capacity. Specifically, the plan calls for spending an additional $3 million per year on advertising during 2015–2017, plus an additional $1 million per year on capital equipment during 2015–2020. Immersion's analysts expect the combined effect of these actions to double the planning period rate of growth in sales to 8% per year, compared to only 4% under the status quo strategy. After achieving the higher target market share in 2020, capital expenditures and marketing expenditures are expected to return to

Table 9-3 **Estimating GRC's Enterprise Value Using DCF Analysis (Growth Strategy)**

Panel (a) Step 1: Estimate the Amount and Timing of the Planning Period Future Cash Flows

Planning Period Pro Forma Financial Statements

	Pre-Acquisition	Post-Acquisition	Pro Forma Income Statements					
	2014	2014	2015	2016	2017	2018	2019	2020
Revenues	$ 80,000,000	$ 80,000,000	$ 86,400,000	$ 93,312,000	$ 100,776,960	$ 108,839,117	$ 117,546,246	$ 126,949,946
Cost of goods sold	(45,733,270)	(45,733,270)	(52,564,000)	(56,089,120)	(59,896,250)	(64,007,950)	(68,448,586)	(73,244,472)
Gross profit	$ 34,266,730	$ 34,266,730	$ 33,836,000	$ 37,222,880	$ 40,880,710	$ 44,831,167	$ 49,097,661	$ 53,705,473
General and administrative expense	(17,600,000)	(17,600,000)	(21,368,000)	(22,197,440)	(23,093,235)	(21,060,694)	(22,105,550)	(23,233,994)
Depreciation expense	(6,500,000)	(6,500,000)	(7,856,682)	(8,023,349)	(8,190,015)	(8,356,682)	(8,523,349)	(8,690,015)
Net operating income	$ 10,166,730	$ 10,166,730	$ 4,611,318	$ 7,002,091	$ 9,597,460	$ 15,413,791	$ 18,468,762	$ 21,781,465
Interest expense	(2,523,020)	(2,523,020)	(2,600,000)	(2,778,968)	(2,887,535)	(2,916,242)	(2,737,729)	(2,453,086)
Earnings before taxes	$ 7,643,710	$ 7,643,710	$ 2,011,318	$ 4,223,123	$ 6,709,925	$ 12,497,549	$ 15,731,034	$ 19,328,378
Taxes	(1,910,928)	(1,910,928)	(502,830)	(1,055,781)	(1,677,481)	(3,124,387)	(3,932,758)	(4,832,095)
Net income	$ 5,732,783	$ 5,732,783	$ 1,508,489	$ 3,167,342	$ 5,032,444	$ 9,373,162	$ 11,798,275	$ 14,496,284

	Pre-Acquisition	Post-Acquisition	Pro Forma Balance Sheets					
	2014	2014	2015	2016	2017	2018	2019	2020
Current assets	$ 41,865,867	$ 41,865,867	45,215,136	48,832,347	52,738,935	56,958,050	61,514,699	66,435,870
Gross property, plant, and equipment	88,164,876	88,164,876	97,021,558	106,044,907	115,234,922	124,591,604	134,114,953	143,804,968
less: Accumulated depreciation	(41,024,785)	(41,024,785)	(48,881,467)	(56,904,815)	(65,094,831)	(73,451,513)	(81,974,861)	(90,664,876)
Net property, plant, and equipment	$ 47,140,092	$ 47,140,092	$ 48,140,092	$ 49,140,092	$ 50,140,092	$ 51,140,092	$ 52,140,092	$ 53,140,092
Goodwill	—	20,819,867	20,819,867	20,819,867	20,819,867	20,819,867	20,819,867	20,819,867
Total	$ 89,005,959	$ 109,825,826	$ 114,175,095	$ 118,792,306	$ 123,698,894	$ 128,918,009	$ 134,474,653	$ 140,395,829

(*Continued*)

Table 9-3 *continued*

Current liabilities	$ 9,825,826	$ 9,825,826	$ 10,214,944	$ 10,628,033	$ 11,067,013	$ 11,533,953	$ 12,031,091	$ 12,560,843
Long-term debt	36,839,923	40,000,000	42,753,361	44,423,608	44,865,262	42,118,906	37,739,792	31,534,189
Total liabilities	$ 46,665,749	$ 49,825,826	$ 52,968,305	$ 55,051,642	$ 55,932,274	$ 53,652,860	$ 49,770,884	$ 44,095,032
Common stock (par)	290,353	340,353	340,353	340,353	340,353	340,353	340,353	340,353
Paid-in-capital	20,712,517	38,322,307	38,322,307	38,322,307	38,322,307	38,322,307	38,322,307	38,322,307
Retained earnings	21,337,340	21,337,340	22,544,131	25,078,005	29,103,960	36,602,489	46,041,110	57,638,136
Common equity	$ 42,340,210	$ 60,000,000	$ 61,206,791	$ 63,740,665	$ 67,766,620	$ 75,265,149	$ 84,703,769	$ 96,300,796
Total	$ 89,005,959	$ 109,825,826	$ 114,175,095	$ 118,792,306	$ 123,698,894	$ 128,918,009	$ 134,474,653	$ 140,395,829

Planning Period Cash Flow Estimates

	Projected Free Cash Flows					
	2015	**2016**	**2017**	**2018**	**2019**	**2020**
Net operating income	$ 4,611,318	7,002,091	$ 9,597,460	$ 15,413,791	$ 18,468,762	$ 21,781,465
Less: taxes	(1,152,830)	(1,750,523)	(2,399,365)	(3,853,448)	(4,617,191)	(5,445,366)
NOPAT	$ 3,458,489	$ 5,251,569	$ 7,198,095	$ 11,560,343	$ 13,851,572	$ 16,336,098
Plus: depreciation	7,856,682	8,023,349	8,190,015	8,356,682	8,523,349	8,690,015
Less: CAPEX	(8,856,682)	(9,023,349)	(9,190,015)	(9,356,682)	(9,523,349)	(9,690,015)
Less: changes in net working capital	(2,563,203)	(2,768,260)	(2,989,720)	(3,228,898)	(3,487,210)	(3,766,187)
Equals FCF	$ (104,715)	$ 1,483,309	$ 3,208,375	$ 7,331,446	$ 9,364,362	$ 11,569,912

Panel (b) Step 1 (continued): Terminal-Value Cash Flow Estimate

Method 1—DCF Using the Gordon Growth Model

Terminal-Value Estimates (for FCFs Received in 2021 and Beyond)

	Growth Rates (*g*)			
Discount Rates	**0%**	**1%**	**2%**	**3%**
7.8%	$148,332,204	$171,847,222	$203,470,865	$248,271,027
8.8%	$131,476,272	$149,815,527	$173,548,679	$205,465,678
9.8%	$118,060,326	$132,791,035	$151,298,849	$175,250,137
10.8%	$107,128,814	$119,240,929	$134,105,798	$152,782,171

Method 2—Multiples Using Enterprise Value to EBITDA Ratio

Terminal-Value Estimates

Enterprise Value / EBITDA	Terminal Value
5.00	$ 104,767,215
5.50	115,243,936
6.00	125,720,658
6.50	136,197,379
7.00	146,674,101

Panel (c) Step 2: Estimate a Risk-Appropriate Discount Rate

Based on the analysis presented in panel (c) of Table 9-1, GRC's WACC is estimated to be 8.8%.

Panel (d) Step 3: Calculate the Present Value of Future Cash Flows

	Present Values of Expected Future Cash Flows				
		Terminal Value		Enterprise Value	
Discount Rate	**Planning Period Firm FCF**	**Method 1**	**Method 2**	**Method 1**	**Method 2**
7.8%	$22,974,650	$129,656,592	$116,502,571	$152,631,242	$139,477,221
8.8%	$21,997,770	$104,629,182	$110,223,616	$126,630,094	$132,221,807
9.8%	$21,073,212	$ 86,342,860	$104,335,942	$107,416,072	$125,409,155

the status quo levels, and the expected growth rate of free cash flows for 2021 and beyond is assumed to be 2%, just as in the status quo case.

Comparing the cash flow projections for the status quo strategy found in panel (a) of Table 9-2 with those of the growth strategy in panel (a) of Table 9-3, we see that the growth strategy has the initial effect of reducing cash flows below status quo levels for 2015–2017. Beginning in 2018, however, the growth strategy expected cash flows exceed those of the status quo strategy ($7,331,446 for the growth strategy versus $6,261,721 for the status quo strategy) and continue to be higher for all subsequent years.

Because the growth strategy initially has lower cash flows than the status quo strategy but later generates much higher cash flows, its incremental value depends on the discount rate that is used to evaluate the strategy. In panel (c) of Table 9-3, we initially assume that the cost of capital for the growth strategy is the same as that for the status quo strategy (i.e., 8.8%). In this case, the enterprise-value estimates are dramatically higher than under the status quo strategy, producing an expected enterprise value of $126,630,094 when the Gordon growth model is used to estimate the terminal value (method 1 in panel [d] of Table 9-3) and $132,221,807 when a six-times-EBITDA multiple is used to estimate the terminal value.

However, the growth strategy is almost certainly more risky than the status quo strategy and should require a higher cost of capital. To evaluate how a higher cost of capital affects the value of the growth strategy, panel (d) of Table 9-3 presents values of the growth strategy cash flows with alternative discount rates. Although the value of the acquisition declines to $125,409,155, it is still higher than the $100 million acquisition price, even using a 9.8% discount rate, which is significantly higher than the 8.8% cost of capital we used to value the status quo strategy.

Sensitivity Analysis

The acquisition of GRC is a risky investment, so it is important that we perform a sensitivity analysis of the proposal. In this instance, we will limit ourselves to the use of breakeven sensitivity analysis, although, as we illustrated in Chapter 3, it is also useful to examine a simulation model that calculates the influence of the key value drivers.

We consider three important value drivers for the GRC acquisition under the growth strategy. The first relates to the cost of capital for the acquisition, and the second and third pertain to determinants of the level of the future cash flows: (1) the estimated rate of growth in GRC's cash flows during the planning period and (2) the terminal-value multiple used to value the post-planning-period cash flows. In the risk analysis that follows, we focus our attention solely on the valuation that uses the EBITDA multiple (method 2) to estimate the terminal value.

Sensitivity Analysis: Cost of Capital

The cost of capital, like all the value drivers, is always estimated with some error. In this instance, however, we have another reason to be concerned about the cost of capital estimate. The growth strategy is a riskier strategy than the status quo strategy, which means that the growth strategy cash flows should be discounted at a higher rate. Quantifying the amount by which the rate should be increased is likely to be difficult, but we can calculate the internal rate of return (IRR) of the investment and ask whether it is plausible that the appropriate discount rate exceed the IRR. Recall that we considered a similar question when evaluating the status quo strategy, where the IRR was only 9.02% and the cost of capital was 8.8%. In that instance, there was little room for error in estimating the WACC.

We calculate the IRR for the acquisition based on the expected cash flows found in panel (a) of Table 9-3 (and a terminal value for 2020 equal to six times $EBITDA_{2020}$) and the \$100 million in invested capital reflected in the asking price. Based on these assumptions, the investment has an IRR of 14.2%. Consequently, if the higher cost of capital for the riskier growth strategy exceeds 14.2%, the acquisition should not be undertaken.

Although the appropriate discount rate for this investment is clearly higher than the discount rate for the status quo investment, it is not likely to exceed 14.2%. In panel (c) of Table 9-2, we noted that GRC's estimated equity beta was 1.28, which generates a cost of equity of 11.42% and a WACC of 8.8%. To generate a cost of capital of 14.2%, GRC's equity beta would have to rise to more than 3.0, which is highly unlikely.

Sensitivity Analysis: Revenue Growth Rate

Next we conduct a breakeven sensitivity analysis of the planning period rate of growth in revenues. This analysis reveals that the 8% expected rate of growth in revenues can be reduced to only 5% (recall that the status quo strategy assumes a 4% rate of growth in revenues) before the acquisition value drops to the \$100 million purchase price.[3] The rate of growth in revenues and consequently firm earnings is very important because it not only determines what the annual cash flows will be during the planning period but also has an important impact on terminal value by increasing the level of $EBITDA_{2020}$.

Sensitivity Analysis: Terminal-Value EBITDA Multiple

The final value driver we consider is the terminal-value multiple (i.e., enterprise value divided by EBITDA) that is used to estimate the terminal value of GRC in 2020. In our earlier analysis, we used a multiple of six, which was the purchase price multiple that Immersion must pay for GRC. However, if we reduce this terminal-value EBITDA multiple to 4.25, the present value of the acquisition drops to the \$100 million acquisition price for GRC.

Scenario Analysis

Up to this point, we have considered three value drivers (the discount rate, the growth rate, and the EBITDA multiple at the terminal date)—one at a time. This analysis suggests that our conclusion about the attractiveness of the investment is not likely to change if we alter any one of the value drivers individually. However, there are scenarios in which all three value drivers differ from their expected values, thus resulting in a negative NPV for the GRC investment. For example, although we argued that a 14% discount rate is very unlikely, a 10% discount rate is plausible. Similarly, one might

[3] Note that we are holding everything constant except the revenue growth rate in this analysis. For instance, the discount rate is still assumed to be 8.8%.

assume that the planning period revenue growth rate may be 6% rather than 8%. If these changes are made, then the terminal-value EBITDA multiple has to drop to only 5.77 times before the enterprise value of GRC under the growth strategy drops to the $100 million acquisition price.

As the following table indicates, there are a number of plausible scenarios under which the acquisition and implementation of the growth strategy might not be value enhancing. For example, with a 5.5 EBITDA multiple for our terminal-value calculation, the acquisition is worth just over $96 million (i.e., becomes a negative NPV investment) if we also make slightly less favorable assumptions about the discount rate (10%) and the revenue growth rate for the planning period (6%). As we learned in Chapter 3, reviewing likely but less favorable scenarios that can lead to a negative NPV is a very powerful tool for learning about an investment's risk.

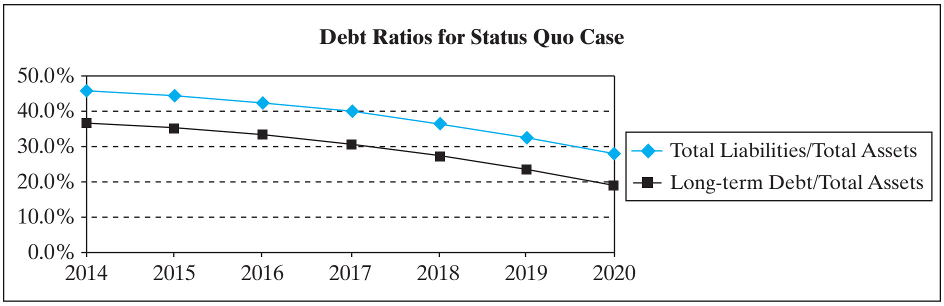
		Breakeven Scenarios			Negative NPV Scenario
Value Driver	**Initial Parameters**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
Cost of capital	8.8%	10%	**10.61%**	9%	**10%**
Revenue growth rate during the planning period	8%	6%	6%	**5.14%**	**6%**
Terminal-value EBITDA multiple	6 times	**5.75 times**	6 times	6 times	**5.5 times**
Enterprise value	$132,221,808	$100,000,000	$100,000,000	$100,000,000	$96,070,358

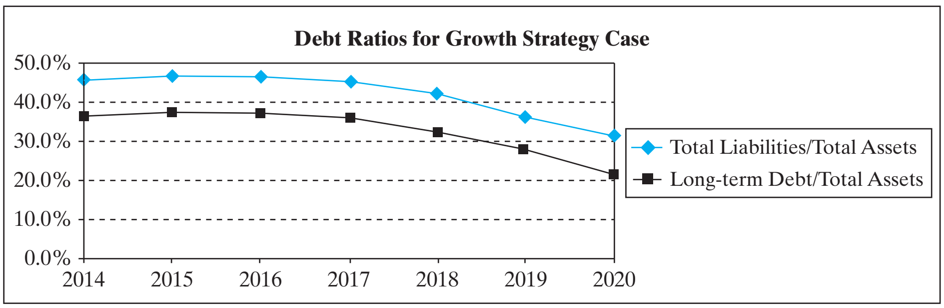
The scenarios reviewed in the table are far from exhaustive, and we can always find scenarios under which almost any investment has either a positive or negative NPV. What this means is that the tools we have developed are just that—decision tools. They provide support and background for the actual decision maker, but they do not actually make the decision. In this particular case, the numbers do not provide a clear picture about whether Immersion should go forward with the acquisition. This will generally be the case. The tools provide managers with valuable information, but ultimately, managers must use their judgment to make the decision.

9.3 Using the APV Model to Estimate Enterprise Value

Up to this point, we have been using the **traditional WACC approach,** which uses a constant discount rate to value the enterprise cash flows. While this approach makes sense for valuing GRC prior to its acquisition by Immersion Chemical Corporation, the constant discount rate is inconsistent with the projected changes in the firm's capital structure after GRC's acquisition. A quick review of the debt ratios found in Figure 9-1 indicates that the capital structure weights (measured here in terms of book values) are

Figure 9-1 Capital Structure Ratios for the GRC Acquisition, 2014 to 2020





Status Quo Case							
	2014	2015	2016	2017	2018	2019	2020
Total Liabilities/Total Assets	45.4%	44.1%	42.3%	39.8%	36.7%	32.9%	28.5%
Long-term Debt/Total Assets	36.4%	35.2%	33.3%	30.9%	27.7%	24.0%	19.5%
Growth Strategy Case							
	2014	2015	2016	2017	2018	2019	2020
Total Liabilities/Total Assets	45.4%	46.4%	46.3%	45.2%	41.6%	37.0%	31.4%
Long-term Debt/Total Assets	36.4%	37.4%	37.4%	36.3%	32.7%	28.1%	22.5%

not constant over time for either the status quo or growth strategy. As a result, *the use of a single discount rate is problematic.*

In situations in which the firm's capital structure is expected to change substantially over time, we recommend that the **adjusted present value (APV) approach** be used.

Introducing the APV Approach

The APV approach expresses enterprise value as the sum of the following two components:

$$\begin{matrix}\text{Enterprise Value}\\ (\text{APV Approach})\end{matrix} = \begin{pmatrix}\text{Value of the}\\ \text{Unlevered}\\ \text{Free Cash Flows}\end{pmatrix} + \begin{pmatrix}\text{Value of the}\\ \text{Interest}\\ \text{Tax Savings}\end{pmatrix} \tag{9.4}$$

The first component is the value of the firm's operating cash flows. Because the operating cash flows are not affected by how the firm is financed, we refer to these cash flows as the unlevered free cash flows. The present value of the unlevered free cash flows represents the value of the firm's cash flows under the assumption that the firm is 100% equity financed. The second component on the right-hand side of Equation (9.4) is the present value of the interest tax savings associated with the firm's use of debt financing. The basic premise of the APV approach is that debt financing provides a tax benefit because of the interest tax deduction.[4] By decomposing firm value in this way, the analyst is forced to deal explicitly with how the financing choice influences enterprise value.

Using the APV Approach to Value GRC Under the Growth Strategy

The APV approach is typically implemented using a procedure very similar to what we did to estimate the enterprise value using the traditional WACC approach, which was found in Equation (9.1) and described in Equation (9.4a):

$$\begin{matrix}\text{Enterprise}\\\text{Value}\\\text{(APV}\\\text{Approach)}\end{matrix} = \left(\begin{matrix}\text{Value of the}\\\text{Unlevered Free}\\\text{Cash Flows for the}\\\text{Planning Period}\end{matrix} + \begin{matrix}\text{Value of the}\\\text{Planning Period}\\\text{Interest Tax}\\\text{Savings}\end{matrix}\right) + \left(\begin{matrix}\text{Present Value}\\\text{of the Estimated}\\\text{Terminal Value}\end{matrix}\right) \quad (9.4a)$$

That is, we make detailed projections of cash flows for a finite planning period and then capture the value of all cash flows after the planning period in a terminal value. From a practical perspective, the principal difference between the APV and traditional WACC approaches is that, with the APV approach, we have two cash flow streams to value: the unlevered cash flows and the interest tax savings.

Figure 9-2 summarizes the implementation of the APV approach in three steps. First, we estimate the value of the planning period cash flows in two components: unlevered (or operating) cash flows and interest tax savings resulting from the firm's use of debt financing. In step 2, we estimate the residual or terminal value of the levered firm at the end of the planning period, and in step 3, we sum the present values of the planning period cash flows and the terminal value to estimate the enterprise value of the firm.

Step 1: Estimate the Value of the Planning Period Cash Flows

The planning period cash flows are comprised of both the unlevered free cash flows and the interest tax savings. We value these cash flows for GRC using two separate calculations. As we show in Equation (9.5), the unlevered free cash flows are the same as the free cash flows that are discounted using the WACC approach. With the APV

[4] Technically, the second term can be an amalgam that captures all potential side effects of the firm's financing decisions. In addition to interest tax savings, the firm may also realize financing benefits that come in the form of below-market or subsidized financing. For example, when one firm acquires assets or an operating division from another, it is not uncommon for the seller to help finance the purchase with a very attractive loan rate.

Figure 9-2 Using the Adjusted Present Value (APV) Model to Estimate Enterprise Value

Step 1: Estimate the value of the planning period cash flows.

Evaluation of Operating (Unlevered) Cash Flows

Definition: Unlevered Free Cash Flows = firm or project Free Cash Flows	*Formula:*
Net operating income Less: taxes Net operating profit after taxes (NOPAT) Plus: depreciation expense Less: capital expenditures (CAPEX) Less: increases in net working capital Equals unlevered free cash flows = FCF	$\text{Value of Planning Period Unlevered Cash Flows} = \sum_{t=1}^{PP} \frac{FCF_t}{(1 + k_{\text{Unlevered}})^t}$ where FCF_t = firm free cash flows (equals equity free cash flows for the unlevered firm) $k_{\text{Unlevered}}$ = discount rate for project cash flows (unlevered equity) PP = planning period

Evaluation of the Interest Tax Savings

Definition: Interest tax savings	*Formula:*
Interest tax savings in year t = interest expense in year t × tax rate	$\text{Value of the Interest Tax Saving} = \left[\sum_{t=1}^{PP} \frac{\text{Interest Expense}_t \times \text{Tax Rate}}{(1 + r)^t}\right]$ where PP = planning period r = firm's borrowing rate

Step 2: Estimate the value of the levered firm at the end of the planning period (i.e., the terminal value).

Evaluation of the Terminal Value

Definition: Terminal value of firm is equal to the enterprise value of the levered firm at the end of the planning period. *Assumptions:* ■ After the planning period, the firm maintains a constant proportion, L, of debt in its capital structure. ■ The firm's cash flows grow at a constant rate g, which is less than the firm's weighted average cost of capital.	*Formula:* $\text{Terminal Value of the Levered Firm}_{PP} = \frac{FCF_{PP}(1 + g)}{k_{WACC} - g}$ where FCF_{PP} = firm free cash flows for the end of the planning period k_{WACC} = weighted average cost of capital g = rate of growth in FCF after the end of the planning period in perpetuity

Step 3: Sum the estimated values for the planning period and terminal-period cash flows.

$$\text{APV Model of Enterprise Value} = \underbrace{\left[\sum_{t=1}^{PP} \frac{FCF_t}{(1 + k_{\text{Unlevered}})^t} + \sum_{t=1}^{PP} \frac{\text{Interest Expense}_t \times \text{Tax Rate}}{(1 + r)^t}\right]}_{\textbf{Step 1: Value of planning period cash flows}} + \underbrace{\left[\frac{FCF_{PP}(1 + g)}{k_{WACC} - g}\left(\frac{1}{1 + k_{\text{Unlevered}}}\right)^{PP}\right]}_{\textbf{Step 2: Value of the terminal-period cash flows}}$$

Table 9-4 GRC's Operating and Financial Cash Flows for the Planning Period

Panel (a) Unlevered Free Cash Flows (same as FCF)						
	2015	**2016**	**2017**	**2018**	**2019**	**2020**
Status quo strategy	\$3,538,887	\$4,411,143	\$5,318,289	\$6,261,721	\$7,242,890	\$ 8,263,306
Growth strategy	\$ (104,715)	\$1,483,309	\$3,208,375	\$7,331,446	\$9,364,362	\$11,569,912
Panel (b) Interest Tax Savings						
	2015	**2016**	**2017**	**2018**	**2019**	**2020**
Status quo strategy	\$ 650,000	\$ 637,462	\$ 613,420	\$ 576,985	\$ 527,216	\$ 463,116
Growth strategy	\$ 650,000	\$ 694,742	\$ 721,884	\$ 729,061	\$ 684,432	\$ 613,272

approach, however, these cash flows are discounted at the unlevered cost of equity rather than the WACC.

$$\begin{pmatrix}\text{Value of the}\\ \text{Planning Period}\\ \text{Unlevered}\\ \text{Free Cash Flows}\end{pmatrix} = \sum_{t=1}^{PP} \frac{\text{FCF}_t}{(1 + k_{\text{Unlevered}})^t} \tag{9.5}$$

Applying Equation (9.5) to the valuation of GRC's operating cash flows for the planning period (2015–2020) for the growth strategy case summarized in Table 9-4, we estimate a value of \$21,372,555:

$$\begin{aligned}\begin{pmatrix}\text{Value of the}\\ \text{Unlevered}\\ \text{Free Cash Flows}\end{pmatrix} &= \left(\frac{\$(104{,}715)}{(1 + .0947)^1} + \frac{\$1{,}483{,}309}{(1 + .0947)^2} + \frac{\$3{,}208{,}375}{(1 + .0947)^3}\right.\\ &\quad \left. + \frac{\$7{,}331{,}446}{(1 + .0947)^4} + \frac{\$9{,}364{,}362}{(1 + .0947)^5} + \frac{\$11{,}569{,}912}{(1 + .0947)^6}\right)\\ &= \$21{,}374{,}469\end{aligned}$$

This valuation is based on an estimate of the unlevered cost of equity equal to 9.47%. We estimate the unlevered cost of equity in Figure 9-3 using the procedure described in Table 4-1 of Chapter 4, where we estimated the firm's WACC, and used again in Chapter 5 to estimate a project's cost of capital. The estimated unlevered beta for GRC is .89, which, when combined with a ten-year US Treasury yield of 5.02% and a 5% market risk premium, generates an unlevered cost of equity of 9.47%.

Figure 9-3 **Three-Step Process for Estimating GRC's Unlevered Cost of Equity**

Step 1: Identify a set of firms that operate in the same line of business as GRC. For each market comp, either estimate directly or locate published estimates of its levered equity beta, β_{Levered}, the book value of the firm's interest-bearing debt, and the market capitalization of the firm's equity.*

GRC: A review of the specialty chemical industry reveals four firms that are reasonably similar to GRC. Their equity betas (i.e., levered equity betas) range from .88 to 1.45, and their debt-to-equity ratios range from 35% to 80%.

Comparable Firms	Levered Equity Betas	Debt/Equity Ratio	Assumed Debt Beta	Unlevered Equity Betas
A	1.45	0.65	0.30	1.00
B	1.40	0.60	0.30	0.99
C	0.88	0.35	0.30	0.73
D	1.25	0.80	0.30	0.83
Averages	1.25	0.60	0.30	0.89

Step 2: Unlever each of the levered equity beta coefficients and average them to get an estimate of GRC's unlevered equity beta. The unlevering process uses the following relationship:†

$$\beta_{\text{Unlevered}} = \frac{\beta_{\text{Levered}} + \left(1 - T \times \dfrac{r_d}{1 + r_d}\right) D/E \beta_{\text{Debt}}}{1 + \left(1 - T \times \dfrac{r_d}{1 + r_d}\right) D/E} \tag{9.7}$$

where $\beta_{\text{Unlevered}}$, β_{Levered}, and β_{Debt} are the betas for the firm's unlevered and levered equity, plus its debt.

Cost of debt $= r_d$

$T =$ the corporate tax rate

$D/E =$ the debt-to-equity ratio

*Typically, debt is estimated using the book value of the firm's interest-bearing liabilities (short-term notes payable, the current portion of the firm's long-term debt, plus long-term debt). Although we should technically use the market value of the firm's debt, it is customary to use book values because most corporate debt is thinly traded if at all. The equity capitalization of the firm is estimated using the current market price of the firm's shares multiplied by the number of outstanding shares. Betas for individual stocks can be obtained from a number of published sources, including almost all online investment information sources such as Yahoo Finance or Microsoft's MoneyCentral Web site.

†This relationship captures the effects of financial leverage on the firm's beta coefficient. It is a more general version of a similar formula discussed in Chapter 4. It applies in the setting where the firm faces uncertain perpetual cash flows and corporate taxes, corporate debt is risky (i.e., debt betas are greater than zero), and the firm's use of financial leverage (i.e., the debt-to-equity ratio, L) is reset every period (discretely as opposed to continuously) to keep leverage constant. When leverage adjustments are made continuously, the formula to use is Equation (4.7), that is, when debt and equity represent the market value of the firm's debt and equity claims. Most analysts prefer to use Equation (4.7), because of its simplicity, even though they are performing a discrete analysis of enterprise value based on discounting annual cash flows due to the simplicity of the formula.

(*Continued*)

Figure 9-3 *continued*

GRC:	Applying Equation (9.7) to the levered equity betas of the four comparable firms produces an average unlevered equity beta of .89. Note that we have assumed a debt beta of .30 for the debt of all four comparable firms and a corporate tax rate of 25%. Research has shown that debt betas range from .20 to .40 in practice. In addition, we assume that the corporate debt yield for each of the comparable firms is equal to GRC's 6.5% borrowing rate. Where significant differences in debt ratings, and consequently borrowing rates, are present, we use firm-specific borrowing rates in the beta unlevering process described in Equation (9.7).
Step 3:	Substitute the average unlevered equity beta into CAPM to estimate the unlevered cost of equity for the subject firm.
GRC:	Substituting our estimate of GRC's unlevered equity beta into CAPM, where the risk-free rate is 5.02% and the market risk premium is 5%, we get an estimated cost of equity for an unlevered investment of 9.47%, that is:

$$k_{\text{unlevered equity}} = \text{risk-free rate} + \beta_{\text{Unlevered}}(\text{market risk premium})$$

$$k_{\text{unlevered equity}} = .0502 + .89 \times .05 = .0947, \text{ or } 9.47\%$$

Next we calculate the value of the interest tax savings for the planning period as follows:

$$\begin{array}{c}\text{Value of the}\\ \text{Planning Period}\\ \text{Interest Tax Savings}\end{array} = \sum_{t=1}^{PP} \frac{\text{Interest Expense}_t \times \text{Tax Rate}}{(1+r)^t} \tag{9.6}$$

where r is the firm's borrowing rate. Substituting GRC's interest tax savings for the growth strategy (found in Table 9-4) into Equation (9.6) produces a $3,307,031 estimate for the value of its planning period interest tax savings:

$$\begin{aligned}\begin{array}{c}\text{Value of the}\\ \text{Planning Period}\\ \text{Interest Tax Savings}\end{array} &= \left(\frac{\$650{,}000}{(1+.065)^1} + \frac{\$694{,}742}{(1+.065)^2} + \frac{\$721{,}884}{(1+.065)^3}\right.\\ &\quad \left. + \frac{\$729{,}061}{(1+.065)^4} + \frac{\$684{,}432}{(1+.065)^5} + \frac{\$613{,}272}{(1+.065)^6}\right)\\ &= \$3{,}307{,}031\end{aligned}$$

The combined value of operating cash flows and interest tax savings for the planning period under the growth strategy, then, is $24,681,500 = $21,374,469 + 3,307,031.

Step 2: Estimate GRC's Terminal Value

The terminal-value calculation for the APV approach is identical to the calculation we made for our WACC analysis. As we previously stated, at the terminal date, GRC's cash flows are assumed to grow at a constant rate of 2% per year, and its capital structure reverts to a constant mix of debt and equity, keeping the debt-to-value ratio at

40%. Therefore, we can use the Gordon growth model to estimate the terminal value of the levered firm at the end of the planning period (PP) as follows:

$$\begin{matrix}\text{Terminal Value of the} \\ \text{Levered Firm}_{\text{PP}}\end{matrix} = \frac{\text{FCF}_{\text{PP}}(1 + g)}{k_{\text{WACC}} - g} \tag{9.8}$$

GRC's FFCF_{PP} in 2020 (which is the end of the planning period) is equal to \$11,569,912 (see Table 9-4), and this FCF is expected to grow at a rate g of 2% in perpetuity; the weighted average cost of capital (k_{WACC}) is 8.8%.[5] Using Equation (9.8), we estimate the terminal value for GRC in 2020 as follows:

$$\begin{matrix}\text{Terminal Value of the} \\ \text{Levered Firm}_{\text{ 2020}}\end{matrix} = \frac{\$11{,}569{,}912(1.02)}{.088 - .02} = \$173{,}548{,}679$$

We have one remaining calculation to make in order to value GRC's terminal value. We need to discount the terminal value estimated in Equation (9.8) back to the present using the unlevered cost of equity, that is:

$$\begin{matrix}\text{Present Value of the} \\ \text{Terminal Value}_{2014}\end{matrix} = \frac{\$11{,}569{,}912(1.02)}{.088 - .02} \times \frac{1}{(1 + .0947)^6} = \$100{,}849{,}653$$

To complete the valuation of GRC using the APV method, we now sum the value of the planning period and terminal value in step 3.

Step 3: Summing the Values of the Planning Period and Terminal Period

Using the APV approach, we estimate the enterprise value of the firm as the following sum:

$$\begin{matrix}\text{Enterprise Value} \\ \text{(APV Approach)}\end{matrix} = \underbrace{\left[\sum_{t=1}^{\text{PP}} \frac{\text{FCF}_t}{(1 + k_{\text{Unlevered}})^t} + \sum_{t=1}^{\text{PP}} \frac{\text{Interest Expense}_t \times \text{Tax Rate}}{(1 + r_d)^t}\right]}_{\textbf{Value of Planning Period Cash Flows}}$$

$$+ \underbrace{\left[\frac{\text{FCF}_{\text{PP}}(1 + g)}{k_{\text{WACC}} - g}\left(\frac{1}{1 + k_{\text{Unlevered}}}\right)^{\text{PP}}\right]}_{\textbf{Value of the Terminal Period Cash Flows}} \tag{9.4a}$$

[5] The weighted average cost of capital can also be related to the unlevered cost of equity capital by using the following relationship:

$$k_{\text{WACC}} = k_{\text{Unlevered}} - r_d(\text{Tax Rate})\frac{D/E}{1 + D/E}\left(\frac{1 + k_{\text{Unlevered}}}{1 + r_d}\right)$$

$$k_{\text{WACC}} = .0947 - .065 \times .25 \times \left(\frac{.40}{1 + .40}\right) \times \left(\frac{1 + .0947}{1 + .065}\right) = .088 \text{ or } 8.8\%$$

where D/E is the ratio of debt to equity for the firm, which is assumed to be 40% in the GRC example.

Substituting for the two components, we estimate GRC's enterprise value using the APV model to be $125,540,207, that is:

$$\begin{matrix}\text{Enterprise Value}\\ (\text{APV Approach})\end{matrix} = [\$21{,}374{,}469 + \$3{,}307{,}031] + \$100{,}858{,}707 = \$125{,}540{,}207$$

Using an EBITDA Multiple to Calculate the Terminal Value

The preceding application of the APV approach to the estimation of GRC's enterprise value used the discounted cash flow (DCF) approach to value both the planning period value and the post-planning-period terminal value. What typically happens in practice, however, is that a market-based multiple is used to estimate the value of the post-planning-period cash flows. Equation (9.4b) defines the APV approach of enterprise value as the sum of the present values of the planning period cash flows (i.e., both the unlevered cash flows of the firm and the interest tax savings) plus the terminal value of the firm, which is estimated using the EBITDA multiple, that is:

$$\begin{matrix}\text{Enterprise Value}\\ (\text{Hybrid APV Approach})\end{matrix} = \left(\begin{matrix}\text{Value of the Unlevered}\\ \text{Free Cash Flows}\\ \text{for the Planning Period}\end{matrix} + \begin{matrix}\text{Value of the Planning}\\ \text{Period Interest Tax}\\ \text{Savings}\end{matrix}\right) + \left(\begin{matrix}\text{Present Value of the}\\ \text{EBITDA Multiple Estimate}\\ \text{of Terminal Value}\end{matrix}\right) \tag{9.4b}$$

The values of the two planning period cash flow streams for GRC under the growth strategy were estimated earlier to equal $21,374,469 for the operating cash flows and $3,307,031 for the interest tax savings. Using the six times multiple of EBITDA from our previous analysis and the estimated EBITDA for 2020 (found using Table 9-4), we calculate GRC's terminal-value cash flow as follows:

$$\begin{matrix}\text{Present Value of the}\\ \text{Estimated Terminal}\\ \text{Value}_{2014}\end{matrix} = \frac{\text{Terminal Value}_{2020}}{(1 + .0947)^6} = \frac{6 \times \text{EBITDA}_{2020}}{(1 + .0947)^6}$$

$$= \frac{\$182{,}828{,}880}{(1 + .0947)^6} = \$106{,}248{,}753$$

EBITDA for 2020 is found using Table 9-3 by summing net operating income, which equals $21,781,465, and depreciation expense, which equals $8,690,015, to get $30,471,480. Multiplying this EBITDA estimate by 6 produces an estimate of the terminal value in 2020 of $182,828,880. Discounting the terminal value back to the present using the unlevered cost of equity, we get $106,248,753. To complete the estimate of enterprise value using the hybrid APV, we simply substitute our estimates of the values of the cash flow streams into Equation (9.4b) as follows:

$$\begin{aligned}\begin{array}{c}\text{Enterprise Value}\\(\text{Hybrid APV Approach})\end{array} &= \$21{,}374{,}469 + \$3{,}307{,}031 + \$106{,}248{,}753\\ &= \$130{,}930{,}253\end{aligned}$$

This value is slightly lower than our earlier estimate because, in this case, the EBITDA multiple provided a more conservative estimate of GRC's terminal value.

Table 9-5 summarizes the APV estimates of enterprise value for the status quo and growth strategies, using our two methods for estimating terminal value.

Table 9-5 APV Valuation Summary for GRC for Status Quo and Growth Strategies

Panel (a) Status Quo Strategy

APV Estimate of Enterprise Value

	Present Values		
	APV Calculation of Planning Period Cash Flows	**DCF Estimates of Terminal Values**	**Total**
Unlevered free cash flows	$ 24,738,517	$ 65,589,453	$ 90,327,970
Interest tax savings	2,830,870	6,444,492	9,275,363
Total	$ 27,569,388	$ 72,033,945	$ 99,603,333

Hybrid APV Estimate of Enterprise Value

	Present Values		
	APV Calculation of Planning Period Cash Flows	**EBITDA Multiple Terminal Value**	**Total**
Unlevered free cash flows	$ 24,738,517	$ 73,060,734	$ 97,799,251
Interest tax savings	2,830,870	—	2,830,870
Total	$ 27,569,388	$ 73,060,734	**$ 100,630,121**

Panel (b) Growth Strategy

APV Estimate of Enterprise Value

	Present Values		
	APV Calculation of Planning Period Cash Flows	**DCF Estimates of Terminal Values**	**Total**
Unlevered free cash flows	$ 21,955,607	$ 91,835,418	$ 113,209,887
Interest tax savings	3,307,031	9,023,290	12,330,321
Total	$ 25,262,638	$ 100,858,708	**$ 125,540,208**

(*Continued*)

Table 9-5 *continued*

Hybrid APV Estimate of Enterprise Value

	Present Values		
	APV Calculation of Planning Period Cash Flows	**EBITDA Multiple Terminal Value**	**Total**
Unlevered free cash flows	$ 21,374,469	$ 106,248,753	$ 127,623,323
Interest tax savings	3,307,031	—	3,307,031
Total	$ 25,262,638	$ 106,248,753	**$ 130,930,253**

Comparing the WACC and APV Estimates of GRC's Enterprise Value

Table 9-6 combines our estimates of GRC's enterprise value using both the traditional WACC approach and the APV approach. Although the estimates are not exactly the same, they are quite similar. In all cases, the GRC acquisition at a price of $100 million appears to be a good investment, and the growth strategy clearly dominates the status quo strategy.

Table 9-6 **Summary of WACC and APV Estimates of GRC's Enterprise Value**

Status Quo Strategy	**Traditional WACC**	**APV**
DCF estimate of terminal value	$ 100,038,943	$ 99,603,333
EBITDA multiple estimate of terminal value	101,104,149	100,630,121
Growth Strategy	**Traditional WACC**	**APV**
DCF estimate of terminal value	$ 126,630,094	$ 125,540,207
EBITDA multiple estimate of terminal value	132,221,808	130,930,253

Status quo strategy represents a set of cash flow estimates that correspond to the current method of operations of the business.

Growth strategy represents cash flow estimates reflecting the implementation of an explicit plan to grow the business by making additional investments in capital equipment and changing the current method of operating the firm.

DCF estimate of terminal value is based on the Gordon growth model, where cash flows are expected to grow indefinitely at a constant rate of 2% per year.

EBITDA multiple estimate of terminal value is based on a six times multiple of EBITDA estimated for 2020 (the end of the planning period).

In this particular application of the WACC and APV valuation approaches, the results are the same for all practical purposes. Sometimes, however, capital structure effects caused by very dramatic changes in debt financing over the life of the investment can lead to meaningful differences in the results of the two valuation approaches. In these instances, the APV approach has a clear advantage because it can accommodate the effects of changing capital structure more easily.

The EBITDA multiple used in the valuation of GRC produced results that were very similar to the DCF estimate, and this is purely an artifact of the particular choices made in carrying out this valuation. Due to the importance of the terminal value to the overall estimate of enterprise value, we recommend that both approaches be used and that, when selecting an EBITDA multiple, close attention be paid to recent transactions involving closely comparable firms. The advantage of the EBITDA multiple in this setting is that it ties the analysis of more distant cash flows back to a recent market transaction. However, the EBITDA multiple estimate of terminal value should be compared to a DCF estimate using the analyst's estimates of reasonable growth rates as a test of the reasonableness of the terminal-value estimate based on multiples.

A Brief Summary of the WACC and APV Valuation Approaches

The following table provides a summary of the salient features of the traditional WACC and APV approaches. As we have discussed, the traditional WACC method is the more commonly used approach. However, when the capital structure of the firm being valued is likely to change over time, the APV is the preferred approach.

	Adjusted Present Value (APV) Method	**Traditional WACC Method**
Object of the analysis	*Enterprise value* as the sum of the values of: ■ The unlevered equity cash flows, and ■ Financing side effects	*Enterprise value* equal to the present value of the firm's free cash flows, discounted using the after-tax WACC.
Cash flow calculation	■ Unlevered free cash flows (equals firm FCFs), plus ■ Interest tax savings	Firm FCFs.
Discount rate(s)	■ Unlevered cash flows—cost of equity for unlevered firm, and ■ Interest tax savings—the yield to maturity on the firm's debt	After-tax WACC.
How capital structure effects are dealt with—discount rates, cash flows, or both	*Cash flows*—Capital structure affects the present value of the interest tax savings only. The value of the unlevered firm is not affected by the firm's use of debt financing.	*Discount rate*—The debt-equity mix affects the firm's WACC. However, the mix of debt and equity is assumed to be constant throughout the life of the investment.

(*Continued*)

Technical Issues—Equations		
Valuation models	*Enterprise Value* $\text{Enterprise Value} = \text{Value of the Unlevered Firm} + \text{Value of Interest Tax Savings}$ $= \sum_{t=1}^{\infty} \frac{FCF_t^{Unlevered}}{(1 + k_{Unlevered})^t} + \sum_{t=1}^{\infty} \frac{\text{Interest} \times \text{Tax Rate}}{(1 + k_d)^t}$ where $FCF_t^{Unlevered}$ = FCFs for an unlevered firm (equals FCF_t). $k_{Unlevered}$ = cost of equity for an unlevered firm	*Enterprise Value* $\text{Enterprise Value} = \sum_{t=1}^{\infty} \frac{FCF_t}{(1 + k_{WACC})^t}$ where FCF_t = firm FCF_t for $year_t$ k_{WACC} = the firm's WACC
User's Guide		
Choosing the right model	Although not as popular as the traditional WACC method, the APV method is gaining support and is particularly attractive when valuing highly leveraged transactions, such as leveraged buyouts, where capital structure changes through time.	Most widely used method for valuing individual investment projects (capital budgeting) and entire firms. Because the discount rate (WACC) assumes constant weights for debt and equity, this method is not well suited for situations where dramatic changes in capital structure are anticipated (e.g., leverage buyouts).

Estimating the Value of Subsidized Debt Financing

In our preceding example, financing affects firm value only through its effect on interest tax savings. It is not uncommon, however, for the seller of a business to offer an incentive to the buyer in the form of below-market-rate debt financing. To illustrate how we might analyze the value of below-market financing, consider the \$40 million loan offer outlined in Table 9-7. Although the current market rate for such a loan is 6.5%, the loan carries an interest rate of 5.0%, which implies a 1.5% reduction in the rate of interest charged on the loan. The loan requires that the firm pay only interest, and no principal is due until maturity. Consequently, the required payments consist of \$2 million per year in interest payments over the next five years, and, in the fifth year (the year in which the loan matures), the full principal amount of \$40 million is due and payable.

To value the subsidy associated with the below-market-rate financing, we calculate the present value of the payments, using the current market rate of interest, as being only \$37,506,592, which indicates that the financing provides the borrower with a subsidy worth \$2,493,407! In essence, the seller has reduced the selling price of the firm or asset being sold by \$2.5 million as an incentive to the buyer.

Table 9-7 The Value of Subsidized Debt Financing

Given:					
Loan amount (Year 0)	$ 40,000,000				
Current market rate	6.5%				
Cost of debt (subsidized)	5.0%				
Term of loan	5				
Type of loan	Interest only				
YEAR	**1**	**2**	**3**	**4**	**5**
Interest payments	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000
Principal payment					40,000,000
Total	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 42,000,000
Evaluation of Subsidized Loan:					
Cash received	$ 40,000,000				
Present value of payments	37,506,592				
Value of loan subsidy	$ 2,493,408				

9.4 Summary

Using DCF analysis to value a *firm* is a straightforward extension of its use in *project* valuation. The added complexity of firm valuation comes largely from the fact that the time horizon of firm cash flows is indefinite, while project cash flows are typically finite. In most cases, analysts solve this problem by estimating the value of cash flows in what is referred to as a *planning period,* using standard DCF analysis, and then using the method of comparables or multiples (as introduced in Chapter 8) to calculate what is generally referred to as the *terminal value* of the investment. In most cases, the planning period cash flows and terminal-value estimates are discounted using the investment's WACC.

As we have noted, the WACC approach that we described in the first half of this chapter is widely used throughout industry to value businesses. It should be emphasized, however, that this approach requires a number of assumptions that may be difficult to justify in many applications. In particular, the analysis assumes that the risks of the cash flows do not change over time and that the firm's financial structure does not change. For this reason, we would again like to add our usual caveat that the tools that we present are imperfect and should be viewed as providing support for managers and not a substitute for managers' judgment.

The second half of the chapter considered the case where the debt ratio of the acquired business changes over time. When this is the case, the APV approach provides an improvement over the WACC approach. Although this approach is not frequently used by industry practitioners, we expect that it will become more popular over time.

EXERCISES

9-1 ENTERPRISE VALUATION Opex Capital is a small investment advisory firm located in Portland, Oregon, that has been hired by Winston Winery to estimate the value of Hilco Wines. Hilco is a small winery that is being considered for purchase by Winston. Opex has obtained the financial statements of Hilco and prepared the following estimates of the firm's free cash flow for the next five years:

Year	Cash Flows
1	$100,000
2	120,000
3	135,000
4	150,000
5	175,000

At the end of five years, Opex has estimated that the winery should be worth approximately five times its year 5 cash flow.

a. If the appropriate discount rate for valuing the winery is 15%, what is your estimate of the firm's enterprise value?

b. Winston Winery plans to borrow $400,000 to help finance the purchase. What is Hilco's equity worth?

9-2 ENTERPRISE VALUATION In summer 2015, Smidgeon Industries was evaluating whether to purchase one of its suppliers. The supplier, Carswell Manufacturing, provides Smidgeon with the raw steel Smidgeon uses to fabricate utility trailers. One of the first things that Smidgeon's managers did was to forecast the cash flows of Carswell for the next five years:

Year	Cash Flows
1	$1,200,000
2	1,260,000
3	1,323,000
4	1,389,150
5	1,458,608

Next, Smidgeon's management team looked at a group of similar firms and estimated Carswell's cost of capital to be 15%. Finally, the team estimated that Carswell would be worth approximately six times its year 5 cash flow in five years.

a. What is your estimate of the enterprise value of Carswell?

b. What is the value of the equity of Carswell if the acquisition goes through, and Smidgeon borrows $2.4 million and finances the remainder using equity?

9-3 ENTERPRISE VALUATION USING THE APV MODEL You have been recently hired as a financial analyst. When you arrive at work on Monday morning, the CFO of the firm sends you a message asking you to step into her office as soon as you have a free minute. Having been on the job just two weeks, you quickly decide you have a free minute and go to the executive floor, where the CFO has her office. You discover that the CFO wants you to educate her on the meaning and use of the APV valuation method. Although she does not elaborate on the reason for her request, you are aware of the office scuttlebutt that the board of directors is considering the prospect of taking the firm private and is in discussions with an investment banker about the particulars of the deal.

After leaving the CFO's office, you decide that the best way to explain the use of the APV methodology is to construct a simple example. After thinking about it for an hour or so, you come up with the following illustration:

Catch-Me Lures, Inc. is a very stable business with expected FCFs of $1,000 per year, which is likely to be constant for the foreseeable future. The firm currently has no debt outstanding and has an equity beta of 1.0. Given a market risk premium of 5% and a risk-free rate of interest of 8%, you estimate the unlevered cost of equity for the firm to be 8%.

a. If Catch-Me Lures' expected FCF is a level perpetuity equal to $1,000 per year, what is your estimate of the enterprise value of the firm?

b. To illustrate the effect of debt financing on the value of Catch-Me Lures, you assume that the firm borrows $5,000 at a rate of 4% and that the firm pays taxes at a rate of 20%. Compute the amount of taxes the firm will "save" by virtue of the tax deductibility of its interest expense each year.

c. It is pretty obvious that borrowing a portion of the firm's capital reduces its tax bill. But how much should you value the interest tax savings due to the use of debt financing? After thinking about it a bit, you decide to implement the basic notion of valuation and discount the future cash flows using a discount rate that reflects the risk of the cash flows. The cash flow estimation was easy; see Exercise 9-4(b). But what discount rate should you use?

d. What is the present value of the expected future tax savings from borrowing? What then is the value of the levered firm (i.e., the APV valuation)?

Problems

9-4 ENTERPRISE VALUATION—TRADITIONAL WACC MODEL Canton Corporation is a privately owned firm that engages in the production and sale of industrial chemicals, primarily in North America. The firm's primary product line consists of organic solvents and intermediates for pharmaceutical, agricultural, and chemical products. Canton's managers have recently been considering the possibility of taking the company public and have asked the firm's investment banker to perform some preliminary analysis of the value of the firm's equity.

To support its analysis, the investment banker has prepared pro forma financial statements for each of the next four years under the (simplifying) assumption that firm sales are flat (i.e., have a zero rate of growth), the corporate tax rate equals 30%, and capital expenditures are equal to the estimated depreciation expense.

Canton Corporation Financials

	Pro Forma Balance Sheets ($000)				
	0	1	2	3	4
Current assets	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000
Property, plant, and equipment	40,000	40,000	40,000	40,000	40,000
Total	$ 55,000	$ 55,000	$ 55,000	$ 55,000	$ 55,000
Accruals and payables	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000
Long-term debt	25,000	25,000	25,000	25,000	25,000
Equity	25,000	25,000	25,000	25,000	25,000
Total	$ 55,000	$ 55,000	$ 55,000	$ 55,000	$ 55,000

	Pro Forma Income Statements ($000)			
	1	2	3	4
Sales	$ 100,000	$ 100,000	$ 100,000	$ 100,000
Cost of goods sold	(40,000)	(40,000)	(40,000)	(40,000)
Gross profit	$ 60,000	$ 60,000	$ 60,000	$ 60,000
Operating expenses (excluding depreciation)	(30,000)	(30,000)	(30,000)	(30,000)
Depreciation expense	(8,000)	(8,000)	(8,000)	(8,000)
Operating income (earnings before interest and taxes)	$ 22,000	$ 22,000	$ 22,000	$ 22,000
Less: interest expense	(2,000)	(2,000)	(2,000)	(2,000)
Earnings before taxes	$ 20,000	$ 20,000	$ 20,000	$ 20,000
Less: taxes	(6,000)	(6,000)	(6,000)	(6,000)
Net income	$ 14,000	$ 14,000	$ 14,000	$ 14,000

In addition to the financial information on Canton, the investment banker has assembled the following information concerning current rates of return in the capital market:

- The current market rate of interest on ten-year Treasury bonds is 7%, and the market risk premium is estimated to be 5%.
- Canton's debt currently carries a rate of 8%, and this is the rate the firm would have to pay for any future borrowing as well.
- Using publicly traded firms as proxies, the estimated equity beta for Canton is 1.60.

  a. What is Canton's cost of equity capital? What is the after-tax cost of debt for the firm?

  b. Calculate the equity free cash flows for Canton for each of the next four years. Assuming that equity free cash flows are a level perpetuity for year 5 and beyond, estimate the value of Canton's equity. (*Hint:* Equity value is equal to the present value of the equity free cash flows discounted at the levered cost of equity.) If the market rate of interest on Canton's debt is equal to the 8% coupon, what is the current market value of the firm's debt? What is the enterprise value of Canton? (*Hint:* Enterprise value can be estimated as the sum of the estimated values of the firm's interest-bearing debt plus equity.)

c. Using the market values of Canton's debt and equity calculated in Problem 9-5(b), calculate the firm's after-tax weighted average cost of capital. *Hint:*

$$k_{\text{WACC}} = \begin{matrix}\text{Cost of}\\ \text{Debt}\end{matrix}\left(1 - \begin{matrix}\text{Tax}\\ \text{Rate}\end{matrix}\right)\left(\frac{\text{Debt Value}}{\text{Enterprise Value}}\right) + \begin{matrix}\text{Cost of}\\ \text{Levered Equity}\end{matrix}\left(\frac{\text{Equity Value}}{\text{Enterprise Value}}\right)$$

d. What are the FCFs for Canton for years 1 through 4?

e. Estimate the enterprise value of Canton using the traditional WACC model. Base your estimate on your previous answers, and assume that the FCFs after year 4 are a level perpetuity equal to the year 4 FCF. How does your estimate compare to your earlier estimate using the sum of the values of the firm's debt and equity?

f. Based on your estimate of enterprise value, what is the value per share of equity for the firm if the firm has 2 million shares outstanding? Remember that your calculations up to this point have been in thousands of dollars.

9-5 TRADITIONAL WACC VALUATION The owner of Big Boy Flea Market (BBFM), Lewis Redding, passed away on December 30, 2014. His 100% ownership interest in BBFM became part of his estate, on which his heirs must pay estate taxes. The IRS has hired a valuation expert, who has submitted a report stating that the business was worth approximately $20 million at the time of Redding's death. Redding's heirs believe the IRS valuation is too high and have hired you to perform a separate valuation analysis in hopes of supporting their position.

a. Estimate the firm FCFs for 2015 to 2019, where the firm's tax rate is 25%, capital expenditures are assumed to equal depreciation expense, and there are no changes in net working capital over the period.

b. Value BBFM using the traditional WACC model and the following information:

1. BBFM's cost of equity is estimated to be 20% and the cost of debt is 10%.

2. BBFM's management targets its long-term debt ratio at 10% of enterprise value.

3. After 2019, the long-term growth rate in the firm's free cash flow will be 5% per year.

9-6 ENTERPRISE VALUATION—APV MODEL This problem uses the information from Problem 9-4 about Canton Corporation to estimate the firm's enterprise value using the APV model.

a. What is the firm's unlevered cost of equity? (*Hint:* The firm's debt beta is .20)

b. What are the unlevered FCFs for Canton for years 1 through 4? (*Hint:* The unlevered FCFs are the same as the firm FCFs.)

c. What are the interest tax savings for Canton for years 1 through 4?

Big Boy Flea Market Financials

	Base Year	Forecast				
Income Statement	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Sales	$ 3,417,500.00	$ 3,700,625.00	$ 3,983,750.00	$ 4,266,875.00	$ 4,550,000.00	$ 4,833,125.00
Depreciation		48,190.60	50,118.22	52,122.95	54,207.87	56,376.19
Cost of goods sold (COGS)		1,402,798.69	1,496,881.13	1,590,963.56	1,685,046.00	1,779,128.44
Other operating expenses		1,078,447.38	1,109,874.25	1,141,301.13	1,172,728.00	1,204,154.88
Earnings before interest and taxes (EBIT)		$ 1,171,188.34	$ 1,326,876.40	$ 1,482,487.36	$ 1,638,018.13	$ 1,793,465.50
Interest		5,110.00	5,110.00	5,110.00	5,110.00	5,860.00
Earnings before taxes		$ 1,166,078.34	$ 1,321,766.40	$ 1,477,377.36	$ 1,632,908.13	$ 1,787,605.50
Income taxes		291,519.58	330,441.60	369,344.34	408,227.03	446,901.38
Net income		$ 874,558.75	$ 991,324.80	$ 1,108,033.02	$ 1,224,681.10	$ 1,340,704.13
Preferred stock dividends		—	—	—	—	—
Net income to common stock		874,558.75	991,324.80	1,108,033.02	1,224,681.10	1,340,704.13
Common stock dividends		874,558.75	991,324.80	1,108,033.02	1,224,681.10	1,340,704.13
Income to retained earnings		—	—	—	—	—

	Base Year	Forecast				
Balance Sheet	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Current assets	$ 170,630.00	$ 185,031.25	$ 199,187.50	$ 213,343.75	$ 227,500.00	$ 241,656.25
Gross fixed assets	1,204,765.00	1,252,955.60	1,303,073.82	1,355,196.78	1,409,404.65	1,540,780.83
Accumulated depreciation	(734,750.00)	(782,940.60)	(833,058.82)	(885,181.78)	(939,389.65)	(995,765.83)
Net fixed assets	$ 470,015.00	$ 470,015.00	$ 470,015.00	$ 470,015.00	$ 470,015.00	$ 545,015.00
Total assets	$ 640,645.00	$ 655,046.25	$ 669,202.50	$ 683,358.75	$ 697,515.00	$ 786,671.25
Current liabilities	$ 129,645.00	$ 144,046.25	$ 158,202.50	$ 172,358.75	$ 186,515.00	$ 200,671.25
Long-term debt	51,100.00	51,100.00	51,100.00	51,100.00	51,100.00	58,600.00
Preferred stock	—	—	—	—	—	—
Common stock	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	68,500.00
Retained earnings	458,900.00	458,900.00	458,900.00	458,900.00	458,900.00	458,900.00
Total common equity	$ 459,900.00	$ 459,900.00	$ 459,900.00	$ 459,900.00	$ 459,900.00	$ 527,400.00
Total liabilities and equity	$ 640,645.00	$ 655,046.25	$ 669,202.50	$ 683,358.75	$ 697,515.00	$ 786,671.25

d. Assuming that the firm's future cash flows from operations (i.e., its FCFs) and its interest tax savings are level perpetuities for year 5 and beyond that equal their year 4 values, what is your estimate of the enterprise value of Canton?

e. Based on your estimate of enterprise value, what is the value per share of equity for the firm if the firm has 2 million shares outstanding? Remember that your calculations up to this point have been in thousands of dollars.

9-7 APV VALUATION The following information provides the basis for performing a straightforward application of the adjusted present value (APV) model.

Assumptions				
Unlevered cost of equity	12%			
Borrowing rate	8%			
Tax rate	30%			
Current debt outstanding	$200.00			
	Years			
	1	**2**	**3**	**4 and Beyond**
Firm FCFs	$100.00	$120.00	$180.00	$200.00
Interest-bearing debt	200.00	150.00	100.00	50.00
Interest expense	16.00	12.00	8.00	4.00
Interest tax savings	4.80	3.60	2.40	1.20

Unlevered cost of equity—The rate of return required by stockholders in the company, where the firm has used only equity financing.

Borrowing rate—The rate of interest the firm pays on its debt. We also assume that this rate is equal to the current cost of borrowing for the firm or the current market rate of interest.

Tax rate—The corporate tax rate on earnings. We assume that this tax rate is constant for all income levels.

Current debt outstanding—Total interest-bearing debt, excluding payables and other forms of non-interest-bearing debt, at the time of the valuation.

Firm FCFs—Net operating earnings after tax (NOPAT), plus depreciation (and other noncash charges), less new investments in net working capital less capital expenditures (CAPEX) for the period. This is the free cash flow to the unlevered firm because no interest or principal is considered in its calculation.

Interest-bearing debt—Outstanding debt at the beginning of the period, which carries an explicit interest cost.

Interest expense—Interest-bearing debt for the period times the contractual rate of interest that the firm must pay.

Interest tax savings—Interest expense for the period times the corporate tax rate.

a. What is the value of the unlevered firm, assuming that its FCFs for year 5 and beyond are equal to the year 4 free cash flow?

b. What is the value of the firm's interest tax savings, assuming that they remain constant for year 4 and beyond?

c. What is the value of the levered firm?

d. What is the value of the levered firm's equity, assuming that the firm's debt is equal to its book value?

9-8 APV VALUATION Clarion Manufacturing Company is a publicly held company that is engaged in the manufacture of home and office furniture. The firm's most recent income statement and balance sheet are found below.

Income Statement ($000)

Sales	$ 16,000
Cost of goods sold	(9,000)
Gross profit	7,000
Selling and administrative expenses	(2,000)
Operating income	5,000
Interest expense	(630)
Earnings before taxes	4,370
Taxes	(1,311)
Net income	$ 3,059

Balance Sheet ($000)

Current assets	$ 5,000	Liabilities[6]	$ 7,000
Fixed assets	9,000	Owners' equity	7,000
	$ 14,000		$ 14,000

a. Clarion's future operating earnings are flat (i.e., no growth), and it anticipates making capital expenditures equal to depreciation expense with no increase anticipated in the firm's net working capital. What is the value of the firm using the APV model? To respond to this question, you may assume the following: The firm's current borrowing rate is the same as the 9% rate it presently pays on its debt, all the firm's liabilities are interest bearing, the firm's "unlevered" cost of equity is 12%, and the firm's tax rate is 30%.

b. What is the value of Clarion's equity (i.e., its levered equity) under the circumstances described in part (a)?

c. What is Clarion's weighted average cost of capital, given your answers to parts (a) and (b)?

d. Based on your answers to parts (a) to (c), what is Clarion's levered cost of equity?[7]

e. If the risk-free rate is 5.25% and the market risk premium is 7%, what is Clarion's levered beta? What is Clarion's unlevered beta?

9-9 TERMINAL-VALUE ANALYSIS Terminal value refers to the valuation attached to the end of the planning period; it captures the value of all subsequent cash flows. Estimate the value today for each of the following sets of future cash flow forecasts.

a. Claymore Mining Company anticipates that it will earn firm FCFs of $4 million per year for each of the next five years. Beginning in year 6, the firm will earn FCF of $5 million per year for the indefinite future. If Claymore's cost of capital is 10%, what is the value of the firm's future cash flows?

[6] All liabilities are assumed to be interest bearing.

[7] A firm's levered cost of equity represents the rate of return that investors require when investing in the firm's common equity, given the firm's present use of financial leverage.

b. Shameless Commerce Inc. has no outstanding debt and is being evaluated as a possible acquisition. Shameless's FCFs for the next five years are projected to be \$1 million per year, and, beginning in year 6, the cash flows are expected to begin growing at the anticipated rate of inflation, which is currently 3% per annum. If the cost of capital for Shameless is 10%, what is your estimate of the present value of the FCFs?

c. Dustin Electric Inc. is about to be acquired by the firm's management from the firm's founder for \$15 million in cash. The purchase price will be financed with \$10 million in notes that are to be repaid in \$2 million increments over the next five years. At the end of this five-year period, the firm will have no remaining debt. The FCFs are expected to be \$3 million a year for the next five years. Beginning in year 6, the FCFs are expected to grow at a rate of 2% per year into the indefinite future. If the unlevered cost of equity for Dustin is approximately 15% and the firm's borrowing rate on the buyout debt is 10% (before taxes at a rate of 30%), what is your estimate of the value of the firm?

9-10 ENTERPRISE VALUATION—TRADITIONAL WACC VERSUS APV Answer the following questions for Canton Corporation, which was described in Problem 9-4. Assume that firm revenues grow at a rate of 10% per year during years 1 through 4 before leveling out at no growth for year 5 and beyond. You may also assume that Canton's gross profit margin is 60%; operating expenses (before depreciation) to sales is 30%; current assets to sales is 15%; accounts payable to sales is 5%; and net property, plant, and equipment (PPE) to sales is 40%, and that Canton maintains equal dollar amounts of long-term debt and equity to finance its growing needs for invested capital. Also assume that the cost of unlevered equity in this case is 13.84% and the cost of levered equity is 15.28%. The cost of debt remains at 8%. The corporate tax rate is 30%.

a. Calculate the enterprise value using the APV method.

b. From (a), calculate the value of equity after deducting the value of book debt from enterprise value. Use the market value of equity and book value of debt as weights to compute WACC.

c. Value the firm's FCFs using the WACC approach.

d. Compare your enterprise-value estimates for the two discounted cash flow models. Which of the two models do you feel best suits the valuation problem posed for Canton?

9-11 TERMINAL VALUE AND THE LENGTH OF THE PLANNING PERIOD Prestonwood Development Corporation has projected its cash flows (i.e., firm FCFs) for the indefinite future under the following assumptions: (1) Last year the firm's FCF was \$1 million, and the firm expects this to grow at a rate of 20% for the next eight years; (2) beginning year 9, the firm anticipates that its FCF will grow at a rate of 4% indefinitely; and (3) the firm estimates its cost of capital to be 12%. Based on these assumptions, the firm's projected FCF over the next 20 years is the following:

Years	Cash Flows (Millions)
1	\$ 1.2000
2	1.4400
3	1.7280
4	2.0736
5	2.4883

(Continued)

6	2.9860
7	3.5832
8	4.2998
9	4.4718
10	4.6507
11	4.8367
12	5.0302
13	5.2314
14	5.4406
15	5.6583
16	5.8846
17	6.1200
18	6.3648
19	6.6194
20	6.8841

a. Based on the information given and a terminal-value estimate for the firm of $89.4939 million for year 20, what is your estimate of the firm's enterprise value today (in 2015)?

b. If a three-year planning period is used to value Prestonwood, what is the value of the planning period cash flows and the present value of the terminal value at the end of year 3?

c. Answer Problem 9-12(b) for planning periods of 10 and 20 years. How does the relative importance of the terminal value change as you lengthen the planning period?

PROBLEM 9-12 MINI-CASE APV VALUATION[8]

Flowmaster Forge Inc. is a designer and manufacturer of industrial air-handling equipment that is a wholly owned subsidiary of Howden Industrial Inc. Howden is interested in selling Flowmaster to an investment group formed by company CFO Gary Burton.

Burton prepared a set of financial projections for Flowmaster under the new ownership. For the first year of operations, firm revenues were estimated to be $160 million, variable and fixed operating expenses (excluding depreciation expense) were projected to be $80 million, and depreciation expense was estimated to be $15 million. Revenues and expenses were projected to grow at a rate of 4% per year in perpetuity.

Flowmaster currently has $125 million in debt outstanding that carries an interest rate of 6%. The debt trades at par (i.e., at a price equal to its face value). The investment group intends to keep the debt outstanding after the acquisition is completed, and the level of debt is expected to grow by the same 4% rate as firm revenues.

[8] © 2015 Scott Gibson, Associate Professor of Finance, College of William and Mary, Williamsburg, Virginia.

Projected income statements for the first three years of operation of Flowmaster following the acquisition are as follows:

	Pro Forma Income Statements ($ Millions)		
	Year 1	**Year 2**	**Year 3**
Revenues	$ 160.00	$ 166.40	$ 173.06
Expenses	(80.00)	$ (83.20)	$ (86.53)
Depreciation (note 1)	(15.00)	$ (15.60)	$ (16.22)
Earnings before interest and taxes	$ 65.00	$ 67.60	$ 70.30
Interest expense (note 2)	(7.50)	(7.80)	(8.11)
Earnings before taxes	$ 57.50	$ 59.80	$ 62.19
Taxes (34%)	(19.55)	(20.33)	(21.15)
Net income	$ 37.95	$ 39.47	$ 41.05

Note 1—Property, plant, and equipment grow at the same rate as revenues so that depreciation expenses grow at 4% per year.

Note 2—The initial debt level of $125 million is assumed to grow with firm assets at a rate of 4% per year.

Burton anticipates that efficiency gains can be implemented that will allow Flowmaster to reduce its needs for net working capital. Currently, Flowmaster has net working capital equal to 30% of anticipated revenues for year 1. He estimates that, for year 1, the firm's net working capital can be reduced to 25% of year 2 revenues, then 20% of revenues for all subsequent years. Estimated net working capital for years 1 through 3 is as follows:

	Current ($ Millions)	**Pro Forma ($ Millions)**		
Net working capital $(t-1)$/revenues (t)	30%	25%	20%	20%
Net working capital	$ 48.00	$ 41.60	$ 34.61	$ 36.00

To sustain the firm's expected revenue growth, Burton estimates that annual capital expenditures that equal the firm's annual depreciation expense will be required.

Burton has been thinking for some time about whether to use Howden's corporate cost of capital of 9% to value Flowmaster and has come to the conclusion that an independent estimate should be made. To make the estimate, he collected the following information on the betas and leverage ratios for three publicly traded firms with manufacturing operations that are very similar to Flowmaster's:

Company	**Leveraged Equity Beta**	**Debt Beta**	**Leverage Ratio***	**Revenues† ($ Millions)**
Gopher Forge	1.61	0.52	0.46	$ 400
Alpha	1.53	0.49	0.44	380
Global Diversified	0.73	0.03	0.15	9,400

*The leverage ratio is the ratio of the market value of debt to the sum of the market values of debt and equity. Debt ratios are assumed to be constraint.

†Revenues are the entire firm's revenues for the most recent fiscal year.

a. Calculate the unlevered cash flows (i.e., the firm FCFs for Flowmaster for years 1 to 3).

b. Calculate the unlevered cost of equity capital for Flowmaster. The risk-free rate of interest is 4.5% and the market risk premium is estimated to be 6%.

c. Calculate the value of Flowmaster's unlevered business.

d. What is the value of Flowmaster's interest tax savings, based on the assumption that the $125 million in debt remains outstanding (i.e., the investment group assumes the debt obligation) and that the firm's debt and consequently its interest expenses grow at the same rate as revenues?

e. What is your estimate of the enterprise value of Flowmaster based on your analysis in Problem 9-13(a) to (d)? How much is the equity of the firm worth today, assuming the $125 million in debt remains outstanding?

f. In conversations with the investment banker who was helping the investment group finance the purchase, Burton learned that Flowmaster has sufficient debt capacity to issue additional debt that would have a subordinate claim to the present debt holders and that would carry an 8.5% rate. The amount of new debt is constrained by the need to maintain an interest coverage ratio (i.e., earnings before interest and taxes divided by interest expense) of five to one. Assuming that Flowmaster's $125 million of 6% senior debt remains in place (and grows at a rate of 4% per year going forward), what is the maximum amount of subordinated debt that can be issued to help finance the purchase of Flowmaster?

PROBLEM 9-13 MINI-CASE TRADITIONAL WACC VALUATION[9]

Setting: It is early January 2015. As the chief financial officer of TM Toys Inc., you are evaluating a strategic acquisition of Toy Co. Inc. (the "target").

Industry Overview: The toys-and-games industry consists of a select group of global players. The $60 billion industry (excluding videos) is dominated by two US toymakers: Mattel (Barbie, Hot Wheels, Fisher-Price) and Hasbro (G.I. Joe, Tonka, Playskool). International players include Japan's Bandai Co. (Digimon) and Sanrio (Hello Kitty), as well as Denmark's LEGO Holding. Success in this industry depends on creating cross-culturally appealing brands backed by successful marketing strategies. Toy companies achieve success through scoring the next big hit with their target consumers and unveiling must-have toys. Historically, we have seen significant merger and acquisition activity and consolidation among brands in this industry.

Target Company Description: Toy Co. Inc. is a multibrand company that designs and markets a broad range of toys and consumer products. The product categories include: Action Figures, Art Activity Kits, Stationery, Writing Instruments,

[9] © 2015 Julia Plotts, Assistant Professor of Clinical Finance and Business Economics, University of California.

Performance Kites, Water Toys, Sports Activity Toys, Vehicles, Infant/Pre-School, Plush, Construction Toys, Electronics, Dolls, Dress-Up, Role Play, and Pet Toys and Accessories. The products are sold under various brand names. The target designs, manufactures, and markets a variety of toy products worldwide through sales to retailers and wholesalers, and directly to consumers. Its stock price closed on 12/31/14 at $19.49 per share.

Valuation Assignment: Your task is to estimate the intrinsic value of Toy Co. Inc.'s equity (on a per share basis) on December 31, 2014, using the enterprise DCF model; this will assist you with determining what per-share offer to make to Toy Co. Inc.'s shareholders. Treat all of the results and forecasts for the fiscal years ended 2015 to 2019 as projections. Your research on various historical merger and acquisition transactions suggests that comparable toy companies have been acquired at enterprise value/EBITDA multiples of 10.5× to 11.5×. This is your assumption for a terminal-value exit multiple at the end of the forecast period, 2019. Exhibit P9-13.1 includes the target's planning period cash flow estimates, and Exhibit P9-13.2 provides market and other data for calculation of WACC for a discount rate.

9-14 THOUGHT QUESTION The hybrid model used in this chapter discounts forecasted cash flows over a planning period and adds this to an estimate of the firm's continuing value, which is estimated using comps. The length of the planning period is typically three to ten years. What are some considerations that arise in determining the length of the planning period, during which time detailed cash flow estimates are made?

Exhibit P9-13.1 Planning Period Cash Flow Estimates

	Projected Firm FCFs				
Toy Co. Inc. ($ Millions) Fiscal Year Ended	**December 31, 2015**	**December 31, 2016**	**December 31, 2017**	**December 31, 2018**	**December 31, 2019**
Net operating income	$733.16	$757.63	$783.64	$799.32	$ 815.30
Less: taxes	201.27	207.98	235.09	239.80	244.59
NOPAT	$531.90	$549.65	$548.55	$559.52	$ 570.71
Plus: depreciation	183.58	186.21	191.80	195.64	199.55
Less: capital expenditures	(180.00)	(212.82)	(219.20)	(223.59)	(228.06)
(Increase) in working capital	(50.37)	43.54	(27.68)	(19.82)	(20.21)
Equals FCFF	**$485.11**	**$566.59**	**$493.47**	**$511.76**	**$ 521.99**
EBITDA	**$916.74**	**$943.84**	**$975.45**	**$994.95**	**$1,014.85**

Exhibit P9-13.2 Estimate a Risk-Appropriate Discount Rate

- Cost of debt—Estimated borrowing rate is 6.125% with a marginal tax of 27.29%, resulting in an after-tax cost of debt of 4.5%.
- Cost of equity—Levered equity beta for Toy Co. is .777; using the capital asset pricing model with a ten-year Treasury bond yield of 4.66% and a market risk premium of 7.67% produces an estimate of the levered cost of equity of 10.57%.
- Other—Diluted shares of common equity outstanding on December 31, 2009: 422,040,500 shares; closing stock price: $19.49; debt value outstanding on December 31, 2009: $618,100,000.
- WACC—Using the target debt to value ratio of 6.99%, WACC is approximately 10.14%.

CHAPTER 10

Valuation in a Private Equity Setting[1]

Chapter Overview

This chapter takes the hybrid valuation method developed in Chapter 9, and applies it to the valuation problems faced by private equity investors. Private equity companies raise funds in limited partnerships with a relatively short life span of seven to ten years. They then invest in companies that span all stages of the life cycle of the firm—from venture capital to vulture capital. In all cases, however, their investments are of relatively short duration, with a targeted investment exit in four to six years. The short duration magnifies the importance of the terminal-value component of the valuation, and because the exit often involves the public capital markets, market-based multiples are commonly used.

We consider two specific private equity valuation examples in this chapter. The first is a deal-structuring problem that arises when a venture capital firm makes an investment in a startup firm. The second example is the valuation of a build-up leveraged buyout (LBO) transaction by an LBO fund. In both cases, private equity is the common source of capital, although the purpose of the investment (providing startup or growth versus restructuring capital) is quite different.

10.1 Introduction

Perhaps the most visible difference between how the valuation problems were approached in earlier chapters and the way in which private equity firms evaluate investments relates to the discount rate. Up to this point, our valuation problems used discount rates in the 8% to 12% range. However, most private equity investors claim to require an internal rate of return in the 25% to 50% range and even higher for startup investments. How do they justify such high required rates of return?

First, these investments tend to be quite risky. They involve the financing of startup firms, the provision of growth capital, or the restructuring of older firms. In the case of buyout firms, they also entail the use of substantial amounts of financial

[1] We would like to express our gratitude to J. William Petty for his many helpful insights in the preparation of this chapter.

> **Did You Know?**
>
> **How Significant Is the Market for Private Equity?**
>
> The largest private equity firms now raise multibillion-dollar funds, so by participating in groups or clubs, they are able to garner the billions needed to acquire some of the largest publicly held firms. For example, on September 15, 2006, four private equity firms (Blackstone Group Funds, Texas Pacific Group, Permira Group Funds, and the Carlyle Group) agreed to pay $17.6 billion for Freescale Semiconductor Inc. (Motorola's spin-off of its semiconductor operations). However, the downturn in the economy that began in 2006 depressed private equity fund investing for two years. By 2009, private equity funds were holding almost $400 billion in unspent funds.

leverage. Moreover, since investments in private equity funds do not benefit from the liquidity offered by public investments in stocks, bonds, or mutual funds, they require a liquidity premium that increases the costs of raising funds.

A second justification for the very high required rates of return is that these rates of return include compensation to the private equity firm for more than just the use of money. They also incorporate the value of the expertise that the private equity firm partners bring to the deal. The partners generally take a seat on the board of the firms in which they invest and provide advice to startups and actually control buyout investments.

The third justification for the very high required rates of return of private equity firms is that they are generally used to discount what we referred to in Chapter 3 as hoped-for cash flows rather than expected cash flows. Consequently, we might interpret the 25% to 50% required rates of return as hoped-for returns rather than expected rates of return.

It should also be emphasized that the required rate of return on these investments is determined by the opportunity cost of capital, which means that when private equity firms have an abundance of good opportunities and scarce capital, they can require very high rates of return. However, when there is abundant capital and fewer opportunities, we expect required rates of return to decline.

The hybrid valuation approach is applied by private equity firms in some rather unique ways. First, in most cases, when a private equity firm makes an investment, it does not expect to receive significant cash flows in the initial planning period, so the valuation emphasis is on the (terminal) value of the enterprise at a future date when the private equity investor hopes to cash out of the investment. This value is generally estimated as a multiple of earnings before interest, taxes, depreciation, and amortization (EBITDA). Second, the object of the valuation exercise generally focuses on the value of the investors' equity investment rather than on the enterprise value of the company receiving funding. Neither of these features provides significant difficulties for the hybrid valuation approach, but they do give rise to some unique terminology and special adaptations of the tools developed in Chapter 9.

Up to this point, we have examined situations where we evaluate whether to invest a specified amount of cash in an investment opportunity that offers an uncertain set of future cash flows. From the perspective of the venture capitalist (VC), the investment problem is similar in that startup firms typically require a specific amount of external funding in order to produce an uncertain set of future cash flows. However, the VC not only evaluates the uncertain future cash flows but also negotiates the ownership fraction of the startup's shares that he or she must have in order to earn a desired return on the investment. Thus, the valuation problem for the VC is generally discussed in the context of deal structuring. Although this is a somewhat different problem from those we have addressed so far, we can solve it with a slight modification of our valuation methods.

This chapter is organized as follows: In Section 10.2, we provide a brief overview of the private equity and venture capital markets. Section 10.3 provides an overview of deal-structuring analysis as it is carried out by venture capital firms. In Section 10.4, we

INDUSTRY INSIGHT

Private Versus Public Equity Investing

Private equity investing differs from public equity investing in four ways:

1. **Private equity investors make *illiquid* investments that cannot be sold because of either a lack of an organized market or investment restrictions.** The investment might take the form of equity or debt securities issued by a privately held firm or restricted shares of stock issued by a publicly held firm.* In either case, the investment cannot be easily sold. In contrast, mutual funds and other passive investors hold publicly traded debt and equity securities that can be bought or sold at any time.
2. **Private equity investors are *active* investors.** They generally take an active role in managing the companies in which they invest (for example, taking a seat on the board) or serve as financial advisers to the firm's management. This contrasts with the hands-off investment style followed by mutual funds and others who invest primarily in the public equity markets.
3. **Private equity investments are made for a *finite* period of time.** Traditional private equity investing involves ownership of limited partnership units that are part of a private equity fund. The partnership typically has a fixed life of seven to ten years, after which time the fund is liquidated and the proceeds are distributed to the partners. Mutual funds and other entities that invest in public equity have no set liquidation date and thus can have a much longer investment horizon.
4. **Private equity investments are risky and illiquid and thus require high returns.** Because the failure rate can be quite high in some types of private equity investing and the investment is illiquid for years, private equity investors typically demand very high promised rates of return.

*The restriction we refer to relates to the fact that the investor cannot sell his or her shares for a prescribed period of time.

look at the valuation of an investment by an LBO firm. We close this section with an application of the adjusted present value (APV) model for a private equity investment. Section 10.5 contains summary comments.

10.2 Overview of the Market for Private Equity

Before we launch our discussion of the valuation of private equity investments, it will be helpful to describe the market for private equity and to gain some perspective on the role of private equity finance in the US economy. When we refer to a private equity firm, we are referring to a financial intermediary that is in the business of raising pools of capital (generally in limited partnerships) and using that capital to invest in companies that need financing. Essentially, private equity is an ownership stake either in a private company or in shares of a public company that are restricted so that they cannot be sold for some specified period of time.[2] In general, a private equity investor is an active investor who acquires some measure of control over the firms in which he or she invests, often by serving on the firm's board. The Industry Insight box (p. 361) summarizes the differences between public equity and private equity investing.

Market for Private Equity—Financial Intermediaries

Figure 10-1 summarizes the three parties involved in the private equity market, including suppliers of funds (e.g., the investors in the private equity partnerships), the private equity investment companies that invest in and manage these funds, and the businesses that use private equity funds. Although it is difficult to know exactly how large the various components of the market are at any moment, it is generally believed that approximately 80% of the funds that flow into private equity come from public and private pension funds. The majority of these funds are then invested by the private equity firms in nonventure activities, which include meeting the expansion, recapitalization, and reorganization needs of companies, as well as acquiring large public firms (see the Industry Insight box, Biggest Buyout Deals, p. 364).

Investors—The Suppliers of Private Equity Finance

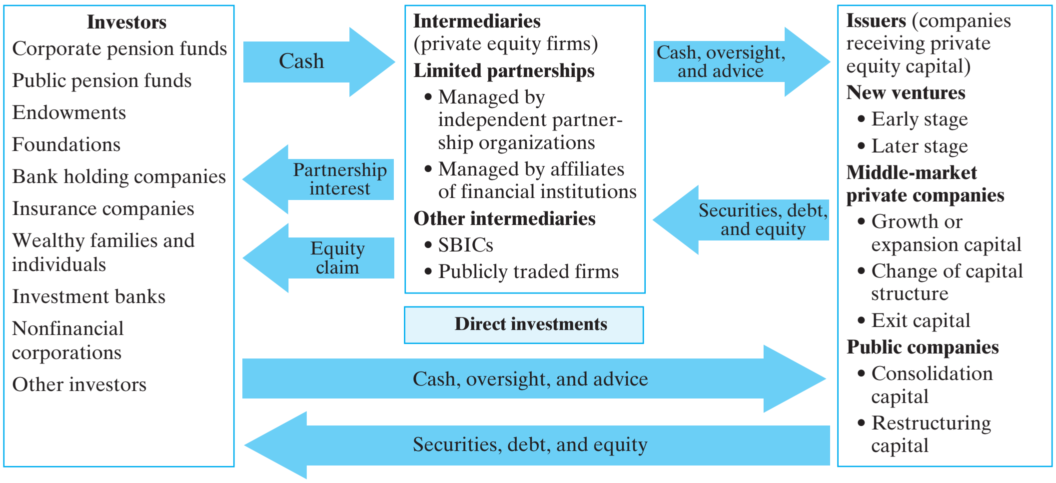
Most private equity firms are organized as *limited partnerships* that raise capital from a small number of sophisticated investors in a private placement. The investors in the fund include public and private employee pension funds, university endowment funds, wealthy families, bank holding companies, and insurance companies. The largest segment (as we noted above) is public and private pension funds, which contribute approximately 80% of all the funds in the private equity market.

Investments—The Demand for Private Equity Finance

Although private equity funds invest in the full spectrum of businesses, individual private equity firms tend to specialize in a very narrow range of activities that coincide roughly with the life cycle of the firms in which they invest, as depicted in Figure 10-2. Seed capital for startups is typically supplied by wealthy individuals, who are commonly referred to as angel investors or business angels. This type of investing typically does not involve the use of an intermediary (i.e., it is a form of direct investing, as depicted at the bottom of Figure 10-1). Venture capitalists typically provide established startup companies with early-stage financing that can carry the companies up to the point where they need to access the public capital markets for their funding needs or where they are sold to other companies (often public companies). This is typically the earliest stage in the firm's life cycle in which a venture capital firm invests. See the Practitioner Insight box on p. 366 for a discussion of the thought process that goes into determining the size of a VC fund and the minimum level of investment in a portfolio company.

[2] These investments are referred to as private investments in public equities (PIPEs).

Figure 10-1 The Market for Private Equity



Private Equity Firms:

Limited partnership. The standard vehicle for raising funds to invest in private equity is a limited partnership that typically has a fixed life of ten years. The partnership's general partner makes investments, monitors them, and finally exits to earn a return on behalf of the investors—limited partners.

Small business investment corporations (SBICs). SBICs were created in 1958. They are privately managed, for-profit investment funds formed to provide equity and/or debt capital to US small businesses.

Categories of Private Equity Investments:

Seed and startup capital. Typically provided by angel investors (i.e., wealthy individuals), this type of capital is provided to develop a concept, create the initial product, and carry out the first marketing efforts. The company that seeks financing is typically very young (less than one year old) and has not produced a product or service for commercial sale.

First-stage capital. The money provided to an entrepreneur who has a proven product to start commercial production and marketing. This is typically the earliest stage at which a venture capital firm invests.

Second-stage capital. The capital provided to expand marketing and meet the growing working capital needs of an enterprise that has commenced production but does not have sufficient cash flows from its operations to fund its capital needs.

Expansion capital. The capital needed to fund the expansion of a profitable firm's operations when the growing firm is incapable of generating sufficient earnings internally to fund its needs for capital.

Bridge capital. A short-term loan that provides needed capital while the borrower arranges for more comprehensive, longer-term financing.

Mezzanine capital. Unsecured, high-yield, subordinated debt or preferred stock that represents a claim on a company's assets and that is senior only to that of a company's shareholders. The term *mezzanine* comes from the fact that these forms of financing are somewhere between debt and equity in terms of the priority of their claim on the firm's earnings and assets in the event of default or bankruptcy.

Source: Based on Figure 3 in Stephen D. Prowse, "The Economics of the Private Equity Market," *Economic Review of the Federal Reserve Bank of Dallas,* 3rd Quarter, 1998, 21–34.

INDUSTRY INSIGHT

Biggest Buyout Deals

By far, the largest fraction of all private equity investing involves nonventure, buyout financing. The following list contains the five largest buyout deals ever done. The 2006–2007 period produced four of the five, which makes this two-year period the largest dollar-volume period for buyouts in US history. Note that only two of the investments involve a single private equity firm. The reason for this relates to the magnitude of the investment being made and concerns by the private equity investors that they not let their investments become too concentrated in a small number of very large investments.

Year	Acquisition Target	Private Equity Buyer(s)*	Equity Value (Inflation Adjusted to 2013)
1989	RJR Nabisco	Kohlberg Kravis and Roberts (KKR)	$55.38 billion
2007	Energy Future Holdings	KKR, Texas Pacific Group (TPG), and GS Capital Partners	$44.23 billion
2007	Equity Office Properties	Blackstone	$41.41 billion
2006	HCA Inc.	Bain Capital, KKR, Merrill Lynch Global Private Equity Group, and Riverstone Holdings	$35.81 billion
2007	First Data	KKR and TPG	$30.87 billion

***Descriptions of the Private Equity Firms (from their websites):**

Bain Capital LLC—Established in 1984, Bain Capital's family of funds includes private equity, venture capital, public equity, and leveraged debt assets.

Blackstone Group—Formed in 1987, the firm managed $28 billion through its Blackstone Capital Partners I, II, III, IV, and V and Blackstone Communications Partners funds.

GS Capital Partners LP—Makes private equity investments on behalf of Goldman Sachs and others.

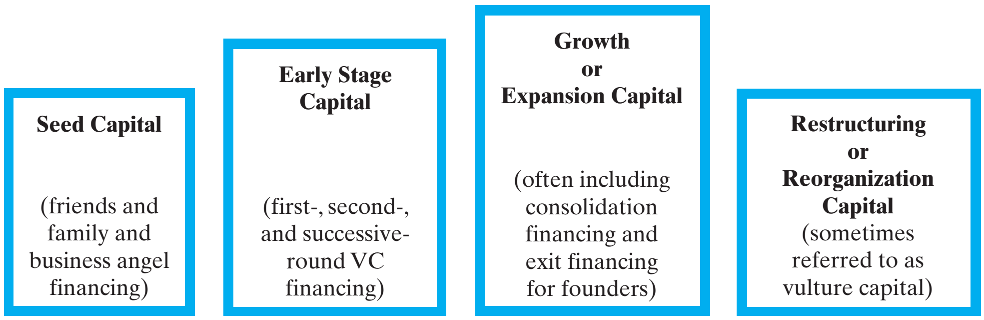
Kohlberg Kravis Roberts & Co. (KKR)—Established in 1976, KKR's investors include corporate and public pension plans, financial institutions, insurance companies, and university endowments.

Merrill Lynch Global Private Equity Group (MLGPE)—The private equity investment arm of Merrill Lynch provides capital to fund growth, financial restructuring, or change of control.

Riverstone Holdings LLC—Founded in 2000, the firm is one of the largest private equity investors in the energy and power industry.

Sources: Thornton McEnery, "The Biggest Private Equity Buyouts in History," Business Insider, April 18, 2011 (http://www.businessinsider.com/the-biggest-private-equity-deals-in-history-2011-4?op=1) and websites of the private equity firms.

Figure 10-2 Stages in the Life Cycle of the Firm



Growth and expansion capital is provided by a mixture of private equity firms, including some firms that consider themselves venture capitalists and others that fall into the buyout category. Finally, providing restructuring or reorganization capital is the domain of the buyout or LBO firm. The motive of the buyout firm can be to finance a reorganization that rationalizes and reconfigures the firm to become competitive or to break up and dissolve the firm's operations. In the latter case, the buyout firm is referred to as a vulture fund.

10.3 Valuing Investments in Startups and Deal Structuring

When a successful new company grows at a pace that cannot be financed by the entrepreneur alone, the entrepreneur frequently seeks funding from a venture capital firm in exchange for partial ownership of the firm. In the negotiation process, a critical question for the entrepreneur is, "How much of the company's equity will the outside investor demand in exchange for providing the needed capital?" The amount that the entrepreneur must give up depends on the VC's assessment of the firm's value. This valuation, in turn, reflects the VC's evaluation of the firm's future prospects and the VC's target rate of return for the investment. Although the venture capital evaluation approach may appear unique, it is actually a variant of the hybrid valuation approach presented in Chapter 9, which combines the methods of multiples and discounted cash flow.

The Cost of Capital for Venture Capital Financing

The venture capital evaluation approach, like any discounted cash flow (DCF) valuation method, requires two primary inputs: a discount rate and an estimate of future cash flows. Figure 10-3 reviews the two basic approaches that we have used to match cash

PRACTITIONER INSIGHT

Determining the Size of a VC Fund to Raise—An Interview with Venture Capitalist Joe Cunningham, MD*

Historically, venture capital (VC) funds that invest in early-stage companies and startups have been relatively small when compared with buyout funds that buy mature businesses. However, in recent years, venture capitalists have raised some very large funds. For example, Austin Ventures, located in Austin, Texas, has over $3 billion under management in nine funds with over $1 billion raised in its fund VII, and Oak Investment Partners raised a $2.56 billion venture fund in 2006. However, the typical venture fund remains small in comparison with the gargantuan buyout funds raised in recent years.

To determine the size of the venture fund that we needed to raise, my two partners and I approached the problem by asking some basic questions and letting the answers guide our choice of a fund size:

1. *How large a portfolio of companies can we effectively manage?*† Based on our experiences in founding and advising startup companies in our target industry (medical technology and services), we estimate that we can each look after five companies, for a total of fifteen.
2. *What is the nature of the typical exit and the value at exit for a startup company in our industry space?* To address this question, we studied the exits of startups in the medical technology and services industry for the last decade. We found that approximately 85% of these exits involved the sale of the startups to larger companies, for a price between $100 million to $200 million with only a half-dozen IPOs [initial public offerings]. We concluded that we should make investments in firms that could be sold at our exit in the $100–$200 million range.
3. *What target return multiples (exit value/invested capital) should the fund use?* Given the risks and opportunities we saw in the industry, we decided on a target exit multiple of ten times our invested capital. Of course, we realize that this multiple will be reached only for the most successful investments and the average for the fund will probably be around five times. Nonetheless, our target when making an investment is ten.
4. *How much money should we plan to invest in each startup?* To get to a $100–$200 million exit value, with an exit value/invested capital ratio of ten times, requires post-money valuations‡ for the startups at the time we invest that are in the $10–$20 million range. Thus, if we invest $5 million in a startup in return for 50% ownership of the firm, this is consistent with a post-money valuation of the firm's equity of $10 million. Using the ten-times target exit multiple implies a valuation of the startup's equity at exit of $100 million. Similarly, if we invest $10 million in the startup company in return for half its equity, the post-money value of the startup will be $20 million and it will have an exit value of $200 million. Consequently, we anticipate investing from $5–$10 million in each startup in two financing rounds.

Putting the answers to these questions together and assuming that we invest an average of $8 million in each of fifteen companies, we determined that the optimal fund size for us was $120 million.

*Joe Cunningham, MD, is managing director for Santé Health Ventures, Austin, Texas. Santé invests in early-stage life science and health care ventures.

†The answer to this question varies from fund to fund, and depends on the industry in which the fund invests and the type of value proposition the VC brings to its portfolio companies. Value proposition refers to the level of VC contribution. A simple monetary investment, or a monetary investment and specialized industry knowledge, and contacts that require more frequent involvement with the company.

‡Post-money valuation is a commonly used term in the venture capital industry, and it refers to the value of the startup business that is implied by the amount of money invested by the VC fund in combination with the fraction of the startup company's shares that the VC acquires.

Figure 10-3 Alternative DCF Valuation Approaches

Approach	Cash Flow	Discount Rate	Applications
Traditional DCF or expected-return valuation model	Expected cash flow	Expected rate of return on comparable-risk investment	Project and business valuation • Traditional WACC approach (Chapters 2 through 5) • Adjusted present value approach (Chapter 9)
Optimistic or "hoped-for" valuation approach	Optimistic cash flow	Optimistic or "hoped-for" rate of return	• Bond valuation (Chapter 4) • Venture capital valuation (Chapter 10) • LBO valuation (Chapter 10)

flows and discount rates. The first is the traditional DCF approach to valuation, which discounts *expected* future cash flows using the *expected* rate of return from a comparable-risk investment (i.e., the opportunity cost of capital). This DCF model is the de facto standard for most applications in finance and was the basis for most of our discussions in prior chapters. The second method is the optimistic or hoped-for DCF valuation approach.[3] This variant of the DCF model discounts optimistic or hoped-for cash flows back to the present using optimistic or hoped-for rates of return. We believe that the venture capital method falls into this latter category, although this terminology is not used by venture capitalists.

In general, the hoped-for cash flows used to value startup firms are those that materialize in scenarios in which everything goes as planned. The optimism embedded in these forecasts comes from the fact that entrepreneurs (whose optimism causes them to underweight the probability of failure) are the primary source of these cash flow estimates. Venture capitalists like to encourage the enthusiasm of the entrepreneurs they fund, so rather than trim optimistic projections, they generally require rates of return that are high enough to offset the entrepreneurs' optimistic cash flow estimates, as well as compensate the venture capitalist for the risk of the venture. Besides, the venture capitalists can turn the entrepreneur's optimistic forecast into ambitious targets that the entrepreneur can be held to in the future.

The rates of return (RORs) required by UC investors vary with the stage of the investment. For example, in the earliest stage of investment, referred to as the *seed* or *startup stage,* venture capitalists typically require rates of return ranging from 50% to

[3] There is yet a third variation of the DCF model that we did not include in Figure 10-3, and it is the certainty equivalent model. This model discounts *certainty equivalent* cash flows (i.e., cash flows adjusted to equal their certain equivalents) using the *risk-free* rate of interest. We will discuss this particular model later, when we consider futures and options.

PRACTITIONER INSIGHT

Investing in Private Equity—An Interview with Jonathan Hook*

How do you think about rates of return you target for private equity investing?

The lack of liquidity in private equity investments is a critical consideration for anyone who considers making this type of investment. Investing in a private equity fund generally means you are tying up your money for several years. Consequently, as a general rule of thumb, we require that private equity investments provide the opportunity to earn 4% to 5% more than the return we anticipate on the S&P 500.

How much of your endowment portfolio do you allocate to private equity?

A primary consideration for us is that we have a balanced and well-diversified portfolio, so we try not to get too overweighted in any one asset class. With private equity, we target 15% of our portfolio, but with the flexibility to move this allocation up or down by 5% as opportunities present themselves.

*Jonathan Hook is vice president and chief investment officer at Ohio State University Endowment Fund. This interview took place when Mr. Hook was the chief investment officer at Baylor University.

100% (per annum!). As the firm progresses through the startup phase into first- and second-round financings, the required rate of return drops, as the following table indicates.[4]

Stage of Investment*	Annual ROR (%)	Typical Expected Holding Period (Years)
Seed and startup	50%–100% or more	More than 10
First stage	40–60	5–10
Second stage	30–40	4–7
Expansion	20–30	3–5
Bridge and mezzanine	20–30	1–3

*See the legend to Figure 10-1 for definitions of each of the types of financing listed here.

Do venture capitalists actually realize these hoped-for returns? It is difficult to answer this question because the private equity funds are just that, private, and do not report the performance of their funds on a regular basis. However, one recent study

[4] Jeffry Timmons and Stephen Spinelli, *New Venture Creation: Entrepreneurship for the 21st Century,* 6th ed. (City, ST: Irwin, 2004).

found that when fees are netted out, buyout funds earn slightly less than the average return of the S&P 500 stock index.[5] The point here is that the average rates of return realized on both venture and nonventure investments are much lower than the required rates of return that are used to discount cash flows.

It is important to emphasize that these required rates of return reflect the opportunity cost of capital, which is in turn determined by the rate of return on alternative investments. See the Practitioner Insight box on p. 368, Investing in Private Equity—An Interview with Jonathan Hook. In the long run, we expect required rates of return to be determined by the risk factors discussed in Chapter 4. However, in the short run, the required rates of return on venture capital and other private equity investments are determined by the supply and demand for capital in this sector. When there is lots of capital chasing very few deals, required rates of return are likely to be relatively low. On the other hand, when capital is tight in this sector or when there are lots of opportunities, required rates of return are likely to be higher.

We offer one final point regarding the high required rates of return for venture capital financing, which relates to the fact that the relationship between a startup firm and its venture capitalist often goes beyond acquiring financing. Frequently, the startup firm receives valuable business advice and business connections from the venture capitalist who sits on their board. Because VCs typically focus their investing narrowly in a limited number of industries, this expertise and knowledge of the industry can prove essential to the future success of the startup. The compensation for this nonfinancial source of value is wrapped up in the cost of VC financing, which also helps explain why VC financing looks so expensive.

Valuing a VC Investment and Structuring the Deal

In most cases, a venture capitalist provides funding to an entrepreneur in exchange for stock in his or her business. The key variable that determines the deal structure is the valuation that the venture capitalist places on the entrepreneur's business.

To illustrate how a venture capitalist values and structures a deal, consider the hypothetical case of Bear-Builders.com. The entrepreneur behind Bear-Builders.com started the business last year with an initial investment of $1 million and now needs an additional $2 million to finance the expansion of its already profitable operations. To raise the funds, the entrepreneur approaches Longhorn Partners, a hypothetical venture capital firm located in Austin, Texas.

Investor Expectations

Longhorn believes that the opportunity is good and is willing to provide the $2 million that Bear-Builders.com needs, in exchange for a share of the company's common equity. Now the key question is, "How much stock will the entrepreneur have to give up in the process of acquiring the needed funds?" Bear-Builders.com is seeking first-stage financing, so Longhorn Partners' required (i.e., hoped-for) rate of return is 50%

[5] See Steven Kaplan and Antoinette Schoar, "Private Equity Performance: Returns, Persistence and Capital Flows," *Journal of Finance* 60, no. 4, pp. 1791–1823.

BEHAVIORAL INSIGHT

Aligning Incentives Among the Participants in the Private Equity Market

Asymmetric information is the norm for business dealings. Very simply, the parties to a transaction do *not* share the same information, and this allows one or both parties to take actions that are personally beneficial but are detrimental to the other.

Two sets of relationships are of concern in our discussion of private equity finance. The first deals with the relationship between the more-informed general partners, who can potentially take advantage of the less-informed limited partners. The second relationship relates to the private equity partnership and the more-informed managers of the portfolio companies. The table below summarizes how partnerships try to limit the costs that arise from these information asymmetries by first performing extensive due diligence. They also control managerial behavior through the use of incentive-based contracts and by restricting access to partnership financing because other financing sources are limited for the portfolio companies.

	Agency Relationship	
Means of Control	**Limited Partners and General Partners in Private Equity Firms**	**Private Equity Firm and Portfolio Companies**
Indirect: Performance Incentives (the Carrot)	■ Reputation of general partner affects future fund-raising ability. ■ General-partner compensation is based on fund performance.	■ Managerial ownership of company shares ensures a long-term interest in company performance. ■ Managerial compensation is tied to company performance.
Direct: Contracts and Internal Controls (the Stick)	■ Covenants of the partnership agreement place boundaries on what the general partner can do and provide for limited-partner intervention in extreme circumstances. ■ Advisory boards (including limited-partner representation) provide direct oversight over general-partner decisions.	■ The private equity firm generally takes a board seat and can gain added seats if performance of the portfolio company falters. ■ The fact that the private equity firm controls the portfolio company's access to additional financing provides a strong source of control over management of the portfolio company.

per year. If Longhorn has a five-year investment horizon[6] and receives no cash distributions until the end of this period (which is frequently the case), then it needs to receive \$15,187,500 at the end of five years in order to realize a 50% per annum rate of return; that is:

$$\$2{,}000{,}000(1 + .50)^5 = \$15{,}187{,}500$$

[6] The term *investment horizon* refers to the desired holding period for an investment. Because VC firms raise their capital with limited partnerships that have a limited life (normally five to seven years), they typically have a very short investment horizon when they invest.

Two variables determine whether the investor will actually receive $15,187,500 in five years: (1) the value of the firm at the end of the five years and (2) the fraction of that value that belongs to the investor. Let's consider each of these factors in turn.

Valuing Bear-Builders.com's Equity

The VC's investment return from providing startup capital to Bear-Builders.com is derived from the value of Bear-Builders.com's equity at the end of the VC's planned investment period (typically four to six years). The approach we take to value Bear-Builders.com's equity entails first estimating the firm's enterprise value, then deducting any interest-bearing debt the firm may have outstanding, and adding back any excess cash. It is important to note, however, that startups seldom have debt or excess cash.

Estimating Enterprise Value at the End of the Planned Investment Period The first step in the valuation process is to determine an estimate of enterprise value for Bear-Builders.com after five years, when the venture capitalist hopes to harvest or exit the investment by selling his or her shares. Venture capitalists typically calculate an estimate of the enterprise value of the firm on the harvest date by forecasting both the firm's ability to produce before-tax cash flows from operations, or EBITDA, and the appropriate multiple of EBITDA for valuing the firm. For example, if Bear-Builders.com's owners forecast the firm's EBITDA in five years to be $6 million and the VC uses an EBITDA multiple of 5, then Bear-Builders.com will be worth $30 million ($6 million × 5) when Longhorn Partners plans to harvest its investment in the firm.

Note that there are typically no interim equity cash flows to the VC (or the entrepreneur) prior to the VC's exit. This is because all available cash is either reinvested in the firm or used to service and pay down the firm's debt.

To recap quickly, the calculations used to estimate the enterprise value of Bear-Builders.com at the end of five years are as follows:

EBITDA in year 5	$ 6,000,000
EBITDA multiple	× 5
Equals: enterprise value	$ 30,000,000

In the absence of debt financing, and cash, equity value is equal to the enterprise value of $30,000,000. Now let's assume that the firm has accumulated an excess cash balance of $300,000 and owes interest-bearing debt of $3,000,000. Equity value can now be calculated as follows:

Enterprise value	$30,000,000
Plus: excess cash	300,000
Less: interest-bearing debt	(3,000,000)
Equity value	$27,300,000

Alternatively, the term *net-debt,* which is equal to the difference in interest-bearing debt and excess cash, is often used so that equity value is computed as follows:

Enterprise value	$30,000,000
Less: net debt	(2,700,000)
Equity value	$27,300,000

In either case, the equity value is the same.

Computing Ownership Interests—Defining the Deal Structure

Up to this point, we have shown that, if all goes as planned, the value of Bear-Builders .com's stockholder equity in five years will be $27.3 million. The venture capitalist requires $15,187,500 at that time in order to earn a 50% per annum rate of return on its $2,000,000 investment. Thus, to achieve this total return, the venture capitalist must own 56% of the firm's stock, computed as follows:

$$\begin{aligned}\begin{array}{c}\text{Venture Capitalist's}\\ \text{Ownership Percentage}\end{array} &= \frac{\text{VC's Required Equity Value (in Year 5)}}{\text{Estimated Equity Value for the Firm (in Year 5)}}\\ &= \frac{\$15{,}187{,}500}{\$27{,}300{,}000} = 56\%\end{aligned}$$

Under this deal structure, the founder will own the remaining 44% of the common stock $(100\% - 56\% = 44\%)$, which would entitle him or her to shares worth $12,112,500 in five years.

Summing Up the Venture Capital Method

We have briefly described the process used by venture capitalists to evaluate an entrepreneurial company and structure a financing agreement. The methodology combines the method of multiples based on comparable transactions along with discounted cash flow. Very simply, the investor (venture capitalist) determines the fraction of the firm's ownership it must get in order to satisfy its return requirement, as follows:

1. The investor first determines a rate of return that he or she hopes to realize from the investment ($k_{\text{hoped-for VC return}}$).
2. The investor's required rate of return is used to determine the dollar value that the investor hopes to realize at the end of the planned holding period, H years (typically four to six), in order to justify making the initial investment in the firm.[7]

$$\begin{pmatrix}\text{Venture Capital}\\ \text{Investment}_{\text{Today}}\end{pmatrix}(1 + k_{\text{Hoped-for VC Return}})^{H} = \begin{pmatrix}\text{Required Value}\\ \text{of the Venture Capital}\\ \text{Investment}_{H}\end{pmatrix} \tag{10.1}$$

3. The investor next estimates the value of the firm's equity at the end of the planned holding period using a multiple of the firm's expected EBITDA in year H; that is:

$$\begin{array}{c}\text{Estimated Equity}\\ \text{Value}_{H}\end{array} = \text{EBITDA}_{H} \times \text{EBITDA Multiple}_{H} + \text{Cash}_{H} - \text{Debt}_{H} \tag{10.2}$$

4. Finally, the investor calculates the fraction (i.e. the ownership share) of the firm's future value that is needed to satisfy his or her total dollar-required return (i.e., the

[7] This relationship holds only if the VC does not receive any interim cash flows, such as interest or preferred dividends in those cases where the firm issues debt or preferred stock. If interim cash flows are paid, then the right-hand side of Equation (10.1) is reduced by an amount equal to the future value of all such interim payments, compounded at the venture capitalist's hoped-for rate of return.

initial investment compounded at the investor's hoped-for rate of return over the investment period), as follows:

$$\text{Ownership Share} = \frac{\left(\begin{array}{c}\text{Required Value}\\ \text{of the Venture Capital}\\ \text{Investment}_H\end{array}\right)}{\text{Estimated Equity Value}_H} \tag{10.3}$$

Thus, the VC method results in an estimate of the VC's ownership share that generates the appropriate hoped-for rate of return.

Pre- and Post-Money Value of the Firm's Equity

We have just pointed out that the venture capital approach focuses on the value of the firm at the future date when the venture capitalist plans to exit the investment. However, venture capitalists also estimate *the value today* for the businesses in which they invest. The implied value of the equity of the firm today is captured by something called the **post-money investment value.** For example, in the BearBuilders.com example, the VC gets 56% ownership for an investment of $2 million; this implies that the value of the firm's equity after (post) the VC firm's investment is $3,571,428; that is:

$$\begin{array}{c}\text{Post-Money}\\ \text{Investment Value}\\ \text{of the Firm's Equity}\end{array} = \frac{\text{Funding Provided by the VC Firm}}{\text{VC Firm's Ownership Interest (\%)}}$$

$$= \frac{\$2{,}000{,}000}{.56} = \$3{,}571{,}428$$

The post-money investment value is the focal point for negotiations between the entrepreneur and the VC. Basically, it provides a shorthand way to describe the structure of the VC deal.

Venture capitalists also use the term **pre-money investment value** to refer to the difference between the post-money implied value of the firm's equity and the amount of money that the venture capitalist puts in the firm. In this case, the pre-money investment value is $1,571,428; that is:

$$\begin{array}{c}\text{Pre-Money}\\ \text{Investment Value}\\ \text{of the Firm's Equity}\end{array} = \begin{array}{c}\text{Post-Money}\\ \text{Investment Value}\\ \text{of the Firm's Equity}\end{array} - \begin{array}{c}\text{Funding Provided}\\ \text{by the VC Firm}\end{array}$$

$$= \$3{,}571{,}428 - 2{,}000{,}000 = \$1{,}571{,}428$$

The critical elements of both post- and pre-money investment value have already been discussed, and the computations are straightforward. The importance of these terms to the financial analyst derives from their common usage among VC investors. The pre- and post-money investment values represent estimates, albeit crude ones, of the value of the firm's equity *on the date of the financing.*

Refining the Deal Structure

Entrepreneurs are often surprised and frustrated to learn how much of the firm they must give up to obtain VC financing. In this section, we discuss how the entrepreneur might lower the rate of return required by the venture capitalist by assuming more of the risk of the venture. Although we cannot explicitly describe how this trade-off works, we can describe how the structure of the deal can be adjusted to reallocate risk and return between the entrepreneur and the private equity investor. We consider two alternative ways to structure the venture capital investment: using *staged-financing* commitments and issuing a different type of security (e.g., preferred stock as opposed to common stock).

Using Staged-Financing Commitments

As we mentioned earlier, the rates of return required by venture capitalists are quite high because the investments are quite risky and the cash flow forecasts tend to be overly optimistic. Thus, anything that can be done to lower the venture capitalist's risks and signal the entrepreneur's confidence will result in lower required rates of return from the VC.

Because venture capitalists tend to be skeptical about cash flow forecasts and want to limit their risks, they generally make what is known as *staged-financing commitments.* Instead of providing the entrepreneur with all the required funding upfront, the VC generally makes partial or staged investments as the firm meets predetermined performance milestones and as money is needed. This process gives the VC control over the firm's access to capital and thereby reduces the risk of the VC's investment. If the VC is not satisfied with the firm's progress, then the next installment is simply not made.

Let's return to our Bear-Builders.com example to illustrate how staged financing can reduce the cost of financing to the entrepreneurial firm. In our original example, the entrepreneur needed \$2 million, and the venture capitalist was willing to provide the funds in return for an annual rate of return of 50%. Thus, the venture capitalist required that the value of its invested capital be worth $\$15{,}187{,}500 = \$2{,}000{,}000\,(1 + .50)^5$ in five years. Because the firm's equity is estimated to be worth \$27,300,000 at this time, we calculated that the venture capitalist must receive $\$15{,}187{,}500/\$27{,}300{,}000 = 56\%$ of the equity of the firm.

Now let's consider a staged-investment alternative in which the venture capitalist invests \$1 million initially (still requiring a 50% rate of return because this is first-stage capital) but invests the second \$1 million two years later, on the condition that the firm has achieved certain performance benchmarks. Because the second-stage investment is less risky than the first, we assume that the VC requires only a 30% return on this second infusion of capital.

Using staged commitments, the venture capitalist requires the following dollar return at the end of five years (assuming the second-stage financing is forthcoming):

Financing Stages	**Funding Provided**	**Return Required at the End of Year 5**
First-stage investment	\$1,000,000	$\$1{,}000{,}000(1 + .50)^5 = \$7{,}593{,}750$
Second-stage investment	\$1,000,000	$\$1{,}000{,}000(1 + .30)^3 = \$2{,}197{,}000$
Total	\$2,000,000	\$9,790,750

The VC now requires $9,790,750 for his or her $2,000,000 investment, which represents $9,790,750/$27,300,000 = 36% of the value of the firm's equity at the end of five years. This dramatic reduction (from 56% to 36%) represents the impact of two factors: First, the VC firm pays only $1 million in capital for the first two years (not $2 million as before); second, the VC's required return in the second-stage financing is only 30%.

Note that the above analysis assumes that the second-stage financing is provided with certainty. This is not necessarily the case, however, because the VC has control over the decision to invest at the second stage and will do so only if the investment looks favorable at that time. In making a staged commitment, the VC has the option to invest at the second stage, rather than an obligation, and will choose not to invest more money if the firm does not perform as planned. Because this option is valuable (as we discuss in Chapter 12), the venture capitalist is willing to provide financing at more favorable terms.

It should be stressed that the entrepreneur gives up less of his or her business, but there is no free lunch here. The entrepreneur is required to take on more risk. If the performance benchmarks are not met after two years, he or she will not be able to obtain the necessary funds to remain in business. But if the entrepreneur is very confident about meeting the benchmark, then the staged financing may be preferable; moreover, a lack of willingness to accept a staged-financing commitment by an entrepreneur could send a negative signal to the VC.

Using Debt or Preferred Stock

A confident entrepreneur may also get more-favorable financing by assuming more of the risk of the venture and limiting the VC's risk exposure by issuing debt or preferred equity securities. The VC's risk is reduced by virtue of the superior claim that debt and preferred stock enjoy over common stock. Again, there is no free lunch here; the entrepreneur receives less-costly financing by limiting the VC's risk exposure and in the process bears more of the risk him- or herself.

To demonstrate how this works, we use the Bear-Builders.com example again. This time, instead of issuing common stock to the venture capitalist, the firm issues convertible preferred stock with a dividend rate of 8%, or an annual dividend of $160,000 ($2 million × .08 = $160,000). The preferred stock can be converted into the firm's common stock at the discretion of the VC. (There is generally no incentive on the part of the investor to convert early.) If the VC wants a 40% return and the investment horizon is five years, the cash flow stream to the VC consists of the following:

VC's hoped-for rate of return	40%					
VC's investment horizon	5					
Annual interest/dividend payments	$ 160,000					
Financing provided by the VC	$ (2,000,000)					
	Year 0	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Dividends	$ (2,000,000)	$ 160,000	$ 160,000	$ 160,000	$ 160,000	$ 160,000
Conversion value in five years						$ 9,003,386
VC cash flows	$ (2,000,000)	$ 160,000	$ 160,000	$ 160,000	$ 160,000	$ 9,163,386

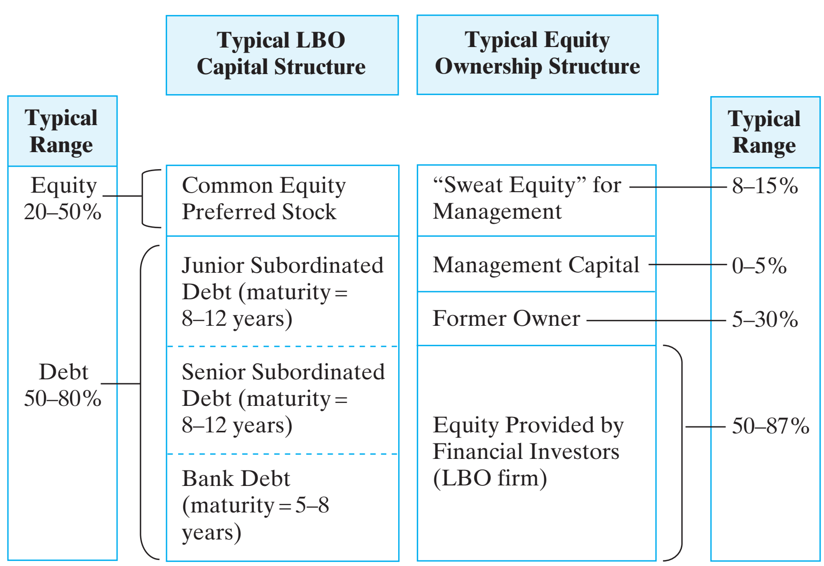
The key calculation we need to make is the required conversion value of the shares that will be realized in year 5. It turns out that, if the preferred shares can be converted into \$9,003,386 worth of common stock, then the VC's \$2 million investment will realize the VC's desired 40% annual rate of return. This, in turn, requires that the VC be given 32.98% of the firm's shares that were earlier valued at \$27,300,000—a substantial savings over the 56% ownership share that was required when using common stock.

10.4 Valuing Leveraged Buyout Investments

Leveraged buyouts (LBOs) represent a business acquisition strategy whereby an investor group acquires all the equity of a firm and assumes its debts.[8] The acquisition is financed predominantly with debt—hence the term *leveraged buyout.* Figure 10-4 illustrates the proportion of the total financing that comes from debt and how it varies over time with market conditions, and it typically constitutes 50% to 80% of the capital structure of the LBO.

The extreme use of financial leverage is a defining characteristic of LBOs when compared to firms' pre-LBO capital structures. Why are private equity investments

Figure 10-4 LBO Capital Structures



Source: Based on Scot Sedlacek, *Leveraged Buyouts: Building Shareholder Value Through Capital Structure* (Broadview International LLC, April 2, 2003). © 2003 Jefferies Broadview. All Rights Reserved.

[8] When the acquisition is made in conjunction with the firm's management, we refer to the transaction as a management buyout (MBO).

so highly leveraged? Perhaps private equity sponsors can attract investors more easily by providing highly leveraged returns rather than more-modest, unleveraged returns. However, this "pure leverage" effect cannot create value on its own. Financial leverage also has an important bonding effect: By saddling their investments with a substantial amount of debt, private equity sponsors force managers to make the tough choices that may be necessary in turnaround situations. In addition, the fact that sophisticated financial institutions are willing to provide the debt for these highly leveraged entities should provide some comfort for the equity investors.

Alternative LBO Acquisition Strategies—Bust-Ups and Build-Ups

As the Practitioner Insight box on page 378 describes, the use of the LBO acquisition strategy was very popular in the 1980s. Most buyouts in that era were known as bust-up LBOs. The term *bust-up* refers to the fact that, once control of the acquired company is complete, the new owner sells off some (or all) of the firm's assets and uses the proceeds to repay the debt used to finance the acquisition. These acquisitions are also associated with efforts to increase efficiency in the operations of the remaining assets, which often entails reductions in the firm's workforce.

Beginning in the 1990s, a different private equity strategy evolved that creates a large public company from the acquisition of an initial company (the platform company), followed by a series of smaller add-on acquisitions. This strategy, described in the Practitioner Insight box featuring the interview with Jack Furst on page 378, is generally referred to as the build-up strategy.

Example—Build-Up LBOs

The build-up LBO is a special case of a roll-up merger strategy where an acquiring firm purchases a group of firms in the same or very closely related businesses and then combines them into a single entity. For example, Hicks, Muse, Tate & Furst—a private equity firm in Dallas, Texas (and predecessor of HM Capital)—purchased Berg Electronics from E I DuPont in 1993 for $370 million. The acquisition became the platform company to which over $100 million in acquisitions were added before Berg's initial public offering (IPO) in 1996.[9]

To illustrate the valuation issues involved in a build-up LBO, we consider a typical build-up transaction by a private equity partnership. The principals of our hypothetical private equity firm, Hokie Partners LP, are considering the acquisition of PMG Inc., an electronics firm that manufactures printed circuit boards used in a wide variety of applications. PMG is a wholly owned subsidiary of a large chemical company that has decided that the business is no longer critical to the firm's future success and seeks to sell PMG to the highest bidder.

Acquisition data for PMG are found in Table 10-1; they indicate that PMG has current earnings before interest, taxes, depreciation, and amortization expense (EBITDA)

[9] For additional details, see S. Kaplan, J. Martin, and R. Parrino, Berg Electronics Corporation, http://ssrn.com/abstract=256107.

PRACTITIONER INSIGHT

How Private Equity Firms Create Value—An Interview with Jack Furst*

Over the last twenty-five years, we've seen seismic shifts in the way private equity investors generate investment returns. At the early part of this decade, we retooled our investment approach to account for changes in lending levels and now seek to add value to our investments using three primary tools.

First, we follow a time-tested/proven investment strategy. We invest in undermanaged, underappreciated, or undercapitalized assets that can be transformed into much-larger, more-valuable companies by investing new capital and creating well-defined operating strategies. This investment approach allows us to generate value for investors by taking advantage of the price premium paid for large public companies compared to small, privately held companies. This strategy can be further simplified by focusing on specific sectors. HM Capital, for example, primarily invests in the energy, food, and media industries—sectors in which the firm has a long history of success and a broad network of contacts.

An example of this investment strategy is HM Capital's investment in Regency Energy Partners in December 2004. Prior to the acquisition, Regency was a set of disparate natural gas-gathering and -processing assets in the Southwest. In just fourteen months, HM Capital transformed Regency from a group of natural gas assets to a significant industry player and took the company public. The IPO provided HM Capital with a means of returning all invested capital to investors, in a structure that allowed our investors to maintain a large stake in Regency.

The second tool we use is *change capital.* We transform our acquisitions through strategies designed to grow revenues, increase profits, and optimize assets. At HM Capital, we refer to these strategies and the activist role we play in transforming our investments as *change capital.* We often acquire companies that have not been run as efficiently as we think is possible. This is sometimes due to the fact that the company is a division of a larger company that has been ignored by the management of the parent company. In other instances, the acquired company is being run by a management team that has little ownership in the company and minimal incentive to manage the company in a lean fashion. In either instance, our goal is to align management's interests with ours to reduce operating costs and create value for owners.

of $100 million. The acquisition is expected to require a purchase price equal to five times the current level of EBITDA, or $500 million. In addition to the equity investment from Hokie Partners and its limited partners, the acquisition is financed with 75% debt that has an interest rate of 14%. The debt has covenants that require that all excess cash be used to retire principal, which means that the equity investors will not receive anything until year 5, when the firm is sold. This requirement is commonly referred to as the *cash sweep.*

Hokie Partners believes that it can grow EBITDA at a rate of 10% per year for five years and then hopes to sell the firm for six times EBITDA. When Hokie sells the firm, the firm's outstanding debt will be repaid and the remaining funds distributed to the equity investors.

During our review of an investment opportunity, we identify the changes that will need to be implemented postacquisition and whether the right management team is in place to execute these strategies. We continue to work with management postacquisition to further refine and implement our *change capital* strategies.

Going back to the Regency example, HM Capital's investment thesis was that the company was an underutilized midstream asset with attractive internal growth characteristics. Along with Regency management, HM Capital developed a *change capital* plan to invest $140 million to expand Regency's transmission capacity and transform it from a natural-gas-gathering- and processing-focused business to a natural-gas-transmission business. This capital expenditure quadrupled Regency's pipeline capacity, doubled its cash flow, and helped position the company for an IPO.

The third tool at our disposal is the use of financial leverage as we engineer our capital structure. Much has been made over the amount of debt utilized by private equity firms. In fact, we were typically referred to as leveraged buyout (LBO) investors during the 1980s because we used high levels of debt to fund our acquisitions. Today, we utilize leverage to provide us with the financial flexibility needed to implement our *change capital* strategies and generate a higher rate of return on our investments. When used properly, financial leverage is simply an equity-return accelerant that turns doubles into triples and triples into home runs.

The private equity industry has changed significantly since I first started in the business. Leverage is more optimally used to balance the debt and equity requirements of the capital structure, and the size of transactions has grown dramatically. It is not uncommon today to have private equity firms join forces to acquire public companies for $15 billion to $25 billion. In addition, the objective of today's private equity investor has evolved—take a company private, restructure its cost structure, and then take the firm back public or sell it to a private investor. Thus, the approach to making money has shifted from "break-ups" in the 1970s and 1980s to "buy and build" in the mid-1980s through the 1990s to "buy, restructure, and build." The more things change, the more they stay the same. Private equity as an asset class is as attractive as it has ever been.

*Jack D. Furst is an adjunct professor of finance at the University of North Texas. He co-founded Hicks, Muse, Tate & Furst in 1989, renamed HM Capital Partners in 2006. Mr. Furst is a philanthropist and is passionate about the mission of the Boy Scouts of America. He received his BS from the Carey School of Business at Arizona State University and his MBA from the McCombs School of Business at the University of Texas.

Estimating Equity Returns for the Platform Company

In Table 10-2, we evaluate the equity free cash flows (FCFs) and corresponding compound rate of return for the case where the estimates set out in Table 10-1 are realized. Recall the definition of equity FCF from Chapter 2, which focuses on the cash flows to the common stockholder (as contrasted with the firm free cash flows).[10] Because of the cash-sweep requirement for the firm's debt, the equity FCFs for each of the five years of

[10] Equity FCF = net income + depreciation expense − capital expenditures (CAPEX) − change in net working capital − principal payments + new debt issued.

INDUSTRY INSIGHT

Leveraged Buyouts—Bust-Ups to Build-Ups

In the 1980s, the term *leveraged buyout (LBO)* became synonymous with corporate greed. Books and movies such as *Wall Street, Barbarians at the Gate,* and *Other People's Money* glamorized the process of buying a company using borrowed money to finance most of the purchase. Technically, an LBO is simply the acquisition of a company using lots of debt and very little equity. However, the extreme use of debt financing has important behavioral implications. The principal and interest requirements of the debt are usually so onerous that they effectively bond the acquired firm's management to a strict regimen of maximizing the cash flow potential of the firm. This can be a very important source of value for a firm that was not run efficiently prior to the LBO.

A popular form of LBO in the 1980s involved acquiring a target firm that was not performing up to its potential. The acquiring firm would then sell off excess capacity (productive assets) and lay off workers at the target firm to make the remaining assets more productive. This type of LBO became known as the bust-up LBO.

In many cases, in a matter of years or sometimes only months, the LBO firm that made the acquisition realized a huge profit from the resale of the acquired firm. Most of the purchase price was financed by borrowing with very high-credit-risk *junk bonds,* and the interest and principal payments were made using the acquisition's future cash flows (a combination of the profits of the firm and the sale of assets in the case of bust-up LBOs). Thus, in a sense, the acquired company essentially paid for itself, while the managers of the LBO firm captured any increase in value of the firm as their profit.

More recently, the build-up LBO has been utilized to consolidate firms in fragmented industries with large numbers of competitors and the potential for economies of size and scale of operations. The process entails first acquiring a platform, or base company, and then purchasing a number of related firms that can be combined to form a firm of sufficient size to be sold in the public markets.

Table 10-1 PMG Inc. Acquisition Data ($ Millions)

Earnings Estimates		**Acquisition and Sale EBITDA Multiples**	
Current-year EBITDA (millions)	$100.00	Purchase multiple—Platform company (PMG Inc.)	5
Growth rate in EBITDA	10%	Purchase multiple—Add-on company (Centex)	3
Planned holding period	5 years	Company sale (harvest) multiple	6
Corporate tax rate	35%		
Depreciable life of assets	10 years		
Depreciation expense (year 0)	$ 40.00		
LBO capital structure			
Debt/assets (book values)	75%		
Interest cost	14%		
Annual capital equipment (CAPEX)	$ 50.00		

Table 10-2 Estimating Equity Returns from the Acquisition of PMG Inc. ($ Millions)

Panel (a) Projected Net Income and Equity FCF						
Pro Forma Income Statements	**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
EBITDA		$ 110.00	$ 121.00	$ 133.10	$ 146.41	$ 161.05
Less: depreciation		(45.00)	(50.00)	(55.00)	(60.00)	(65.00)
EBIT		$ 65.00	$ 71.00	$ 78.10	$ 86.41	$ 96.05
Less: interest		(52.50)	(52.06)	(50.34)	(47.11)	(42.14)
Earnings before taxes		$ 12.50	$ 18.94	$ 27.76	$ 39.30	$ 53.91
Less: taxes		(4.38)	(6.63)	(9.72)	(13.75)	(18.87)
Net income		$ 8.13	$ 12.31	$ 18.04	$ 25.54	$ 35.04
Calculation of equity FCF						
Plus: depreciation		$ 45.00	$ 50.00	$ 55.00	$ 60.00	$ 65.00
Less: CAPEX		(50.00)	(50.00)	(50.00)	(50.00)	(50.00)
Less: Principal payments		(3.13)	(12.31)	(23.04)	(35.54)	(50.04)
Equity free cash flow		—	—	—	—	—
	Year 0	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Outstanding loan	$ 375.00	$ 371.88	$ 359.57	$ 336.52	$ 300.98	$ 250.93

Panel (b) Valuing the Platform-Company LBO in Year 5 and the Internal Rate of Return (IRR) on the Investment		
	Year 0	**Year 5**
Debt	$ 375.00	$ 250.93
Equity	$ 125.00	$ 715.37
Firm	$ 500.00	$ 966.31
Internal rates of return (IRR)		
Equity (with debt—leveraged)	41.75%	
Equity (no debt—unleveraged)	22.46%	

the planning period are set to zero,[11] which implies that the projected principal payments on the firm's debt equal the amount of cash left over after meeting all the firm's required expenditures (including new capital equipment purchases).

Note that the transaction requires an investment of $500 million, and if all works as planned, it will produce an EBITDA of $161.05 million in five years. Under this scenario, Hokie Partners will sell PMG for the projected six times EBITDA, which implies a value of $966.31 million and an equity value of $715.37 million (net of the outstanding debt in year 5

[11] Note that, in Table 10-2, the equity FCFs are forced to equal 0 through the retirement of $3.13 million in debt in year 1, thereby reducing the firm's debt from $375 million to $371.88 million; the retirement of $12.31 million in year 2 reduces the debt further to $359.57 million; and so forth.

of $250.93 million). Given these projections, the equity investor's original $125 million investment grows to $715.37 million in five years, which represents a compound annual rate of return of 41.75%.[12] This, of course, should be viewed as a hoped-for (rather than expected) return, based on a scenario where EBITDA grows quite quickly and the firm is sold for a higher multiple than was paid for it. The returns are also quite high because they represent the returns to a highly leveraged equity investment.

To understand the effects of financial leverage on the equity return, we consider the *unleveraged* returns on this investment given the same scenario. If the equity investor put up the full $500 million acquisition price, then the investment would have thrown off cash flows each year equal to the principal and after-tax interest. Again assuming the firm sells for $966.31 million after five years, the compound annual rate of return is only 22.46% per year.[13] This rate of return is still high, but it is much lower than the 41.75% leveraged-equity rate of return.

Similarly, we can consider the returns on this investment under a much less favorable scenario where the EBITDA growth rate is 4% rather than 10% and the EBITDA multiple in year 5 is only four instead of six. In this scenario, the equity holders realize a value in five years of only $156.95 million, which implies a leveraged return of only 4.66%. In this less-favorable scenario, the unleveraged return is 7.90%, which exceeds the leveraged return because the investment earns less than the interest rate on the debt. Financial leverage is truly a two-edged sword! It magnifies returns when outcomes are favorable, but it decreases returns when outcomes are not favorable.

Analyzing the Returns from the Add-On Investment

The second stage of a build-up LBO involves the acquisition of one or more add-on investments. To illustrate how to evaluate these add-on acquisitions, we consider the acquisition details for Centex PowerPak Systems Inc. in Table 10-3.

Table 10-3 Acquisition Details for Centex PowerPak Systems Inc. ($ Millions)

Current-year EBITDA	$12.00	EBITDA acquisition multiple	3
Growth rate in EBITDA	10%	Planning period	5 years
Corporate tax rate	35%	Annual CAPEX	$10.00
Depreciable life of assets	10 years	Depreciation expense (year 0)	$ 3.00
LBO capital structure			
Debt/assets	100%		
Interest cost (planning period)	14%		
Interest cost (post–planning period)	9%		

[12] $125 million $(1 + \text{IRR})^5 = \$715.37$ million; thus, that IRR is 41.75%.

[13] The IRR to the equity investor who invests $500 million in return for the following cash flows (millions) is 22.46%. Note that, in year 5, the investor receives the annual equity cash flow of $77.43 million plus the anticipated sale value of the firm of $966.31 million (= $1,043.74 million).

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
$(500.00)	$37.25	$46.15	$55.77	$66.17	$1,043.74

This acquisition differs from the platform-company acquisition in two important respects. First, it is a much smaller company, with annual EBITDA of only $12 million in the current year. As discussed earlier in the Practitioner Insight box featuring Jack Furst, small companies are often acquired for lower price multiples, and we will assume that, in this case, Centex can be purchased at three times its current level of EBITDA, or $36 million. Adding the relatively cheap assets of the add-on firm to the more highly valued platform company and selling them for the higher multiple of the platform company in five years provides added value, which private equity firms refer to as *multiples expansion.*

The second difference between the platform-company acquisition and the acquisition of the add-on company relates to financing. The add-on company's debt is generally guaranteed by the platform company, so it is difficult to determine exactly how much of the debt can be attributed to the add-on. In the particular example we are considering, the platform company finances the acquisition entirely with debt.

Once again, the initial equity FCFs are set to zero because all of the firm's cash flow will be used to pay down its debt. However, the firm's initial cash flows are not sufficient to cover the debt service (interest) and capital equipment (CAPEX) requirements (see Table 10-4), so it will need to borrow more in years 1 through 4. In year 1, the cash flows fall short by $3.3 million, increasing the total debt for the Centex acquisition from

Table 10-4 Analysis of the Add-On Acquisition of Centex PowerPak Systems Inc. ($ Millions)

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
EBITDA		$ 13.20	$ 14.52	$ 15.97	$ 17.57	$ 19.33
Less: depreciation		(4.00)	(5.00)	(6.00)	(7.00)	(8.00)
EBIT		$ 9.20	$ 9.52	$ 9.97	$ 10.57	$ 11.33
Less: interest		(5.04)	(5.50)	(5.84)	(6.02)	(6.03)
Earnings before taxes		$ 4.16	$ 4.02	$ 4.14	$ 4.55	$ 5.30
Less: taxes		(1.46)	(1.41)	(1.45)	(1.59)	(1.86)
Net income		$ 2.70	$ 2.61	$ 2.69	$ 2.96	$ 3.45
Plus: depreciation		$ 4.00	$ 5.00	$ 6.00	$ 7.00	$ 8.00
Less: CAPEX		(10.00)	(10.00)	(10.00)	(10.00)	(10.00)
Less: principal payments*		3.30	2.39	1.31	0.04	(1.45)
Equity free cash flows†	—	—	—	—	—	$ 74.36
	Year 0	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Debt	$ 36.00	$ 39.30	$ 41.68	$ 43.00	$ 43.04	$ 41.59

*Note that principal payments are subtracted, whereas additional borrowing is added. Thus, in year 1, it is necessary to borrow an added $3.3 million in order to meet the firm's cash flow needs.

†Because 100% of the purchase price is financed by borrowing, the equity investment in year 0 is zero. Furthermore, in year 5, Centex's equity FCF includes the estimated value of the equity in the firm, based on the assumption that the firm is sold. Because there is no added equity investment in year 0, the IRR for the add-on investment is undefined (translation—very large). If only 75% of the acquisition price were borrowed, as was the case for the platform company, the IRR would have been 57.88%, which is still quite high.

$36 million to $39.3 million. Beginning in year 5, the growth in operating income is sufficient to pay interest, cover CAPEX, and pay down the debt of the add-on investment by $1.45 million.

Table 10-4 presents an analysis of the projected earnings and equity cash flow from the Centex PowerPak add-on acquisition. In this case, the rate of return on equity is determined by how much of the new debt that is issued to acquire the firm can be attributed to Centex PowerPak. If we had assumed 75% debt financing, just like the platform company, the internal rate of return (IRR) on the $9 million = 25% × $36 million investment in the add-on company would have been 57.88%, which is very high.

Does the add-on make sense? If the platform company and the add-on companies are of similar risk, and the platform company is deemed a good investment with its 41.75% rate of return on equity, the add-on, with its much higher return, is an even more attractive investment.

In panel (a) of Table 10-5, we see that the combined (platform plus add-on acquisitions) EBITDA reaches $180.38 million by year 5, which, based on the assumed harvest or sale multiple of six times EBITDA at the end of year 5, implies an expected exit value of $1,082.26 million. Netting out the $292.53 million in debt still owed by the combined firms at the end of year 5 generates an estimated equity value of $789.74 million. Comparing our initial equity investment of $125 million to this terminal value, we estimate a compound annual rate of return on the equity investment of 44.58%. In contrast, if no debt had been used and the combined purchase price of $536 million had been raised through equity financing, the combined equity FCFs for the platform and add-on investment would have been the following:

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
EBITDA		$ 123.20	$ 135.52	$ 149.07	$ 163.98	$ 180.38
Less: depreciation expense		(49.00)	(55.00)	(61.00)	(67.00)	(73.00)
EBIT		$ 74.20	$ 80.52	$ 88.07	$ 96.98	$ 107.38
Less: interest expense		—	—	—	—	—
EBT		$ 74.20	$ 80.52	$ 88.07	$ 96.98	$ 107.38
Less: taxes		(25.97)	(28.18)	(30.83)	(33.94)	(37.58)
Net income		$ 48.23	$ 52.34	$ 57.25	$ 63.04	$ 69.80
Plus: depreciation		49.00	55.00	61.00	67.00	73.00
Less: CAPEX		(60.00)	(60.00)	(60.00)	(60.00)	(60.00)
Less: principal payments		—	—	—	—	—
Equity FCF	$ (536.00)	$ 37.23	$ 47.34	$ 58.25	$ 70.04	$ 1,165.06

The compound annual rate of return to the equity shareholders based on the equity FCFs on the bottom row of the table above, then, is 23.07%, which is quite high for an unleveraged return.

Where is the value creation from this strategy coming from? Two possible sources of synergies can create what private equity professionals refer to as multiples expansion. The first is the fact that the combined company (build-up LBO) is larger and more liquid than the platform company and the individual add-ons it acquires. Consequently, the combined firm may sell for a higher multiple when it is sold in the public market.

Table 10-5 Analysis of the Build-Up LBO ($ Millions)

Panel (a) Pro Forma Income Statements and Equity FCF

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
EBITDA		$ 123.20	$ 135.52	$ 149.07	$ 163.98	$ 180.38
Less: depreciation expense		(49.00)	(55.00)	(61.00)	(67.00)	(73.00)
EBIT		$ 74.20	$ 80.52	$ 88.07	$ 96.98	$ 107.38
Less: interest expense		(57.54)	(57.56)	(56.17)	(53.13)	(48.16)
EBT		$ 16.66	$ 22.96	$ 31.90	$ 43.85	$ 59.21
Less: taxes		(5.83)	(8.03)	(11.16)	(15.35)	(20.73)
Net income		$ 10.83	$ 14.92	$ 20.73	$ 28.50	$ 38.49
Plus: depreciation		49.00	55.00	61.00	67.00	73.00
Less: CAPEX		(60.00)	(60.00)	(60.00)	(60.00)	(60.00)
Less: principal payments*		0.17	(9.92)	(21.73)	(35.50)	(51.49)
Equity FCF†	$ (125.00)	—	—	—	—	—
	Year 0	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Debt	$ 411.00	$ 411.17	$ 401.25	$ 379.52	$ 344.02	$ 292.53

Panel (b) Valuing the Build-Up (Combined) LBO in Year 5 and the IRR on the Investment

Evaluation of IRR on the Platform-Company Investment

	Year 0	Year 5
Debt	$ 411.00	$ 292.53
Equity	$ 125.00	$ 789.74‡
Firm	$ 536.00	$ 1,082.26
Internal rates of return (IRR)		
Equity with debt (leveraged)	44.58%	
Equity with no debt (unleveraged)	23.07%	

*Note that principal payments are subtracted, whereas additional borrowing is added. Thus, in year 1, it is necessary to borrow an added $3.3 million in order to meet the firm's cash flow needs.

†Because 75% of the purchase price for the platform company and 100% of the purchase price of the add-on are financed by borrowing, the equity investment in year 0 is $125 million. Furthermore, in year 5, Centex's equity FCF includes the estimated value of the equity in the two acquisitions, based on the assumption that the firm is sold.

‡Equity value (year 5) = firm value (year 5) − interest-bearing debt (year 5) + cash (year 5).
Thus, equity value (year 5) = $1,082.26 − $292.53 = $789.74

The second is that the combined company is more diversified and thus has a higher debt capacity, which can also result in a higher multiple.

A Limitation of the Private Equity (LBO) Valuation Approach

A weakness of the private equity valuation approach, illustrated in Figure 10-5, is that it does not explicitly account for the risks associated with these investments. For example, the risk of the build-up acquisition strategy is an important determinant of whether the 44.58% anticipated return is sufficient to warrant engaging in the investment strategy.

This does not imply that the managers of private equity firms ignore risk and simply choose the investments with the highest projected rates of return. Indeed, it would not be unusual for a private equity firm to select an investment with a projected rate of return of 22% over an alternative investment with a projected rate of return of 28% if the latter were deemed to be much more risky. However, the point remains that the LBO valuation approach that we observe from industry practice does not explicitly consider how the riskiness of the investments influences the discount rates that should be used.

Explicitly accounting for risk in these transactions is somewhat difficult because of the changing use of financial leverage over the life of the investment. The transactions are very highly leveraged at the outset, but due to the cash-sweep provision typically contained in the debt covenants, the debt ratio and the risk of the project decline over

Figure 10-5 Summary of the Industry Private Equity Valuation Method

Step 1: Estimate EBITDA at the end of the planned holding period by preparing pro forma income statements such as those found in Tables 10-4 and 10-5. This entails a careful analysis of the acquired firm's past performance and the planned changes that the private equity firm has in mind.

Step 2: Estimate the enterprise value at the end of the planned holding period as the product of the predicted EBITDA for year N and an appropriate EBITDA valuation multiple, $M_{\text{EBITDA Year } N}$.

$$\text{Enterprise Value}_{\text{Year } N} = M_{\text{EBITDA Year } N} \times \text{EBITDA}_{\text{Year } N} \tag{10.4}$$

Step 3: Calculate the value of the equity of the acquired firm at the end of the planned holding period as follows:

$$\begin{aligned}\text{Equity Value}_{\text{Year } N} = {} & \text{Enterprise Value}_{\text{Year } N} \\ & - \text{Interest-Bearing Debt}_{\text{Year } N} + \text{Cash}_{\text{Year } N}\end{aligned} \tag{10.5}$$

We calculate the firm's outstanding interest-bearing debt at the end of the planned holding period (year N) by subtracting all the principal payments made during the holding period from the initial debt used to finance the acquisition, plus any added borrowing up until year N. Cash is added back, under the assumption that it is not accounted for in the estimation of enterprise value and constitutes a nonoperating asset.

Step 4: Calculate the IRR of the equity investment as follows:

$$\text{Equity Value}_{\text{Year } 0} = \frac{\text{Equity Value}_{\text{Year } N}}{(1 + \text{IRR})^N} \tag{10.6}$$

time (see panel [a] of Table 10-5). In Chapter 9, we pointed out that the adjusted present value (APV) model provides an appropriate method to value businesses whose capital structures change over time in a predictable way. We consider this approach in the next section.

Valuing PMG Inc. Using the Hybrid Adjusted Present Value Approach

This section applies the adjusted present value (APV) approach (introduced in Chapter 9 and reviewed in Figure 10-6) to value PMG Inc. To implement this approach, we use the cash flow forecasts from panel (a) of Table 10-6 for a five-year planning period (N), plus an estimate of the terminal value for the enterprise in year N. Panel (a) of Table 10-6 provides estimates for both the unlevered operating cash flows (firm FCFs) and interest tax savings for this acquisition. The firm FCFs grow

Figure 10-6 Review of the Hybrid Adjusted Present Value (APV) Model

Enterprise value is defined as follows:

$$\begin{matrix}\text{Enterprise}\\ \text{Value (APV)}\end{matrix} = \begin{matrix}\text{Present}\\ \text{Value}\end{matrix}\begin{pmatrix}\text{Planning}\\ \text{Period}\\ \text{Cash Flows}\end{pmatrix} + \begin{matrix}\text{Present}\\ \text{Value}\end{matrix}\begin{pmatrix}\text{Post-Planning-}\\ \text{Period}\\ \text{Cash Flows}\end{pmatrix} \tag{10.7}$$

where

$$\begin{matrix}\text{Present}\\ \text{Value}\end{matrix}\begin{pmatrix}\text{Planning}\\ \text{Period}\\ \text{Cash Flows}\end{pmatrix} = \sum_{t=1}^{N}\frac{\text{Firm FCF}_t}{(1+k_u)^t} + \sum_{t=1}^{N}\frac{(\text{Interest}_t \times \text{Tax Rate})}{(1+r_d)^t} \tag{10.8}$$

and

$$\begin{matrix}\text{Present}\\ \text{Value}\end{matrix}\begin{pmatrix}\text{Post-Planning-}\\ \text{Period}\\ \text{Cash Flows}\end{pmatrix} = \frac{\text{Terminal (Enterprise) Value}}{(1+r_u)^N} \tag{10.9}$$

Legend

Firm FCF = Firm free cash flow, which is the same as the unleveraged equity free cash flow because its calculation does not entail deductions for either principal or interest. When firm FCF is discounted to the present at the unleveraged cost of equity capital (k_u), it represents the value of the unleveraged equity of the firm.

Interest expense$_t$ × tax rate = interest tax savings, which represent the reduction in taxes owed that results from interest expense deductions.

Terminal (enterprise) value = enterprise value estimated at the end of the planning period, which represents the present value of the post-planning-period firm FCFs. The terminal value is estimated as a multiple of EBITDA for year N (i.e., $M_{\text{EBITDA}} \times \text{EBITDA}_N$).

N = planning period for which detailed estimates of cash flows are prepared (usually three to five years).

r_u = unlevered cost of equity capital.

r_d = cost of debt financing.

Table 10-6 APV Valuation of the PMG Inc. Build-up LBO Transaction

Panel (a) Projected Free Cash Flow (FCF) and Interest Tax Savings

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
EBITDA		$ 123.20	$ 135.52	$ 149.07	$ 163.98	$ 180.38
Less: depreciation		(49.00)	(55.00)	(61.00)	(67.00)	(73.00)
EBIT		$ 74.20	$ 80.52	$ 88.07	$ 96.98	$ 107.38
Less: taxes		(25.97)	(28.18)	(30.83)	(33.94)	(37.58)
Net operating profit after taxes (NOPAT)		$ 48.23	$ 52.34	$ 57.25	$ 63.04	$ 69.80
Plus: depreciation		49.00	55.00	61.00	67.00	73.00
Less: CAPEX		(60.00)	(60.00)	(60.00)	(60.00)	(60.00)
Firm FCF		$ 37.23	$ 47.34	$ 58.25	$ 70.04	$ 82.80
Interest expense		$ 57.54	$ 57.56	$ 56.17	$ 53.13	$ 48.16
Interest tax savings		$ 20.14	$ 20.15	$ 19.66	$ 18.60	$ 16.86
Debt	$ 411.00	$ 411.17	$ 401.25	$ 379.52	$ 344.02	$ 292.53

Panel (b) APV Valuation Analysis

Assumptions

Terminal value multiple	$6 \times \text{EBITDA}_{\text{year 5}}$
Interest rate on debt	14%
Unlevered beta	1.19
Risk-free rate	5.00%
Market equity risk premium	5.50%
Unlevered cost of equity	11.56%
Tax rate	35%

Hybrid APV Valuation ($ Millions):

	Present Value of		
	Unleveraged Equity Free Cash Flows (Discount Rate = $k_{\text{unlevered}}$)	**Interest Tax Savings (Discount Rate = k_d)**	**Total**
Planning period cash flows	$206.48	$66.20	$ 272.69
Terminal-value cash flow (discount rate = k_u)			$ 626.28
Enterprise value (year 0)			$ 898.97
Less: debt (year 0)			(411.00)
Equals: equity value (year 0)			$ 487.97

steadily over the planning period (N), from \$37.23 million to \$82.80 million, as a result of the planned growth in revenues. Over this same period, the interest tax savings decline from \$20.14 million to \$16.86 million as a result of the cash-sweep provision in the firm's debt agreement, which requires that the firm pay down the debt using all available cash flows.

In addition to the cash flows, we need estimates of three rates that we will use to discount the cash flows: First, we will need the firm's borrowing rate (r_d), which is used to discount the interest tax savings. Second, we will need the unlevered cost of equity, k_u, to discount the unlevered equity cash flows over the five-year planning period. Third, we need a cost of capital to discount the terminal value at the end of year 5, which we will assume is also equal to the unlevered cost of equity. The borrowing rate we use to discount the interest tax savings is 14% (panel [b] of Table 10-6). Finally, the unlevered cost of equity is 11.56%. Although the details are not shown here, we use the same procedure to estimate the unlevered cost of equity that we first demonstrated in Table 4-1.

We can now estimate the value of PMG Inc. *as of today* (not at the end of year 5). Panel (b) of Table 10-6 contains the APV estimate of the value of PMG Inc. The terminal value contributes \$626.28 million to the total estimated enterprise valuation of \$898.97 million. Netting out the firm's initial debt of \$411.00 million produces an estimated value of the private equity firm's equity investment of \$487.97 million.

Is the proposed acquisition worthwhile? These numbers indicate that this is a great investment because it generates an equity value of \$487.97 million on an equity investment of only \$125 million. It should be emphasized however, that the estimated cash flows used in our analysis may correspond more closely to hoped-for cash flows than to expected cash flows, which suggests that one might want to use a much higher discount rate to value them. Consequently, before undertaking an investment of this magnitude, the private equity firm would be wise to engage in a wide range of sensitivity analyses of the key value drivers of the investment, following the procedures outlined in Chapter 3.

Private Equity Value Drivers

There are five drivers of value in the example just discussed: (1) the estimate of the first year's EBITDA, (2) the anticipated rate of growth in EBITDA for each year of the planning horizon, (3) the level of capital expenditures required each year, (4) the EBITDA multiple used to estimate the terminal value in five years, and (5) the unlevered cost of capital. We will look at the sensitivity of the project outcome to each of these value drivers.

The simplest form of sensitivity analysis involves calculating the critical values of each of the five value drivers to determine the level of each required to produce an equity value for the investment equal to the \$125 million investment. The results are as follows:

Value Driver (Variable)	Estimated Value	Critical Value	Margin of Error (Estimate − Critical)
Year 1 EBITDA	\$123.20 = \$110 + 13.20	\$76.38	\$46.81
EBITDA growth rate	10%	−1.82%	11.82%
CAPEX	\$60 million/year	\$181.2 million/year	\$121.2 million/year
Harvest multiple	6 × EBITDA	2.523 × EBITDA	3.477 × EBITDA
Unlevered cost of equity	11.56%	26.81%	15.25%

Clearly, this investment creates value even in the face of very significant changes in the individual estimates of the key value drivers. For example, the initial year's projected EBITDA can drop from the projected $123.2 million to only $76.38 million, and the investment will still produce a value of $125 million.[14] Moreover, the growth rate in EBITDA (holding the other three value drivers at their prior levels) can drop to −1.82% before the value of the investment will drop below the $125 million in equity capital that is invested in the project. Annual capital expenditures (CAPEX) can increase to $181.2 million over the expected $60 million before the project NPV becomes negative. Similarly, the EBITDA (harvest) multiple at the end of year 5 that is used to determine the terminal value of the firm can drop to 2.523 and the unlevered cost of equity can be as high as 26.81% before the project's value drops below the $125 million invested in the equity of the deal.

In the preceding analysis, we analyzed only one value driver at a time. Such single-variable analysis can easily understate the true risks of the investment in cases where the value drivers vary together. For example, if both the initial EBITDA estimate and the growth rate in EBITDA are 20% lower than anticipated, and the CAPEX estimate is 20% higher than expected, then an exit multiple of EBITDA of 2.88 generates an enterprise value just large enough to cover the debt payment, thereby leaving nothing for the equity holders. Although the above scenario may be unlikely, it illustrates the fact that this is a risky investment.

10.5 Summary

Private equity firms are becoming an increasingly important source of capital for startup firms as well as for more mature firms that are going through some sort of transition. In most cases, private equity firms evaluate their investments using a variant of the hybrid valuation approach that was described in the previous chapter. Typically, the focus of the valuation is on the investor's equity investment, and because there are generally no planning period cash flows to the equity holders, the focus of the valuation is on the firm's terminal value, which is usually calculated as a multiple of EBITDA.

Another notable feature of the valuation approach used by private equity firms relates to their use of very high discount rates. These investments should have high expected rates of return given their high risk and illiquidity. However, the discount rates required by private equity firms are high, even given the nature of these investments, and probably reflect the fact that they are used to discount cash flows that are likely to be overly optimistic.

We would again like to emphasize that there are reasons why, in practice, investors often evaluate optimistic or hoped-for cash flows. Because of this, the valuation approaches used in practice often differ from those recommended by academics. We recommend that, in situations where private equity investors have estimates of expected cash flows rather than hoped-for cash flows, they evaluate the investment using the APV approach that we introduced in Chapter 9. Although this approach is not widely used in the private equity industry, we think it is appropriate given that most of these transactions involve a substantial amount of initial debt that is paid down fairly quickly over the planning period.

[14] Note that in this analysis, we assume that both the platform and add-on EBITDAs for year 1 are changed simultaneously by the sensitivity parameter.

In closing, we should point out that this chapter has considered a couple of investments that should really be viewed as options. First, in the venture capital example, we consider staged financing, which involves an initial investment that gives the venture capitalist an option, not an obligation, to make additional investments in the firm when those investments look favorable. Second, in the LBO example, we discussed the investment in a platform company that provides the option—again, not the obligation—to acquire add-on companies in situations where doing so is favorable to the private equity firm. Over the past twenty years, financial economists have developed methods for explicitly valuing investments that include such options. These methods will be the subject of the chapters that conclude this book.

Exercises

10-1 USING DEBT FINANCING TO ENHANCE EQUITY RETURNS Kimble Electronics is a small toy manufacturing company with total assets of \$1.5 million. The company has the opportunity to do a leveraged recapitalization that would involve borrowing 30% to 50% of the firm's assets at a rate of 9% per year. The firm's annual return on its total investment in assets varies from 4% to 15%.

Analyze the effects of financial leverage on the rate of return earned on Kimble's equity if the firm borrows 30% or 50% of its assets (i.e., complete the following table). You may ignore taxes in your calculations.

	15% Return on Assets	4% Return on Assets
30% debt to assets	?	?
50% debt to assets	?	?

10-2 PRE- AND POST-MONEY VALUATION SPC Venture Partners has evaluated an early-stage investment in a startup company (Startco). Startco needs \$4 million in financing, and SPC has offered to provide the financing in exchange for a 40% interest in the company.

a. What is SPC's post-money valuation of Startco?
b. What is the pre-money valuation of Startco implicit in the deal terms offered by SPC Venture Partners?

10-3 DEAL STRUCTURING CP Venture Partners is looking at the possible investment of \$1 million in an early-stage company (Startco). Given the stage of the investment, CP requires a 40% annual rate of return. The company earned \$750,000 in EBITDA last year, and this amount is expected to grow at a rate of 30% per year over the next five years. Companies like Startco are currently being valued at five times EBITDA, and CP Venture Partners thinks this is a reasonable multiple for the valuation of the firm in five years.

a. Assuming that Startco currently has no debt and does not plan to borrow over the next five years, what do you estimate the enterprise value of the company will be at the end of five years?
b. What fraction of Startco does CP Venture Partners need to own at the end of five years in order to realize the required rate of return on its investment?

PROBLEMS

10-4 VC VALUATION AND DEAL STRUCTURING Chariot.com needs $500,000 in venture capital to bring a new Internet messaging service to market. The firm's management has approached Route 128 Ventures, a venture capital firm located in the high-tech startup mecca known as Route 128 in Boston, Massachusetts, which has expressed an interest in the investment opportunity. Chariot.com's management made the following EBITDA forecasts for the firm, spanning the next five years:

Year	EBITDA
1	−$175,000
2	75,000
3	300,000
4	650,000
5	1,050,000

Route 128 Ventures believes that the firm will sell for six times EBITDA in the fifth year of its operations and that the firm will have $1.2 million in debt at that time, including $1 million in interest-bearing debt. Finally, Chariot.com's management anticipates having a $200,000 cash balance in five years.

The venture capitalist is considering three ways of structuring the financing:

1. Straight common stock, where the investor requires an IRR of 45%.
2. Convertible debt paying 10% interest. Given the change from common stock to debt, the investor would lower the required IRR to 35%.
3. Redeemable preferred stock with an 8% dividend rate, plus warrants entitling the VC to purchase 40% of the value of the firm's equity for $100,000 in five years. In addition to the share of the firm's equity, the holder of the redeemable preferred shares will receive 8% dividends for each of the next five years, plus the face value of the preferred stock in year 5.

TERMINOLOGY

A *convertible* security (debt or preferred stock) is replaced with common stock when it is converted. The principal is not repaid. In contrast, the face value of a security with *warrants* is repaid, and the investor has the right to receive common stock shares by remitting the warrants.

Redeemable preferred stock is typically straight preferred with no conversion privileges. The preferred always carries a negotiated term to maturity, specifying when it must be redeemed by the company (often, the sooner of a public offering or five to eight years). The preferred shareholders typically receive a small dividend (sometimes none), plus the face amount of the preferred issue at redemption, plus a share of the value of the firm in the form of common stock or warrants.

a. Based on the offering terms for the first alternative (common stock), what fraction of the firm's shares will it have to give up to get the requisite financing?

b. If the convertible debt alternative is chosen, what fraction of the firm's ownership must be given up?
c. What rate of return will the firm have to pay for the new funds if the redeemable preferred stock alternative is chosen?
d. Which alternative would you prefer if you were the management of Chariot.com? Why?

10-5 VC VALUATION Southwest Ventures is considering an investment in an Austin, Texas–based startup firm called Creed and Company. Creed and Company is involved in organic gardening and has developed a complete line of organic products for sale to the public that ranges from composted soils to organic pesticides. The company has been around for almost twenty years and has developed a very good reputation in the Austin business community, as well as with the many organic gardeners who live in the area.

Last year, Creed generated earnings before interest, taxes, and depreciation (EBITDA) of $4 million. The company needs to raise $5.8 million to finance the acquisition of a similar company called Organic and More that operates in both the Houston and Dallas markets. The acquisition would make it possible for Creed to market its private-label products to a much broader customer base in the major metropolitan areas of Texas. Moreover, Organic and More earned EBITDA of $1 million in 2015.

The owners of Creed view the acquisition and its funding as a critical element of their business strategy, but they are concerned about how much of the company they will have to give up to a venture capitalist in order to raise the needed funds. Creed hired an experienced financial consultant, whom they trust, to evaluate the prospects of raising the needed funds. The consultant estimated that the company would be valued at a multiple of five times EBITDA in five years and that Creed would grow the combined EBITDAs of the two companies at a rate of 20% per year over the next five years if the acquisition of Organic and More is completed.

Neither Creed nor its acquisition target, Organic and More, uses debt financing at present. However, the VC has offered to provide the acquisition financing in the form of convertible debt that pays interest at a rate of 8% per year and is due and payable in five years.

a. What enterprise value do you estimate for Creed (including the planned acquisition) in five years?
b. If the VC offers to finance the needed funds using convertible debt that pays 8% per year and converts to a share of the company sufficient to provide a 25% rate of return on his investment over the next five years, how much of the firm's equity will he demand?
c. What fraction of the ownership in Creed would the venture capitalist require if Creed is able to grow its EBITDA by 30% per year (all else remaining the same) and the VC still requires a 25% rate of return over the next five years?

10-6 VC VALUATION AND DEAL STRUCTURING SimStar Manufacturing Co. needs $500,000 to fund its growth opportunities. The founder of the firm has approached Morningstar Ventures (a Phoenix-based venture capital firm), which has expressed an interest in providing the financing if acceptable terms can be worked out.

The venture capitalist asked SimStar's CFO to provide an EBITDA forecast for the next five years. The forecast found below depicts the rapid growth opportunities the firm anticipates:

Year	EBITDA
1	−$350,000
2	200,000
3	340,000
4	1,050,000
5	1,500,000

If the VC provides the needed funds, she will plan on an exit after five years, at which time she believes that the firm can be sold for six times EBITDA. Moreover, based on pro forma financials and the above projections, the VC estimates that SimStar will have approximately $1.2 million in debt outstanding, including $1 million in interest-bearing debt, at the end of the planned five-year investment. Finally, SimStar expects that it will have $200,000 in cash at the end of five years.

The VC is considering three ways of structuring the financing:

1. Straight common stock, where the VC receives no dividends for a period of five years but wants 49% of the firm's shares.
2. Convertible debt paying 10% interest. Given the change from common stock to debt, the VC wants only 30% of the firm's equity upon conversion in five years.
3. Redeemable preferred stock with an 8% dividend rate plus warrants for 40% of the firm's equity in five years. Moreover, the exercise costs for the warrants total $100,000. Note that because this is "redeemable preferred," the investor not only receives an 8% dividend for each of the next five years plus the face value of the preferred stock but can also purchase 40% of the firm's equity for $100,000.

Which of the alternatives would you recommend that SimStar's founder select? Explain your decision.

10-7 VC VALUATION AND DEAL STRUCTURING Brazos Winery was established eight years ago by Anna and Jerry Lutz with the purchase of 200 acres of land. The purchase was followed by a period of intensive planting and development of the grape vineyard. The vineyard is now entering its second year of production.

In March 2015, the Lutzes determined that they needed to raise $500,000 to purchase equipment to bottle their private-label wines. Unfortunately, they have reached the limits of what their banker can finance and have put all their personal financial resources into the business. In short, they need more equity capital, and they cannot provide it themselves.

Their banker recommended that they contact a venture capital (VC) firm in New Orleans that sometimes makes investments in ventures such as the Brazos Winery. He also recommended that they prepare for the meeting by organizing their financial forecast for the next five years. The banker explained that VCs generally target a five-year term for their investments, so it was important that they provide the information needed to value the winery at the end of five years.

After doing a careful analysis, the Lutzes estimate that their venture will generate earnings before interest, taxes, depreciation, and amortization (EBITDA) in five years of $1.2 million. In addition to the EBITDA forecast, the Lutzes estimate that they will need to borrow $2.4 million by 2019 to fund additional expansion of their operations. Their banker indicated that his bank could be counted on for $2 million in debt, assuming they were successful in raising the needed equity funds from the VC. Furthermore, the remaining $400,000 would be in the form of accounts payable. Finally, the Lutzes believe that their cash balance will reach $300,000 at the end of five years.

The Lutzes are particularly concerned about how much of the firm's ownership they will have to give up in order to entice the VC to invest. The VC offers three alternative ways of funding the winery's $500,000 financing requirements; each alternative calls for a different ownership share:

- Straight common stock that pays no dividend. With this option, the VC asks for 60% of the firm's common stock in five years.
- Convertible debt paying 10% annual interest and 40% of the firm's common stock at conversion in year 5.
- Convertible preferred stock with a 10% annual dividend and the right to convert the preferred stock into 45% ownership of the firm's common stock at the end of year 5.

a. If the VC estimates that the winery should have an enterprise value equal to six to seven times estimated EBITDA in five years, what do you estimate the value of the winery to be in 2019? What will the equity in the firm be worth? (*Hint:* Consider both the six- and seven-times-EBITDA multiple.)

b. Based on the deal terms offered, what rate of return does the VC require for each of the three financing alternatives? Which alternative should the Lutzes select based on the expected cost of financing?

c. What is the pre- and post-money value of the firm based on the three sets of deal terms offered by the VC? Why are the estimates different for each of the deal structures?

d. How is the cost of financing affected by the EBITDA multiple used to determine enterprise value? Is it in the VC's best interest to exaggerate the size of the multiple or to be conservative in his estimates? Is it in the entrepreneurs' best interest to exaggerate the estimated EBITDA levels or to be conservative? If entrepreneurs are naturally optimistic about their firm's prospects, how should the VC incorporate this into his deal-structuring considerations?

e. Discuss the pros and cons of the alternative sources of financing.

10-8 VC VALUATION AND DEAL STRUCTURING In 2014, Dub Tarun founded a firm using $200,000 of his own money, $200,000 in senior (bank) debt, and an additional $100,000 in subordinated debt borrowed from a family friend. The senior debt pays 10% interest, while the subordinated debt pays 12% interest and is convertible into 10% of the firm's equity ownership at the option of the investor, J Martin Capital. Both debt issues have ten-year maturities. In March 2015, the firm's financial structure appeared as follows:

Dub Tarun Inc., March 2015

Accounts payable	$100,000
Short-term notes	150,000
Total short-term debt	$250,000
Senior debt (10% interest rate)	200,000
Subordinated debt (12% interest rate, convertible into 10% stock)	100,000
Equity (Dub Tarun)	200,000
Total debt and equity	$750,000

Dub has determined that he needs an additional $250,000 if he is going to continue to grow his business. To raise the necessary funds, he intends to use an 8% convertible preferred stock issue.

Dub projects that the firm's EBITDA will be $650,000 in five years. Although Dub isn't interested in selling his firm, his banker recently told him that businesses like his typically sell for five to seven times their EBITDA. Moreover, by March 2020, Dub expects that the firm will have $300,000 in cash and that the firm's pro forma debt and equity will be as follows:

Dub Tarun Inc. Pro Forma Financial Structure, March 2020

Accounts payable	$ 200,000
Short-term notes	250,000
Total short-term debt	$ 450,000
Senior debt (10%)	400,000
Subordinated debt (12%, convertible into 10% of the firm's stock)	100,000
Equity (Dub Tarun)	800,000
Additional financing needed	250,000
Total debt and equity	$2,000,000

a. What would you estimate the enterprise value of Dub Tarun Inc. to be on March 2020? (*Hint:* Enterprise value is typically estimated for private companies using a multiple of EBITDA plus the firm's cash balance.) If the subordinated debt converts to common in 2020, what is your estimate of the value of the equity of Dub Tarun in 2020?

b. If the estimated enterprise value of the firm equals your estimate in Problem 10-8(a), what rate of return does the subordinated debt holder realize if he converts in 2020? Would you expect the subordinated debt holder to convert to common stock?

c. If the new investor were to require a 45% rate of return on his $250,000 purchase of convertible preferred stock, what share of the company would he need, based on your estimate of the value of the firm's equity in 2020? What is your estimate of the ownership distribution of Dub Tarun's equity in 2020, assuming that the new investor gets what he requires (to earn his 45% required rate of return) and the subordinated debt holder converts to common? What rates of return do each of the equity holders in the firm expect to realize by 2020, based on your estimate of equity value? Does the plan seem reasonable from the perspective of each of the investors?

d. What would be Dub Tarun's expected rate of return if the EBITDA multiple were five or seven?

e. What was the post-investment and pre-investment value of Dub Tarun's equity in 2015, based on the investment of the new investor?

10-9 LBO VALUATION Randy Dillingwater is the chief investment officer for Clearstone Capital. Clearstone is a private equity firm located in Orlando, Florida, that specializes in what Randy describes as make-over or fixer-upper investments. The firm tries to find privately held firms whose owners tried to grow their business too fast and ran into liquidity problems. Clearstone has been in this business for eleven years and has had reasonable success.

Clearstone is now completing the investment of its second fund and considering the acquisition of a local manufacturing and distribution company, Flanders Inc. Flanders was founded by Mark Flanders eighteen years ago and grew rapidly. Recently, however, the firm made a large acquisition of a competitor firm, and the problems the firm encountered when assimilating the acquisition led to financial difficulties for Flanders. The owner has recently voiced his interest in a buyout proposal to his local banker, who notified Randy (his next-door neighbor) of the opportunity.

Randy contacted Mark, and the two decided to open a dialogue about the possible acquisition of Mark's firm. After several meetings, Mark decided to solicit an offer from Clearstone. In response to Randy's request, Mark supplied him with the following set of pro forma income statements spanning 2016 to 2020:

Pro Forma Income Statements	2016	2017	2018	2019	2020
EBITDA	$ 11,000,000.00	$ 12,100,000.00	$ 13,310,000.00	$ 14,641,000.00	$ 16,105,100.00
Less: depreciation	(3,900,000.00)	(4,300,000.00)	(4,700,000.00)	(5,100,000.00)	(5,500,000.00)
EBIT	$ 7,100,000.00	$ 7,800,000.00	$ 8,610,000.00	$ 9,541,000.00	$ 10,605,100.00
Less: interest	(6,300,000.00)	(6,235,600.00)	(6,040,288.80)	(5,690,457.10)	(5,159,103.90)
Earnings before taxes	$ 800,000.00	$ 1,564,400.00	$ 2,569,711.20	$ 3,850,542.90	$ 5,445,996.10
Less: taxes	(240,000.00)	(469,320.00)	(770,913.36)	(1,155,162.87)	(1,633,798.83)
Net income	$ 560,000.00	$ 1,095,080.00	$ 1,798,797.84	$ 2,695,380.03	$ 3,812,197.27

In addition, Randy asked Mark to estimate capital expenditures for each of the next five years. Mark indicated that he thought the firm would have to spend about $4 million a year and that the new capital would have a ten-year depreciable life. (Depreciation expense for 2015 was $3.5 million so the addition of $4 million in capital expenditures will add $400,000 in added depreciation expense for 2016.)

Mark indicated to Randy that his research suggested that a five-times-EBITDA multiple would be appropriate. Randy, however, was not sure that Clearstone could afford to pay this much for the firm. He decided to do a quick analysis using the LBO method of valuation based on the following assumptions:

- The firm can be purchased for five times the firm's 2015 EBITDA of $10 million and resold in five years for the same multiple of the firm's year 5 EBITDA.
- Clearstone will finance 90% of the purchase price using debt that carries a 14% rate of interest. The debt will require a cash sweep so that all available cash flow will go toward the repayment of the note.

- A tax rate of 30% is assumed in all calculations.
- Capital expenditures (CAPEX) are estimated to be \$4 million per year, and no net new investments in working capital are anticipated.
- Flanders does not carry any excess cash and has no nonoperating assets.
  - **a.** What is the projected enterprise value of Flanders in five years? What is the estimated value of Clearwater's equity in the firm at the end of five years if everything works out as planned?
  - **b.** What rate of return should Clearstone expect on its equity in the acquisition under the projections made above?
  - **c.** After further review, Randy estimated that the firm's operating expenses could be shaved by roughly \$1 million per year. How would this affect your answers to Problem 10-9(a) and (b)?

10-10 LBO VALUATION USING THE APV MODEL *This problem utilizes information from Problem 10-9 but can be analyzed independently.*

Randy Dillingwater wanted to perform a discounted cash flow analysis of the proposed acquisition of Flanders Inc. However, the cash-sweep provision of the debt financing meant that the debt ratio was expected to change systematically over the five-year planned investment period used by Randy's firm (Clearstone Capital). This, Randy recalled, would make the traditional weighted average cost of capital (WACC) model for valuing firms tough to use. Instead, he decided to use the APV model, which separates the valuation of operating and financial cash flows into two separate calculations.

In preparation for his analysis, Randy did some initial research to determine reasonable estimates of the capital market components of the capital asset pricing model (CAPM). First, he noted that the twenty-year long-term government bond yield was currently 5% and that the return premium of the equity market in excess of the long-term government bond yield had historically averaged about 5.5%. All that remained to do was estimate the unleveraged beta coefficient for Flanders. To perform this analysis, Randy decided that he needed to calculate the unleveraged equity betas for a sample of similar firms and use the average of the sample as his estimate of Flanders' unleveraged beta. He then collected the following information on four publicly traded firms that were deemed close substitutes for Flanders:

Company	Equity Betas	Debt	Equity Value	Debt to Equity	Marginal Tax Rate
Company A	1.400	\$ 6.58 m	\$ 22.1 m	29.77%	30%
Company B	1.750	11.34 m	25.8 m	43.95%	30%
Company C	1.450	3.42 m	10 m	34.20%	30%
Company D	1.230	6.59 m	25.2 m	26.15%	30%

The equity betas were what Randy referred to as leveraged equity betas because they were calculated using stock market returns, which in turn reflected the firm's use of debt in its capital structure. Consequently, Randy needed to unleverage the equity betas. To perform this analysis, Randy decided to assume that the firm's debt had a zero beta so that the unleveraged beta was defined as follows:

$$\begin{array}{c}\text{Unlevered}\\ \text{Equity}\\ \text{Beta}\end{array} = \frac{\text{Levered Equity Beta}}{1 + \text{Debt Ratio}\ (1 - \text{Tax Rate})}$$

a. What is your estimate of Flanders' unleveraged equity beta? (*Hint:* Refer back to Table 4-1.)
b. Using CAPM, what is the required rate of return that Randy should use to value Flanders' operating cash flows?
c. What is the value of Flanders' estimated operating cash flows, based on Mark Flanders' original estimates from Problem 10-9, for the planning period (2016–2020)? What is the value of the firm's interest tax savings for the same period? Recall that the firm's borrowing rate from Problem 10-9 was 14%.
d. Randy decided to estimate the continuing or terminal value of the firm using a five times multiple of the firm's EBITDA (following the discussion from Chapter 9). What is the terminal value of the firm today using this procedure, with the terminal value discounted back to 2015 using the unleveraged cost of equity capital? What is your estimate of the enterprise value of Flanders using the APV method (and your estimates from Problem 10-10[c])? What is the estimated value of Clearstone's equity investment based on the APV estimate of enterprise value?

10-11 LBO VALUATION USING SIMULATION *This problem utilizes information from Problem 10-9 and requires that the LBO valuation model be constructed.*

Randy was happy with the anticipated results from the acquisition of Flanders Inc., but he wanted to do some exploratory analysis of the risks involved in the acquisition so that he might be able to anticipate the risks inherent in the investment. He planned to construct a spreadsheet model using the industry-standard LBO valuation model (using information from Problem 10-9) and then identify the key sources of risk in the model, constructing what he felt were reasonable characterizations of the probability distributions for each of these variables. Specifically, Randy decided on the following variables (value drivers) and distributional characterizations:

- Mark Flanders estimated EBITDA growth to be 10% per year, but this rate is far from certain. Randy decided that he would set the most likely growth rate to be 10%, but he would use a triangular distribution with a minimum value of 0% and a maximum of 15% to characterize the annual rate of growth in EBITDA over the planning period. Randy felt that the rate of growth each year would be related to what happened in the subsequent year, so he decided to impose a .80 correlation on the growth rates for successive years. That is, the correlation between the rate of growth in 2018 and 2017 is estimated to be .80, and so forth.
- Another key determinant of the value of the Flanders acquisition is the exit multiple that Clearstone will encounter in five years when it sells the firm. Randy has estimated that they will be able to exit at the same multiple (five) at which they purchase Flanders Inc.; however, this variable is subject to uncertainty. Based on Clearstone's past experience, Randy estimates a 10% chance of the exit multiple being as low as three times EBITDA, a 20% chance of it being four, a 40% chance of it being five, a 20% chance of it being six, and a 10% chance of it being as high as seven.
  a. After incorporating Randy's two assumptions about the uncertainties in the acquisition of Flanders Inc., what is the mean and median rate of return on Clearstone's investment in the firm's equity?
  b. What is the probability that the Flanders acquisition will yield a rate of return to Clearstone that is below the firm's target of 40%?

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PART V

Futures, Options, and the Valuation of Real Investments

Our focus throughout the first ten chapters has been on valuation techniques that are widely used in practice. In particular, we have examined the discounted cash flow (DCF) approach, which first forecasts expected cash flows and then assigns a discount rate to each cash flow to determine its present value. Although we have emphasized what we consider cutting-edge industry practice, we have also pointed out a number of disconnects between industry practice and DCF theory.

One notable disconnect that we identified in Chapter 2 is that managers tend to propose cash flow forecasts that are overly optimistic. Specifically, their forecasts often represent what will happen if everything goes as planned rather than the expected cash flows called for in DCF theory. To counter this optimism, it is common business practice to use discount rates that are somewhat higher than the expected rates of return suggested by textbook DCF theory. This is perhaps nowhere more apparent than in the cash flow forecasts made by naturally optimistic entrepreneurs in their business plans—which lead venture capitalists to use discount rates that are in the 30% to 40% range.

The second distinction between business practice and DCF theory is that firms often utilize a single discount rate to evaluate all their projects. This is at odds with DCF theory in two ways: First, risk differences across projects should be reflected in unique project discount rates. Second, using a single discount rate for all future cash flows is tantamount to assuming that the term structure of discount rates is flat for all projects. As we emphasized in Chapter 5, however, these distinctions reflect sound and very practical managerial reasons why firms tend to prefer simpler procedures to evaluate their investment projects.

In Part V, we consider what is generally referred to as the real options approach to valuation. This approach, which is based on academic research from the mid-1980s, is widely used in the natural resources industries as well as by some technology companies. Perhaps because of the managerial issues that lead firms to use a single versus multiple discount rates, firms in other industries have been slow to adopt this approach. The slow adoption rate may also be due to the complexity of the approach and the fact that the real options approach can require a number of inputs. We hope that our discussion of real options, along with software that can easily be adapted to these problems, will make it more accessible to managers and broaden its use.

The real options approach is based on two important ideas: The first is that financial markets often provide prices that can be used to value future cash flows. This is an idea we used previously, in Chapter 8, where we discussed how one would use information from market values of publicly traded companies or recent transactions in the private markets to infer the value of a business's future cash flows. Similarly, in this part of the text, we consider how one can use transactions in the forward, futures, and options markets to value the future cash flows of investment projects.

The second idea that underpins the real options approach is that uncertainty and flexibility interact in ways that influence expected cash flows. We first introduced this concept in Chapter 2, where we described how simulation can be used to estimate expected cash flows. In this part, we go one step further and discuss how these cash flows can be valued. In particular, we will discuss the concept of certainty equivalence, which was mentioned briefly in Chapter 2. The idea here is that instead of determining the expected value of a risky future cash flow, one determines the certain cash flow that has the same value as the risky cash flow. In other words, instead of adjusting for risk by using a higher discount rate, the cash flows themselves are adjusted for risk. The principal advantage of this approach, which we discuss in more detail in Chapter 11, is that certainty-equivalent cash flows are discounted at the risk-free rate, so the concerns about using different discount rates for different investments that we discussed in Chapter 5 are no longer an issue. In most cases, however, coming up with the certainty-equivalent cash flows is quite a challenge.

Our discussion in Chapter 11 focuses on what we call *contractual options,* which are options that are embedded in financial contracts. For example, as we will discuss, a levered equity investment provides the owners with the option to default on their debt obligations when the investment is doing poorly. Contractual options can be contrasted with *real options,* discussed in Chapter 12, which are options that are inherent in the nature of the physical investment. For example, almost all of the investments that a firm makes will provide the firm's management with some degree of flexibility in terms of when the investment is initiated, when and if the investment is abandoned, and how the investment is operated. All else equal, the more flexibility a project provides to management, the more valuable it will be. Real options analysis is used to quantify the value of this flexibility.

Finally, in Chapter 13, we analyze *strategic options*, which are options that arise from investments that improve the firm's capabilities or position the firm in ways that can potentially generate value-enhancing investment opportunities in the future. For example, the contacts a firm establishes through an initial investment in a foreign country might generate lucrative opportunities in the future. An important part of corporate strategy is identifying investment opportunities that are not only value-enhancing on their own but also lead the firm in a direction that is likely to generate future opportunities. Strategic option analysis is designed to value those potential opportunities.

Before proceeding, we should note that we will not go through all the technical details that are involved in the pricing of real options. Option pricing can get quite complicated, and valuation models that are used in practice are developed and implemented by individuals with PhDs in technical fields such as physics, mathematics, and computer science. These more technically inclined individuals generally collaborate with project sponsors and other less technical individuals who do not necessarily need to understand all the gory technical details. However, these less technical individuals need to be able to identify the options embedded in investment projects and to roughly gauge how those options contribute to an investment's value. This section of the text is designed to provide that level of expertise.

CHAPTER 11

Using Futures and Options to Value Real Investments

Chapter Overview

In this chapter, we use the market prices of traded derivative securities, such as options, forwards, and futures contracts, to value real investment opportunities. These prices allow us to convert risky future cash flows into their certainty equivalents, which can then be discounted using the risk-free rate.

The chapter describes a three-step valuation process that is closely related to the three-step discounted cash flow (DCF) process described in earlier chapters. The following grid summarizes the traditional DCF and the derivative securities approaches to valuation and reveals that the relevant difference between the approaches lies in how we adjust for risk. In the traditional DCF approach, we estimate expected cash flows and adjust for risk by using a risk-adjusted discount rate, whereas in the derivative securities approach, we use market prices of publicly traded securities to estimate certainty-equivalent cash flows, which are then discounted using the risk-free rate. An important advantage of the derivatives approach is that it uses market forecasts based on market prices, whereas the traditional DCF approach relies on management's own price forecasts.

	Traditional DCF Approach to Valuation	**Derivative Securities Approach to Valuation**
Step 1	Forecast the amount and timing of future cash flows.	Forecast the amount and timing of future cash flows.
Step 2	Estimate a risk-appropriate discount rate.	Use observed market prices to estimate certainty equivalents of expected future cash flows.
Step 3	Discount the investment's expected cash flows using the risk-adjusted discount rate to find its present value.	Discount the certainty equivalents of the cash flows of the investment using the risk-free rate to find its present value.

11.1 Introduction

Two important developments occurred in spring 1973 that had a profound effect on both the theory and practice of finance. The first was the April opening of the first organized exchange for trading stock options, the Chicago Board Options Exchange (CBOE).[1] The second development was the May publication of the Black-Scholes model, which provided a formula for valuing options.[2] In the ensuing decades, we have seen the proliferation of a variety of financial markets that trade options as well as other financial derivatives.

Financial derivatives are securities whose value is *derived from* the value of another security or asset. The latter is commonly referred to as the underlying asset, which could be shares of stock, a commodity, or any other asset.[3] The three most popular types of derivative securities include options, forwards, and futures. An **options** contract provides the holder with the right, but not the obligation, to purchase (call option) or sell (put option) a specified asset (e.g., shares of common stock or a parcel of land) for a specified price (called the exercise or strike price) within a specified period of time. **Forward** contracts and **futures** contracts are similar to option contracts in that they also represent agreements to buy or sell an asset at a certain time in the future for a certain price. However, unlike options, which do not obligate the holder to exercise the contract, forward and futures contracts do. For a review of specific differences between forward and futures contracts, see the Technical Insight box on page 407. In addition, Appendix A reviews the basics of options for those who want a brief refresher.

The development of markets for futures, forwards, and options is having an important influence on how investment projects are valued in practice. In this chapter, we provide two examples to illustrate how this is done. The first example uses a technique commonly referred to as pricing against the forward curve. Here, we use forward market prices to estimate the certainty equivalent of future cash flows. The second example uses option prices to help value investment opportunities that have option-like features. In this example, we show how option prices can be used to capture the value of a firm's option to default on its debt obligations. Both of these examples illustrate the benefits of using market prices, whenever possible, when valuing risky investments.

Although the valuation approach used in this chapter is indeed somewhat different from the approaches used in earlier chapters, the similarities are really more important than the differences. In all cases, we are ultimately forecasting future cash flows that

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[1] Derivative markets for futures contracts had long existed. For example, the Chicago Board of Trade (CBOT) was established in 1848 to allow farmers and merchants to contract for basic commodities.

[2] Fischer Black and Myron Scholes, "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy* 81 (May–June 1973): 637–659.

[3] Swaps provide another important type of derivative contract that is widely used in hedging transactions; however, we will not utilize them in our examples. A **swap** is a derivative contract in which two counterparties exchange one stream of cash flows for another stream. These streams are called the "legs" of the swap. For example, take the case of a plain vanilla fixed-to-floating interest rate swap. Party A makes periodic interest payments to party B based on a variable interest rate, while party B makes periodic interest payments to Party A based on a fixed rate of interest. The payments are calculated using a notional amount. Swaps are over-the-counter (OTC) derivatives, which means that they are negotiated outside exchanges and cannot be bought and sold like securities or futures contracts.

are discounted to the present; the difference comes from the method of coming up with the cash flows and the discount rate that is used. Moreover, using derivatives prices to value cash flows is also directly analogous to the use of comparables introduced in Chapter 8. However, instead of using another business as the comparable to value a stream of future cash flows, we use derivative prices as the appropriate comparable to value individual cash flows.

The techniques that we focus on in this chapter were originally designed for commodity-based businesses like mining, basic chemicals, and oil and gas exploration, where the cash flow risks are derived from commodity prices for which there are publicly traded derivatives. For this reason, the examples we present in this chapter focus on extractive industries, with a particular focus on the oil and gas industry, where this approach is very popular. However, in Chapters 12 and 13, we describe how these techniques can be used more broadly to evaluate projects in a variety of industries.

Before we launch into the study of the derivatives approach to asset valuation, we want to emphasize a few important points that we hope will influence how you approach the material in this chapter:

- Because this approach is newer than traditional DCF analysis, there is a tendency to think that this material represents "another approach" to the study of valuation. This conclusion is bolstered by the fact that much of the language used is different and that we use different tools such as decision trees and the binomial lattice. The truth of the matter, however, is that we are still doing DCF analysis. The innovation in this chapter is that we use observed market prices of derivative securities to *improve* our DCF analysis (not replace it).
- The concepts developed in this chapter provide a critical building block to your understanding of Chapters 12 and 13, where we consider the value of flexibility and strategic options. So, if it has been a while since you studied derivatives or if you have never done so, spend some extra time on Appendix A, where we provide a basic review of options and their payoffs. You may also find it helpful to visit one of the many excellent online resources for a review of derivative contracts.[4]
- Finally, in this chapter, we use the binomial lattice for the first time. This will be a new tool for many readers. Consequently, you would do well to spend the time you need to understand this tool fully because it will also be used in the next two chapters.[5] This tool is as crucial for understanding real options as understanding time value of money calculations for doing DCF analysis, so "don't leave this chapter without it"!

This chapter is organized as follows: Section 11.2 discusses the certainty-equivalence method for valuing risky future cash flows. Section 11.3 provides an example where we value a risky investment whose primary source of risk is that associated with the price of a commodity. As we show, the presence of forward markets to hedge this risk greatly reduces the complexity of the task (if you are not familiar with the concept of financial hedging with forward and futures contracts or if you would benefit from a review, see

[4] For example, see http://www.financialpolicy.org/dscprimer.htm.

[5] If you find you need some extra help with the use of binomial lattices, see Chapter 10 in Robert L. McDonald, *Derivative Markets,* 2nd ed. (Boston: Addison Wesley, 2006).

TECHNICAL INSIGHT

A Primer on Forward and Futures Contracts

Forward and futures contracts are similar in that they both represent agreements to buy or sell an asset at a specified time in the future for a specified price. The principal difference between a futures contract and a forward contract is that the *futures contract* is traded on an organized exchange and the *forward contract* represents a private or over-the-counter agreement between two financial institutions or between a financial institution and one of its corporate clients. In addition, forward contracts usually specify a single date for delivery of the commodity on which the contract is written, whereas a futures contract may offer a range of delivery dates. Still another important difference between forwards and futures is the method of settlement for the gains and losses on the contracts. For a forward contract, the gains and losses are settled at the termination of the contract; in the case of a futures contract, the gains and losses are settled *daily* through a procedure called *marking-to-market.* Finally, futures contracts, unlike forwards, are usually terminated or closed out prior to delivery; the physical commodity is not (usually) delivered.

The following exhibit summarizes the unique features of forward and futures contracts:

	Forward	Futures
Market	Private contract between two parties.	Traded on an organized exchange.
Contract	Not standardized.	Standardized.
Delivery	Generally one delivery date.	Range of delivery dates.
Settlement	At the end of the contract.	Daily (marked-to-market).
Termination	Delivery of commodity or final cash settlement.	Generally, the contract is closed out prior to maturity.

You might think that the market for immediate or current delivery of a commodity would be called the current market to contrast with the forward or futures market. However, this is not the case. This market is referred to as the *spot market.*

Each forward or futures transaction has a buyer and a seller. The party that agrees to buy the commodity at a future date is said to have a *long position,* whereas the party that agrees to sell the commodity in the future is said to have taken a *short position.*

the Technical Insight box on page 408 entitled Hedging Financial Risks). Section 11.4 opens our discussion of options by providing an example of the valuation of an equity investment in a levered oil field. This example illustrates how firms can use options to capture the value of the decision flexibility inherent in many investment opportunities.

In the context of this example, we introduce the binomial option valuation technique, which is widely used to value financial options as well as real investments that have option-like components (Appendixes B and C provide details for anyone who would like to understand the binomial model in more depth). Section 11.5 discusses a number of caveats or limitations of the methods we propose in this chapter. In Section 11.6, we demonstrate the use of the binomial option pricing model as a tool for valuing options. Section 11.7 provides summary comments.

11.2 The Certainty-Equivalence Method

The approach that we will use to value investments in this chapter is a special case of the **certainty-equivalence (CE)** approach, which requires that we first *risk-adjust* the risky future cash flows, creating what we call *certainty-equivalent* cash flows. A **certainty-equivalent** cash flow is defined as the certain cash flow that has the same value to the recipient as the uncertain cash flow that is being evaluated. For example, suppose the holder of a lottery ticket that is worth either \$70 or \$100 with equal probability is willing to accept a sure payment of \$82 in exchange for the ticket. We can say that the certainty equivalence of the uncertain cash flow to the lottery ticket is \$82, which is lower than the \$85 expected payoff (i.e., $\$85 = .5 \times \$100 + .5 \times \$70$). The holder of the lottery ticket is willing to take less than the expected value because of his aversion to risk.

The certainty-equivalence approach to valuation is fundamentally the same as the traditional discounted cash flow (DCF) approach except that the former adjusts the cash flows for risk rather than adjusting the discount rate. In most cases, either adjustment is appropriate, but in general you should *not* risk-adjust *both* the cash flows *and* the discount rate. As it turns out, for the natural resource valuation problems that we consider in this chapter, forward prices can be used to calculate risk-adjusted cash flows, which makes it more convenient to use the certainty-equivalence approach.

Technical Insight — Hedging Financial Risks

Hedging is the process of reducing the firm's risk exposure by transferring part or all of it to another firm or entity. For some risks, such as the risk of fire or property damage to the firm's facilities, the hedge might entail the purchase of insurance. Other risks can be hedged in the financial derivatives market.

For example, a firm that sells its products and services to international clients who pay for them at a later date in a foreign currency is exposed to currency risk. Similarly, firms that need to borrow money in the future may be exposed to interest rate risk. Both the risk of adverse changes in foreign exchange rates and a rise in interest rates can be hedged using financial markets. For example, we can hedge the risk from the obligation to buy an asset in the future by locking in the selling price today in the forward market.

Forward Prices as Certainty-Equivalent Cash Flows

There are two potential advantages associated with the certainty-equivalence approach. The first is that, in some cases, managers can estimate the certainty equivalence of a cash flow more accurately than they can its expected value. The second advantage is that, when the certainty-equivalent cash flow can be observed, the cash flows can be discounted at the risk free rate, which allows the analyst to avoid the problems associated with coming up with a risk adjusted discount rate.

In this section, we consider the case where the risk associated with a cash flow is closely related to the risk of securities traded in the derivative markets. To illustrate this, let's first consider the **forward prices** of commodities like oil, grains, or metals. The forward price of a commodity is the price that is set today at which market participants are willing to buy and sell the commodity for delivery at some future date. In other words, it is the certain price today, which has the same current value as the uncertain price that will occur in the future. As such, forward prices can be viewed as the certainty equivalents of the uncertain prices that will be realized in the future.

To better understand this concept, consider an investment that generates 100,000 barrels of oil in one year. Because oil prices are uncertain, the cash flows from this investment are uncertain. However, suppose that there exists a forward market that allows you to buy or sell oil, for delivery in one year, for a price of $60 per barrel. In this case, we would say that the certainty equivalence of the uncertain future oil price in one year is $60 and that the certainty equivalence of the investment's cash flow is $6 million ($60/barrel × 100,000 barrels). The owner of the oil can obtain this amount for certain by selling his or her oil in the forward market rather than facing the uncertain cash flow associated with the uncertain price of oil.

It should be stressed that the forward price is generally not equal to the expected price in the future. For example, suppose the price of oil next year is equally likely to be either $100/barrel or $80/barrel, implying that the expected price of oil is $90/barrel. If market participants have no aversion to risk, then this is also likely to be the forward price. However, if a sufficient number of risk-averse oil producers choose to hedge their oil price risk by selling forward contracts, the forward price will

Did You Know?

Where Is the World's Largest Commodity Futures Market?

The New York Mercantile Exchange Inc. (NYMEX) is the world's largest physical commodity futures exchange and a major trading forum for energy and precious metals. The exchange pioneered the development of energy futures and options contracts and offers options on all major futures contracts: light, sweet crude oil; Brent crude oil; heating oil; unleaded gasoline; natural gas; coal; gold; silver; platinum; copper; and aluminum. Also available are two crack spread options contracts—one for the differential, or the spread, between heating oil futures and light, sweet crude oil futures and one on the New York Harbor unleaded gasoline/light, sweet crude spread.

Did You Know?

Southwest Airlines' Oil Price Hedge

Southwest Airlines' successful efforts to hedge the risk of rising jet fuel provide a classic example of the use of forward contracts. Specifically, the company used forward contracts to lock in the price of jet fuel for much of its expected fuel needs for 2005 to 2009. Southwest locked in 65% of its expected jet fuel needs in 2006 at $32 a barrel, more than 45% of its needs for 2007 at a maximum price of $31 per barrel, 30% of its planned 2008 fuel purchases at $33 per barrel, and 25% of its 2009 fuel needs at $35 per barrel.

Source: http://money.cnn.com/2005/04/14/news/fortune500/southwest_oil/

be below $90/barrel. The actual price that is realized in the forward market will be determined by supply-and-demand conditions that relate to the number of producers who want to hedge their oil price exposure by selling oil in the forward market and the number of oil users (like airlines) and speculators (like hedge funds) that are willing to buy oil in the forward market. Although the equilibrium forward prices can, in theory, equal the expected price, in general this will not be the case.

11.3 Using Forward Prices to Value Investment Projects

Natural resource investments, such as oil and gas fields, illustrate how forward prices are used in discounted cash flow valuation. Application of this method is possible because oil and gas are commodities with well-developed forward and futures markets, which provide prices that can be used to calculate certainty-equivalent cash flows.

Before valuing an investment with the certainty-equivalence approach, it is useful to first review how analysts value oil and gas investments using the traditional DCF approach. With the traditional method, expected cash flows are calculated by multiplying expected prices by expected quantities and then discounting these cash flows using risk-adjusted discount rates. This traditional DCF method requires the analyst to make a number of estimates, including estimates of the underlying determinants of both the investment's expected cash flows (based on forecasted prices and estimated extraction rates and operating costs) as well as the appropriate cost of capital to use in discounting the expected cash flows. In contrast, by utilizing information from the oil futures market, we can apply the certainty-equivalence method described in the previous section without having to forecast future oil prices or the appropriate discount rate because the relevant information is impounded in forward prices. In the oil and gas industry, this practice is referred to as pricing against the forward price curve. The following example illustrates how this can be done.

Example: Pricing Against the Forward Price Curve

Cutter Exploration and Drilling Company is considering a promising opportunity to develop acreage in Giddings, Texas, that has been in production for many years but has been plagued by recovery problems. Cutter developed a new procedure for recovering oil from this type of geologic structure that has proven to be very successful in similar situations along the Louisiana Gulf Coast. Let's see how we might use futures prices and the certainty-equivalence model to evaluate Cutter's investment.

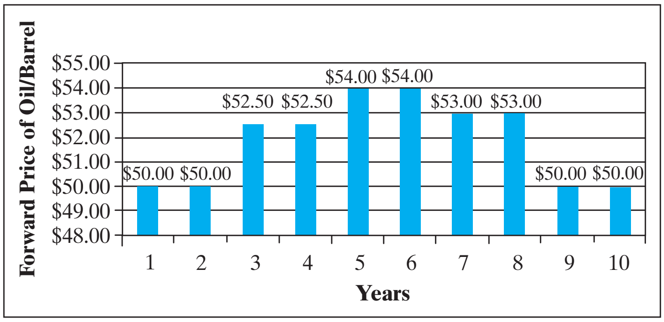
Cutter's geologists are confident that the Giddings lease has 1,000,000 barrels of recoverable oil reserves, which can be extracted at a rate of 100,000 barrels per year over a period

Did You Know?

What Fraction of an Underground Oil Reserve Is Recoverable?

Total oil reserves and recoverable reserves are not the same thing. For example, using standard recovery techniques, it is possible to extract no more than 15% to 20% of the total reserves found in the Austin chalk region near Giddings, Texas. However, using newly developed horizontal drilling and fracturing methods (commonly referred to simply as fracking), the extraction percentage increases to about 50%.

Figure 11-1 Forward Price Curve for Crude Oil



of ten years using Cutter's new technology. To acquire this opportunity, Cutter will have to pay $7,000,000 for the lease (i.e., the right to drill for and produce the oil) and will incur drilling costs of $12,000,000. For simplicity, we assume that the total investment of $19,000,000 is spent at the beginning of the first year of the investment (i.e., at time $t = 0$) and that the cost of extracting and transporting the oil is $28 per barrel. Note that we assume that the quantity of oil to be extracted is known and that the costs of extracting it are fixed at $28 per barrel. These assumptions leave only the price of oil as a source of risk to the investment. We return to this point later in the chapter.

Cutter's banker is willing to write a forward contract for the delivery of 100,000 barrels per year over the next ten years. The forward price curve specified in this contract is found in Figure 11-1. For example, oil produced in years 1 and 2 has a forward price of $50 per barrel, oil sold in years 3 and 4 is priced at $52.50 per barrel, and so forth. Currently, the risk-free rate of interest on ten-year US government bonds is 5%.

We can use the certainty-equivalence method to estimate the value of the investment to Cutter using the three-step process outlined in the Chapter Overview:

Step 1: Forecast the amount and timing of future cash flows. The most difficult part of this step has already been done because the total production volume is assumed to be 100,000 barrels per year over the next ten years.

Step 2: Use the forward price curve to calculate the certainty-equivalent future cash flows from the project.

Step 3: Discount the certainty-equivalent cash flows back to the present using the risk-free rate of interest.

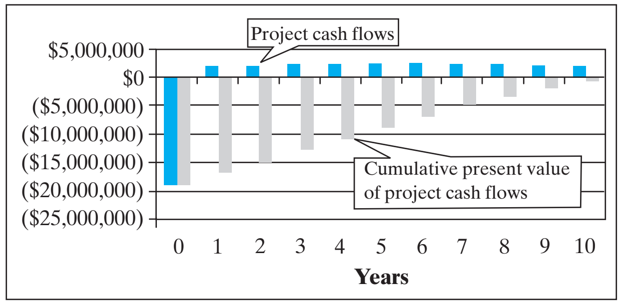
Figure 11-2 depicts the cash flows generated by our simple investment example. Because the forward price for oil is equal to the certainty-equivalent price, the annual certainty-equivalent cash flow in years 1 and 2 equals $\$50 - \$28 = \$22$ per barrel times 100,000 barrels, or $2,200,000. In years 3 through 6, the annual cash flow rises because the forward price increases.

Did You Know?

What's the "Lingo" of the Forward Price Curve?

Forward price curves can be either upward sloping (i.e., forward prices for more distant periods are higher) or downward sloping. An upward-sloping forward curve is said to be in **contango,** and a downward-sloping curve is said to be in **backwardation.**

Figure 11-2 Natural Resource Investment Project Analysis



By discounting these certainty-equivalent cash flows for years 1 through 10 using the risk-free rate, we get a value for the project of $18,437,605. Subtracting the $12,000,000 cost of drilling and completing the well and the $7,000,000 cost of acquiring the lease from the $18,437,605 estimated value of the production during years 1 through 10 generates a negative net present value for the property of ($562,395), found in Table 11-1. Given this negative net present value (NPV), Cutter should reject the investment. In the next section, we investigate the validity of this analysis more fully.

In the preceding example and for the balance of this chapter, we will simplify the analysis by ignoring the effects of taxes and the use of debt financing. A discussion of the certainty-equivalence method with debt tax shields is described in the Technical Insight box on page 412.

Convincing Your Skeptical Boss

Now suppose that you completed your analysis of Cutter's investment opportunity and delivered it to your boss. To your surprise, he strongly disagrees with your analysis. He believes that oil prices will average close to $60 per barrel over the next ten years and believes that the forward prices you have used to forecast cash flows are not relevant because he does not plan to hedge the price of oil (that is, he does not plan to take up the bank's offer and commit to selling the production at the quoted forward prices). Based on his more optimistic forecast of $60 per barrel and a discount rate of 10%, he estimates that the project has a positive NPV of $662,615.[6]

How can you convince him that his analysis is wrong and your analysis is correct? As we will show, since the derivatives valuation approach uses market prices, the analysis implies that the derivatives market offers a better investment opportunity regardless of your boss's beliefs about future oil prices. By showing your skeptical boss that there exists a superior alternative investment opportunity, we should be able to convince him that the investment under evaluation is not attractive.[7] Specifically, we will devise an

[6] The annual cash flow is calculated as follows: 100,000 barrels ($60/barrel − $28/barrel) = $3,200,000. Discounting these cash flows using a 10% discount rate generates provides a present value of $19,662,615. Subtracting the total investment costs of $19 million produces an NPV of $662,615.

[7] Keep in mind that, by showing your boss that he is in error, you may be proven right, but you may also find yourself working from a new office in one of the company's most obscure locations!

Table 11-1 Project Cash Flows and Present Value

Year	Forward Price/Barrel*	Project Free Cash Flows†	Present Values‡	Cumulative Present Values
0		$ (19,000,000)	$ (19,000,000)	$ (19,000,000)
1	$ 50.00	2,200,000	2,095,238	(16,904,762)
2	50.00	2,200,000	1,995,465	(14,909,297)
3	52.50	2,450,000	2,116,402	(12,792,895)
4	52.50	2,450,000	2,015,621	(10,777,274)
5	54.00	2,600,000	2,037,168	(8,740,106)
6	54.00	2,600,000	1,940,160	(6,799,946)
7	53.00	2,500,000	1,776,703	(5,023,242)
8	53.00	2,500,000	1,692,098	(3,331,144)
9	50.00	2,200,000	1,418,140	(1,913,004)
10	50.00	2,200,000	1,350,609	(562,395)§

*The prices in the forward price curve have been set through a contract with the bank.

†For year 0, the project cash flow consists entirely of the $12 million cost of drilling plus the $7 million cost of acquiring the drilling lease (rights). In year 1, the cash flow equals the difference in total revenues ($5 million = $50/barrel × 100,000 barrels), and the cost of extracting and transporting the oil ($28/barrel × 100,000 barrels = $2.8 million), or $2.2 million. Note that we assume a zero tax rate.

‡Because the oil prices are hedged, they don't involve any future risk. Thus, we discount future cash flows using the risk-free rate of interest.

§Because these are cumulative present values, the value for year 10 incorporates the present values of all ten years of cash flows, including the initial outlay such that this is the NPV. The present value of the cash flows for years 1 through 10 is $18,437,605. Subtracting the initial outlay for the project of ($19,000,000), we get the NPV of ($562,395).

alternative investment strategy consisting of the purchase of a risk-free bond and a set of long positions in oil forward contracts that replicates exactly the cash flows of the oil investment project over the next ten years. As we will show, this investment costs less than the $19 million required to make the oil investment, but it generates identical cash flows.

Here's how you can construct the alternative investment:

- First, the company purchases a portfolio of risk-free bonds that generate annual cash flows equal to the project's certainty-equivalent cash flows. For example, you could purchase ten zero coupon bonds with maturity values that are equal to the ten annual cash flows found in Table 11-1. This portfolio would cost an amount equal to the present value of the ten annual cash flows, or $18,437,605.
- Next, in addition to buying the portfolio of bonds, the company enters into a series of forward contracts with the bank, in which the bank agrees to sell 100,000 barrels of oil to be delivered at the end of each of the next ten years at the prices found in the forward price curve in Figure 11-1. The profit (or loss) on these contracts will be the difference between the uncertain future market price that is realized at those delivery dates and the forward price per barrel specified in the contract.

TECHNICAL INSIGHT

The Certainty-Equivalence Approach with Debt and Taxes

Accounting for an investment's debt tax shield is straightforward with the certainty-equivalence approach. If the free cash flows of an investment are calculated as certain equivalents, they should be discounted using the risk-free rate for the cost of both equity and debt. Adjusting for the tax deductibility of interest costs results in an after-tax weighted average cost of capital (WACC) equal to the following:

$$k_{WACC} = r_f - \left(\frac{\text{Tax}}{\text{Rate}}\right) r_f \left(\frac{\text{Debt}}{\text{Value}}\right) = r_f\left[1 - \left(\frac{\text{Tax}}{\text{Rate}}\right)\left(\frac{\text{Debt}}{\text{Value}}\right)\right]$$

where r_f is the risk-free rate of interest. For example, if the tax rate is 20%, the risk-free rate is 5%, and the debt-to-value ratio is 40%, then the WACC that would be used with the certainty-equivalence approach is calculated as follows: $5\%(1 - .2 \times .4) = 4.6\%$.

As we learned in Chapter 9, we can also calculate the debt tax shield using the adjusted present value (APV) approach, which separately values the unlevered or operating cash flows and the debt tax shield. When using this approach, we recommend that the first component be valued by discounting the before-tax certainty-equivalent free cash flow at the risk-free rate of interest. However, we do not recommend calculating the certainty equivalence of the interest tax savings component; this should be calculated and discounted at the cost of debt, as described in Chapter 9.

To see how this works, let's assume your boss is right, and the price per barrel of oil climbs to \$60; thus, the oil field generates a cash flow for year 1 equal to \$3,200,000:

$$\text{Cash Flow}_1 = (\$60/\text{Barrel} - \$28/\text{Barrel}) \times 100{,}000 \text{ Barrels} = \$3{,}200{,}000$$

Alternatively, if we had invested in the bond and the forward contracts, our bond payment would be \$2,200,000 (the year 1 cash flow based on the forward price of \$50 per barrel) and the profit from our forward contract would be $(\$60 - \$50)$/barrel $\times$ 100,000 barrels = \$1,000,000. Added together, the year 1 cash flow from the bond investment and the forward contract is \$3,200,000, which is identical to the cash flow from the oil investment. Panel (a) of Table 11-2 contains the calculations for both the replicating strategy (i.e., bond plus forward contracts) and the actual project, where the price of oil is expected to equal \$60 per barrel every year.

Now consider a different scenario for year 1: Let's assume that the Organization of the Petroleum Exporting Countries (OPEC) falls apart and crude oil prices drop to \$35/barrel. In this scenario, owning the well generates cash flow of only \$700,000, that is:

$$\text{Cash Flow}_1 = (\$35/\text{Barrel} - \$28/\text{Barrel}) \times 100{,}000 \text{ Barrels} = \$700{,}000$$

From our alternative investment, we would earn \$2,200,000 from the bond payment and lose (\$1,500,000) = (\$35/barrel $-$ \$50/barrel) $\times$ 100,000 barrels from our forward contracts, netting the identical \$700,000 cash flow. Panel (b) of Table 11-2 contains the cash flows for both the replicating strategy (using bonds and forward contracts) and the actual project, under the assumption that the price of crude equals \$35 per barrel in each of the next ten years.

Table 11-2 Replicating Project Cash Flows Using Forward Contracts

Panel (a) Expected Price of Oil Equal to $60 per Barrel

	(A)	(B)	(A + B)	
Year	Bond Payouts	Gain/Loss on Forwards	Replicating Cash Flows	Actual Project Cash Flows
1	$2,200,000	$1,000,000	$3,200,000	$3,200,000
2	2,200,000	1,000,000	3,200,000	3,200,000
3	2,450,000	750,000	3,200,000	3,200,000
4	2,450,000	750,000	3,200,000	3,200,000
5	2,600,000	600,000	3,200,000	3,200,000
6	2,600,000	600,000	3,200,000	3,200,000
7	2,500,000	700,000	3,200,000	3,200,000
8	2,500,000	700,000	3,200,000	3,200,000
9	2,200,000	1,000,000	3,200,000	3,200,000
10	2,200,000	1,000,000	3,200,000	3,200,000

Panel (b) Expected Price of Oil Equal to $35 per Barrel

	(A)	(B)	(A + B)	
Year	Bond Payouts	Gain/Loss on Forwards	Replicating Cash Flows	Actual Project Cash Flows
1	$2,200,000	$(1,500,000)	$700,000	$700,000
2	2,200,000	(1,500,000)	700,000	700,000
3	2,450,000	(1,750,000)	700,000	700,000
4	2,450,000	(1,750,000)	700,000	700,000
5	2,600,000	(1,900,000)	700,000	700,000
6	2,600,000	(1,900,000)	700,000	700,000
7	2,500,000	(1,800,000)	700,000	700,000
8	2,500,000	(1,800,000)	700,000	700,000
9	2,200,000	(1,500,000)	700,000	700,000
10	2,200,000	(1,500,000)	700,000	700,000

What this simple example illustrates is that we *can* replicate the cash flow stream from the risky oil drilling investment using risk-free bonds and forward contracts to purchase oil. Note the key difference between the two alternatives, however: The upfront cost of the replicating strategy using the forward market to purchase oil and investing in a risk-free bond is equal to the cost of the bond, or $18,437,605, because the forward contracts have no cost associated with them at the time they are initiated. On the other hand, it costs $19,000,000 to purchase and develop the oil field investment. Clearly, the replicating strategy dominates investing in the Giddings project because it generates *identical* annual cash flows, yet the replicating strategy costs $562,395 less (which is the negative NPV loss associated with making the investment).

11.4 Using Option Prices to Value Investment Opportunities

The investment considered in the previous section was quite simple. The buyer did not use any debt financing, and the implementation of the investment required no managerial choices beyond the initial decision to undertake the investment. The key insight we gained from our analysis was that we could value the investment using the forward price curve for oil.

This section illustrates how a similar process can be used to value investment opportunities that have option-like components. Specifically, we show how companies can use **financial options** (i.e., options that are traded in financial markets) to replicate investment cash flows and to value investments in much the same way that we used forward contracts in the earlier example.

We will start our discussion by considering the **default option** embedded in debt contracts. This is an example of what we refer to as a **contractual option,** which is an option that arises because of the design of the contract that defines the terms of an investment. To illustrate the importance of the default option, we will consider an investment that is financed with *nonrecourse debt,* or debt that is collateralized only by the specific assets being financed, with no separate guarantee by the firm. When a firm uses nonrecourse debt to finance an investment, it has the option to default on the debt and simply walk away from the investment if it is doing especially poorly. As we will show,

Technical Insight: Option Terminology

The type of option contract. Put or call. A *call* (*put*) option gives its owner the right, but not the obligation, to buy (sell) a specified asset at a contractually agreed-upon price (commonly referred to as the option's *exercise price*) within a specified period of time. Appendix A provides a brief review of option-contract payoffs.

The underlying asset. The *underlying asset* is the common stock, tract of land, and so on, that the owner of the option contract buys or sells if the contract is exercised. We say the option is *written* on the underlying asset.

The expiration date of the option. Options have a finite life during which they can be exercised. The final date on which the option can be exercised is referred to as its *expiration date.*

The exercise (*or strike*) *price.* The *exercise* (*strike*) *price* is the price at which the option owner may buy or sell the underlying asset on which the option is written. We will use the symbol K to refer to the option's exercise price.

The terms of exercise. American or European. A *European option* provides the holder with the right to exercise the option only on its expiration date. The *American option* allows the holder to exercise the option at any time up through the expiration date.

observed option prices can sometimes be used to determine the value of the firm's equity investment in such a project.

Option Value and Nonrecourse Financing

To illustrate how information from the prices of financial options can be incorporated in the evaluation of productive investments, consider the following investment opportunity:

- For a price of \$5 million, you have the opportunity to purchase the equity of the Cotton Valley oil field, which contains 5 million barrels of reserves. Note that the oil field investment will be partially financed by borrowing, so this is a levered investment.
- The oil can be extracted in one year at a cost of \$12 per barrel, for a total cost of \$60 million = \$12/barrel × 5 million barrels. For simplicity, we assume that the extraction costs are paid at the end of the year, when the oil is produced.
- The current owner borrowed \$200 million to finance the purchase of the field. If you purchase the equity, you will assume this debt, which requires a onetime payment at the end of the year of \$220 million (including interest of 10%).
- The debt is *nonrecourse,* which means that the debt holders cannot lay claim to the acquiring firm's other assets if it defaults on the debt payments. They can lay claim only to the oil field. As an equity investor, your firm has the option to default on the loan and to walk away from the investment if it is in your financial interest to do so. If you choose to do so, you forfeit any rights of ownership to the oil field, which would transfer to the lender. Indeed, you plan to walk away from the field if the revenues generated by the oil field at the end of the year turn out to be worth less than \$280 million—the \$220 million needed to retire the note plus the \$60 million needed to develop the property and produce the oil. Note that the \$280 million breakeven point equals \$56/barrel = \$280 million/5 million barrels.
- The forward price of oil to be delivered in one year is \$54.17, and the price of a call option to purchase one barrel of crude oil in one year, at an exercise price of \$56 per barrel, is \$1.75.

Valuing the Investment Using Forward Prices

Before proceeding with our formal analysis of the default option, we begin by explaining why the approach from Section 11.3 that used forward prices is not appropriate in this case. In the previous example, we valued the investment by assuming that the oil price risk is hedged or sold in advance in the forward market. However, in this particular case, if the oil from the field is sold today for the forward price of \$54.17, the equity investment will have no value. To understand this, note that if the investor sells the crude oil forward for \$54.17 per barrel, this will guarantee revenues of \$270,850,000 = 5,000,000 barrels × \$54.17/barrel. The equity cash flow at the end of one year for the hedged investment is then:

$$\begin{aligned}\text{Equity Cash Flow} &= \text{Revenues} - \text{Extraction Costs} - \text{Note Payoff}\\ &= \$270{,}850{,}000 - 60{,}000{,}000 - 220{,}000{,}000 = (\$9{,}150{,}000)\end{aligned}$$

Hence, if the oil is sold forward, the equity investment generates a negative cash flow of (\$9,150,000) if the investor chooses not to default. As a result, the equity investor will in fact default on his debt obligation, so the actual cash flow to the equity holders is zero.

Because of the option to default, the investment in the project's equity has a higher value if the oil price risk is not hedged. Indeed, when we value this investment opportunity in a way that incorporates the option to default on the debt, we see that the equity investment does have a positive value when the oil price risk is not hedged.

Analyzing Equity Value with the Default Option—Managing the Project

We begin our analysis by showing that the payoff to the equity in the project is identical to an investment in a one-year call option on 5 million barrels of oil with an exercise price of \$56 per barrel (i.e., the cost of extracting a barrel of oil from the oil field in one year).

- If the price of oil exceeds \$56 per barrel, the option will be exercised and generates a profit equal to the price of oil times 5 million barrels minus \$280 million (the \$56 exercise price per barrel times 5 million barrels). This profit is identical to the profit from the equity investment, which also generates cash flows equal to the price of oil times 5 million minus \$280 million (the sum of the \$60 million in extraction costs plus the \$220 million needed to retire the note).
- If oil prices fall below \$56 per barrel, the option expires worthless. When this is the case, the equity investor defaults on the debt and walks away from the investment.

Just as having forward prices simplified the analysis of Cutter Exploration Company in the example discussed earlier, having observable option prices simplifies the valuation of this equity investment. In this case, the **tracking portfolio**—that is, the portfolio of traded securities that replicates the real investment cash flows—for the oil investment consists of a portfolio of call options on 5 million barrels of crude oil with an exercise price of \$56 per barrel. If these call options have a price of \$1.75/barrel, then the tracking portfolio is worth \$8.75 million $=$ \$1.75 per barrel $\times$ 5 million barrels of oil. Because the equity investment in the project has the same cash flows as the tracking portfolio, it too is worth \$8.75 million. Given that the equity of the Cotton Valley oil field investment can be acquired for \$5 million, this seems like a pretty good investment. Indeed, the NPV of the investment is \$3.75 million $=$ \$8.75 million $-$ \$5 million.

Convincing Your Skeptical Boss

Again, because this kind of analysis is relatively new, we might expect to encounter a skeptical boss, who may be reluctant to take the project because of its risk. Because this is a positive NPV investment, we cannot create a better transaction using derivatives, as we did earlier in the Cutter example by using risk-free bonds and forward contracts. Instead, to convince your skeptical boss to take the investment, you can show her how to use the derivative market to hedge the risk associated with this investment and thereby guarantee that the NPV of the investment is realized.

To lock in the positive NPV of the investment, we write (sell) call options on 5 million barrels of oil for \$1.75 per barrel when we acquire the equity position in the oil property for \$5 million. Because the option transaction generates a total cash inflow of \$8.75 million $=$ 5 million $\times$ \$1.75, the combination of these two transactions nets \$3.75 million in the current period. As we illustrate in Table 11-3, the combination of these two transactions, which generates a positive initial cash flow, generates no cash outflows in the following year; the cash flows of the two investments in the following year exactly offset each other.

TECHNICAL INSIGHT

Settlement Differences in Forward Versus Option Contracts and Discounting

When a forward contract is initiated, no cash changes hands until the contract's delivery date. Consequently, when forward prices are used to calculate the certainty equivalent of future project cash flows, we discount the resulting cash flows back to the present using the risk-free rate to determine their value. However, when the market prices of options are used to value an investment, we do not discount them. The reason for this difference is that, with options, the buyer of an option pays upfront—i.e., the option price we observe is the discounted value of the certainty-equivalent payoff of the option.

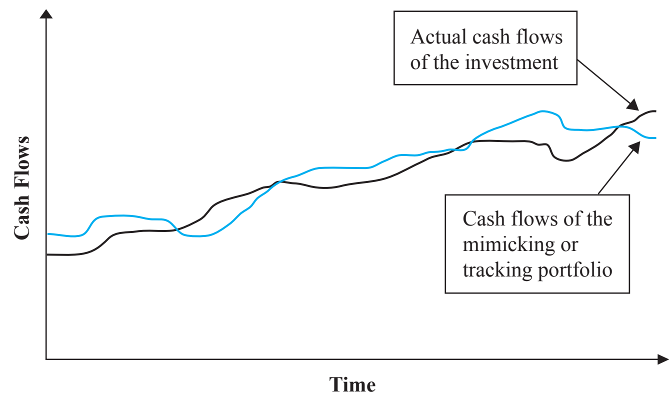
Table 11-3 Locking in a Positive NPV Using Options—Cotton Valley Example

Year	Hedging Strategy		Cash Flows
0	(1) Sell call options on 5 million barrels of crude oil for \$1.75 each		\$8.75 million
	(2) Purchase the oil investment		\$ (5 million)
	(3) Net cash flow for year 0		**\$3.75 million**
		Cash Flows for Alternative Crude Oil Prices	
		\$60/barrel	\$ 56/barrel
1	(1) Payoff (loss) from sale of call options	(\$4) $\times$ 5 million = (\$20 million)	\$0.00
	(2) Payoff (loss) from the oil investment	\$300 million − \$280 million = \$20 million	\$0.00
	(3) Net cash flow for year 1	**\$0.00**	**\$0.00**

11.5 Caveats and Limitations—Tracking Errors

Most of our discussion up to this point assumed that it is possible to construct a portfolio of traded financial securities whose cash flows are a *perfect match* for the cash flows of the real investment we are trying to value. In practice, it is not always possible to match cash flows perfectly with the payoffs of traded financial securities. As a consequence, the value of the tracking portfolio will differ from that of the investment. Figure 11-3 illustrates the problem of tracking error. The black line depicts fluctuations in the true value of the project over time, and the blue line reflects fluctuations in the value of the tracking portfolio. Obviously, the greater the difference between the two lines, the less precise the valuation of the investment using the value of the tracking portfolio.

Figure 11-3 Tracking Error



Cash flows of the tracking portfolio can deviate from those of the investment being analyzed for three fundamental reasons. The first relates to the reliability of market prices for derivatives. The second relates to what we will refer to as *omitted project risks,* which are simply sources of risk that are not captured in the cash flows of the tracking portfolio. Finally, there is something that derivatives traders refer to as *basis risk,* which arises out of differences in the specific nature of the assets underlying the derivative contracts and the assets that underlie the investment being evaluated. We describe each of these sources of tracking error in detail below.

How Liquid Are Futures, Forward, and Option Markets?

If derivative markets are very illiquid, the market prices may not provide a reliable estimate of the certainty-equivalent prices. Our analysis assumes that the investor can transact at the quoted financial market prices. For example, suppose we are considering a project to extract 2 billion barrels of oil over a five-year period (a bit more than 1 million barrels per day). Although the derivative markets have sufficient depth to hedge multibillion-dollar oil price exposures, it may not be possible to hedge such a huge exposure without significantly affecting forward prices. Because of this, large oil producers tend to hedge very little and, as a result, they do not believe the derivatives approach is applicable for their investments and prefer to use the traditional DCF approach. Although they may use futures prices as a guide to their estimates of expected oil prices, they also use their own judgment about expected future oil prices.

Uncertain Quantities and Operating Costs

Our second caveat has to do with project risks that have been omitted from our analysis. Here, tracking errors arise from sources of variation in cash flows that cannot be known in advance and consequently cannot be used to determine the tracking portfolio. Specifically, although the tracking portfolio procedure accounts for commodity price risks in capital investments, there are typically other sources of risk that affect an investment's cash flows that are not driven by commodity prices. Two important sources of noncommodity price risk are the quantity of the commodity produced and the operating costs associated with extracting and processing the commodity.

Our oil and gas examples assumed that the quantity of oil and the cost of extraction were both known with certainty, so that the only source of risk was the uncertain price of crude oil. In practice, valuing an oil field (or any investment in a commodity industry) requires estimates of the quantity of oil produced and the costs of extracting the oil. To accommodate the effects of uncertain production quantities, managers may opt for conservative estimates of those quantities to adjust for this source of uncertainty. One might also use relatively conservative estimates of extraction costs (i.e., costs on the high end of what is expected) for the same reason.

Basis Risk

The final source of tracking error that we consider is something analysts refer to as **basis risk,** which, as we noted earlier, arises out of differences in the specific nature of the assets underlying the derivative contracts and the assets that underlie the real investment being evaluated. We will discuss three sources of such differences: product quality, geographic location, and contract terms.

Differences in Product Quality

Although the list of traded derivatives on commodities is quite lengthy, it is not encyclopedic. This means that the analyst will often have to use a surrogate commodity contract because a derivative contract for the exact commodity that underlies the risks of the investment being analyzed may not exist. For example, if the investment involves the production of heavy crude oil, the analyst might use derivative contracts based on light, sweet crude because this is the contract that is traded on NYMEX. The problem is that the price of light, sweet crude is imperfectly correlated with the price of other forms of crude oil. Consequently, the resulting valuation of the investment using the light, sweet crude contracts will differ from the true value of the investment because of the differences in the *quality of the products* underlying the investment and the derivative contract.

Differences in Geographic Locations

Basis risk also arises out of *geographic differences.* For example, crude oil futures are priced for delivery in Cushing, Oklahoma, and natural gas futures are priced for delivery at Henry Hub in Louisiana. Obviously, differences in the physical location of crude oil or natural gas from the standard locations used in the option contracts give rise to tracking errors. In this instance, the tracking error is due to delivery costs.

Differences in Contract Terms

These are cases where the match between traded options and the option component of the investment that is being valued is far from perfect. For example, call options on oil with an exercise price of \$50 may exist, but there may be no traded options with an exercise price of $56, which is what we need to solve our valuation problem. An even more common problem is that the analyst is evaluating an investment that offers cash flows distributed over many years, whereas traded options have maturities extending out only one year. In these cases, we will need an option pricing model to value the investment, which is the topic we discuss in the next section.

The Relation Between Tracking Error and Imperfect Comps

The astute student will recognize that the problem of finding an appropriate tracking portfolio is analogous to the problem of finding appropriate comparison firms that can be used to value a business. As we mentioned in earlier chapters, it is generally impossible to find a perfect comp when we are trying to identify either the appropriate valuation multiple or the appropriate risk-adjusted cost of capital. In general, managers consider a variety of comps and then use their judgment to determine a weighted average that provides the appropriate information.

11.6 Using an Option Pricing Model to Value Investments

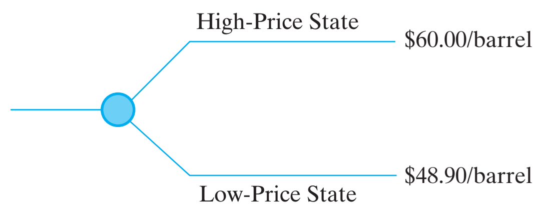
Identifying the appropriate tracking portfolio to determine the certainty-equivalent cash flows is also an imperfect procedure, but no more so than the procedures that are used to identify appropriate valuation ratios and discount rates. We again need to stress that there are inherent uncertainties in valuing future cash flows whether we use the traditional DCF model (which focuses on the estimate of risk-adjusted discount rates) or the real options approach (which focuses on identifying a tracking portfolio), and both approaches require sound judgment on the part of the user.

Example—Valuing the Cotton Valley Investment Using the Binomial Option Pricing Model

In the Cotton Valley oil example, the financial options exactly matched the investment that was being evaluated. However, as our discussion in the last section indicates, in even the best cases, there is likely to be some basis risk, and in other cases, there may be no traded option that even remotely resembles the option embedded in the investment being valued. As we will show in this section, when you cannot match an investment's cash flow with a traded option, you *may* be able to price the option component of the investment using information from forward prices. However, this requires an option pricing model, along with assumptions about the distribution of oil prices in the future.

In this section, we illustrate how to estimate the value of a call option on oil using a single-period **binomial option pricing** model, which makes the assumption that the future oil price follows a **binomial distribution** (see the Technical Insight box titled Probability Trees and the Binomial Distribution on page 423). In our reexamination of the Cotton Valley oil field investment, we make an assumption about the distribution of oil prices. Specifically, as we illustrate in Figure 11-4, we assume that oil prices in the next period will be equal to a high price of $60.00 per barrel or a low price of $48.90 per barrel.

Figure 11-4 Distribution of Year-End Oil Prices



TECHNICAL INSIGHT

Probability Trees and the Binomial Distribution

The idea behind a probability tree is not new to most students of finance. Very simply, a *probability tree* specifies the outcomes of an uncertain event such as the price of a pound of copper at the end of next year and the probabilities associated with each of the possible prices. If there are only two possible outcomes, the probability tree is a binomial tree; if there are three possible outcomes, it is a trinomial tree; and so forth. For our purposes, we will stick to the simplest case—the binomial probability tree.

To illustrate the construction of a binomial tree, consider the binomial distribution of oil prices at the end of one year that are found in Figure 11-4. The high and low prices of oil at the end of one year are calculated in terms of the forward price of oil observed today for oil delivered at the end of year 1, $F_{0,1}$:[8]

$$\text{High Price} = F_{0,1}u \text{ where } u = e^{+\sigma} \quad \text{and} \quad \text{Low Price} = F_{0,1}d \text{ where } d = e^{-\sigma}$$

To calculate these prices, we need the forward price of oil to be delivered in one year, $F_{0,1} = \$54.17$, and the standard deviation in annual oil price changes, $\sigma = .10232$. Therefore, $u = e^{+\sigma} = e^{.10233} = 1.10775$ and $d = .9027$, which implies that at the end of one year, the price of oil will be either

$$\text{High Price} = F_{0,1}u = \$54.17 \times 1.10775 = \$60.00$$

or

$$\text{Low Price} = F_{0,1}d = \$54.17 \times .9027 = \$48.90$$

The single-period binomial model can be extended to multiple periods with a few slight modifications. We demonstrate this procedure in Appendix B.

[8] There are other ways to characterize the distribution of prices in a binomial lattice; however, we follow the approach taken by Robert L. McDonald, *Derivative Markets,* 2nd ed. (Boston: Addison Wesley, 2006).

TECHNICAL INSIGHT

Continuous Time Discounting

In the option literature, the standard convention is to use continuous time compounding/discounting. Consequently, the future value of $1.00 compounded using continuous compounding at a rate of 10% for one year is equal to $e^{.10}$, which is equivalent to discrete time compounding using an annual rate of 10.517%, i.e., (1 + .10517).

The first step in the investment valuation process is to identify the cash flows that accrue to the equity holder under each of the crude-oil-price scenarios. The cash flows equal the revenue generated by 5 million barrels of production sold for either $60.00 per barrel or $48.90 per barrel, minus the $12 per barrel cost of extracting the oil, minus the $20.0 million due on the note. Thus, the summary information for the oil field investment is as follows:[9]

- The oil price next year will be either $48.90 or $60.00 per barrel, as illustrated in Figure 11-4.
- Extraction and transportation costs are known and equal $12 per barrel.
- The risk-free interest rate is 8%.
- The forward price for oil observed today for delivery in one year is $54.17 per barrel.
- A total of 5 million barrels of oil can be extracted from the property, and the entire amount can be extracted next year.
- The oil field serves as the sole collateral for a $200 million note that is due at the end of next year and that requires 10% interest compounded annually.
- The owner of the oil field has offered to sell his equity for $5 million, and the buyer will assume the $200 million note, which is secured by the property.

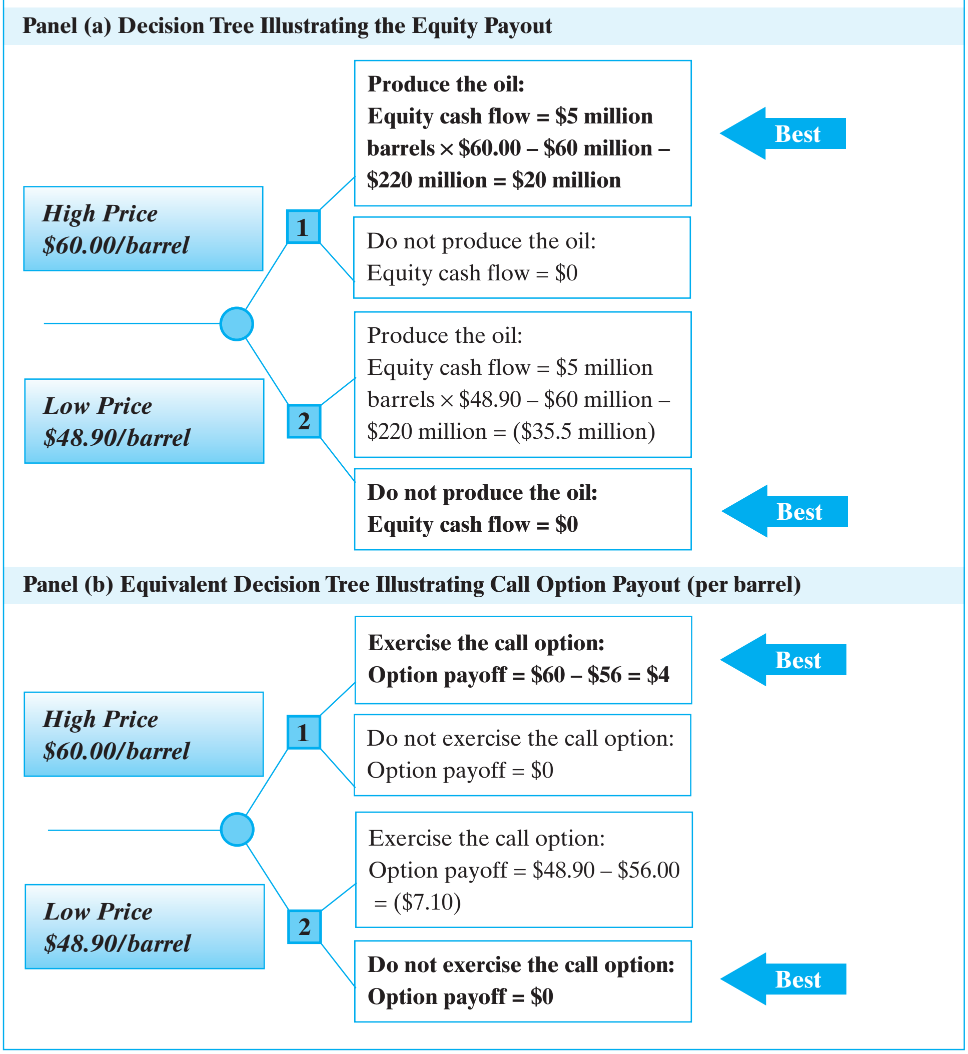
The question, then, is this: Is the offer a good one?

The decision trees found in panels (a) and (b) of Figure 11-5 provide a convenient way to illustrate graphically how the decision process unfolds over time. The circle nodes represent uncertain events, such as different oil price possibilities, and the square nodes represent decision events—for example, whether or not to drill. The numbers found in the square nodes are used to keep track of the particular decision that is to be made as part of the decision problem (e.g., investment) being described.

Panel (a) of Figure 11-5 presents a detailed analysis of the cash flows that are realized from an uncertain future price of crude oil if the firm does not sell the oil in the forward market. If oil prices increase to $60.00 per barrel, the investment revenues will be $300 million = 5 million barrels × $60.00/barrel, leaving a profit of $20 million after paying the extraction costs ($60 million) and retiring the debt ($220 million). If oil prices at year-end equal the low price of $48.90 per barrel, the investment will lose $35.5 million after extraction costs and repayment of the debt. Because the loan is nonrecourse, the investor will default when oil prices are low, making the cash flow to equity equal to 0.

[9] This is an existing note that has a $200 million face value; however, given the assumptions in this example, its market value would be less.

Figure 11-5 Decision Tree for the Oil Production Problem



As Figure 11-5 illustrates, the payoff to the equity investors is identical to the payoff from holding a call option to buy 5 million barrels of oil with an exercise price of $56 per barrel. In both cases, the investment pays $20 million if oil prices turn out to be $60 per barrel and nothing if oil prices are $48.90 per barrel.

Again, it is worth noting that the traditional DCF approach requires (1) estimating the possible cash flow outcomes for the option in the high and low crude oil price scenarios, (2) calculating the expected cash flow by weighting these cash flows using the probabilities of the high- and low-price states, and (3) then discounting the expected cash flow at an appropriate risk-adjusted discount rate. The alternative that is used in practice is to calculate the option's certainty-equivalent cash flow rather than its expected cash flow and to discount this value at the risk-free rate.

The advantage of this approach is that we do not need to know the *actual* probabilities of the two oil price scenarios. Instead, we calculate what is referred to as risk-neutral probabilities. Specifically, the **risk-neutral probabilities** *are hypothetical probabilities that make the forward price equal the expected price of oil next year.* We can solve for the risk-neutral probabilities using Equation (11.1) as follows:

$$\begin{aligned}\begin{matrix}\text{Forward}\\ \text{Price for Oil}_{\text{Year } t}\end{matrix} &= \begin{pmatrix}\text{High}\\ \text{Price for Oil}_{\text{Year } t}\end{pmatrix} \times \begin{pmatrix}\text{Risk-Neutral}\\ \text{Probability}_{\text{High Price}}\end{pmatrix}\\ &+ \begin{pmatrix}\text{Low}\\ \text{Price for Oil}_{\text{Year } t}\end{pmatrix} \times \begin{pmatrix}\text{Risk-Neutral}\\ \text{Probability}_{\text{Low Price}}\end{pmatrix}\end{aligned} \tag{11.1}$$

Substituting values from our current example, we solve for *p,* which represents the risk-neutral probability that the \$60.00 price will prevail, as follows:

$$\$54.17 = p \times \$60.00 + (1 - p) \times \$48.90$$

where $(1 - p)$ is the corresponding risk-neutral probability that the \$48.90 price will prevail. By solving the above equation, we see that the risk-neutral probability of the high price occurring is 47.48%, which leaves a 52.52% risk-neutral probability for the low price.[10]

Using the risk-neutral probabilities, the risk-neutral expected value or certainty equivalence of the option payoff at its expiration date in one year can be calculated as $.4748 \times \$4.00 + .5252 \times \$0.00 = \$1.90$. Discounting this certainty-equivalence payoff using the 8% risk-free rate provides the value of the call option today. Thus, the value of one call option to acquire a barrel of oil via the investment just described is $\$1.75 = \$1.90e^{-.08}$, which is what we assumed earlier, and the value of an option to acquire 5 million barrels is \$8.75 million.[11]

How Does Volatility Affect Option Values?

How is the value of this equity position affected if uncertainty increases? In our discounted cash flow analysis, we learned that an increase in risk, other things remaining the same, led to an increase in the discount rate and a corresponding decrease in the present value of expected future cash flows. As we now illustrate, this is not necessarily the case for investments with option components.

Consider the case where the forward price stays at \$54.17 per barrel, but the oil price when the economy is strong is increased to \$66.00 per barrel, and the price when

[10] As we discussed in Section 11.2, forward prices need not equal the expected value of future spot prices because hedging pressure from market participants may cause forward prices to be either higher or lower than the expected future prices. This in turn implies that risk-neutral probabilities, which make the forward price equal to its certainty-equivalent value, will not generally equal actual probabilities. For example, if the forward price is lower than the expected price in the future, the risk-neutral probability of the high-price state will be lower than the actual probability, and the risk-neutral probability of the low-price state will be higher than the actual probability.

[11] The astute reader will notice that we have not presented anything that might be construed as an *option pricing model* in the traditional sense. Instead, we have valued the call option, simply using the certainty-equivalent DCF model that we have been using throughout this chapter. We were able to do this because we can observe forward prices for the underlying asset. In Chapter 12, we tackle situations in which forward prices are not observable.

the economy is weak is decreased to \$44.50/barrel. In this case, the risk-neutral probabilities can be computed using Equation (11.1) to be 45% for the high-price state and 55% for the low-price state.[12] Because the equity position has value only when the price of oil is \$66.00, the value of the equity in year 1 is calculated as follows:

$$\frac{.45 \times (\$66/\text{barrel} \times 5 \text{ million barrels} - \$280 \text{ million})}{1.08} = \$20.833 \text{ million}$$

This is a substantial increase from the \$8.75 million value calculated with the lower volatility.

This result may seem odd because we normally associate greater uncertainty with higher risk, not higher value. However, the equity investor benefits from the increased volatility, which leads to the possibility of both higher and lower future oil prices, because higher *and* lower oil prices have an asymmetric effect on cash flows. Although higher oil prices always generate higher revenues, the loss associated with lower oil prices has a floor. Because the investor has the option to walk away from the investment, the investor cannot lose more than her original investment no matter how much oil prices decline.

Calibrating Option Pricing Models

Traded options often resemble the embedded option being valued, but the basis risk is quite large. When this is the case, financial analysts infer information from the best available option and forward prices, and use this information in combination with an *option pricing model* to value the options under consideration. Specifically, analysts use observed option prices to back out the volatility (or, equivalently, the spread between the price in the high and low states) of the price of the underlying commodity. For example, if the prices of traded options on oil are relatively high, they infer that oil prices are expected to be relatively volatile, which means that a higher volatility should be used to value the options embedded in an oil field. This process of using observed option prices to infer the parameters that are used for a model is known as *calibrating* the model. Appendix C contains an illustration of this process using the binomial option pricing model.

11.7 Summary

The central point of this chapter is that observable market prices of derivative contracts (forwards, futures, and options prices) provide information that can be used to value investment projects. For example, forward prices provide the information needed to calculate certainty-equivalent cash flows, which can be valued by discounting them at the risk-free rate of interest. This approach should not be viewed as an alternative to DCF analysis. Indeed, a key learning point of this chapter is that observed prices of traded derivatives can be used to perform more accurate DCF analysis.

[12] Where the forward price remains \$54.17, the risk-neutral probability of the high-price state, p, is calculated as follows:

$$\$54.17 = p \times \$66.00 + (1 - p) \times \$44.50$$

In reality, it is unlikely that an investment's cash flows can be replicated exactly with publicly traded financial derivatives. However, this problem is no different from the problem of finding comparable firms for implementing relative valuation, as discussed in Chapter 8, or the problem of estimating a project's risk-adjusted cost of capital, as discussed in Chapters 4 and 5. When this problem arises in a valuation analysis—and it almost always does, regardless of the method being used—financial analysts must exercise their professional judgment to determine combinations of futures and/or options that track the investment cash flows as closely as possible.

In some cases, managerial judgment is required to select derivative prices for a traded commodity that is closely related to the commodity that underlies the project cash flows. For example, if an investment's cash flows are derived from the production and sale of heavy oil from Alberta, the analyst may use the West Texas crude oil futures price, adjusted for the typical difference in the prices of the two sources of crude. In other cases, more complex transformations are required. For example, if the terms of the traded option contracts do not match the specific attributes of the option embedded in the investment being valued, an option pricing model, such as the binomial option pricing model introduced in this chapter, can be used. To apply such a model, you should use information from the prices of traded options that have attributes that closely resemble the real options being valued.

As we mentioned at the outset of this chapter, we have illustrated the derivative valuation approach with examples of oil investments. The techniques that we have described were originally developed to value oil, gas, and other natural resource investments. However, as we illustrate in Chapters 12 and 13, the approach that we have described is currently being extended to value a wide range of investments in an expanding variety of industries.

EXERCISES

11-1 DISTINGUISHING BETWEEN FORWARD AND FUTURES CONTRACTS Both forward and futures contracts represent agreements to buy or sell something at a specified period of time in the future and at a specified price. What distinguishes a forward from a futures contract? Explain your answer.

11-2 DISTINGUISHING BETWEEN AN OPTION AND FUTURES CONTRACT Option and futures contracts are both referred to as derivative contracts because the value of both types of contracts is derived from the value of the underlying asset on which the contract is based. However, options and futures are different in several ways. Discuss.

11-3 USING THE FORWARD PRICE CURVE TO VALUE RISKY INVESTMENTS Pontiac Producing Company (PPC) is a domestic producer of natural gas. The firm is considering the purchase of some gas-producing property in the Bakin Shale located in North Dakota. The property has estimated production volumes of 100 Million cubic feet (100,000 MCF) per year for the next five years. However, the price of natural gas is currently very low, selling for $4 per MCF. The projected demand for natural gas is growing, however, with the prospect of using it as fuel by large trucking and bus firms. In fact, the forward price of gas for the next five years is \$4.50, \$4.75, \$5.30, \$6.00, and \$6.50. If PPC decides to sell its production forward, what is your forecast of the revenues it might receive from the Bakin project?

11-4 HEDGING WITH COMMODITY FUTURES Patterson Farms grows corn used in the production of ethanol, which is used as a gasoline additive. Each year, the firm plants thousands of acres of corn, which is eventually harvested and sold to ethanol plants. How can corn futures contracts be used by Patterson to reduce the risk of its operations? Can futures contracts be used to eliminate all the risk that Patterson faces? Discuss.

PROBLEMS

11-5 USING DERIVATIVES TO ANALYZE A NATURAL GAS INVESTMENT Morrison Oil and Gas is faced with an interesting investment opportunity. The investment involves the exploration for a significant deposit of natural gas in southeastern Louisiana near Cameron. The area has long been known for its oil and gas production, and the new opportunity involves developing and producing 50,000 cubic feet (MCF) of gas. Natural gas is currently trading at around \$14.03 per MCF; the price next year, when the gas is produced and sold, could be as high as \$18.16 or as low as \$12.17. Furthermore, the forward price of gas one year hence is currently \$14.87. If Morrison acquires the property, it will face a cost of \$4.00 per MCF to develop the gas.

The company trying to sell the gas field has a note of \$450 million on the property that requires repayment in one year plus 10% interest. If Morrison buys the property, it will have to assume this note and responsibility for repaying it. However, the note is nonrecourse; if the owner of the property decides not to develop the property in one year, the owner can simply transfer ownership of the property to the lender.

The property's current owner is a major oil company that is in the process of fighting off an attempted takeover; thus, it needs cash. The asking price for the equity in the property is \$50 million. The problem faced by Morrison's analysts is whether the equity is worth this amount. Answer the following assuming zero taxes.

- **a.** Estimate the value of the equity in the project for the case where all the gas is sold forward at the \$14.87-per-MCF price. The risk-free rate of interest is currently 6%.
- **b.** Alternatively, Morrison could choose to wait a year to decide on developing it. By delaying, the firm chooses whether to develop the property based on the price per MCF at year-end. Analyze the value of the equity of the property under this scenario.
- **c.** The equity in the property is essentially a call option on 50 MCF of natural gas. Under the conditions stated in the problem, what is the value of a one-year call option on natural gas with an exercise price of \$13.90 MCF worth today? (*Hint:* Use the binomial option pricing model.)

11-6 VALUING AN ENERGY INVESTMENT USING OIL OPTIONS The Pampa Oil Company operates oil and gas exploration throughout the panhandle of Texas. The firm was recently approached by a wildcatter named William "Wild Bill" Donavan with the prospect to develop what he thinks is a sure thing. Wild Bill owns the lease and wants to sell it to Pampa to meet some rather pressing gambling debts.

Wild Bill is extremely confident that there are 20,000 barrels of oil to be found, and he has engineering and geological reports to support his view. The value of the proposition hinges on the price of oil, the cost of exploration, and the cost of extracting the oil. Pampa Oil is very familiar with exploration and production in the area and is confident about its cost estimates. Pampa Oil estimates that the exploration would involve efforts expended over a period of one year and a cost of $600,000 (which, for simplicity, we assume is paid at the end of the year). Pampa Oil also feels confident that the cost of extracting oil will be no more than $8 per barrel. However, oil prices have been very volatile, and the experts in the economy predict that oil prices might hit $50 a barrel by year-end or drop back to $35, depending on progress made in securing a lasting peace in the Middle East. Therefore, Pampa Oil is considering the possibility of deferring development of the oil field for one year. Waiting for a year will place Pampa Oil in a better position to determine whether to go ahead with exploration. The risk-free rate of interest is currently 5%, and the forward price of oil one year in the future is now trading at $40 a barrel. Is the option to delay development of the property valuable? You may assume a zero income tax rate.

11-7 THE LOGIC OF HEDGING WITH OPTIONS Morrison Oil and Gas Company's (from Problem 11-5) chief financial analyst is Samuel (Sam) Crawford. Sam completed his analysis, suggesting that the investment is indeed a good one for the company, and presented it to the firm's executive committee, which consists of the firm's CEO, CFO, and COO. The CFO thought Sam's analysis was on target, but the COO and CEO were concerned about the fact that the hedging strategy would not work for the investment. In fact, they wondered why hedging the investment is such a good idea. Sam explained that the project is a good one because it allows them to perfectly hedge the investment cash flows using one-year call options on natural gas. These call options, which have a $13.90-per-MCF strike price, are selling for $1.86 per MCF. Show how selling call options on 50 MCF of gas today and undertaking the investment provides Morrison with a hedged (i.e., risk-free) investment.

11-8 VALUING A COPPER MINING PROJECT USING FORWARD PRICES Harrington Explorations Inc. is interested in expanding its copper mining operations in Indonesia. The area has long been noted for its rich deposits of copper ore. With copper prices at near-record levels, the company is considering an investment of $60 million to open operations into a new vein of ore that was mapped by company geologists four years ago. The investment would be expensed (a combination of depreciation of capital equipment and depletion costs associated with using up the ore deposit) over five years toward a zero value. Because Harrington faces a corporate tax rate of 30%, the tax savings are significant.

The company's geologists also estimate that the ore will be of about the same purity as existing deposits, meaning that it will cost $150 to mine and process a ton of ore containing roughly 15% pure copper. The company estimates that there are 75,000 tons of ore in the new vein that can be mined and processed over the next five years at a pace of 15,000 tons per year.

Harrington's CFO asked one of his financial analysts to come up with an estimate of the expected value of the investment using the forward price curve for copper as a guide to the value of future copper production. The forward price curve for the price per ton of copper spanning the next five years when the proposed investment would be in production is as follows:

2016	\$7,000/ton
2017	\$7,150/ton
2018	\$7,200/ton
2019	\$7,300/ton
2020	\$7,450/ton

In a study commissioned by the CFO last year, the firm's cost of capital was estimated to be 9.5%. The risk-free rate of interest on five-year Treasury bonds is currently 5.5%.

a. Estimate the after-tax (certainty-equivalent) project free cash flows for the project over its five-year productive life.
b. Using the certainty-equivalent valuation methodology, what is the NPV of the project?
c. Assume now that the analyst estimates the NPV of the project using the certainty-equivalent methodology and it is negative. When the firm's CFO sees the results of the analysis, he suggests that something must be wrong because his own analysis using conventional methods (i.e., expected cash flows and the firm's weighted average cost of capital) produces a positive NPV of more than \$450,000. Specifically, he estimates that the price of copper for 2016 would indeed be \$7,000 per ton but that this would increase by 12% per year over the five-year life of the project. How should the analyst respond to the CFO's concerns?

11-9 VALUING A GOLD INVESTMENT OPPORTUNITY Jim Lytle, a financial adviser, recommends that his clients invest in gold. Specifically, he is advising a client to invest \$100,000 to purchase 175 ounces of gold bullion, with the expectation of holding the gold for a period of one year before selling it. The client points out that the futures price for 175 ounces of gold to be delivered in one year is \$104,000, which represents a 4% return on the \$100,000 investment, while the one-year Treasury yield is currently 5%. "Wouldn't it be better," the client asks, "if I sold 175 ounces of gold today for \$100,000, while purchasing a forward contract to purchase the gold in one year at a price of \$104,000? I could then invest the \$100,000 in 5% Treasury bonds maturing in one year."

a. Analyze the returns for the client's proposed strategy. What is your recommendation?
b. Why might the two alternatives offer different returns?

11-10 VALUING GOLD RECLAIMED FROM OLD PERSONAL COMPUTERS A number of industrial products include gold and silver as a component because they have very good conductive properties. The S&M Smelting Company engages in the recovery of gold from such products and is considering a contract to begin extracting the gold from the recycling of personal computers (PCs). The project involves contracting with the state governments of three midwestern states to dispose of their PCs. The project will last for five years, and the contract calls for the disposal of 200,000 PCs per year. Three tons of electronic scrap contains approximately one Troy ounce of gold. Moreover, each PC contains approximately 6 pounds of electronic scrap, and the processing cost involved in extracting the gold is $67.50 per ton of scrap. In addition, the current (spot) price of gold is $592.80, and the forward price curve for the price per ounce of gold spanning the next five years is as follows:

2016	$679.40/ounce
2017	$715.10/ounce
2018	$750.60/ounce
2019	$786.90/ounce
2020	$822.80/ounce

S&M estimates that the firm's cost of capital is 10.5%, and the risk-free rate of interest on five-year Treasury bonds is currently 5.0%. In addition, S&M faces a 30% tax rate, and the entire investment of $450,000 made in the project in 2015 will be depreciated using straight-line depreciation over five years with a zero salvage value.

a. Estimate the after-tax (certainty-equivalent) project free cash flows for the project over its five-year productive life.
b. Using the certainty-equivalent valuation methodology, estimate the NPV of the project.
c. Assume that gold prices will increase at a rate of 7% per year over the next five years. What is the NPV of the project using the traditional WACC method of analysis based on expected project free cash flows, where the WACC is estimated to be 10.5%? What rate of growth in gold prices is required to produce the same NPV using the traditional WACC approach as with the certainty-equivalent approach used in Problem 11-10(b)?

Option Basics—A Quick Review

This appendix is targeted toward the reader whose knowledge of options and their payoffs is either limited or just rusty from years of nonuse. Our objective is to develop a platform from which to build an understanding of the use of options throughout this chapter and the two that follow.

What Is an Option?

An **option** gives its owner the right, but not the obligation, to buy or sell a specified asset at a contractually agreed-upon price (the option's *exercise price* or *strike price*) within a specified period of time. A **call option** gives the owner the right (but, again, not the obligation) to buy the asset at the exercise price. A **put option** gives the owner the right (but, again, not the obligation) to sell the asset at the exercise price. In either case, the option owner can walk away if it is not in his or her best interest to buy or sell.

Option contracts come in two basic types that differ in *when* they can be exercised: The **European option** provides the holder the right to exercise the option *only* on its expiration date; the **American option** allows the holder to exercise it at *any time* up until the expiration date of the option.

How Can We Characterize the Payoffs to Option Contracts?

Consider the economic consequences of owning a call option on a share of stock. The payoff to the holder of the option at maturity (i.e., date T when the option expires) can be represented graphically using the position diagram in Figure 11A-1. The expiration-date payoff to owning the call option (or being long in the call) is represented by the 45° line moving up and to the right, beginning at the exercise price, K, of \$30. If the stock price, $P(T)$, is, say, \$50 and the exercise price, K, is \$30, then on the day the option expires, it has a value of $P(T) - K = \$50 - 30 = \$20$. However, if the stock price falls below \$30 on the expiration date of the option, the option is worthless. For example, if the stock price on the expiration day were only \$25, then the holder would not exercise the option because it has no value. (Who would pay \$30 to exercise an option to buy a share of stock that one could purchase in the market for only \$25?) Thus, we want to own call options when we expect that prices of the underlying asset are going to increase.

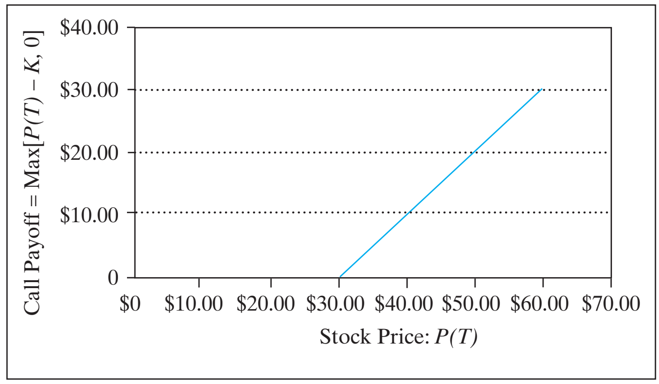
Defining Call Option Payoffs

Analytically, we write the payoff to the call option as $\max[P(T) - K, 0]$, which is read "the maximum of $P(T)$ minus K or zero." When the option payoff is positive

Figure 11A-1 **Expiration-Date Payoff to a Call Option [Exercise Price (*K*) = $30]**

K = $30

P(T)	Max[*P(T)* – *K*, 0]
$ 0	$ 0
$ 5.00	$ 0
$10.00	$ 0
$15.00	$ 0
$20.00	$ 0
$25.00	$ 0
$30.00	$ 0
$35.00	$ 5.00
$40.00	$10.00
$45.00	$15.00
$50.00	$20.00
$55.00	$25.00
$60.00	$30.00
$65.00	$35.00



[i.e, $P(T) > K$], the option is said to be "in the money." Similarly, when $P(T) = K$, the option is "at the money," and when $P(T) < K$, the option is "out of the money." Consequently, for a call option there are two critical states at expiration—the stock price is either greater than the exercise price or it is not—that are summarized in Equation (11A.1):

$$\begin{array}{c}\text{Call Option}\\ \text{Payoff at}\\ \text{Expiration } (T)\end{array} = \text{Max}[P(T) - K, 0] = \begin{cases} P(T) - K & \text{if} \quad P(T) > K \\ 0 & \text{if} \quad P(T) \le K \end{cases} \qquad (11\text{A}.1)$$

If $P(T) > K$, then the call option has value equal to $P(T) - K$. Otherwise, the call expires worthless.

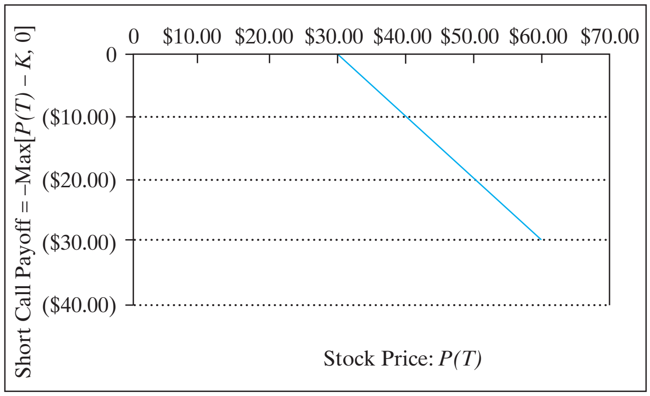
Figure 11A-1 represents the expiration-day payoff to *the owner of a call option* with an exercise price, *K,* of $30. What does the payoff look like for the *person who sold the call option*? The answer is straightforward. For every dollar the owner of the call option makes, the seller loses a dollar. For example, if the price of the stock is $50, the owner of the call owns a security that is worth $20. (She can purchase a share of stock worth $50 by exercising the call option for $30.) However, the issuer of the call option is obligated to deliver the share of stock worth $50 in the market for the exercise price of $30 (a loss of $20). Therefore, the payoff to selling (shorting, which is referred to as *writing*) the call option, shown in Figure 11A-2, is the mirror, or inverse, image of Figure 11A-1. Analytically, the payoff to shorting a call is the negative of the payoff to owning (being "long in") the call—that is, $-\max[P(T) - K, 0]$.

Defining Put Option Payoffs

A put option gives its owner the right, but not the obligation, to sell an asset at a prescribed exercise price and within a specified time period. Thus, we want to own put options when we expect that prices of the underlying asset are going to fall. This is because the put option has value when the price of the underlying asset falls below the stated exercise price.

Figure 11A-2 **Expiration-Date Payoff to the Seller of a Call Option [Exercise Price (K) = \$30]**

K = \$30	
$P(T)$	$-\text{Max}[P(T) - K, 0]$
\$ —	\$ —
\$ 5.00	\$ —
\$ 10.00	\$ —
\$ 15.00	\$ —
\$ 20.00	\$ —
\$ 25.00	\$ —
\$ 30.00	\$ —
\$ 35.00	\$ (5.00)
\$ 40.00	\$ (10.00)
\$ 45.00	\$ (15.00)
\$ 50.00	\$ (20.00)
\$ 55.00	\$ (25.00)
\$ 60.00	\$ (30.00)
\$ 65.00	\$ (35.00)

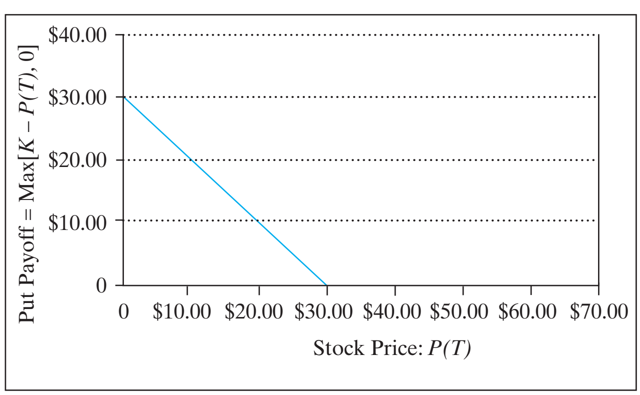


Consider the put option payouts in Figure 11A-3, where the put option has an exercise price of \$30. If the price of the underlying asset on which the put is written has a price of \$25, then the holder of the put can exercise the option to sell the stock for the \$30 exercise price. However, if the price of the stock is \$40, the put will expire worthless because the stock can be sold in the market for \$40, while the put exercise price is only \$30.

You can think of a put option contract like an insurance policy. That is, in the event that the value of the underlying asset drops below some threshold level, we are protected because the payoff to the put increases dollar for dollar with any further decline in the value of the underlying asset. Similarly, in the event your home burns down, a homeowner's insurance policy provides you with the right to sell the home to the insurance company for the value of the insured damage.

Figure 11A-3 **Expiration-Date Payoff to the Owner of a Put Option [Exercise Price (K) = \$30]**

K = \$30	
$P(T)$	$\text{Max}[K - P(T), 0]$
\$ 0	\$30.00
\$ 5.00	\$25.00
\$10.00	\$20.00
\$15.00	\$15.00
\$20.00	\$10.00
\$25.00	\$ 5.00
\$30.00	\$ 0
\$35.00	\$ 0
\$40.00	\$ 0
\$45.00	\$ 0
\$50.00	\$ 0
\$55.00	\$ 0
\$60.00	\$ 0
\$65.00	\$ 0



Analytically, we can express the payoff to owning the put option (a long position) as max[$K - P(T), 0$]. That is, the put has positive value equal to [$K - P(T)$] only when the price of the stock falls below the exercise price, K. Equation (11A.2) captures the payoff structure of the put option on date T:

$$\begin{array}{c}\text{Put Option}\\ \text{Payoff at}\\ \text{Expiration } (T)\end{array} = \text{Max}[K - P(T), 0] = \begin{cases} K - P(T) & \text{if} \quad P(T) \le K \\ 0 & \text{if} \quad P(T) > K \end{cases} \quad (11A.2)$$

Once again, the payoff to the seller of the put option is the mirror (or inverse) image of the payoff to the one who buys it (i.e., the owner), as Figure 11A-4 illustrates.

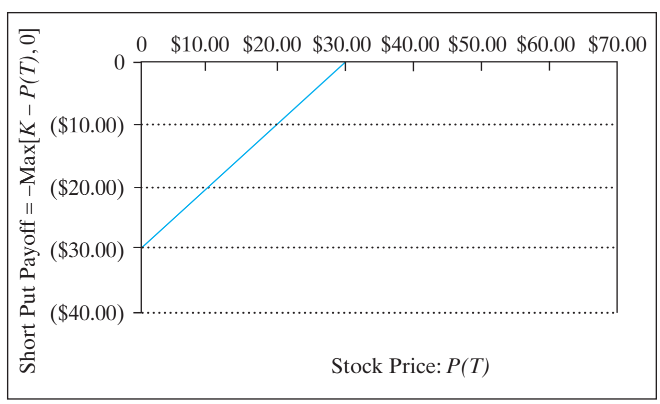
If the stock price is \$25, the put option is worth \$5 to the holder of the option. Correspondingly, the person who sold the put (commonly referred to as the *put writer*) is obligated to pay the exercise price of \$30 for the share of stock that is worth only \$25 in the market and consequently faces a loss of \$5.

Risk and the Valuation of Options

An important feature of most option contracts is that their value is higher when the underlying asset becomes more volatile or risky. For example, stock options are more valuable when the volatility of the stock is higher. The intuition that supports this statement is straightforward. For most investments, volatility is viewed negatively because the increased probability of achieving very high returns is offset by a higher probability that very negative returns will be realized. However, the expected payoff of an option generally increases as the volatility of the underlying investment increases. This is because higher volatility increases the probability that

Figure 11A-4 Expiration-Date Payoff to the Seller of a Put Option [Exercise Price (*K*) = \$30]

K = \$30	
$P(T)$	$-\text{Max}[K - P(T), 0]$
\$ —	\$(30.00)
\$ 5.00	\$(25.00)
\$10.00	\$(20.00)
\$15.00	\$(15.00)
\$20.00	\$(10.00)
\$25.00	\$ (5.00)
\$30.00	\$ 0
\$35.00	\$ 0
\$40.00	\$ 0
\$45.00	\$ 0
\$50.00	\$ 0
\$55.00	\$ 0
\$60.00	\$ 0
\$65.00	\$ 0



the option payoff will be very high, but because the maximum loss on an option contract is fixed, the increase in the upside potential is not completely offset by increases in downside risk.

Valuing Call Options Using the Black-Scholes Model

To this point, we have restricted our discussion to the expiration-date payoff of the option, or the value of the option on the day it expires. Valuing options prior to the expiration date provides a much more challenging problem, and perhaps the best-known valuation model is the one developed by Fisher Black and Myron Scholes. Their model can be used to value options that can be exercised only at expiration (i.e., European options). Another significant difference between their model and the binomial option pricing model that we discuss in Appendix C of this chapter is that the distribution of stock prices in the Black-Scholes model is assumed to be continuous rather than binomial. However, the basic approach to the derivation of the pricing model is the same. By buying shares of stock and simultaneously selling options on the stock, the investor can create a risk-free payoff. The resulting option pricing equation for a call option on a stock whose current price is P_{today} and that expires in period T can be written as follows:

$$\text{Call}(P, T, K) = P_{\text{Today}} N(d_1) - Ke^{-r_f T} N(d_2) \tag{11A.3}$$

where $K =$ the option's strike price, $r_f =$ the risk-free rate of interest,

$$d_1 = \frac{\text{In}\left(\frac{P_{\text{Today}}}{K}\right) + \left(r_f + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}, \quad \text{and} \quad d_2 = d_1 - \sigma\sqrt{T}$$

$N(d_i)$ is the probability that a value less than d could occur under the standard normal distribution (i.e., mean zero and standard deviation equal to 1); σ^2 is the annualized variance in the returns (continuously compounded) on the stock, i.e., $\text{In}[P(t+1)/P(t)]$; and all the remaining terms retain their previous definitions.

To illustrate the use of the Black-Scholes formula, let us consider the following example: The current price of the stock on which the call option is written is $P_{\text{Today}} = \$32.00$; the exercise price of the call option $K = \$30.00$; the maturity of the option is $T = 90$ days or .25 years; the (annualized) variance in the returns of the stock is $\sigma^2 = .16$; and the risk-free rate of interest is $r_f = 12\%$ per annum. To estimate the value of the call option using Equation (11A.3), we must first solve for d_1 and d_2 as follows:

$$d_1 = \frac{\text{In}\left(\frac{P_{\text{Today}}}{K}\right) + \left(r_f + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} = .572693$$

and

$$d_2 = .1432 - .4\sqrt{.25} = .372693$$

Now, using Equation (11A.3) and the table of areas under the standard normal distribution (found in any standard statistics book), we calculate the value of the option by substituting the appropriate values into Equation (11A.3), that is:[13]

$$\text{Call}(P, T, K) = P_{\text{Today}}\, N(d_1) - Ke^{-rfT}\, N(d_2)$$
$$\text{Call}(P, K, T) = \$32\,(.716574) - \$30\, e^{-.12(.25)}(.645311) = \$4.1437$$

Note that the option's value is $4.14 even though the current $32 price of the stock is only $2.00 greater than the exercise price of $30. This premium arises because there is the potential for the value of the call option to go up even higher if the stock price should rise over the next ninety days. In fact, if the term to maturity of the option were six months rather than three months, the value of the option would be $5.58.

[13] We can use the Normsdist (d_1) function in Excel to calculate $N(d_1)$ directly.

Multiperiod Probability Trees and Lattices

In the chapter, we introduced the binomial tree to characterize the outcomes of uncertain future oil prices. In this appendix, we extend the single-period tree to multiple periods using forward prices. There are multiple ways to construct a binomial tree, and the method we describe here develops a forward tree.[14]

Figure 11B-1 produces a three-year binomial lattice for the price of crude oil with a volatility (σ) estimate of .10 for the annual changes in oil prices. We calculate the high and low prices for year 1 based on today's forward price for oil to be delivered at the end of year 1 ($F_{0,1}$) as follows:

$$\text{High Price (for Year 1)} = F_{0,1}\, u$$

where $u = e^{+\sigma}$ and σ is the volatility in oil price changes, and

$$\text{Low Price (for Year 1)} = F_{0,1}\, d$$

where $d = e^{-\sigma}$.

Given a \$52.04-per-barrel forward price for crude oil at the end of year 1 and an estimated volatility in annual price changes (σ) equal to .10, we calculate the high and low prices for year 1 as follows:

$$\text{High Price (for Year 1)} = F_{0,1}\, u = \$52.04 e^{.10} = \$57.51$$

and

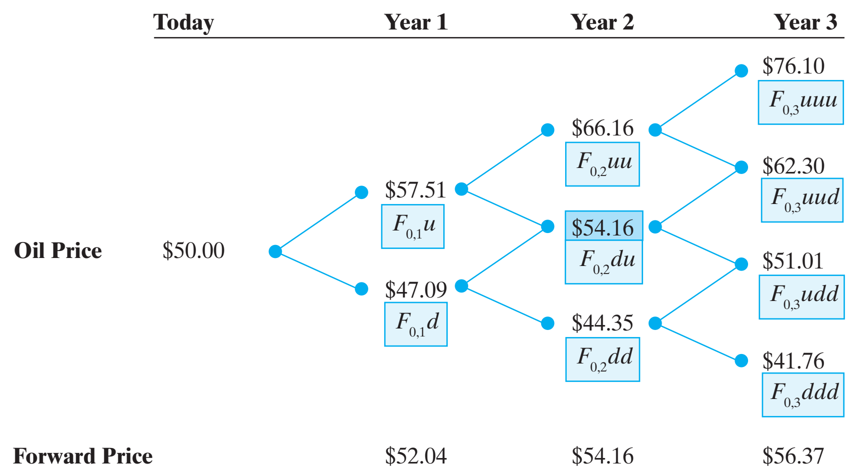
$$\text{Low Price (for Year 1)} = F_{0,1}\, d = \$52.04 e^{-.10} = \$47.09$$

The formulas used to calculate the possible prices in the binomial lattice for years 2 and 3 are based on the forward prices for each year and are found just below the price in each node of the lattice.

The binomial tree found in Figure 11B-1 is a recombining binomial tree or lattice. The practical importance of this is that the resulting tree utilizes fewer price nodes. For example, consider the middle node found in year 2 of Figure 11B-1, equal to \$54.16. This price can be achieved by a sequence of one high price in year 1 followed by a low price in year 2, or a low price in year 1 followed by a high price in year 2. This shared price-node feature of the recombining binomial tree or lattice means that there are fewer price nodes to deal with in the tree.

[14] See Robert McDonald, *Derivative Markets,* 2nd ed. (Boston: Addison Wesley, 2006).

Figure 11B-1 Binomial Distribution for the Price of Crude Oil



Summing Up

We close our brief overview of the construction of the binomial lattice with a few key observations:

- First, we construct a special form of binomial tree, known as a recombining tree or lattice, in which up moves and down moves are restricted and can be symmetrical only. This restriction facilitates the computation of large multiperiod trees.
- Second, the source of uncertainty in future values contained in the lattice is determined by the underlying volatility in the annual price changes.
- Third, the technique we use to construct the binomial lattice is designed to be consistent with observed forward prices.
- Fourth, although the examples we use in this chapter all use annual periods, the length of each time step is not restricted to one year. We simply adjust the risk-free rate and annualized volatility to correspond to the length of one *time step* in the lattice. Note that, by using multiple time steps per year, we greatly expand the number of data points (value estimates) per year, thereby improving the precision with which we can replicate the distribution of end-of-year values.

Calibrating the Binomial Option Pricing Model

This chapter introduces a valuation approach that employs information from the financial derivatives markets to value real investment opportunities. This calibration and valuation process involves three steps:

Step 1: Select an option pricing model that provides a reasonable description of option prices. For our purposes, we will use the binomial model.

Step 2: Calibrate the option pricing model by determining which model parameters do the best job of describing observed option prices. Most of the model parameters, including contract terms and the risk-free interest rate, are observable. The key unobservable variable is the volatility of the future commodity prices. In the binomial model, this is the risk-neutral probabilities of the high and low states. The volatility that best explains observed option prices is generally referred to as the volatility that is implied by observed option prices (i.e., the **implied volatility**).

Step 3: Finally, we substitute the contract terms for the option we are trying to value, along with the implied volatility from the observable options, into the binomial option pricing model and estimate the value of the option.

To illustrate how this calibration to observed market prices can be done, consider the problem we face if we need to know the value of a call option on a barrel of crude with one year to maturity and an exercise price of \$52. If options with exercise prices of \$50 and \$54 were publicly traded, we might be tempted simply to interpolate these option values and use an average of the two observed values as our estimate of the value of the \$52 option. However, as the Technical Insight box on page 442 illustrates, the relationship between exercise prices and option value is not linear, and such an interpolation could provide a very poor estimate of the value of the option with a \$52 exercise price.

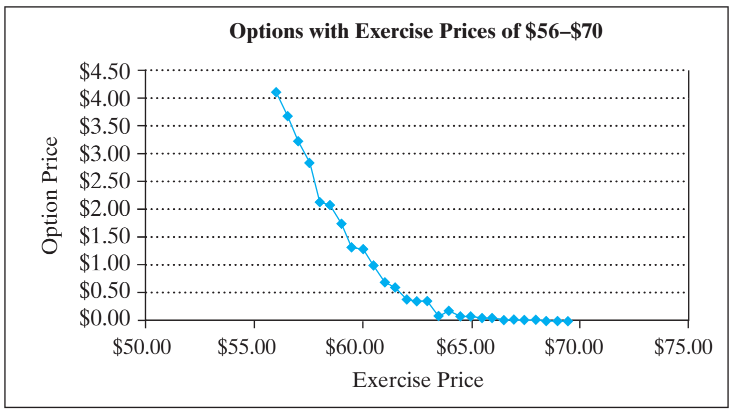
Figure 11C-1 contains the binomial distribution of prices used to derive this option value. What we want to do now is to use the information reflected in the valuation of the option with the \$56 exercise price to value the new option.

Panels (b) and (c) of Figure 11C-1 describe the option valuation process for the single-period binomial option pricing model. In panel (b), we define the call option payoff for each of the two price states to be \$8 [= Max(\$60 − 52, 0)] for the high-price state and \$0 [= Max(\$48.90 − 52, 0)] for the low-price state. We would like to estimate the value of a call option with an exercise price of \$52. However, what we can observe in the option market is a call option for crude oil with a one-year maturity and a \$56 exercise price that sells for \$1.75.

TECHNICAL INSIGHT

Option Values and Exercise Prices

When trying to value a call option with an exercise price that is not observed in the option market, we may be tempted to try simply to interpolate a price using observed market prices and their exercise prices. Unfortunately, interpolation (which involves the use of a linear approximation) does not work well with option prices because, as the following graph indicates, the relationship between option values and exercise prices is not linear. The option prices represent call options on crude oil, with exercise prices ranging from \$56.00 to \$70.00 at a time when the price of crude was around \$55.00 a barrel. The nonlinearity in option prices is very pronounced, suggesting that any use of linear interpolation will be fraught with estimation error.



Solving for the implied volatility, we estimate that $\sigma = .10232$. We use the implied volatility to calculate the risk-neutral probability of the high price of oil as follows:

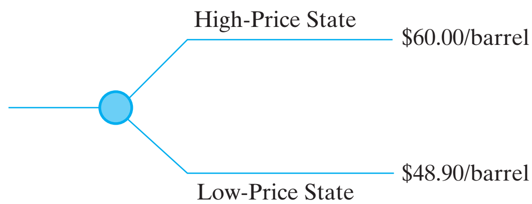
$$P = \frac{e^{r} - e^{r-\sigma}}{e^{r+\sigma} - e^{r-\sigma}} = 0.4744$$

We are now ready for step 3 (see panel [c] in Figure 11C-1) in the three-step calibration process. Using the \$52 exercise price, and the risk-neutral probability of .4744, we get the option price estimate of \$3.51.

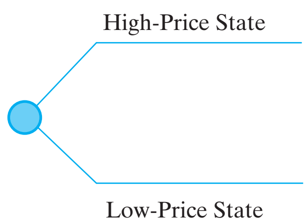
In this brief appendix, we have demonstrated how observed market price information can be incorporated into an option pricing model to calibrate a model that can be used to value options that are not publicly traded. The simple example we used

Figure 11C-1 Using the Binomial Option Pricing Model

Panel (a) The Price Distribution for Crude Oil in One Year



Panel (b) Option Valuation Using the Binomial Option Pricing Model



Price of Crude Oil	Call Option Payoff	Risk-Neutral Probability*
\$60.00/barrel	Max (\$60 – 52, 0) = \$8	.4744
\$48.90/barrel	Max (\$48.90 – 52, 0) = 0	.5256

*The forward price of crude oil for the end of year 1 is equal to the current price, \$50.00, compounded one year at the risk-free rate of 8% or $\$50e^{.08} = \$54.17$. Risk-neutral probabilities are the probabilities that we apply to both the high- and low-price states for crude to obtain an average equal to the forward price of crude oil.

Panel (c) Calculate the Value of the Call Option

$$\begin{aligned} \text{Call option (exercise price} &= \$52.00, 1 \text{ year to maturity)} \\ &= (\$8.00 \times .4744 + \$0.00 \times .5256)\, e^{-.08} \\ &= (\$3.80 \times .9231 = \$3.51) \end{aligned}$$

involved the estimation of an option with an exercise price that is not observed in the market. However, we also could have estimated the value of an option with a maturity not represented in the market or even estimated the value of an option for a particular commodity for which options are not traded but that is closely related to another commodity whose option prices are available.

CHAPTER 12

Managerial Flexibility and Project Valuation: Real Options

Chapter Overview

This chapter considers situations where management has flexibility in the implementation of investment projects. For example, managers may be able to choose the timing of an investment's implementation as well as when it is shut down. We also consider embedded real options that present themselves before an investment has been initiated. For example, an investment project can be designed to provide management with flexibility with respect to the products the firm produces or the inputs it uses. To value investments that benefit from managerial flexibility, we utilize (1) decision trees in combination with binomial lattices, (2) a real option pricing formula, and (3) simulation analysis.

12.1 Introduction

In the last half of the previous chapter, we evaluated the equity portion of a project that was financed with debt as well as equity. There, we learned that the option to default on the debt and walk away from the project adds significant value to the equity investment. In this chapter, we extend our analysis to consider optionality that is embedded within the very nature of investment opportunities. These embedded options, which are generally referred to as real options, exist whenever managers have the ability to exercise discretion. This discretion may involve timing issues such as determining when to initiate a new project or shut down an old one. In addition, managerial discretion can be exercised over how an existing investment is operated. For example, managers can respond to changing product demand by altering the mix of products and they can respond to changing input prices by changing the mix of inputs they use. They can also speed up or slow down production of existing products, decide to extend existing product lines to incorporate new products, and implement a myriad of other choices that enable the firm to adapt to changing circumstances. Consequently, when we value real options, we are in a sense determining the value that an active management team can add when it responds in a dynamic way to a changing environment.

Consider, for example, an investment in a copper-mining operation. An important feature of copper ore is that it does not spoil or otherwise lose value when it is left in the ground. Consequently, if the price of copper drops below the cost of extracting, processing, and shipping the ore, management may choose to slow down production or temporarily shut down operations until market conditions improve. Similarly, if a real estate developer purchases land that is well suited for developing an office building and the market for office space weakens due to a slowdown in the local economy, the developer may decide to delay the construction until the market begins to turn around or may consider other uses for the property. In both these examples, a key contributor to investment value is the embedded flexibility of the investment opportunities.

In the first half of this chapter, we will continue to illustrate concepts relating to real options within the context of oil field examples, which build on the ideas developed in the last chapter. Specifically, we will consider an oil field that provides its owner with the option to extract oil if oil prices are high and to keep the oil in the ground if oil prices are low. We start with a simple case, where the oil can be extracted at only one date, and then progress to a more realistic setting where the extraction options can be exercised at multiple dates. In these cases, the valuation problem resembles the problem of valuing an American-style stock option, which is an option that can be exercised at any time prior to its expiration date. However, these real options are more difficult to value than stock options because the underlying assets have uncertain payouts (analogous to dividends on a stock) and, in general, the exercise date is uncertain.

We demonstrate three approaches for solving the kinds of real option problems that are likely to arise in practice. The first is the binomial lattice, which is a multiperiod extension of the binomial option pricing model introduced in Chapter 11. The second approach applies an option pricing formula that was originally developed to value American call options that have infinite lives. Finally, we use simulation to analyze operating options that arise when producers have the flexibility to choose between multiple modes of operation.

The analysis of real options is relatively new, and we are aware of a number of different mistakes that are made in its application. To help our readers avoid these mistakes, we close our discussion of real options by identifying some common mistakes that analysts often make. Many of these errors arise out of the differences between options on financial assets (i.e., securities) and the options embedded in real investments.

12.2 Types of Real Options

Real options contribute to an investment's value whenever the following two conditions hold: (1) the environment is uncertain, and (2) managers can respond to changing circumstances by altering the way in which the investment is implemented and/or managed. It is useful to think about real options in terms of choices that are made before an investment has been launched and choices that are available to the managers who oversee the operations of an ongoing business venture. In either case, the availability of embedded optionality provides management with opportunities to exercise discretion that can have an important effect on the value of the project.

Real Options to Consider Before an Investment Launch

Before an investment is launched, the firm's focus is generally on timing issues and design-for-flexibility issues. The company grapples with questions such as the following:

Staged-investment options. In many cases, such as the venture capital investments discussed in Chapter 10, investments are made in stages. For example, a pharmaceutical startup may invest in research in the first stage, which provides the firm with *an option* to develop and market a new drug if the research turns out favorably and if market conditions are promising. Another example is the acquisition of undeveloped land, which gives the owner *the option* to construct an office building, condos, or whatever is appropriate given future market conditions and zoning restrictions. Similarly, the acquisition of an undeveloped oil field gives the owner *the option* to develop the field and extract the oil. In each of these examples, we can think of the initial investment in the project as the *cost of a call option to invest in the next stage.*

Timing options. *Timing options* arise when it is possible to postpone the implementation date of an investment. The benefit of deferring an investment comes from the fact that the value of the investment is uncertain and some of this uncertainty will be resolved in the future.

Operating options. The fundamental problem here is how best to design or structure an investment so that it provides the firm with the operating flexibility necessary to respond to changes in the environment. The investment is more valuable if it is designed to allow management to make choices that can capitalize on changing circumstances and the opportunities they bring.

Real Options to Consider After an Investment Launch

After an investment has been launched, the firm generally faces a different set of issues. In general, we refer to these as operational issues, and they too give rise to optionality that can enhance the value of the investment. Some examples where this optionality contributes to value include the following:

Growth options. This type of option includes the opportunity to expand both the scale and the scope of an investment. Expanding the *scale* of the investment refers to growing the specific project output through increased volume of production. Growing the *scope* of an investment includes things such as follow-on projects. These options, sometimes called *strategic options,* are often used to justify investing in projects that have negative net present values (NPV,) when viewed in isolation. They may still be good investments, however because they open the door for a sequence of future investments that do have positive NPVs.

Shutdown options. Almost all businesses have both good and bad times. Clearly, the business will be more valuable if management has the flexibility to shut it down during bad times and to operate it when the business is profitable.

Abandonment options. If a business is currently unprofitable and is expected to remain unprofitable in the future, it may make sense to abandon or sell it. The decision to abandon is influenced not only by the current profitability of the investment but also by the amount the firm could get for the business if it were to be sold.

Switching options—outputs. The ability to vary the output mix to reflect the relative value from alternatives can be a very valuable source of managerial flexibility.

Switching options—inputs. The ability to switch between two or more inputs provides managers with the opportunity to minimize input costs.

Even a cursory examination of the above list of real options suggests that most investments contain some degree of optionality or discretion for the managers who design, implement, and operate them. The simple truth is that most investment projects are not the static opportunities that are frequently characterized in traditional discounted cash flow analysis. Therefore, it is critical that when the investments are valued, consideration is given to the inherent flexibilities that each investment opportunity offers.

12.3 Why Real Option Valuation Is Difficult

In general, real options are much more difficult to value than stock options and other options on financial claims. Perhaps the most obvious difference between real and financial options is that real option values are often determined by the values of other assets that are not actively traded. For example, in contrast to a stock—which might be traded every minute—factories, buildings, and other real assets are bought and sold very rarely. This fact makes it difficult to estimate how their returns are distributed and makes it impossible to hedge the risk associated with the real option by buying or selling the underlying asset.

A second difference between real and financial options is that the exercise choices are much more complicated with real options. With a stock option, one simply decides whether to buy the stock at some prespecified price. For real options, the decisions can be much more complicated. For example, a landowner must decide more than just whether to build on his land. He must decide what to build and how quickly to construct the building. In addition, he must consider the effect of changing construction costs (that is, an uncertain exercise price) and uncertainty about the value of the building. For example, the developer may want to design the building so that it can be expanded easily to take advantage of the possibility of higher rents in the future.

12.4 Valuing Investments That Contain Embedded Real Options

This section opens our discussion of real option analysis with some simple examples that provide a framework for analyzing the importance of real options to project valuation. We then move progressively toward more-complex examples that better illustrate how these valuation problems are solved in practice. Where it is possible to do so, we utilize the valuation procedure outlined in Chapter 11; that is, we combine traded options into a tracking portfolio that mimics the payout of the real investment. In most cases, however, this is not possible, and we will need to develop an approach to value the embedded options directly.

PRACTITIONER INSIGHT

Applications of Option Pricing Methods to Energy Investments—A Conversation with Vince Kaminski, PhD*

We use option pricing methods extensively in the energy industry to value physical assets and long-term contracts. In general, any source of flexibility in quality, time of delivery, and so forth, can be modeled as an option. Moreover, every source of rigidity in a contract contains embedded option components that can be modeled as interactive, multilayer options.

Traditional valuation methods for energy investments depend on estimates of future prices, and these forecasts are subject to the inherent limitations and biases of the individuals making the projections. Consequently, one advantage of the option valuation approach is that it relies on market prices that reflect the consensus across a wide range of traders. A second advantage of the option approach is that it relies on mathematical algorithms that were developed for use in valuing financial derivatives.

A very common example of the application of option valuation methods to physical assets is the valuation of a natural gas power plant. This investment can be viewed as a portfolio of short-term spread options on the difference between electricity prices and natural gas prices (adjusted for thermal efficiency, commonly referred to as the heat rate of the plant). However, there are complications that have to be incorporated into the modeling of such a plant. The plant operator faces physical constraints in the form of startup costs, ramp-up and ramp-down costs, and added maintenance resulting from the wear and tear associated with switching the plant on and off in response to the demand for electricity. If these costs are ignored, then the estimated value of the plant (i.e., the spread options) will be biased upward.

Yet another example of the application of option valuation methods in the energy industry involves the valuation of natural gas storage facilities. Depleted oil fields are often used to store natural gas produced during the summer months so that it can be sold during the winter months when the price of gas is higher. In this instance, the gas storage facility creates value as a calendar spread option. Salt domes can serve the same function. However, because the gas can be refilled and extracted from the salt dome much more quickly than from a depleted oil field, this type of storage facility provides the opportunity to respond much more frequently to short-term gas price spikes.† Consequently, this latter type of storage facility is often referred to as a peaker storage facility.

*Vince Kaminski has had extensive industry experience related to the development of option valuation, price, and credit risk management models for energy trading. He has been a managing director of research groups at Citigroup Commodities (Houston, Texas), Sempra Energy Trading (Stamford, Connecticut), and Citadel Investment Group (Chicago, Illinois), as well as director of research for Enron Corp. (Houston, Texas). He is currently a professor in the Jesse H. Jones Graduate School of Management, Rice University, Houston, Texas.

†Although these salt dome facilities can be abandoned salt mines, they often are not. After locating a salt deposit within a layer of relatively impervious rock, a hole is drilled into the formation, water is used to dissolve the salt, and the solution is pumped out to form the storage facility.

The Option to Invest: Staged Investments

In this section, we use an oil field investment example to illustrate the use of options for valuing a staged investment. In this particular case, the firm acquires an oil lease in the first stage that provides it with the opportunity to extract oil in later stages, depending on market conditions. To illustrate the value of this option to extract oil now or at a later date, we consider the investment opportunity faced by Master Drilling Company, which is considering the purchase of an oil lease costing $450,000. The lease provides Master Drilling Company with the opportunity to develop oil reserves on a specified piece of property during the next year (later we relax this assumption and use a two-year lease). Because this particular lease is on property adjacent to a producing oil field, the company geologists are very confident about the quantity of oil that will be produced. Consequently, the primary concern that Master Drilling's management has about the venture relates to the price at which the oil will be sold.

Did You Know?

Texas Hold 'Em Is a Game of Options

A great analogy can be drawn between the game of Texas Hold 'Em and real options. To see the connection, let's review how the game is played. Initially, players receive two down cards as their personal hand (hole cards), after which there is a round of betting. Each player must decide whether to match the highest bet, which buys her the option to continue to play, or fold at the next round of betting. If a player decides not to bet, then she is choosing to abandon the hand. Next, three board cards are turned simultaneously (called the flop) and another round of betting occurs, followed by two more board cards turned one at a time, with a round of betting after each card. Each round of betting provides the players with the opportunity to match or raise the highest bet or to fold. The winner is the player who forms the highest-ranking five-card hand using the hole cards plus community cards. Clearly, Texas Hold 'Em is a game of deciding when to acquire the option to stay in the game (betting) and when to exercise the abandonment option (folding).*

*Oddly enough, this notion of options was immortalized in the chorus of the country hit "The Gambler" by Kenny Rogers when he sang,

> You got to know when to hold 'em, know when to fold 'em,
> Know when to walk away and know when to run.

Words and music written by Don Schlitz. © Copyright Capitol Records Nashville. All Rights Reserved.

Valuing an Oil Lease

To demonstrate the value of the option to delay the development of the property, we will initially assume that by purchasing the lease, the company is committed to start developing immediately and will extract the oil the following year. This requires an initial expenditure of $300,000 and an expenditure of $45 per barrel for each of the 100,000 barrels of oil extracted the following year. The following table summarizes the investment opportunity:

Today (Year 0)	**Year 1**
a. Purchases the lease for $450,000	**a.** Produces 100,000 barrels of oil at a cost of $45 per barrel
b. Spends $300,000 to develop the property in preparation to extract the oil in one year	**b.** Sells the oil at the prevailing market price

In addition, we make the following assumptions concerning the Master Drilling Company lease:

- The current forward price for the delivery of oil in one year is $50 per barrel.
- An option to deliver a barrel of oil in one year with an exercise price of $45 per barrel can be bought or sold today for $8.50 per barrel.
- The risk-free rate of interest is 5%.

Traditional (Static) DCF Analysis of the Lease

Let's assume that Master Drilling begins development immediately and extracts and sells the 100,000 barrels of oil in one year. To evaluate the decision to acquire the lease using a traditional DCF analysis, we compute the NPV of the investment as expressed in Equation (12.1):

$$NPV_{\text{Oil Lease}} = \frac{\left(\begin{array}{c}\text{Expected Price}\\ \text{of Oil per Barrel}_{\text{Year 1}}\end{array} - \begin{array}{c}\text{Extraction Cost}\\ \text{per Barrel of Oil}\end{array}\right) \times \begin{array}{c}\text{Barrels of}\\ \text{Oil Produced}_{\text{Year 1}}\end{array}}{\left(1 + \begin{array}{c}\text{Risk-Adjusted}\\ \text{Discount Rate}\end{array}\right)} - \left(\begin{array}{c}\text{Cost of Acquiring}\\ \text{and Developing the Oil Lease}\end{array}\right) \tag{12.1}$$

Substituting for the values and estimates that we already know leaves the following:

$$NPV_{\text{Oil Lease}} = \frac{\left(\begin{array}{c}\text{Expected Price of}\\ \text{Oil per Barrel}_{\text{Year 1}}\end{array} - \$45.00\right) \times 100{,}000 \text{ barrels}}{\left(1 + \begin{array}{c}\text{Risk-Adjusted}\\ \text{Discount Rate}\end{array}\right)} - \$750{,}000$$

Thus, to solve for the project's NPV, we need to estimate an expected price for crude oil one year hence and also a risk-adjusted discount rate that is appropriate to the risks of developing the oil lease.

Certainty-Equivalent Analysis—Using the Forward Price to Value the Lease

As we learned in Chapter 11, the lease can also be valued with the certainty-equivalent approach using the observed forward price of oil. Specifically, to calculate the cash flow, we use the forward price, which is the certainty-equivalent price. The resulting cash flow is now the certainty equivalent of the risky future cash flow, and we can calculate its present value by discounting at the risk-free rate, as shown in Equation (12.2), that is:

$$NPV_{\text{Oil Lease}} = \frac{\left(\begin{array}{c}\text{Forward Price}\\ \text{of Oil per Barrel}_{\text{Year 1}}\end{array} - \begin{array}{c}\text{Extraction Cost}\\ \text{per Barrel of Oil}\end{array}\right) \times \begin{array}{c}\text{Barrels of}\\ \text{Oil Produced}_{\text{Year 1}}\end{array}}{\left(1 + \begin{array}{c}\text{Risk-Free}\\ \text{Rate}\end{array}\right)} - \left(\begin{array}{c}\text{Cost of Acquiring}\\ \text{and Developing the Oil Lease}\end{array}\right) \tag{12.2}$$

Substituting the forward price of oil in one year and the risk-free rate of interest into the above equation, we calculate the NPV of developing the oil lease as follows:

$$\begin{aligned} NPV_{\text{Oil Lease}} &= \frac{(\$50.00 - 45.00) \times 100{,}000}{(1 + .05)} - \$750{,}000 \\ &= \$476{,}191 - 750{,}000 = (\$273{,}810) \end{aligned}$$

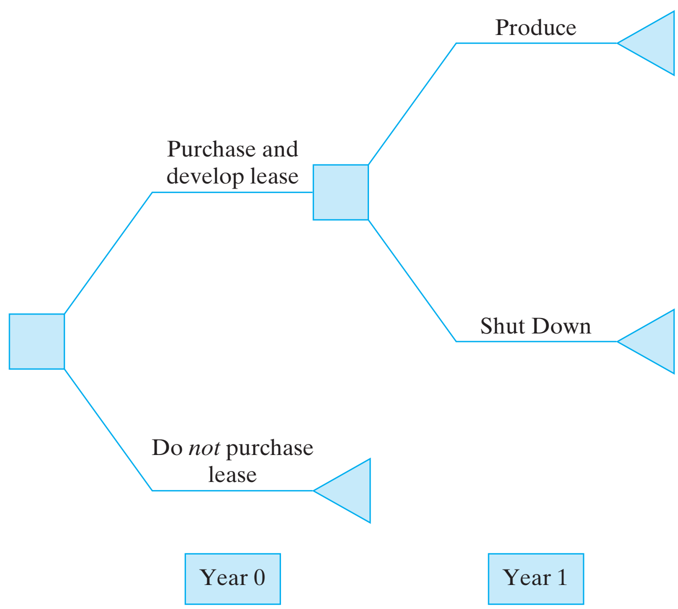
Clearly, under the assumption that Master Drilling must begin immediate development and commits to the production and sale of the oil reserves at the end of year 1, the lease has a negative NPV! However, the typical lease does not commit the acquirer of the lease to produce and sell the oil reserves, but gives the buyer the right, not the obligation, to do so. In other words, the lease can be viewed as a call option on 100,000 barrels of crude oil that can be produced at a cost of $45 per barrel and sold one year hence.

Dynamic Analysis—Valuing the Lease As an Option to Produce Oil

Up to now, we have assumed that, when Master Drilling Company makes the investment to acquire the lease, it is obligated to develop and produce the reserves in the oil field. As the decision tree in Figure 12-1 illustrates, however, the firm has the option, but not the obligation, to produce the oil reserves and will extract the oil only if the revenue from selling the oil exceeds the \$45-per-barrel cost of extraction; otherwise, it will let the lease expire.

We assumed earlier that an oil option with a \$45-per-barrel exercise price currently has a price of \$8.50 per barrel. Hence, the lease should have the same value as 100,000 of these call options, or \$850,000. The relatively high price of the oil options in the derivatives market reflects the uncertainty of future oil prices, suggesting that the option to walk away from the lease without producing, or producing only when the price of oil exceeds extraction costs, is quite valuable.[1] This value exceeds the sum of the \$450,000 acquisition

Figure 12-1 Dynamic Analysis—Oil Lease Investment As a Call Option



[1] Using the binomial option pricing relation presented in Chapter 11, we can evaluate just how volatile the future price of oil must be to warrant an option price of \$8.50 per barrel where the exercise price is \$45 per barrel. For example, assume that the price of oil in one year can be one of two prices: a high price of \$62.85 per barrel or a low price of \$37.15 per barrel. Using the forward price of \$50, we can calculate the implied risk-neutral probabilities of the two prices to both be 50% (i.e., \$50 = \$62.85 × risk-neutral probability of the high price + \$37.15 × risk-neutral probability of the low price). The payoff to an option for one barrel of oil with an exercise price of \$45, then, is either \$62.85 − 45 = \$17.85 for the high price or \$0 if the low price occurs. We calculate the value of the option today as the risk-neutral probability-weighted average payoff to the option (i.e., its certainty-equivalent payoff), discounted at the risk-free rate of interest, that is:

$$\text{Call Option Value}_{\text{Today}} = \frac{\$17.85 \times .50 + \$0.00 \times (1 - .50)}{(1 + .05)} = \$8.50$$

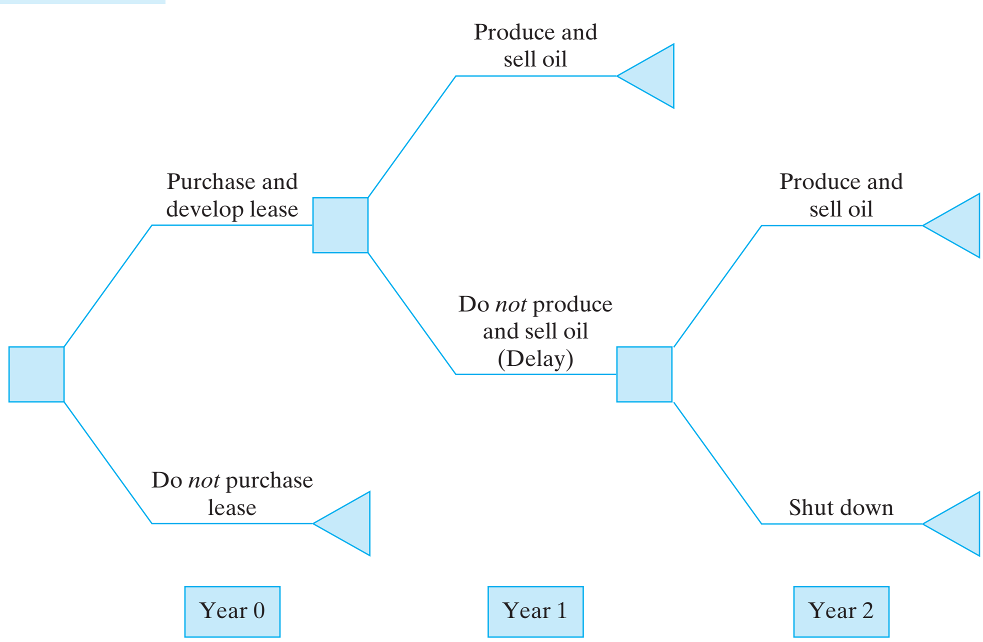
price of the lease plus the initial \$300,000 development costs, indicating that acquiring the lease and developing the oil field for possible production in one year (at a total cost of \$750,000) is a positive NPV investment (i.e., NPV = \$850,000 − 750,000 = \$100,000).

Valuing the Option to Delay or Wait

In our preceding example, we analyzed the value of the lease as an option to extract oil either in the following year or not at all. However, like many other investments, oil leases also contain timing options that allow the owner to choose when to extract the oil. To illustrate the timing option, we continue with the Master Drilling Company example, but with a minor twist. We now assume that the lease allows Master Drilling two years to develop and produce the oil and that the company is now sitting at the end of the first year after having purchased the lease and spent the \$300,000 required to develop the property. In other words, the company can produce the oil at the end of year 1 but has the option instead to wait a year and, if conditions are favorable, produce at the end of year 2. The revised investment opportunity is illustrated in Figure 12-2, which specifies the three decisions the company must make, as indicated by the decision nodes (squares) in the figure: (1) Should the company purchase the lease or not in year 0? (2) If the answer to the first question is yes, then should the company produce and sell the oil reserves at the end of year 1 or wait until the end of year 2? (3) If the answer to the second question is to wait until year 2 (i.e., do not produce in year 1), then should the company produce and sell the oil at the end of year 2 or abandon the lease?

Let's assume that the observed (spot) price of oil at the end of year 1 is \$50 per barrel, which exceeds the \$45 cost of extracting the oil. Consequently, the option to drill is in the money. However, Master Drilling's management now realizes that they have an additional option. They can extract the oil today or wait one more year and consider

Figure 12-2 Oil Lease Investment with the Option to Delay



extracting the oil then. If they do not extract the oil at the end of this second year, the lease will expire worthless. In addition to assuming that the price of oil is now \$50 per barrel, we will assume that the one-year forward price (for year 2) is also \$50 and that the value of an option to acquire oil one year hence (in year 2), with a \$45 exercise price, still is \$8.50 per barrel.

Because the price of oil at the end of year 1 is \$50 per barrel, immediately extracting the oil generates \$5 million in oil revenues. Subtracting the extraction costs of \$4.5 million (= \$45/barrel × 100,000 barrels of oil) generates a net profit of \$500,000. Note that this calculation does not consider the \$450,000 cost of acquiring the lease or the \$300,000 spent to develop the oil field and prepare it for production. These expenditures were made in year 0 and, as such, represent sunk costs that do not influence the extraction decision. Consequently, the relevant comparison is between the \$500,000 cash flow from extracting the oil today and the discounted value of the expected cash flow from waiting and having the option to extract the oil at the end of year 2.

Let's first ignore the option associated with the year 2 extraction choice and consider the certainty-equivalent profits if the owner extracts the oil at the end of year 2 of the original lease contract. Because the forward price is \$50 per barrel for year 2, the certainty-equivalent profit one year hence (at the end of year 2) is the same as it was at the end of year 1, or \$500,000, which has a present value (discounted at the risk-free rate) of \$476,190 at the end of year 1. In this particular case, because the spot price for year 1 and the forward price for year 2 are equal (both are \$50 per barrel), the difference between the value of extracting now and extracting in the future arises solely because of the time value of money.[2]

Let's now consider how uncertainty and the flexibility to pass up the investment in the future affect the incentive to wait. As we have already shown, if the value of an equivalent oil option in the financial markets is \$8.50 per barrel, and if we extract the oil in one year only when oil prices exceed extraction costs, the oil lease is worth \$850,000. This exceeds the \$500,000 value realized from extracting the oil immediately. Hence, the gains from waiting to develop the field only when oil prices are high more than offsets the effect of the time value of money, which makes it optimal to wait before investing.

Hedging the Price Risk of Delaying the Decision to Invest

You may find it counterintuitive to wait to invest when the environment is very uncertain. After all, if you delay the decision to drill, you face the risk of a declining oil price that can potentially make your lease expire worthless. Would it make sense instead to take a sure positive NPV investment today rather than wait and hope for a higher NPV investment in the future?

This intuition may have merit when the project's risks cannot be hedged. When no hedge is available, the investor's risk aversion may be an important factor in the decision problem.[3] However, if the Master Drilling Company can sell call options on oil

[2] Note too that the slope of the forward curve also provides an incentive to either produce now or wait. If forward prices in the future are much higher than the current spot price, this offsets the effect of the time value of money and increases the incentive to delay production. For example, if the forward price of oil is \$55 per barrel rather than \$50, it would clearly pay to wait.

[3] In theory, risk aversion should not enter the decision of a publicly traded firm. In reality, however, risk-averse managers may not want to delay positive NPV investments that may need to be abandoned in the future. Also, as we discussed in Chapter 7, accounting issues may influence the decision to delay an investment.

Table 12-1 Hedging the Option to Delay with Call Options

	Price of Oil	
	$45.00 or Less	**$ 60.00**
Project earnings per barrel (= price/barrel − extraction costs)	$ 0.00	$ 15.00
Minus call payoff per barrel (= max[price/barrel − $45, 0])	$ 0.00	$ (15.00)
Call price per barrel	$ 8.50	$ 8.50
Total	$ 8.50	$ 8.50

with a strike price of $45 per barrel, it can hedge these risks and lock in the gains associated with waiting to invest. Table 12-1 describes the payoffs per barrel of oil associated with maintaining the option to extract the oil in the following year and hedging the uncertainty by selling call options on 100,000 barrels of oil with an exercise price of $45 per barrel at the current market price of $8.50 per barrel. As the numbers in the table indicate, the waiting-and-hedging strategy locks in a gain of $8.50 per barrel, which exceeds the gain from extracting the oil immediately.

If the price of oil drops below $45 per barrel, then both the project and the call options that the firm sold are worthless. Similarly, if the price of oil were to rise to $60 per barrel, then the project payoff is $60 per barrel − $45 per barrel = $15 per barrel, which again is exactly equal to the payout Master Drilling must pay to the holders of the call options it sold. In both cases, the payoff from the hedged position is simply the $8.50-per-barrel proceeds from the sale of the options.

More Complicated Options and the Incentive to Wait

The preceding example indicates that price uncertainty provides an incentive for firms to delay their investments. This example is easy to evaluate because the risks associated with oil price uncertainty can be hedged, providing the firm with the opportunity to lock in the gains associated with waiting. However, the option to delay should be viewed broadly, and one should not conclude that realizing the value to delay requires that the risks be hedged. The general principle, that the value of the option to delay comes from the opportunity to learn more about the investment's prospects, can be applied to almost any investment. By learning more, the firm may decide to configure the investment in a different way or simply to expand or contract the scale of the investment in light of what it learns during the delay.

One straightforward example arises in the context of undeveloped land, which can be viewed as an option to acquire a building at the cost of construction. When there is only one type of building that can be built, the option is a simple call option, just like the oil lease. However, the owner of the land may have the opportunity to build a number of different types of structures on the land, such as condos, a hotel, or an office building. When this is the case, the investor's options are somewhat more complicated, making them more difficult to value and hedge. However, the intuition is still the same: Greater uncertainty makes the options more valuable and increases the incentives to wait to invest. In general, when the options provide more flexibility, they are more valuable and the benefits from waiting are greater. Intuitively, when you have more choices, it pays to wait to see how uncertainty unfolds to make sure that you are making the best choice.

Do Firms Delay Optimally?

For a variety of reasons, managers may be less willing to delay the initiation of positive NPV investments than the real options model suggests. Our introductory finance classes may be partially to blame because they tend to place too much emphasis on the static NPV rule, which suggests that firms should undertake all projects with positive NPVs. However, these same textbooks also say that positive NPV investments may be passed up when other, mutually exclusive investments with even higher NPVs exist.

In essence, whenever an investor has discretion about the timing of an investment, this creates mutually exclusive alternatives. For example, project 1 is taking the project immediately, and project 2 is waiting and taking the same project at a future date. Maybe project 1 has a positive NPV, but project 2, which requires waiting (and, of course, cannot be implemented if project 1 has already been implemented), may have a higher NPV and would therefore be preferred.

We should also stress that this tendency to initiate positive NPV investments too early relative to the specification of the real options model may not simply be a mistake. Managers may be reluctant to wait on a positive NPV investment for a number of good reasons:

1. In reality, we cannot perfectly hedge the real option by selling financial options. As a result, waiting is risky.
2. The investor may be credit-constrained or may face very high borrowing costs. Credit constraints can have the effect of speeding up some investments and slowing down others. For example, an investor may extract oil more quickly than he otherwise would if doing so provides capital that can be invested in positive NPV investments that could not be funded otherwise. However, if speeding up extraction requires new capital, then having limited access to financial markets to raise the capital can delay the investment.
3. Initiating the project may generate information that *helps* the firm's managers *evaluate* future investments. For example, the quantity of oil that is extracted may provide information about the potential amount of oil in similar regions. In this instance, the information gleaned from early exercise provides the firm with valuable information about future prospects. In essence, exercising one option may increase the value of a firm's other options.
4. It may be important to *show* outside investors that the firm does indeed have a positive NPV investment. If outside investors are not as well informed as the firm's management, it may be important that the firm periodically provide signals related to its ability to generate positive NPV projects. For example, to show investors that they have the best geologists, an oil firm may need to develop some of its oil fields. Once again, early exercise may provide extra value and benefits to the firm and its future projects. If, for example, the firm is about to enter the capital markets to raise additional financing, revealing information about the prospects of new investments could lead to a higher stock price and a lower cost of capital. These benefits may overshadow the lost value from exercising early.
5. Managers may undertake early initiation for personal reasons. The compensation practices of firms that reward current-period performance (see the discussion in Chapter 7) can provide very strong incentives for managers to exercise their investment options too early. These practices tend to reward executives for immediate performance and penalize long-term investments that have too detrimental an impact on current-period performance.

Option to Abandon

Financial analysts have long recognized the value of the option to abandon an investment that is not performing as planned. For example, if you own a widget factory that is generating very low cash flows, you may be better off closing the factory and selling the property to a real estate developer who wants to convert the space for loft apartments. Moreover, if the cash flows are negative, you might want to abandon the factory even if the property has no alternative use.

The abandonment option has an important timing component that is very much in the same spirit as the option to defer or delay that we considered earlier. Just as option theory implies that there is an incentive to defer a positive NPV investment, there may also be an incentive to continue operating a money-losing investment. Intuitively, the combination of uncertainty and flexibility should make decision makers more cautious about making irreversible decisions either to initiate a project or to abandon a project. The key assumption that drives this conclusion is that the decision to shut down or abandon an investment permanently is, of course, irreversible.

Stripper Well Example

To illustrate the shutdown or abandonment option, we analyze the decision to shut down a stripper well, which is an oil well that produces relatively low volumes of oil each year and frequently is just barely profitable. Prior to 1998, there were a number of stripper wells in Texas that had annual production volumes of 1,000 barrels of oil or fewer. Because these wells produce very little, their operating costs per barrel of oil are relatively high, which means that, although they can be quite profitable when oil prices are high, many operate at a substantial loss when oil prices are low.

At the end of 1998, oil prices fell to close to $10 per barrel, making most of the Texas stripper wells unprofitable. Because of their operating losses, a number of the wells were closed in 1999 without the possibility of being reopened.[4] Oil prices subsequently increased substantially, making the stripper wells that had not been shut down quite profitable. With the benefit of hindsight, one can argue that the decision to shut down the wells at the end of 1998 was a mistake. What we need to consider here, however, is whether shutting down the wells was a wise, or at least a defensible, decision in 1999, given the information that was available at that time.

To illustrate how we might use real option analysis to evaluate the option to abandon these wells, we will consider a regional oil producer with 100 stripper wells that can produce 100,000 barrels both this year and next year before depleting its reserves. The cost of operating the wells and transporting the oil is $14 per barrel, and the wells can be shut down either now or at the beginning of next year. The current price of oil is $10 per barrel, and the forward price for delivery in one year is also $10 per barrel. However, because oil prices are extremely volatile, an option to buy oil in one year for an exercise price of $14 a barrel sells for $4.50 today.

[4] The problem encountered in shutting down production is that the formation may collapse or otherwise stop the flow of oil. This, in turn, means that, for practical purposes, the decision to shut down production is tantamount to abandoning the well.

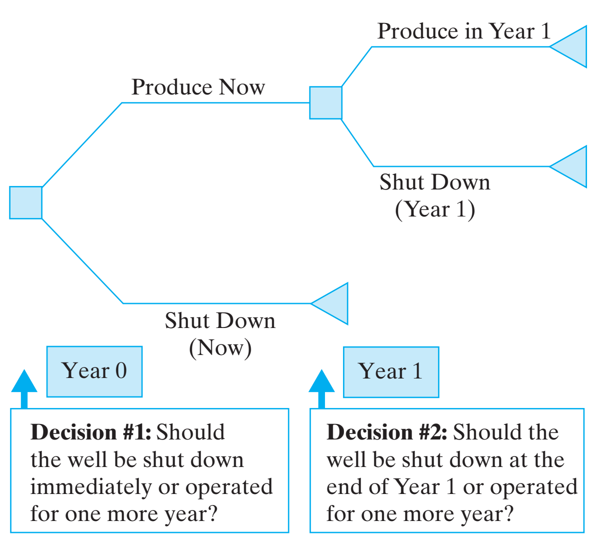
Given the current oil price and the forward price in one year, we can evaluate the current value of the 100 stripper wells, assuming that the oil producer will operate the wells this year and next year. We again assume a risk-free rate of 5%:

$$\begin{array}{c}\text{Present Value of}\\ \text{Stripper Well}\\ \text{Cash Flows}\end{array} = \underbrace{100{,}000 \text{ bbls} \times (\$10/\text{bbl} - \$14/\text{bbl})}_{\substack{\text{Present Value of Operating}\\ \text{the Wells in Year 0}}} + \underbrace{\frac{100{,}000 \text{ bbls} \times (\$10/\text{bbl} - \$14/\text{bbl})}{(1 + .05)}}_{\substack{\text{Present Value of Operating}\\ \text{the Wells in Year 1}}}$$

This analysis indicates that if the only alternative is to operate the well for the next two years, it is best to shut the wells down because the investment has a large negative NPV. However, if the owner of the wells has the option to shut down the wells next year if oil prices continue to be low (see Figure 12-3), it may in fact make sense to continue operating the wells this year at a loss of \$400,000 because shutting them down now eliminates the option to produce next year. If the loss from producing now is less than the value of the option to produce next year, it makes sense to continue to operate the wells.

In this particular example, we see that an option to buy oil at \$14 per barrel generates the same cash flow as the stripper wells in one year. If oil prices recover and rise above \$14, the wells will produce per-barrel profits equal to the oil price minus the \$14-per-barrel extraction costs. This net cash flow is exactly the same as the payoff on the option contract in this situation. If oil prices stay below \$14 per barrel, however, the options will expire worthless and the oil wells will be shut down and will also generate no revenue. Hence, the real option to extract oil in the next year has the same value as the financial option to purchase oil for \$14 per barrel, which we assumed earlier could be bought and sold for \$4.50 per barrel.

Figure 12-3 Decision Tree for the Stripper Well Abandonment Problem



In a sense, by continuing to produce this year, the investor maintains the option to produce next year. When prices are very volatile, having the right, but not the obligation, to produce in the following year can be very valuable, and this option may exceed the loss incurred by operating the wells in year 1. So what is the value of continuing to operate the stripper wells? The total value equals the sum of the profits from extracting the oil this year, which is a negative number, plus the value of the option to extract next year. Our analysis indicates that the stripper wells should not be shut down because the loss suffered from operating the wells in the current year is more than offset by the value of the option to extract 100,000 barrels next year, that is:

$$\begin{array}{c}\text{Value of the}\\ \text{Stripper}\\ \text{Well}\end{array} = \left(\begin{array}{c}\text{Value}\\ \text{of Operating}\\ \text{in Year 0}\end{array}\right) + \left(\begin{array}{c}\text{Value of the}\\ \text{Option to Operate}\\ \text{in Year 1}\end{array}\right)$$

$$= 100{,}000 \text{ barrels} \times (\$10/\text{barrel} - \$14/\text{barrel}) + \$4.50 \times 100{,}000 \text{ barrels}$$

$$= (\$400{,}000) + \$450{,}000 = \$50{,}000$$

Hence, there is positive value from operating the stripper wells this year. The positive value is derived from the fact that, by operating the wells, the firm obtains the option to operate them next year. Consequently, it is best not to shut down the wells.

Note that, in the preceding example, we assumed there was no cost of shutting down the stripper wells immediately, beyond the loss of value derived from the option to produce in the second year. In many types of investments, however, costs are incurred when shutting down or decommissioning an investment, and these costs are sometimes so large that they dominate the decision. For example, refineries and chemical plants can face large cleanup costs when they are shut down. These cleanup costs may be so massive that the opportunity to delay incurring them may be a primary reason for keeping an old plant operating.

12.5 Analyzing Real Options As American-Style Options

The previous discussion presented very simple examples that included, at most, two possible drilling or abandonment dates. Our objective in these examples was to develop a framework that would help build intuition for how analysts and firms solve these problems in practice. In this section we introduce a more realistic but also more complex example that illustrates how these examples are solved in practice.

Evaluating National Petroleum's Option to Drill

National Petroleum, a small exploration and production (E&P) company, has a lease that provides the company with an option to drill on the property within a period of three years. If National drills and finds oil, it has the option to extract oil on the property until the reservoir is depleted, which is estimated to be ten years after drilling is initiated. The property is expected to produce oil at the rate described in Figure 12-4,

Figure 12-4 **Production Volume for the National Petroleum Lease**

Year 0	0 barrels
Year 1	400,000 barrels
Year 2	300,000 barrels
Year 3	200,000 barrels
Years 4–10	100,000 barrels

where year 0 is the drilling date. If the company chooses not to drill within the next three years, however, the lease and the option to drill will expire.

Hedging Oil Price Risk

National Petroleum estimates the cost of drilling to be $38 million, and the extraction and delivery costs to be $28 per barrel. Once again, our problem is to place a value on the lease. To establish a base value for the property, we assume that drilling begins immediately and that all of the production is sold forward at the forward prices found in Table 12-2. This strategy, as we learned in Chapter 11, effectively hedges the price risk

Table 12-2 **Calculation of Project Revenues Using Forward Prices for Oil**

Year	Forward Price	Volume (Barrels)	Revenue	Extraction Cost	Net Cash Flow
1	$59.00	400,000	$23,600,000	$(11,200,000)	$12,400,000
2	$60.00	300,000	18,000,000	(8,400,000)	9,600,000
3	$61.00	200,000	12,200,000	(5,600,000)	6,600,000
4	$62.00	100,000	6,200,000	(2,800,000)	3,400,000
5	$62.00	100,000	6,200,000	(2,800,000)	3,400,000
6	$63.00	100,000	6,300,000	(2,800,000)	3,500,000
7	$63.00	100,000	6,300,000	(2,800,000)	3,500,000
8	$63.00	100,000	6,300,000	(2,800,000)	3,500,000
9	$63.00	100,000	6,300,000	(2,800,000)	3,500,000
10	$63.00	100,000	6,300,000	(2,800,000)	3,500,000
PV(6%) =	$42,034,394				
Drilling cost =	(38,000,000)				
NPV =	$ 4,034,394				

of the project cash flows and locks in the profits based on these forward prices.[5] Because the resulting profits are now hedged (i.e., risk-free), we can value the project by discounting the future cash flows using the risk-free rate of 6%.

Table 12-2 presents the hypothetical forward prices for the next ten years, in addition to volumes, revenues, extraction costs, and the resulting free cash flows for the investment. We have calculated the NPV of drilling today using the forward price curve to hedge oil price risk and found the NPV to be $4,034,394. However, National does not have to drill immediately. Indeed, given the forward price curve, drilling at the end of year 1 and producing in years 2 through 11 might be even more valuable. Similarly, National could initiate drilling at the end of year 2 or even year 3. If we know the forward prices for oil in years 11 through 13, we can use the same hedging strategy to value the opportunity to drill in each of these three years and then select the best time to drill. If the forward price curve remains flat at $63 a barrel in years 11 through 13, then the decision today to commence drilling in each of the next three years produces the following NPVs:

Commence Drilling in Year	NPV (Present Values as of Year 0)
0	$4,034,394
1	$4,642,831
2	$5,024,001
3	**$5,197,453**

Clearly, given this forward price curve, National should not drill immediately. As shown above, the firm can lock in a higher value by committing to drill in three years and hedging the oil price risk. Moreover, National can do even better by making no commitments and keeping the flexibility to drill when doing so is optimal.

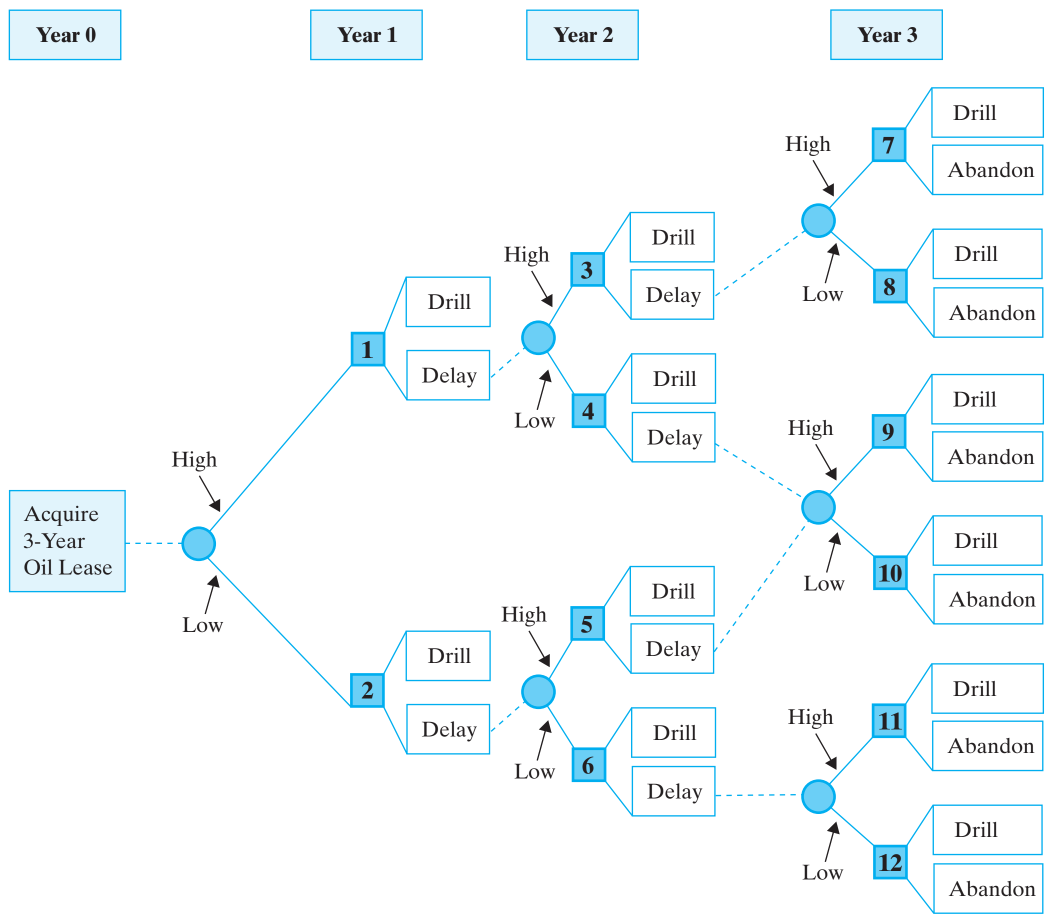
Considering the Option to Delay

To value the lease under the assumption that National makes the optimal drilling choice, we start with the decision tree in Figure 12-5. This decision tree has as its basis the binomial model that specifies oil prices, discussed in Chapter 11, along with an illustration of the decisions that can be made. Recall that the circles indicate a random event (in this case, whether the price of oil will be the high price or the low price) and the squares indicate that a decision must be made. For example, assume that, at the end of year 1, the price of oil is equal to the high price.[6] National's management now faces decision node 1 and will have to decide whether it is best to drill now or delay until year 2. If the decision is made to drill (i.e., exercise the option to drill), then that is the end of that branch of the decision tree. However, if the decision is made to delay until year 2, then we follow the dashed line to the appropriate probability node for year 2, where we learn whether the price of oil will be high or low, leading to decision nodes 3 and 4, respectively. Note that if National has not exercised its option to develop the property by the end of the three-year lease term, it effectively abandons the investment opportunity.

[5] Recall that this assumes that we know the quantity that will be produced. This caveat is important because profits depend on both oil prices *and* the volume of oil produced. Thus, our ability to hedge the risk associated with our profits depends on both price and production volume.

[6] To simplify our exposition, we assume that decisions are made annually and that the time step used to define the binomial lattice is also one year.

Figure 12-5 Decision Tree for the Option to Delay



To this point, we have not described how the decision should be made with regard to drilling now versus delaying the decision to drill. Incorporating the option to defer drilling for up to three years into our analysis requires that we evaluate the investment opportunity as follows: To determine whether the option to drill should be exercised, we compare the value of the oil field today, minus drilling and development costs, with the value of maintaining the option to drill and develop the well in the future. When the value of the option to drill in the future exceeds the value of drilling immediately, it is better to wait, and vice versa.

In this particular case, National Petroleum has the option to drill at any time up to the expiration of the three-year lease, which provides the firm with what is analogous to an American call option on a stock. That is, National Petroleum has what is equivalent to an option to acquire a producing oil well at an exercise price that equals the cost of drilling. If there was, in fact, a traded financial option that exactly matches this real option, the valuation problem would be straightforward. However, because publicly traded options that exactly match real investment opportunities are rare, we generally

Table 12-3 Comparing Real Options with American Stock Options

Inputs for Valuing American Stock Options	Oil and Gas Field Counterparts
1. Stock return volatilities	*Volatility* of the value of the producing field
2. Value of underlying stock	The present value of the cash flows from the producing wells
3. Dividend yield	The *convenience yield* is the benefit associated with the physical ownership of the commodity.*
4. Expiration date	The *expiration date* on the lease
5. Exercise price	The *cost of drilling*

*A high convenience yield implies that commodity users are willing to pay a premium for the commodity today relative to the expected price in the future. The convenience yield is important because it determines the expected rate at which the commodity will appreciate and is related to the slope of the forward curve minus the risk-free rate.

need a model to value the option. Such a model requires estimates of several key inputs, which are analogous to the inputs needed to value an American stock option on a share of stock. Table 12-3 summarizes the analogy between the American call option problem and the option to extract oil problem.

Valuing the option to drill is substantially more difficult, however, than solving a typical American stock option valuation problem. This is true primarily because the input that determines the expected change in the value of the developed well—the convenience yield (the counterpart to the dividend yield)—changes from period to period as the prices in the forward curve change. In addition, the volatility of the returns to investing in the producing well is likely to change over time and is difficult to estimate.

Valuing American Options Using a Binomial Lattice

In practice, analysts frequently use a multiperiod version of the binomial option pricing model discussed in Chapter 11 to evaluate American-style real options. To show how this works, we will apply such a model to the valuation of the drilling investment opportunity faced by the National Petroleum Company. Because National has the option to initiate drilling at any time until the end of a three-year period, the problem National faces is to value a three-year American call option.

Earlier, we estimated the value of the drilling opportunity to be $42,034,394 if drilling begins immediately. However, this value does not reflect the added value that might be captured if the firm exercises its option to delay drilling until a later period, when oil prices might be more favorable. To value this option, we start by constructing the multiperiod binomial lattice found in Figure 12-6. This lattice, which is based on the decisions illustrated in Figure 12-5, describes the possible values that the drilling opportunity might have in each of the next three years (the life of the American call option we wish to value).

We can think of the values at each node of the binomial lattice as the discounted values of future project cash flows based on the forward curve of oil prices as they evolve through time. The actual future values of the developed oil field that are specified in the binomial lattice can be somewhat arbitrary and may depend on the judgment of the decision maker. (We address this issue in more detail in the appendix to this chapter.) First, let's walk through the valuation process assuming that we know the value of developing the oil field at each node of the binomial lattice.

Four values are listed at each node of the binomial lattice in Figure 12-6. We will refer to them as valuations 1 through 4, and they represent (from top to bottom):

Valuation 1: The value of the developed field—the estimated value of initiating the development of the undeveloped oil field on this date, which is equal to the DCF valuation based on the forward price curve for this period and the assumption that drilling begins in this year and production follows in the subsequent ten-year period.

Valuation 2: The NPV of waiting to drill—the expected value of the undeveloped field if the option to drill is not exercised this period.

Valuation 3: The NPV of drilling now—that is, the value of the oil field if developed this period (valuation 1 above) less the \$38 million cost of drilling and developing the field.

Valuation 4: The value of the undeveloped oil field—This valuation is analogous to that of an American call option, which is equal to the maximum of either the NPV of waiting until the next period to drill (valuation 2 above) or the NPV of drilling in the current period (valuation 3 above).

Solving for the Value of the Undeveloped Oil Field

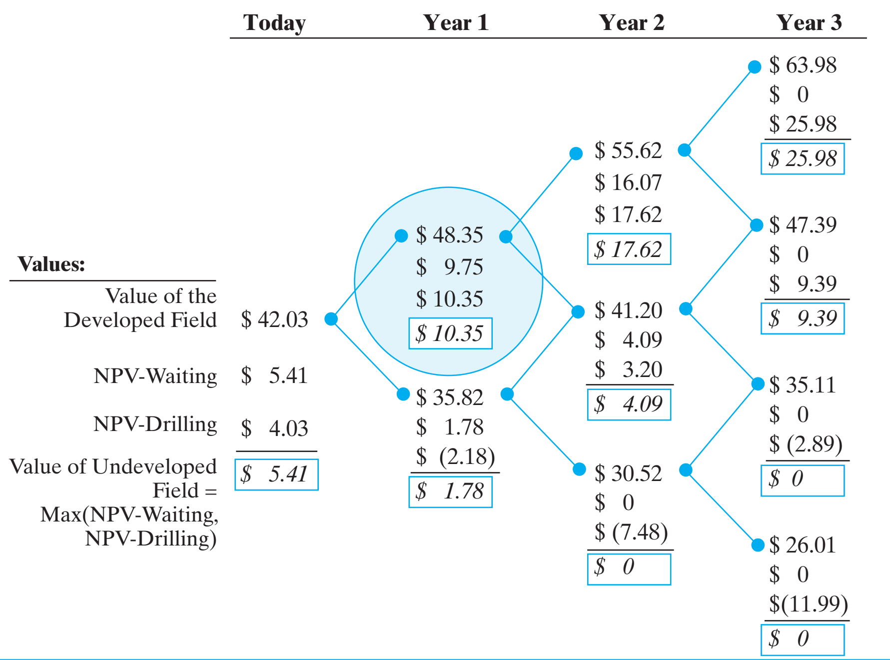
To value the option associated with owning the undeveloped field, we must work backward in the binomial lattice, beginning in year 3 (the year in which the option expires). This procedure is commonly referred to as rolling back the branches of the decision tree. The analysis for year 3 proceeds as follows: The value of the option to drill in year 3 is the maximum of the NPV of drilling in year 3 (i.e., the value of the developed oil field minus the \$38 million development cost) or zero. For example, if the value of the developed field is \$63.98 million in year 3 (the highest-value node), then the value of the undeveloped oil field equals:

$$\text{Max}(\$63.98\text{ million} - \$38\text{ million}, 0) = \$25.98\text{ million}$$

In this particular node, it is optimal to develop the field; however, this is not always the case. For example, if the value of the developed oil field in year 3 were equal to the lowest node in the lattice, which is \$26.01 million, the value of the undeveloped field is zero because the NPV of drilling at this node is negative (i.e., \$26.01 million $-$ \$38 million $= -\$11.99$ million).

After evaluating all the year 3 nodes of the lattice, we now consider the nodes for the end of year 2. In the highest-value node for year 2, the value of the developed oil

Figure 12-6 **Binomial Tree Describing the Possible Values of the Drilling Opportunity (in Millions)**



Definitions

(a) *Value of the developed field.* The value of the developed field equals the present value of future cash flows from the oil field spanning a period of ten years from the date of the valuation. For example, in the circled node at the end of year 1, this value is equal to $48.35 million = the present value of the oil field if developed at the end of year 1 and if evaluated using the forward price curve for oil produced in years 2 through 11. Technically, this is the way to think about the value of the oil field if drilling and development commence during year 1. However, the forward curve that will exist at the end of year 1, where the high-price state occurs, is not observable today when we are performing our analysis. Consequently, we model the price distribution for the value of the oil field using the binomial process described in the appendix to this chapter.

field is equal to $55.62 million. The NPV of waiting is equal to the present value of the certainty-equivalent payoff[7] from the option to begin drilling in year 3, that is:

$$\text{NPV of Waiting to Drill} = e^{-.06}[\$25.98 \text{ million} \times .4626 + \$9.39 \text{ million} \times (1 - .4626)]$$

$$= \$16.07 \text{ million}$$

The NPV of drilling at the end of year 2 is $17.62 million, calculated as the value of the developed property minus the $38 million drilling cost. Because the NPV of drilling

[7] Recall from Chapter 11 that the certainty-equivalent payoff from the option is equal to the weighted-average payoff where the weights are the risk-neutral probabilities. In the binomial lattice found in Figure 12-6, the risk-neutral probabilities of up and down prices are equal to .4626 and $(1 - .4626)$, respectively.

(b) *Risk-neutral probabilities.* In Chapter 11, we calculated the risk-neutral probability using the forward price of oil. This method can be translated into the following calculation to get the risk-neutral probability of the high-price state (P) using the following relationship:

$$P = \frac{e^{(r-\delta)} - e^{(r-\delta)-\sigma}}{e^{(r-\delta)+\sigma} - e^{(r-\delta)-\sigma}}$$

where r is the risk-free rate of interest, δ is the convenience yield, and σ is the volatility of the returns to the oil field investment. As discussed in the appendix to this chapter, we assume that $r = 6\%$, $\delta = 7\%$, and $\sigma = 15\%$. These values imply that $P = 0.4626$.

(c) *NPV of waiting.* The NPV of waiting equals the present value of exercising the option to drill at a later date. For the circled node at the end of year 1, this is equal to \$9.75 million = the present value of the risk-neutral probability-weighted expected value of the call option in year 2, that is:

$$\begin{aligned}\text{NPV of Waiting to Drill} &= e^{-.06}[\$17.62 \text{ million} \times .4626 + \$4.09 \text{ million} \times (1 - .4626)] \\ &= \$9.75 \text{ million}\end{aligned}$$

Note that the payoff to the option to wait to drill (evaluated at circled node at the end of year 1) is based on the maximum of the NPV of waiting until year 2 to decide whether to drill or not for each potential node; that is, for the high-price node, the payoff to waiting until year 2 is max(\$16.71 million, \$17.62 million). For the low-price node, the payout to waiting is equal to max(\$4.09 million, \$3.2 million). The risk-neutral probability of the high-value state was defined in part (b).

(d) *NPV of drilling now.* The NPV of drilling now equals the value of developed oil field cash flows if drilling takes place in the current period (part [a] above) minus the cost of drilling = \$10.35 million for the circled node in year 1—calculated as follows: NPV of drilling now (circled node) = value of the developed field (circled node) − cost of developing the field, that is:

$$\$10.35 \text{ million} = \$48.35 \text{ million} - \$38 \text{ million}$$

(e) *Value of the undeveloped oil field.* The value of the undeveloped oil field equals the maximum of the NPV associated with waiting to exercise the option to drill (part [c]) and the NPV of exercising the option in the current period (part [d]). This is analogous to the value of an American call option on the value of developing the oil field—\$10.35 million = maximum of the NPV of waiting and the NPV of drilling now:

$$\begin{aligned}\text{Value of the Undeveloped Oil Field} &= \text{Max}(\{e^{-.06}[\$17.62 \text{ million} \times .4626 + \$4.09 \text{ million} \times (1 - .4626)]\}, \\ &\qquad \{\$48.35 \text{ million} - \$38 \text{ million}\}) \\ &= \text{Max}(\$9.75 \text{ million}, \$10.35 \text{ million}) = \$10.35 \text{ million}\end{aligned}$$

exceeds the NPV of waiting to drill, the optimal decision is to drill if this node in the lattice occurs. Hence, the value of the undeveloped oil field is defined as follows:

$$\text{Value of the Undeveloped Oil Field} = \text{Max}(\text{NPV of Exercising Now, NPV of Waiting to Exercise})$$

where "exercising" refers to the initiation of drilling and production of the field. Substituting for the appropriate values needed to evaluate the option in the highest-value node for year 2:

$$\begin{aligned}\text{Value of the Undeveloped Oil Field} &= \text{Max}\{\$55.62 \text{ million} - \$38 \text{ million}, \\ &\qquad e^{-.06}[\$25.98 \text{ million} \times .4626 + \$9.39 \text{ million} \times (1 - .4626)]\} \\ &= \text{Max}(\$17.62 \text{ million}, \$16.07 \text{ million}) = \$17.62 \text{ million}\end{aligned}$$

Note that when we evaluate the option to wait at the end of year 1, the value that we use for year 2 to calculate the certainty-equivalent value is the maximum of the NPV of the field if it is developed in year 2 (i.e., \$17.62 million in the example calculation above) and the value of waiting until year 3. The latter is the present value of the expected NPV of drilling or waiting for each of the two value nodes connected to the top node in year 2. That is, for the high-value node in year 3, we have already determined that the maximum of the NPVs of drilling and waiting (abandoning the opportunity because the lease expires) is to drill, for an NPV of \$25.98 million. Similarly, if the next-lower node (the low-value state compared to the high-value node in year 2 that we are analyzing) occurs, then the maximum NPV for the investment entails drilling, and this opportunity has an NPV of \$9.39 million.

We now have all the information we need to determine the optimal exercise strategy for developing the three-year lease of the oil field. Specifically, reviewing the completed binomial lattice found in Figure 12-6, we see that exercising the option immediately in year 0 has a positive NPV of \$4.03 million = \$42.03 million − \$38 million. The value of waiting to implement the investment at a later date is \$5.41 million. Therefore, National should not begin drilling immediately but should wait until the end of year 1 and reevaluate. If at the end of year 1 the undeveloped oil field is worth \$48.35 million, it will be better to exercise the option to drill and develop the property. Put another way, the value of waiting until the end of year 2 is worth only \$9.75 million, while the NPV of developing the oil and gas reserves at the end of year 1 is \$10.35 million. If the value of the undeveloped oil field is equal to \$35.82 million (the lower node in year 1) at the end of year 1, however, then the field should not be developed. This is because the NPV of waiting is worth \$1.78 million, while the NPV realized by implementing the development process at the end of year 1 is negative (i.e., −\$2.18 million).

Constructing the Binomial Lattice for the Developed Oil Field

In Figure 12-6 in the preceding example, we provided the valuations of the oil field investment in each node at the end of years 1, 2, and 3. In practice, the analyst would not be given these values but would have to estimate them. Because this estimation process, which is referred to as calibrating the model, is quite complex, we will briefly summarize how it is done in practice. (Calibration was introduced in Appendix C in Chapter 11 and is discussed in more detail in the appendix at the end of this chapter.) We will not delve into the specifics of the calibration process here because that is where much of the "heavy lifting" occurs in modeling commodity prices, and it can be quite technical.

The first step in the estimation process is to specify a binomial tree that illustrates the distribution of future oil prices. Because it takes ten years to produce the oil field's reserves and production may not commence for three years, we need to specify the distribution of crude oil prices for the next thirteen years. The price distribution should be chosen so that the expected future prices at each date are equal to the forward prices for crude oil that we observe in the financial markets. In addition, the discounted values of option payoffs calculated from the binomial lattice should equal the option prices that are observed in the financial markets. In the next step, one can calculate the value of the producing oil field at each node of the binomial tree by discounting the value of the cash flows that will be generated given the oil prices that are realized in successive branches of the tree.

While this is somewhat more complicated than simply plugging in observed option prices from the financial derivatives markets for their real counterparts, it accomplishes the same thing. By calibrating the model, we are effectively using prices in the financial markets to determine real option values.

Real Option Valuation Formula

Because the Black-Scholes option pricing formula is so well known and can be programmed into handheld calculators, there is a temptation to apply the formula to real option problems. In most cases, the Black-Scholes formula is completely inappropriate for real option problems because it assumes that the options can be exercised only at a pre-specified maturity date and that the underlying investment has no cash payouts.

In this section, we provide an option pricing formula that we think is much more appropriate for valuing real options. This formula, which was developed by McDonald and Siegel (1986) based on earlier work by Samuelson and McKean (1965),[8] is based on the Black-Scholes assumptions, with the exception that it allows the underlying investment to have cash payouts and assumes the option can be exercised at any time and never matures. In other words, this is a formula for pricing an infinite-life American option.

The infinite-life option pricing model can be used to value real options in much the same way that the Black-Scholes formula (see Appendix A in Chapter 11) is used to value European options. Although the formula looks complicated, it can be put into a spreadsheet and requires relatively few inputs. You can use it to calculate an initial value of a real option and perform sensitivity analysis to develop your intuition about what determines real option values.

Under these assumptions, the following equation describes the value of an American-style call option:

$$\text{Real Option Value} = (V^* - I)\left(\frac{V}{V^*}\right)^{\beta} \tag{12.3}$$

where each of the terms is defined as follows:

- V^* is the value of the underlying investment that "triggers" exercise of the real option. Note that this variable is an output of the model rather than an input. The threshold value (V^*) is defined by

$$V^* = \frac{\beta}{(\beta - 1)} I \tag{12.4}$$

where

$$\beta = \frac{1}{2} - \frac{r_f - \delta}{\sigma^2} + \sqrt{\left(\frac{r_f - \delta}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r_f}{\sigma^2}} \tag{12.5}$$

- I is the initial cost of making the investment. Hence, $V^* - I$ is the net present value that triggers the exercise of the real option. This difference is also sometimes referred to as the NPV hurdle because it measures how high the NPV must be before the investment is initiated.
- V is the current value of the underlying investment.

[8] Robert L. McDonald and D. Siegel, "The Value of Waiting to Invest," *Quarterly Journal of Economics* 101, no. 4 (1986): 707–27, and Paul A. Samuelson and H. P. McKean Jr., "Rational Theory of Warrant Pricing," *Industrial Management Review, 6, 2* (1965): 13–39.

TECHNICAL INSIGHT

Comparing the Black-Scholes and Infinite-Life Real Option Pricing Models

Like the Black-Scholes formula, the infinite-life real option pricing model formula assumes that the value of the underlying asset changes randomly and that the volatility of the returns earned by the underlying investment and the interest rate are fixed. However, there are three important differences between the assumptions underlying this formula and the assumptions that are the basis of the Black-Scholes model:

- The first is that this model assumes that the option never expires, which should be contrasted to the Black-Scholes assumption that the option has a predetermined expiration date.
- The second difference is that the Black-Scholes formula assumes that the underlying investment pays no dividends. In contrast, the real option valuation formula assumes that the underlying investment generates cash flows that are proportional to the value of the investment and that this proportion does not change over time.
- The final difference is that the Black-Scholes formula assumes that the option is a European-style option that can be exercised only on the option's maturity date. In contrast, the real option valuation formula found in Equation (12.3) assumes that the option can be exercised at any time (is an American-style option) and that the option never expires.

- The risk-free rate of interest is r_f.
- The cash flow yield, or cash distribution as a fraction of the value of the investment, is represented by δ, which is assumed to remain constant over the life of the investment.
- σ is the standard deviation, or the volatility of the rate of return of the underlying investment.

We warned you that this formula looks complicated! As with the Black-Scholes formula, however, we can learn from this formula without understanding all of its mathematical intricacies. For example, from this formula, we can show that increased volatility increases real option values and, in addition, increases the NPV hurdle—that is, the minimum NPV required before the investment is triggered. Similarly, an increase in an investment's cash flow yield decreases the option's value because it implies that the investment's value appreciates at a slower rate.

Real Estate Development Option

To illustrate the use of this real option valuation model, we start with a simple example involving the purchase of 50,000 square feet of land that can be used to develop a 60,000-square-foot office building at a cost of \$10 million (I in Equation [12.3]). It is currently not economical to initiate development because the current value of such a building is only \$9 million (V in Equation [12.3]). However, existing buildings in the area can be leased to yield (after taxes and all expenses) an 8% rate of return to the owner (δ in Equation [12.5]). The volatility (i.e., standard deviation—σ) of the annual rates of return of the building is 10%, and the risk-free rate, r_f, is assumed to equal 6%.

Note that if the building were built today, it would have a value of only $9 million but would cost $10 million to develop, so the owner would lose money developing this property at the current time. However, the land has substantial value because it provides the owner with the option to build in the future. Substituting into Equation (12.3), we estimate that this property, which provides the owner with the option to build the above-described building, has a value of about $287,667, that is:

$$\text{Real Option Value} = (V^* - I)\left(\frac{V}{V^*}\right)^{\beta}$$

$$= (\$11{,}732{,}501 - \$10{,}000{,}000)\left(\frac{\$9{,}000{,}000}{\$11{,}732{,}501}\right)^{6.772} = \$287{,}667$$

where β is calculated using Equation (12.5) as follows:

$$\beta = \frac{1}{2} - \frac{r_f - \delta}{\sigma^2} + \sqrt{\left(\frac{r_f - \delta}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r_f}{\sigma^2}}$$

$$= \frac{1}{2} - \frac{.06 - .08}{.01} + \sqrt{\left(\frac{.06 - .08}{.01} - \frac{1}{2}\right)^2 + \frac{2 \times .06}{.01}} = 6.772$$

Consequently, as a speculator, you would be willing to pay up to $287,667 for the right to develop this property.

The model also provides information about what we call the trigger point—in other words, how high the value must be before it makes sense to commence construction. Using Equation (12.4),

$$V^* = \left(\frac{\beta}{\beta - 1}\right)I = \left(\frac{6.772}{6.772 - 1}\right)\$10{,}000{,}000 = \$11{,}732{,}501$$

This calculation indicates that we should not begin construction until the value of the developed property exceeds $11,732,501. Once the property value reaches this trigger point, the option to develop should be exercised.

How Do Changes in Model Parameters Affect Real Option Values?

It is useful to examine how the value of the option to develop the vacant land is affected by changes in the parameter estimates. For example, if the volatility parameter is increased to 15%, the option to develop the land, calculated using Equation (12.3), increases to $669,762. If we reset the volatility to 10%, but increase the dividend yield to 9%, the value of the option to develop the vacant land is reduced to $191,225. Higher payouts make options less attractive relative to the underlying investments because the owner of the building receives a payout on his or her investment, while the owner of the vacant land (i.e., the option holder) receives nothing.

Extensions of the Model

The real option valuation model in Equation (12.3) can be extended in a number of ways without too much difficulty. For example, suppose that the land is not completely vacant and is currently being used as a parking lot that generates income of $100,000 per year. We can account for this complication by simply determining the value of the parking lot and adding this to the construction costs. For instance, in the earlier example, we assumed that the cost of constructing the building was $10 million. To account for the loss of parking lot revenues valued at, say, \$1.8 million, we simply increase the development costs to \$11.8 million. In the same way, one can account for taxes on the undeveloped land, which would generate a positive cost associated with holding the land.

Applying the Model to a Chemical Plant

We now apply the model to the valuation of a potential opportunity to build or reposition a manufacturing facility. Suppose, for example, that DuPont has an ethylene plant that currently produces 10,000 tons of ethylene per year. The plant is old and inefficient, but it still shows a fairly stable profit of \$1 million per year. DuPont is considering an opportunity to convert this facility to make diethelyne, which is a specialty chemical that is substantially more profitable. DuPont's analysts estimate that the conversion will cost \$90 million and will generate an initial cash flow next year of \$10 million. The analysts expect these profits to increase 2% per year for the foreseeable future, and the standard deviation of the returns to the investment is estimated to be 15% per year. Under the assumption that these profit changes are random and that the discount rate is constant at 12% per year, we can estimate the value of the plant with a simple growth model, that is:

$$\begin{matrix}\text{Value of the}\\\text{Plant}\end{matrix} = \frac{\text{Cash Flow(Year 1)}}{\text{(Discount Rate} - \text{Growth Rate)}} = \frac{\$10\text{ million}}{.12 - .02} = \$100\text{ million}$$

Under these assumptions, the investment has a value of \$100 million and a corresponding payout rate of 10%.

To evaluate this opportunity, one must also value the ethylene plant because part of the cost of building the new plant is the opportunity cost associated with liquidating the old plant. We will assume that the old plant has a value of \$8.5 million, which is the capitalized value of the plant's cash flow at a 12% discount rate, i.e., \$1 million $\div$ .12 = \$8.33 million. The total opportunity cost of building the new plant is equal to the \$90 million direct cost of converting the old plant to produce the new product plus the \$8.33 million opportunity cost associated with closing the old plant, for a total of \$98.33 million. Consequently, the new plant has a net present value of \$1.67 million, which equals the estimated value of the new plant (\$100 million) less the opportunity loss associated with closing the old plant and the cost of building the new plant (\$98.33 million), or NPV = \$100 million − \$98.33 million = \$1.67 million.

Although the investment has a positive NPV, the NPV is quite small compared to the value of the investment (i.e., 1.67%). Hence, DuPont may create more value by delaying the investment. To analyze this possibility, we value the project using the real option valuation formula found in Equation (12.3), with inputs as follows: The risk-free rate is 6%, the cash flow yield is 10%, and the volatility of the underlying investment is 15%. Using Equation (12.3), we estimate that the chemical plant should not be converted until the new plant has a value of \$120,284,902. Under this conversion strategy, the option to convert has a value of \$7,918,553, that is:

$$\begin{aligned}\text{Real Option Value} &= (V^* - I)\left(\frac{V}{V^*}\right)^{\beta}\\ &= (\$120{,}284{,}902 - \$98{,}330{,}000)\left(\frac{\$100{,}000{,}000}{\$120{,}284{,}902}\right)^{5.5215}\\ &= \$7{,}918{,}553\end{aligned}$$

where β is calculated using Equation (12.5) as follows:

$$\beta = \frac{1}{2} - \frac{r_f - \delta}{\sigma^2} + \sqrt{\left(\frac{r_f - \delta}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r_f}{\sigma^2}}$$
$$= \frac{1}{2} - \frac{.06 - .10}{.0225} + \sqrt{\left(\frac{.06 - .10}{.0225} - \frac{1}{2}\right)^2 + \frac{2 \times .10}{.0225}} = 5.5215$$

such that

$$V^* = \left(\frac{\beta}{\beta - 1}\right)I = \left(\frac{5.5215}{5.5215 - 1}\right)\$98{,}500{,}000 = \$120{,}284{,}902$$

Limitations of the Model

We need to emphasize that this model makes a number of strong assumptions. For example, the valuation model assumes that interest rates and volatilities are fixed for the life of the options. The model also requires payouts to be a fixed percentage of the investment's value and assumes that the investment opportunity lasts forever or never expires. However, as restrictive as this final assumption may sound, we can modify the model to accommodate deterioration in the value of the option due to the effects of competition by assuming that the value of the opportunity deteriorates at a fixed rate (say, 2% per year) over time. In essence, we assume that the growth rate in the value of the investment is negative.

It should also be noted that, in the real estate and chemical plant examples considered in this section, no financial options correspond with the options that are being valued. Consequently, managers have much more leeway in how these investments can be valued than they would if their assumptions were constrained by the values that are observed in financial markets. Given this fact, it is imperative that, when doing valuations like these, managers perform a sensitivity analysis that examines the extent to which the investment value is sensitive to the choices of the various parameters of the model.

12.6 Using Simulation to Value Switching Options

Three basic approaches are used to evaluate real options: the binomial lattice, the real option formula for options with an infinite maturity, and simulation. In this section, we illustrate the third approach.

Simulation is commonly used to solve very complex real option problems that involve multiple and interactive sources of uncertainty. To illustrate how simulation can be used, we will consider the valuation of an investment with a switching option, which provides managers with the flexibility to alter operations as economic conditions change. For example, in response to changes in demand for their products, managers generally have the flexibility to speed up or slow down production as well as to shift the mix of products they produce and sell. In addition, if the cost of inputs changes over time, managers can often switch to a lower-cost alternative input.

The type of switching option that we focus on in this section is the option to exchange one input for another—specifically, the option to switch between natural gas and fuel oil to fire an electric power plant. Another form of switching option is the option to exchange one output for another. For example, a toy-manufacturing plant that produces stuffed animal toys might switch between teddy bears and stuffed lions in response to perceived changes in demand. Designing a plant in a way that allows for such switching can be costly, so it is important to be able to value this option to switch.

Option to Switch Inputs

To illustrate the value derived from switching options, we examine the CalTex Power Company, which is considering the installation of a large electric power plant and has three alternative technologies under consideration: a natural gas-fired plant, a fuel oil-fired plant, and a co-fired or flexible plant that has the capability of switching between fuel oil and natural gas depending on which is the cheaper power source. The gas- and oil-fired plants each cost $50 million to build, while the flexible plant costs $55 million.

All three plants can produce the same amount of electricity and are expected to run at full capacity every year of their ten-year lives. Table 12-4 summarizes the expected revenues and costs of operating all three plant alternatives. To simplify the analysis, we assume the following:

- Plant revenues equal $32,550,000 in year 1 and grow at a rate of 5% per year.
- All three plant technologies incur two costs of operations: fuel costs and fixed operating expenses.
- There are no costs associated with switching between the fuel alternatives with the flexible plant.[9] Moreover, the costs of the two fuels change only once per year, at the end of each year.
- The current price of natural gas is $7.75 per million British thermal units (Btu), and this cost is expected to rise at a rate of 2.5% per year. The price of fuel oil is currently $7.00 per million Btu, and it is expected to rise at a rate of 4.5% per year.[10]
- There are no income taxes.
- The plants are assumed to have no salvage values at the end of year 10.

The question that we will address is whether the added cost of the flexible power plant is worthwhile. Very simply, is the option to switch fuel sources worth the added $5 million it would cost?

Static NPV Analysis of the Plant Choices

Traditionally, DCF analysis calculates and discounts the cash flows that arise given the expected outcome scenario. We refer to this as the static DCF analysis. The results of the static analysis are presented in Table 12-4 for each of the three power plant alternatives. This analysis is static in that it assumes that the oil-versus-gas choice for the flexible plant is determined in advance based on the most likely scenario or, equivalently, the expected cost of the fuel at each future date. As we illustrate in Figure 12-7, the expected cost of oil is less than that of gas for years 1 through 5, but then rises above it, triggering a switch from fuel oil to natural gas in year 6.

[9] In practice, setup or changeover costs often deter a firm's willingness to switch from one mode of operation to another.

[10] Note that the prices of natural gas and fuel oil have been standardized in terms of the cost per million Btu of energy they are expected to produce. This allows us to compare the costs of the two fuel sources in terms of a common unit that can be related directly to the production of electric power.

Table 12-4 **Static DCF Analysis of the Gas-Fired, Oil-Fired, and Flexible (Gas or Oil)-Fired Power Plants**

	Expected Cost of Fuel/Btu*		Expected Fuel Costs†				Expected Free Cash Flow§		
Year	Gas	Fuel Oil	Gas	Fuel Oil	Other Expenses	Revenues‡	Gas	Fuel Oil	Flexible‖
0							$(50,000,000)	$(50,000,000)	$(55,000,000)
1	$7.94	$7.32	$(27,803,125)	$(25,602,500)	$(800,000)	$32,550,000	3,946,875	6,147,500	6,147,500
2	8.14	7.64	(28,498,203)	(26,754,613)	(800,000)	34,177,500	4,879,297	6,622,888	6,622,888
3	8.35	7.99	(29,210,658)	(27,958,570)	(800,000)	35,886,375	5,875,717	7,127,805	7,127,805
4	8.55	8.35	(29,940,925)	(29,216,706)	(800,000)	37,680,694	6,939,769	7,663,988	7,663,988
5	8.77	8.72	(30,689,448)	(30,531,457)	(800,000)	39,564,728	8,075,281	8,233,271	8,233,271
6	8.99	9.12	(31,456,684)	(31,905,373)	(800,000)	41,542,965	9,286,281	8,837,592	9,286,281
7	9.21	9.53	(32,243,101)	(33,341,115)	(800,000)	43,620,113	10,577,012	9,478,998	10,577,012
8	9.44	9.95	(33,049,179)	(34,841,465)	(800,000)	45,801,119	11,951,940	10,159,654	11,951,940
9	9.68	10.40	(33,875,408)	(36,409,331)	(800,000)	48,091,175	13,415,767	10,881,844	13,415,767
10	9.92	10.87	(34,722,293)	(38,047,751)	(800,000)	50,495,733	14,973,440	11,647,983	14,973,440

	Gas	Oil	Flexible
NPV#	$ (503,157)	$462,277	$(528,142)
IRR	9.81%	10.19%	9.81%

*The expected cost of fuel per Btu for gas and fuel oil is estimated from the current costs and the expected rate of inflation. For example, the current cost of natural gas is $7.75 per Btu, and the anticipated rate of inflation is 2.5%. Thus, the expected price of gas in one year is equal to $\$7.94/\text{Btu} = \$7.75/\text{Btu} \times (1 + .025)$.

†The expected cost of fuel equals the product of the total fuel (in Btus) consumed by the plant to produce 500,000 kilowatt-hours (kWh) of electricity times the fuel cost per Btu from either gas or fuel oil. We calculate the total fuel required to produce electricity using the heat rate for the plant, which can differ if the plant is being run with natural gas. However, we assume a heat rate of 7.0 for gas and oil here. The heat rate equals the ratio of total fuel consumed in Btus divided by the total kWh of electricity produced.

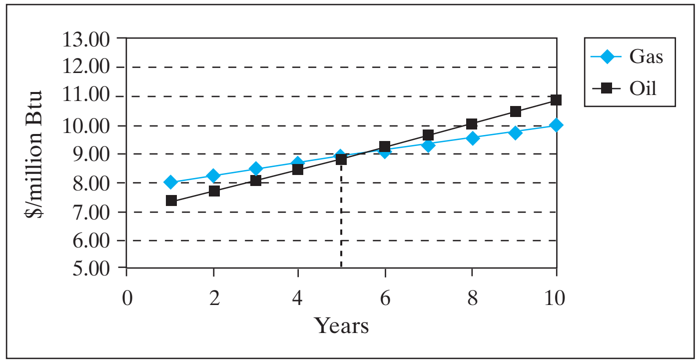
‡Plant revenues are the same for each of the three plant alternatives and are expected to grow at a rate of 5% per year.

§Free cash flow = revenues − expected fuel cost − other expenses. We assume that there are no taxes or salvage value for any of the plant alternatives.

‖The fuel cost incorporated into the calculation of the expected free cash flow for the flexible plant is equal to the lower of the expected fuel cost using natural gas or fuel oil for each year.

#Net present value is calculated using a 10% cost of capital for each plant alternative.

Figure 12-7 Expected Costs of Natural Gas and Fuel Oil



Although the cash flows from these plants are not necessarily equally risky and the risk of the switching plant may change over time as the preferred fuel changes, we will initially value these plants assuming a constant 10% discount rate. As we show in Table 12-4 with this discount and the assumed cash flows, the fuel oil plant is the preferred alternative and the flexible plant has a negative NPV. Based on this static analysis, it appears that the flexible plant does not offer sufficient expected fuel cost savings to warrant spending an additional $5 million.

Our static NPV analysis, however, ignores an important benefit associated with the flexible plant: It assumes that the fuel input is predetermined based on the expected cost of the alternative fuels and thus ignores the possibility that management can alter its choice of fuel throughout the life of the flexible plant by using gas in those years in which gas is less expensive and oil in those years in which oil offers the better alternative. Because the costs of natural gas and fuel oil are uncertain, there is a benefit to having the flexibility to respond to future market conditions that cannot be known at the time the analysis is being done. As we demonstrate below, the value of this flexibility can be estimated with a simulation model that incorporates the dynamic effects of having the option to switch fuel sources and thus minimize the cost of fuel.

Dynamic Analysis—Valuing the Option to Switch Fuel Sources

In our static analysis, we established that the fuel oil–fired plant is preferred to the natural gas-fired plant. Now we must determine whether adding the option to switch between fuel oil and natural gas. Specifically, we want to value the expected fuel cost savings from using the flexible plant rather than the fuel oil–fired plant.

Modeling Future Oil and Gas Prices

Although this problem is somewhat more difficult to solve than the problems that we have described up to now, the overall process is very similar. The basic idea is to specify a price process for the commodities that are the value drivers for the power plant projects. In this case, we have two value drivers—the price of natural gas and the price of fuel oil per Btu—so we must specify a price process for both commodities (by this we mean the process that describes their volatilities and how the prices change over time).

Did You Know?

Origins of Brownian Motion

Studying the random behavior of pollen particles suspended in water, Scottish scientist Robert Brown is credited with identifying the phenomenon we now refer to as Brownian motion. Many years later, Albert Einstein developed the mathematical properties of Brownian motion that are commonly used today.

However, Louis Bachelier (1870–1946), in his 1900 dissertation *Theorie de la Spéculation* (and in his subsequent work, especially in 1906 and in 1913), described the ideas behind the random walk of financial market prices, Brownian motion, and martingales (before Einstein!) Sadly, his innovativeness was not appreciated until it was rediscovered in the 1960s.

Source: http://cepa.newschool.edu/het/profiles/bachelier.htm

Up to now, we have assumed that commodities are like stocks and follow a random walk, which means that price changes in any given time period are independent of the previous price changes. This assumption simplifies option pricing problems, but it is not realistic for most commodities. Commodity prices are generally assumed to be mean-reverting, which means that if prices increase a lot in one year, they are likely to fall in the following year. In the Technical Insight box on page 469 titled Modeling Natural Gas Prices Using Geometric Brownian Motion and Mean Reversion, we will provide more detail about the price processes that analysts use to describe oil, gas, and other commodity prices.

We will also use observed prices from the financial markets to value the option to switch between natural gas and fuel oil, but in this case, we cannot simply plug in the prices of traded derivatives. Instead, we must first specify a price process for natural gas and fuel oil, and then calibrate the process so that it generates values for observed forward and option prices that are consistent with the prices observed in the financial markets. We will not provide the technical details of such a calibration process, but we will assume that from such a process we arrive at the following set of parameter estimates:

	Rate of Reversion in Prices*	Mean-Reversion Price = Forward Price†	Standard Deviation of Price Changes
Natural gas	1.0	\$7.75/Btu	30%
Fuel oil	0.6	\$7.00/Btu	20%

*Historical estimates of the rate of reversion to the mean for natural gas have been faster than for oil prices.

†This is also the initial price of each commodity in the current period (year 0).

Because we have two commodity prices (natural gas and fuel oil) that must be considered when valuing the switching option, it is also necessary that we estimate the correlation between the prices of natural gas and fuel oil per Btu. If the prices of natural gas and fuel oil are very highly correlated, the option to switch will be less valuable. Intuitively, the gain from switching is much less if fuel oil prices are likely to be high whenever natural gas prices are high. Because fuel oil and natural gas are frequent substitutes, high demand for one is likely to put pressures on the price of the other, which does make the two commodities positively correlated. However, the correlation is not particularly high, and for our purposes, we assume a positive correlation of 0.25.

We must again note that because the simulated price process has been calibrated using derivative prices, the resulting prices that we estimate using Equation (12.6) are

> **Did You Know?**
>
> **What's a Wiener Process?**
>
> The increment to Brownian motion defined by Equation (12.7) is often referred to as a *Wiener process,* named after the American mathematician Norbert Wiener (1894–1964).

not the actual expected prices; instead, they are risk-adjusted expected prices or certainty-equivalent prices. Consequently, the expected cash flows that we calculate from this calibrated price process are certainty-equivalent cash flows that can be valued by discounting them at the risk-free rate.

Using Simulation to Value the Flexibility Option

At this point, we have made all the assumptions and forecasts we need to characterize the future prices of natural gas and fuel oil, and we are ready to value the option to switch between the two sources of fuel. To solve for the value of this flexibility option, we use the simulation process that we previously discussed in Chapter 3. This process requires the following three steps (refer back to Chapter 3 for a more thorough review):

Step 1: Identify the sources of uncertainty, characterize the uncertainty using an appropriate probability distribution, and estimate the parameters of each distribution. In this example, the sources of uncertainty associated with the value of the option to switch fuel sources are the costs of natural gas and fuel oil for each of the next ten years. We have modeled the prices of natural gas and fuel oil per Btu using Equation (12.6).

Step 2: Define the summary measure that we are attempting to estimate. In this instance, our objective is to evaluate the present value of the expected fuel cost savings for years 1 through 10 if the flexible plant is constructed.

Step 3: Run the simulation. We use 10,000 iterations, or trials, in the simulation of fuel prices. The iterations begin with the cost of fuel per Btu observed in year 0. Then the change in price is simulated using Equation (12.7) (once for natural gas and once for fuel oil) and added to the cost/Btu for year 0 to get the simulated price for year 1. The process is repeated to obtain fuel prices for years 2 through 10. The simulated prices for gas and oil form a single price path for each of the fuels. We repeat this process a total of 10,000 times to form 10,000 price paths for oil and 10,000 price paths for natural gas. These simulated costs of gas and oil per Btu are then used to calculate the annual fuel cost savings that accrue to the flexible plant alternative. Because we are analyzing the value of the flexible plant compared to that of the fuel oil plant alternative, the flexibility option creates savings only when the cost of natural gas falls below the price of fuel oil.

Once we have identified the distributions of fuel cost savings from the simulation, we calculate the value of these expected annual savings by discounting them using the risk-free rate of 6%.

The column titled Average Annual Fuel Savings in panel (a) of Table 12-5 contains the average annual cash flow savings that are expected to accrue to the flexible plant when it always selects the lower-cost fuel source. Discounting these savings back to the present using the risk-free rate of interest produces a value of $22,252,213, which, when compared to the $5 million added cost of building the flexible plant, provides an NPV of $17,252,213. Based on this analysis, CalTex should select the flexible plant technology.

Panel (b) of Table 12-5 contains a histogram of the values generated from each of the simulations for the flexibility option. We will not engage in a full sensitivity analysis using the simulated distribution here (see Chapter 3), but note that the discounted value of the simulated cash flows associated with the switching option is at least equal to the $5 million additional investment in 94.88% of the simulation trials.

TECHNICAL INSIGHT

Modeling Natural Gas Prices Using Geometric Brownian Motion and Mean Reversion

Brownian motion without mean reversion has been compared to the path that a drunk might take home after a night out on the town. We can think of the path marked by the staggering steps of the drunken man as he wanders toward home as a representation of Brownian motion. Based on this analogy, Brownian motion is sometimes referred to as a random walk.

Now consider the possibility that the drunken man takes his faithful dog, Sparky, to the bar. Because Sparky doesn't drink, he can lead his master home. With Sparky along to guide him, the man staggers along aimlessly until the dog's leash tugs him back toward the direct path taken by Sparky. The path of the drunken man as he staggers along behind Sparky's lead provides a rough approximation of Brownian motion with mean reversion. The leash, like mean reversion, keeps the drunken man from wandering too far from the path home.

Stock prices are generally modeled as Brownian motion without mean reversion—that is, as a random walk. However, the prices of a commodity, such as natural gas, are generally modeled as Brownian motion with mean reversion, which means that if prices get too far away from a long-term equilibrium price, they tend to gravitate back toward that price, which is usually governed by the cost of production and the level of demand.

We can express this price process mathematically in Equation (12.6), which defines the price of natural gas at the end of year 1, $P_{Gas}(1)$, as the sum of the observed price of natural gas today, $P_{Gas}(0)$, plus the change in the price of gas over the coming year, $\Delta P_{Gas}(1)$:

$$P_{Gas}(1) = P_{Gas}(0) + \Delta P_{Gas}(1) \tag{12.6}$$

Next, for a mean-reverting geometric Brownian motion process, $\Delta P_{Gas}(1)$ can be defined by the following equation:

$$\Delta P_{Gas}(1) = P_{Gas}(0)[\text{Predictable Component}(\mu) + \text{Unpredictable Component}(\sigma_{Gas}\varepsilon)]$$

$$\Delta P_{Gas}(1) = P_{Gas}(0)[\mu + \sigma_{Gas}\varepsilon] \tag{12.7}$$

where the predictable component $\mu = \alpha_{Gas}[\ln(L) - \ln(P_{Gas}(0))]$ and α_{Gas} is the rate at which gas prices revert back to the mean price, L_{Gas}. For example, a reversion rate of 2 would suggest that prices would revert to the mean price in half a period (six months in our example). The unpredictable component is described by ε, which is a normal random variable with mean zero and unit standard deviation, and σ_{Gas}, which represents the volatility of the logarithm of natural gas price changes. The unpredictable component is the source of randomness in the price path.

Substituting Equation (12.7) into Equation (12.6), we see that the price of gas next year is:

$$P_{Gas}(1) = P_{Gas}(0)[1 + \alpha_{Gas}[\ln(L) - \ln(P_{Gas}(0))] + \sigma_{Gas}\varepsilon] \tag{12.8}$$

Common Valuation Mistakes

Valuing Real Options

Because of the difficulties associated with valuing real options, it is no surprise that it is very easy to make mistakes in the valuation process. Some of the more common mistakes are discussed below.

Trying to Fit the Problem into the Black-Scholes Model

There is a natural tendency to use financial formulas even when the underlying assumptions on which the models were developed are not consistent with the realities of the situation. This tendency has led many analysts to "force-fit" the Black-Scholes option pricing formula into real option problems in cases where the model is not even remotely appropriate.

The Black-Scholes model is derived using a set of assumptions, but a particularly onerous assumption is that the option can be exercised only at maturity (i.e., it is a European option). In fact, real options should generally be viewed as American options that can be exercised at any time. Still another issue with the Black-Scholes model is that it assumes that there are no intermediate cash flows from the underlying asset. This is so even though, in most cases, the underlying investment generates cash flows, and these cash flows, like dividends on a share of stock, affect the value of the investment and consequently the value of any options based on the investment's value. Finally, the exercise price of real options, unlike the fixed exercise price of the Black-Scholes model, is typically unknown.

Using the Wrong Volatility

Analysts often use the wrong volatility when valuing natural resources investments with embedded real options. In particular, when valuing options on natural resources investments, the volatility of the price of the underlying commodity is erroneously used rather than the volatility in the value of the appropriate underlying asset. For example, as we described earlier, the volatility of the value of a producing oil field is the volatility that should be used to value a lease that gives the holder the option to extract oil. In practice, however, it is difficult to determine this volatility, so analysts sometimes take the shortcut of using the volatility of oil prices. This shortcut would produce the correct answer if oil prices were like stock prices and followed a random walk (that is, price changes are serially uncorrelated). However, oil prices, like most commodity prices, tend to be mean-reverting. This means that a very large positive price change is more likely to be followed by a drop in price than by another increase. When this is the case, the volatility of commodity prices will be greater than the

12.7 Summary

The growth in the use of real option analysis over the last two decades can largely be attributed to its broad-based appeal as a tool to communicate and estimate the value that flexibility can add to real investments. The examples in this chapter illustrate that there can be a substantial increment to project value whenever managers have the flexibility to act opportunistically when managing real investments in an uncertain environment.

Surveys of business practice indicate that MBA programs have been very successful in ingraining the use of discounted cash flow analysis into hoards of newly minted MBAs. However, this success has had an unfortunate side effect: DCF analysis has sometimes supplanted commonsense business judgment that recognizes the importance of operational flexibility. This means that the early adherents of a more quantitative approach to project analysis based on DCF analysis may have underestimated the extent to which flexibility is a source of value. The computational power of computer spreadsheets, simulation software, and specialized option valuation software on the desks of volatility of investments that generate cash flows that depend on the commodity prices. This will, in turn, lead to an overvaluation of real options.

Assuming That the Exercise Price of the Real Option Is Fixed

Unlike financial or contractual options, the exercise price for a real option is generally not fixed. For example, your firm may have the option to undertake a project today at a cost of $8 million or to delay the investment for another year. However, if over the year the price of the project's output increases significantly, it is likely that the cost of initiating the project will also have risen. In fact, as a general rule, the costs of initiating a project are higher when the project is more valuable. For example, when housing prices increase, we often see a building boom, which drives up the costs of lumber and other building materials. In general, a high correlation between an investment's value and the cost of implementing the investment has the effect of lowering the value of the option to invest. So ignoring this factor leads to overvaluation of the real option.

Overestimating the Value of Flexibility

The fundamental source of the value of real options comes from optimally taking advantage of flexibility. To capture this value, however, the firm's management must be both willing and able to exercise the options when conditions warrant doing so. In reality, managers tend not to exercise real options as ruthlessly as our models indicate. For example, management may be reluctant to shut down a facility (i.e., exercise an abandonment option) because of loyalties to employees, suppliers, or customers. Furthermore, even without conflicting motives, management may not have the incentives or the ability to exercise real options in an optimal fashion. The message here is that one should not place much value on options that can be exercised *in theory* but are unlikely to be exercised *in reality*.

Double-Counting Risk

In our analysis of the value of embedded options in oil fields, we used forward prices to calculate certainty-equivalent cash flows and discounted these cash flows at the risk-free rate of interest. This analysis *correctly* associates a risk-free discount rate to certainty-equivalent cash flows. However, industry applications sometimes mistakenly use forward prices to represent expected prices, which are then used to calculate what are erroneously *assumed* to be expected cash flows, which are then discounted at a risk-adjusted rate. Hence, the analyst ends up adjusting both the cash flows and the discount rate for risk, which results in a conservative estimate of value.

analysts today makes real option analysis a practical reality. However, as we learned with the adoption of quantitative techniques such as DCF, change takes time, so it may be years before the real option approach to project valuation is as prevalent as static DCF. But we believe that this is the direction of the future.

In this chapter, we presented three approaches that can be used to value investments with real options:

- The first was the binomial lattice approach. This and related approaches are used extensively on Wall Street to value financial options, and because of its success there, it has been adopted in some settings to value real investments.
- The second approach was the application of a real option formula, which to our knowledge is not really used in industry. We presented this formula because, like the Black-Scholes formula, it is simple to program and provides a rough estimate of real option values. Like the Black-Scholes formula, it provides estimates that are a bit too simple and too rough to use for a final valuation of a major investment.

Table 12-5 Dynamic Analysis of the Option to Switch Fuels—Comparing the Fuel Oil–Fired Plant and the Flexible Plant

Panel (a) Certain Equivalent Expected Annual Fuel Cost Savings

Year		Average Annual Fuel Savings
1		2,518,650
2		3,215,166
3		3,180,391
4		3,094,741
5		3,138,945
6		3,121,089
7		3,038,148
8		3,012,766
9		3,001,547
10		2,972,366
Risk-free rate	6.0%	
Value switching option (fuel savings)	$ 22,252,213	
Less: cost of option	(5,000,000)	
NPV (switching option)	$ 17,252,213	

These savings correspond to the benefits of having the option to switch between fuel sources compared to the fuel oil–fired plant. The latter was determined to be the better alternative when the natural gas- and fuel oil-fired plants were compared.

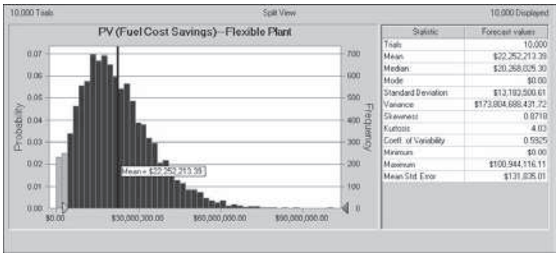
However, it may provide a useful starting point to determine whether a more refined analysis is warranted.

- The final tool that we discussed was simulation analysis. This is becoming increasingly important for valuing investments, and we think that this is the tool of the future. Simulation is capable of handling the most complicated investments in a way that does not require a great deal of technical sophistication from the analyst. In reality, major investments often contain many sources of managerial flexibility as well as a number of sources of uncertainty, and simulation is the only available tool that is capable of dealing with this level of complexity.

The application of real option analysis varies across industries and even firms within industries. For example, real option analysis is used extensively in the energy and natural resources industries, where commodity markets are active and derivative prices are readily observable. We hasten to point out that, although the complexity of the analysis presented in this chapter is greater than that in prior chapters, the real option valuation approaches that are actually used in practice can be even more complicated. However, because these industry approaches are generally based on either the simulation approach or the binomial approach described in this chapter, an understanding of this material provides the foundation for understanding the most complicated valuation approaches used in industry.

Table 12-5 *continued*

Panel (b) Distribution of Flexible Option Values (*Crystal Ball* Output)

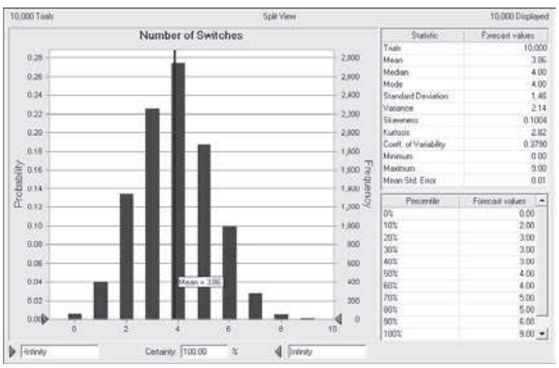


Present value (fuel cost savings) = present value (PV) of the cost of reduced fuel consumption due to switching fuel to a low-cost source.

Fuel cost savings = the difference in the total annual fuel cost of fuel oil and natural gas when natural gas is cheaper than fuel oil.

Certainty = percentage of the 10,000 iterations when the present value of the fuel cost savings exceeds the $5 million added cost of the flexible plant.

Panel (c) Distribution of the Number of Switches over Ten Years (*Crystal Ball* Output)



Definitions:

- A fuel switch occurs whenever the cost of fuel can be lowered by changing from one fuel to another.
- The number of switches equals the number of times within the ten-year plant life.

In other industries, real options are evaluated with approaches that are less sophisticated than those described in this chapter. For example, although flexibility plays a very important role in real estate development, real estate investors typically do not use explicit valuation models to value real estate development options. In addition, while managers do understand the value of timing options (which exist for almost any major investment project), they tend to use relatively simple and intuitive approaches for valuing the option to wait as well as the option to abandon.

Why are real option valuation approaches more popular in energy and natural resources industries than in other industries? In natural resources industries, the payoffs between the real options and the options that are traded in the financial markets are quite close, allowing managers to value the investments without having to use a lot of judgment. In other valuation examples, such as the valuation of land with development opportunities, there are no financial option prices that are directly analogous to the development option being valued. In these cases, real option analysis is viewed less favorably because the manager must substitute his or her judgment about the future distribution of the relevant values for the financial option prices that do not exist. While the need to exercise judgment in a valuation problem is not unique to the application of real option models, it is natural for managers to be more reluctant to exercise judgment in the application of tools they are less familiar with and thus to be less confident about their judgment. As we have emphasized earlier, in those cases where more managerial judgment is required, it is important that the valuation analysis also include a detailed sensitivity analysis.

In the next chapter, we evaluate investment strategies that have the potential for a series of follow-up investment opportunities. For example, when Toyota considers an assembly plant to build pickup trucks in Texas, it is considering a single investment. However, when the company considers whether it makes sense to assemble cars in Eastern Europe, where the company does not currently build automobiles, it is evaluating an investment strategy that can eventually lead to assembly plants in multiple locations for a variety of cars and trucks. The fact that both flexibility and uncertainty are inherent in all investment strategies implies that some sort of option analysis is required for a disciplined approach to evaluating the strategy.

EXERCISES

12-1 CONCEPTUAL ANALYSIS OF REAL OPTIONS The destruction that Hurricane Katrina brought to the Gulf Coast in 2005 devastated the city of New Orleans as well as the Mississippi Gulf Coast. The burgeoning casino gambling industry along the Mississippi coast was nearly destroyed. CGC Corporation owns one of the oldest casinos in the Biloxi, Mississipi, area, and it was not destroyed by Katrina's tidal surge because it is located several blocks off the beach. Because of the near-total destruction of many of the gambling properties located along the beach, CGC is considering the opportunity to make a major renovation in its casino. The renovation would transform the casino from a second-tier operation into one of the top attractions along the Mississippi Gulf Coast. The question that the firm faces involves placing a value on the opportunity to renovate the property.

CGC's analysts estimate that it would cost \$50 million to do the renovation. However, based on the uncertainties associated with the redevelopment of the region, the firm's financial analyst estimated that the casino, under the current conditions, would be valued at only \$45 million. Alternatively, CGC could continue to operate the casino, in which case it expects to realize an annual rate of return of 10% on the value of the investment. Moreover, the estimated return of 10% is highly uncertain. In fact, the volatility (standard deviation) in this rate of return is probably on the order of 20%, while the risk-free rate of interest is only 5%.

a. What is the NPV of renovation of the property if the renovation is undertaken immediately?

b. What is the value of having the option to renovate in the future? (Hint: You can assume that the option never expires.)

PROBLEMS

12-2 ANALYZING AN OIL LEASE AS AN OPTION TO DRILL FOR OIL Suppose you own the option to extract 1,000 barrels of oil from public land over the next two years. You are deciding whether to extract the oil immediately, allowing you to sell the oil for \$20 per barrel, or to wait until next year to extract the oil and sell it then for an uncertain price. The extraction costs are \$17 per barrel. The forward price is \$20, and you know that oil prices next year will be either $15 per barrel or $25 per barrel, depending on demand conditions. Are you better off extracting the oil today or waiting one year? Explain how your answer might be different if prices next year are either more or less certain but have the same mean.

12-3 CONCEPTUAL ANALYSIS OF REAL OPTIONS Huntsman Chemical is a relatively small chemical company located in Port Arthur, Texas. The firm's management is contemplating its first international investment, which involves the construction of a petrochemical plant in São Paulo, Brazil. The proposed plant will have the capacity to produce 100,000 tons of the plastic pellets that are used to manufacture soft drink bottles. In addition, the plant can be converted to produce the pellets used in the manufacture of opaque plastic containers such as milk containers.

The initial plant will cost $50 million to build, but its capacity can later be doubled at a cost of $30 million should the economics warrant it. The plant can be financed with a $40 million nonrecourse loan provided by a consortium of banks and guaranteed by the Export Import Bank. Huntsman's management is enthusiastic about the project because its analysts think that the Brazilian economy is likely to grow into the foreseeable future. This growth, in turn, may offer Huntsman Chemical many additional opportunities in the future as the company becomes better known in the region.

Based on a traditional discounted cash flow analysis, Huntsman's analysts estimate that the project has a modest NPV of about $5 million. However, when Huntsman's executive committee members review the proposal, they express concern about the risk of the venture, based primarily on their view that the Brazilian economy is very uncertain. Toward the close of their deliberations, the company CEO turns to the senior financial analyst and asks him whether he has considered something the CEO has recently read about called real options in performing his discounted cash flow estimate of the project's NPV.

Assume the role of the senior analyst and provide the CEO with a brief discussion of the various options that may be embedded in this project. Sketch very roughly how these options can add to the value of the project. (Hint: No computations are required.)

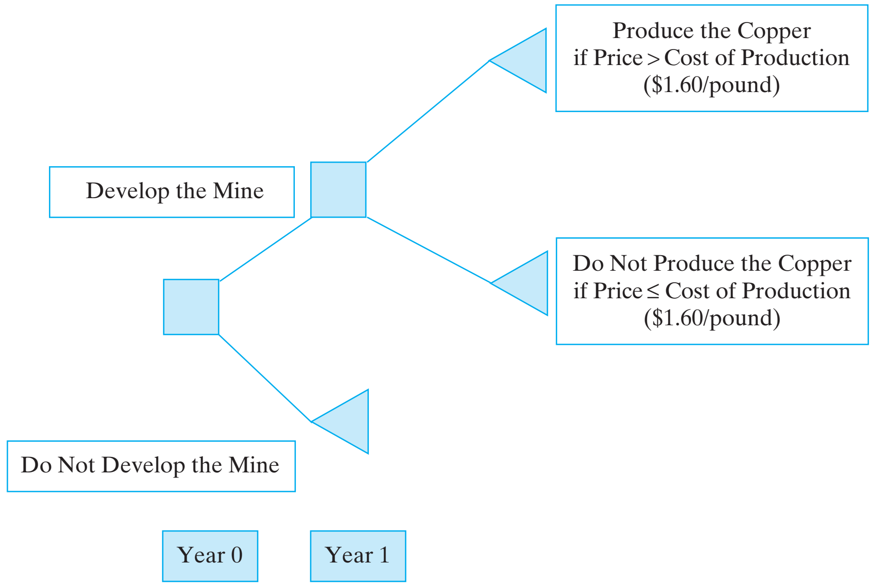
12-4 OPTION TO ABANDON Newport Mining has a lease, with two years remaining, in which it can extract copper ore on a remote island in Indonesia. The company has completed the exploration phase and estimates that the mine contains 5 million pounds of ore that can be extracted. The ore deposit is particularly rich and contains 37.5% pure copper.

Newport can contract with a local mining company to develop the property in the coming year at a cost of $1.2 million. Three-fourths of the cost of development must be paid immediately and the remainder at the end of one year. Once the site is developed, Newport can contract with a mine operator to extract the ore for a cash payment equal to $0.60 per pound of ore processed or $1.60 per pound of copper produced.[11] The total cost must be paid in advance at the beginning of the second year of operations. This amounts to a cash payment in one year of $3 million.

At the end of one year, Newport can contract to sell the copper ore for the prevailing spot price at that time. However, because the spot price at the end of the year is unknown today, the proceeds from the sale of the refined copper are uncertain.

[11] Because the ore contains 37.5% copper and there are 5 million pounds of ore in the mine, the total is 1.875 million pounds of copper to be produced at a cost equal to $0.60 × 5 million pounds of ore, or $3.0 million. Thus, the cost per pound to produce the ore is $3.0 million/1.875 million pounds, or $1.60 per pound.

Newport's Options to Develop and Produce a Copper Mine



The current price is \$2.20 per pound, and commodity analysts estimate that it will be \$2.50 a pound at year-end. However, because the price of copper is highly volatile, industry analysts have estimated that it might be as high as \$2.80 or as low as \$1.20 per pound by the end of the year. The price of copper is expected to stay at \$2.80 or as low as \$1.20 throughout the second year. As an alternative to selling the copper at the end-of-year spot price, Newport could sell the production today for the two year forward price of \$2.31 and eliminate completely the uncertainty surrounding the future price of copper. However, this strategy would require that the firm commit today to producing the copper. This, in turn, means that Newport's management would forfeit the option to shut down the plant should the price be less than the cost of producing the copper.

Given the risk inherent in exploration, Newport requires a rate of return of 25% for investments at the exploration stage but requires only 15% for investments at the development stage. The risk-free rate of interest is currently only 5%.

a. What is the expected NPV for the project if Newport commits itself to the development, extraction, and sale of the copper today and sells the copper in the forward market?

b. What is the NPV of the project if the production is not sold forward and Newport subjects itself to the uncertainties of the copper market?

c. Using the decision tree on page 484, construct a diagram that describes Newport's payoff from the investment that includes the option to extract the ore at the end of one year.

d. What is the lease worth to Newport if it exercises its option to abandon the project at the end of year 1? Should the firm proceed with the development today?

e. If Newport decided to extract the ore itself, how could it use the copper call options to hedge the risk of mining for the copper? The price of a European call option on one pound of copper with an exercise price of \$1.68 and maturity of two years is \$0.70.

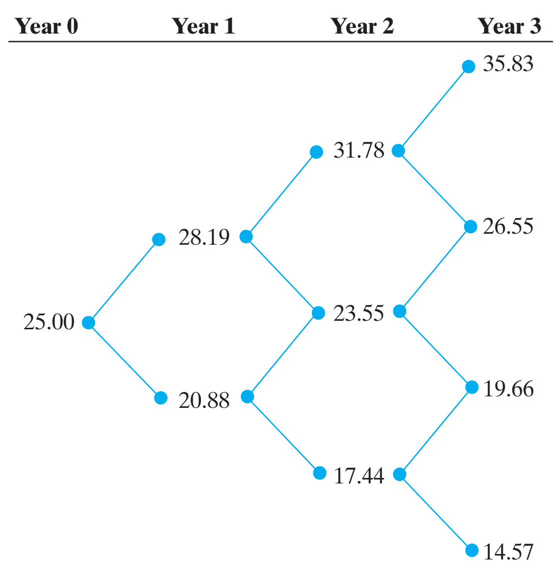
12-5 VALUING AN AMERICAN OPTION J&B Drilling Company has recently acquired a lease to drill for natural gas in a remote region of southwest Louisiana and southeast

Texas. The area has long been known for oil and gas production, and the company is optimistic about the prospects of the lease. The lease contract has a three-year life and allows J&B to begin exploration at any time up until the end of the three-year term.

J&B's engineers have estimated the volume of natural gas they hope to extract from the leasehold and have placed a value of $25 million on it, on the condition that explorations begin immediately. The cost of developing the property is estimated to be $23 million (regardless of when the property is developed over the next three years). Based on historical volatilities in the returns of similar investments and other relevant information, J&B's analysts have estimated that the value of the investment opportunity will evolve over the next three years, as shown in the figure on page 485. The risk-free rate of interest is currently 5%, and the risk-neutral probability of an uptick in the value of the investment is estimated to be 46.26%.

a. Evaluate the value of the leasehold as an American call option. What is the lease worth today?

b. As one of J&B's analysts, what is your recommendation about when the company should begin drilling?



12-6 OPTION TO SWITCH INPUTS—*CRYSTAL BALL* EXERCISE The Central and Southeast Power Company of Mobile, Alabama, is considering a new power plant that will allow it to switch between gas and oil. The company has a contract to provide it with gas for $8 that is sufficient to produce one unit of electric power. (The numbers are standardized to one unit for ease of computation.) However, the plant can also be run using fuel oil. The price of fuel oil is uncertain, and the firm's analysts believe that the uncertain future price can be characterized as a triangular distribution with a minimum value of $2, a most likely value of $7, and a maximum value of $12. Next year, the plant is expected to produce one standard unit of electrical power that can be sold for $10.

a. What is the expected cash flow from the power plant for next year if the cost of fuel is set equal to the minimum of the expected costs of gas and oil? (Hint: There are no taxes, and the only expenses that the plant incurs are for fuel.)

b. Construct a simple *Crystal Ball* simulation model for the plant's cash flow using a triangular distribution for the cost of fuel oil and selecting the minimum-cost source of fuel to run the plant. What is the expected cash flow from the power plant based on your simulation?

c. If the cost of capital for the plant is 10% and the cash flows for the plant are expected to be constant forever, what is the value of the plant?

12-7 REFINERY WITH THE OPTION TO SWITCH OUTPUTS—*CRYSTAL BALL* EXERCISE The Windsor Oil Company is considering the construction of a new refinery that can process 12 million barrels of oil per year for a period of five years. The cost of constructing the refinery is $2 billion, and it will be depreciated over five years toward a zero salvage value. The plant can produce either gasoline or jet fuel, and the product can be changed once each year based on the prices of the two products. The refinery can convert the 42 gallons of oil in one per barrel of crude into 90% of this quantity of gasoline, or 70% if jet fuel is produced. The residual can be sold but for no net profit.

Windsor's analysts characterize the distribution of gasoline prices for next year and each of the next five years using a triangular distribution that has a minimum value of $1.75 per gallon, a most likely value of $2.50, and a maximum of $4.00. They characterize the price per gallon of jet fuel using a triangular distribution with a minimum value of $2.50 per gallon, a most likely value of $3.25, and a maximum value of $5.00 a gallon. The price of crude is fixed via forward contracts over the next five years at $25 per barrel. Windsor also estimates that the cost of refining is equal to 35% of the selling price of the particular product being produced.

Windsor faces a 30% tax rate on its income and uses a cost of capital of 10% to analyze refinery investments. The risk-free rate is 5.5%.

a. What is the NPV of the refinery if it produces only jet fuel (because the revenues under this alternative are higher based on the most likely price)?

b. Construct a simulation model for the refinery, with the triangular distributions described above, that makes the price of gasoline and jet fuel random variables. What is the NPV of the refinery investment if the firm selects the higher-valued product to produce, based on the realized prices of gasoline and jet fuel?

12-8 CONCEPTUAL ANALYSIS OF REAL OPTIONS Highland Properties owns two adjacent four-unit apartment buildings that are both on 20,000 square feet of land near downtown Portland, Oregon. One of the properties is in very good condition, and the apartments can be rented for $2,000 per month. The units in the other property require some refurbishing and in their current condition can be rented for only about $1,500 per month.

Recent zoning changes, combined with changes in market demand, suggest that both lots can be redeveloped. If they are redeveloped, the existing units would be torn down and new luxury apartment building would be built on the site, with ten apartment units. The cost of the ten-unit building is estimated to be about $1.5 million, and each of the ten apartment units can be rented for $2,500 per month under current market conditions. Similar properties that have been refurbished are selling for ten times their annual rentals.

a. Identify the real option(s) in this example.

b. What are the basic elements of the option(s), that is, the underlying asset on which the option is based, the expiration date, and the exercise price?

c. Estimate the value of the option to develop the property. (Hint: Make any assumptions you must to arrive at an estimate.)

Constructing Binomial Lattices

The binomial option pricing model utilizes a binomial tree to specify the evolution of the value of the underlying asset through time. The tree begins with the current value of the underlying asset equal to S_0. In one period, the value is equal to either uS_0 or dS_0. Moreover, to ease the computational problem involved in evaluating the tree when there are many periods, it is now standard practice to restrict the price changes in the tree to be symmetrical, such that u equals $1/d$. This means that in the next period, the possible values are reduced to three: u^2S_0, udS_0, and d^2S_0. This version of the binomial tree is called a recombining binomial tree or a binomial lattice.

When the risk-neutral valuation approach is used to value options, we construct what is referred to as a risk-neutral binomial lattice, in which the expected return to the underlying asset is the risk-free rate, r, but the asset's volatility, σ, is the same as that of the risky asset.

To illustrate how u and d are determined, let's first assume that the asset is risk-free. In this setting, the value of the asset appreciates at the risk-free rate less any payout over the period. For example, the value of a share of stock will appreciate at the risk-free rate less the dividend yield, δ. If the stock were worth \$10.00 at the beginning of the period, the risk-free rate is 6%, and the dividend yield is 4%, then the value of the stock at the end of one period will be $\$10e^{.06-.04} = \$10.20$.[12] Thus, in the absence of uncertainty, we can now define u as follows:

$$S_1 = S_0e^{r-\delta}$$

Now we introduce uncertainty into S_1 using the annualized volatility of the returns to the asset, σ:

$$uS_0 = S_0e^{r-\delta}e^{\sigma} = S_0e^{r-\delta+\sigma} \quad \text{and} \quad dS_0 = S_0e^{r-\delta-\sigma}$$

Multiple Time Steps per Year

To this point, we have assumed that one period equals one year; however, this need not be the case. For example, if one period equals one month, then the risk-free rate, payout, and annual volatility have to be adjusted to reflect one-twelfth of a year; that is, the monthly volatility would be $\sigma\sqrt{\frac{1}{12}}$, and S_1 would become:

$$uS_0 = S_0e^{(r-\delta)\left(\frac{1}{12}\right)+\sigma\sqrt{\frac{1}{12}}} \quad \text{and} \quad dS_0 = S_0e^{(r-\delta)\left(\frac{1}{12}\right)-\sigma\sqrt{\frac{1}{12}}}$$

[12] For a commodity such as oil held in the tanks of a refinery or cattle in the feed lots of a meatpacker, the payout is referred to as a *convenience yield* because owning the physical commodity has value to the holder (e.g., it meets an inventory need) that is lost with the passage of time.

More generally, if there are n time steps per year such that each time step is of length $1/n$th of a year, we define the value of the underlying asset at the end of one time step as follows:

$$uS_0 = S_0 e^{(r-\delta)\left(\frac{1}{n}\right)+\sigma\sqrt{\frac{1}{n}}} \quad \text{and} \quad dS_0 = S_0 e^{(r-\delta)\left(\frac{1}{n}\right)-\sigma\sqrt{\frac{1}{n}}}$$

Building the Binomial Lattice for the National Petroleum Oil Field Investment

To implement the binomial option pricing model and thus value the National Petroleum Company's investment opportunity, we must first determine the future values of the drilling opportunity specified in the binomial lattice. We will specify these values using the procedure just discussed, and to do so, we need the following information:

a. The starting point for the value of the oil field investment opportunity today is \$42.034 million.
b. The risk-free rate of interest (r) is 6%.
c. The convenience yield (δ) is 7%.
d. The standard deviation (volatility) of the annual returns to the drilling investment (σ) is assumed to be .15.

Given this information, we can calculate the binomial distribution of values for the oil development project at the end of the first year as follows:

$$\text{High Value} = S_0 u \quad \text{where} \quad u = e^{r-\delta+\sigma}$$

or

$$\text{Low Value} = S_0 d \quad \text{where} \quad d = e^{r-\delta-\sigma}$$

Substituting for the determinants of u and d, we calculate the following

$$u = e^{r-\delta+\sigma} = e^{.06-.07+.15} = 1.1503 \quad \text{and} \quad d = .852$$

such that the two possible values for National's drilling opportunity at the end of year 1 are

$$S_0 u = \$42.03 \text{ million} \times 1.1503 = \$48.35 \text{ million}$$

and

$$S_0 d = \$42.03 \text{ million} \times .852 = \$35.82 \text{ million}$$

At the end of year 2, there are three possible valuations for the drilling opportunity, corresponding to the following sequence of events:

$$S_0 uu = \$42.03 \text{ million} \times 1.1503 \times 1.1503 = \$55.62 \text{ million}$$

$$S_0 ud = S_0 du = \$42.03 \text{ million} \times 1.1503 \times .852 = \$41.20 \text{ million}$$

$$S_0 dd = \$42.03 \text{ million} \times .852 \times .852 = \$30.51 \text{ million}$$

In year 3, the number of nodes expands to four, corresponding to $S_0 uuu$, $S_0 uud$, $S_0 udd$, and $S_0 ddd$. Figure 12-6 contains the completed binomial lattice for the National Petroleum drilling opportunity.

CHAPTER 13

Strategic Options: Evaluating Strategic Opportunities

Chapter Overview

This chapter offers three important lessons for corporate managers. First, when evaluating individual projects, the analyst should always be aware of the project's role in the firm's overall business strategy. What this means is that firms may not want to pass up what might at first appear to be a negative net present value (NPV) investment if the investment can be viewed as the first stage of a very promising strategy. Second, although the evaluation of a firm's strategy requires considerable judgment on the part of senior management, strategic decisions are not purely qualitative. Indeed, as we will show, the quantitative tools we have used to evaluate individual investment projects are also useful for evaluating investment strategies. And third, not all organizations have the same capabilities regarding the exercise of strategic options. Prior to embarking on a strategy with valuable embedded options, executives must determine as best they can whether their organizations will have the financial flexibility and the managerial wherewithal to exercise the options appropriately when the time comes.

13.1 Introduction

Faced with a saturated market for burgers in the United States, McDonald's Corporation changed its growth strategy in the 1990s to focus on global markets and now has restaurants in over 100 countries. Changing demographics produced another shift of focus in the 1990s toward developing new types of restaurants for the US market, including the acquisition of the Chipotle Mexican food restaurant chain in 1998.[1] Under McDonald's ownership, Chipotle had grown to more than 450 restaurants in twenty-two states by January 2006, when McDonald's spun off a significant portion of Chipotle's equity in an initial public offering (IPO).

McDonald's, like most successful companies, follows a flexible strategy that allows it to adapt to changing business conditions. Does this sound familiar? It should. McDonald's flexible strategy allows it to exercise important options that are

[1] Sandra Guy, "McDonald's Plans Big Chipotle Boost," *Chicago Sun-Times*, May 24, 2002.

embedded in the investments that it makes. Indeed, the original Chipotle acquisition included an important option to abandon the strategy if it proved to be unsuccessful, as well as options to speed up or slow down the rollout of new restaurants in the chain. The strategy could also have included options to redesign the restaurants, making them upscale by expanding the menu to include more expensive items or making them downscale by offering more affordable menu items.

In Chapter 12, we focused on the analysis of well-defined individual investment projects. In this chapter, we consider the murkier concept of corporate strategy. More specifically, we will discuss the evaluation of strategic opportunities. Such opportunities are less straightforward to evaluate than well-defined projects because the actual investments materialize out of initiating strategies that cannot be defined precisely and involve investments that take place in the distant future. For example, DuPont may want to expand its presence in the specialty chemical business in Brazil, or Toyota may decide that there are long-term opportunities to sell heavy-duty trucks in South America. These strategies have as their components individual investment projects (e.g., individual chemical plants or truck-assembly plants) that can be evaluated as we did in the previous chapters. However, these investments must also be evaluated within the context of an *overall* strategy that includes investments that may or may not take place in the future.

We begin the chapter with a brief discussion of the origins of positive NPV investments. Up to this point, we have taken the characteristics of the investments as given. The evaluation of an investment strategy, however, must examine the extent to which investment choices position the firm in ways that allow it to exploit investment opportunities in the future. In other words, we must consider not only the NPV of the individual investment but also the extent to which the investment creates opportunities, or options, to invest in the future.

To illustrate these ideas and to demonstrate how the value of these future opportunities can be quantified, we will consider a detailed example of an investment strategy involving the construction of a series of coal-fired power plants. The plants utilize a green (environment-friendly) strategy in the form of a new, clean-burning technology for controlling plant emissions. Although the initial plant is a negative NPV project, it enables the firm to launch what may be a promising strategy of building successive plants, that may become profitable as the technology and construction methods improve. Within the context of this example, we will show how companies can use the real option analysis developed in the last chapter to evaluate a business strategy.

13.2 Where Do Positive NPV Investments Come From?

Good investment opportunities do not simply fall from the heavens. In fact, projects with positive NPVs all share one common characteristic: They leverage some type of *comparative advantage* that the investing firm has over its competitors. The advantage for the firm could be, among others, the ability to produce a product more cheaply, exclusive access to customers, or strong brand recognition that allows the firm to charge a premium for its products and services. Whatever the source, every project must be founded on some type of comparative advantage in order to be successful.

But where do these capabilities come from? One possibility is that they come from more-capable managers, which is, of course, a correct but not particularly helpful observation. Alternatively, we can view these capabilities as synergies with the firm's existing businesses that arise because the firm's organization has developed better know-how and better business relationships from past experiences. In other words, opportunities today are likely to have arisen from investment choices that were made in the past. Viewed from this perspective, we can define a good strategic opportunity as *an investment that enhances a firm's capabilities,* generating comparative advantages that create positive NPV investment opportunities in the future.

Did You Know?

Who Is the Largest Automaker?

Since establishing manufacturing operations in the United States, Toyota (soon to be the number-one automaker in the world) has steadily increased its market share while US automakers have lost market share. Specifically, Toyota sat atop the list of automakers for the second year in a row with over 10 million units produced in 2012, followed by General Motors (GM) with just over 9 million units, and third place went to Germany's Volkswagen (VW) with 9 million units. Although GM's production rose modestly in 2012 over 2011 by 2.5%, Toyota sales jumped 25%.

Sources: Douglas A. McIntyre, Thomas C. Frohlich, and Alexander E. M. Hess "The World's Largest Automakers," September 13, 2013. http://247wallst.com/special-report/2013/09/13/the-worlds-largest-automakers/3/ and autoblog http://www.autoblog.com/2014/01/26/toyota-worlds-largest-automaker-2014/.

If positive NPV investments do in fact come from capabilities that are developed as a result of prior investments, then it is important that when evaluating an investment opportunity we account for two factors: (1) how the investment contributes directly to the firm's cash flows, as well as (2) how the investment contributes to the firm's capabilities. For example, does the investment provide access to new markets that can be exploited in other ways? Does the investment allow the firm to build business relationships or create alliances that are likely to be valuable in the future? Does the investment generate new technologies that can be applied to other businesses in the future?

It is not difficult to come up with examples of investment projects that create capabilities that are likely to be exploited in subsequent projects. This is frequently true whenever a firm enters a new market. For example, when Toyota initially started assembling its Camry line of automobiles in the United States (the plant was located in Georgetown, Kentucky, and opened production in 1988), significant costs made the startup assembly plant very costly. However, this initial experience made it easier for Toyota to get permits and attract workers as it added an additional eleven plants by 2005. Moreover, Toyota's expanded presence in the United States, and the fact that Toyota was employing US workers, may have enhanced the Toyota brand in the US market, making it easier for Toyota to sell cars here—even cars built in Japan. In summary, the original Kentucky plant contributed to the value of Toyota by enhancing the firm's capabilities in a way that allowed it to initiate subsequent positive NPV investments.

A second example is Walmart's foray into the grocery business. Walmart's ability to enter this business would not have been possible if it had not first acquired the expertise to mass-market merchandise from its years as a discount retailer. Despite Walmart's expertise, however, it is unlikely that its initial investment in the grocery business was a positive NPV investment if viewed in isolation. Rather, the initial investment was probably viewed as a learning experience that gave the organization the expertise to pursue a much larger investment in this business if the opportunity looked sufficiently attractive. In other words, the initial stores could be viewed as an investment that gave Walmart the option, but not the obligation, to enter a very large grocery market.

13.3 Valuing a Strategy with Staged Investments

It is useful to start our discussion by looking at the movie business and considering an important difference between romantic comedies and superhero action movies. Although these movie genres differ along a number of dimensions, from our perspective, the relevant difference is that successful superhero movies (for example, those featuring Spiderman, Batman, and Superman) result in sequels, but romantic comedies generally do not. Hence, a romantic comedy can be evaluated as a single investment with traditional discounted cash flow (DCF) analysis. However, if you want to evaluate the script of, say, a Ratman action movie (e.g., a bizarre lab experiment creates a super-strong and intelligent rat that fights crime, trades options, and gets the girl), then you must evaluate an overall strategy because in the unlikely event that the movie is successful, there will be sequels, cartoons, toys, and so on. What this means is that a studio may be willing to produce the Ratman movie, even if its NPV is negative, because by producing the movie, the studio is in effect buying an option on a series of future projects.

The example that follows illustrates the distinction between a single investment and an investment strategy, and demonstrates that in some situations, companies should take on negative NPV projects because doing so allows them to initiate a positive NPV strategy. This example also illustrates three of the most important characteristics of a good investment strategy:

- First, the strategy allows the firm to develop relatively unique capabilities that cannot be replicated easily by competitors.
- Second, the strategy can be abandoned in later stages if economic conditions turn out to be unfavorable.
- Third, the strategy can be scaled up in later stages if economic conditions turn out to be favorable.

Did You Know?

How Does Walmart Rank As a Grocer?

Walmart began selling groceries in its stores in 1988, and by 2002, it was the nation's leading grocer, with more than $53 billion in grocery sales.

Source: Patricia Callahan and Ann Zimmerman, "WalMart, After Remaking Discount Retailing, Now Nation's Largest Grocery Chain," *Wall Street Journal,* May 31, 2003.

Description of Vespar's New Coal Technology

Vespar Energy Inc. is a (hypothetical) Houston-based diversified energy company. It has acquired a new green technology for generating electricity using high-sulfur-content coal that pollutes substantially less than other coal-burning technologies. Typically, coal-fired plants that use low-quality soft coal must have very expensive antipollution equipment, called scrubbers, to reduce the pollutants they emit into the atmosphere. Vespar's proprietary technology promises to reduce these costs dramatically.

Because the technology is new, Vespar anticipates that it will not be able to capture the cost-savings potential of the new technology in the first plant it builds. Instead, the company will need to develop capabilities and knowledge through the construction and operation of multiple plants over several years. In fact, by Vespar's calculations, the first plant clearly has a negative NPV when viewed in isolation. However, the company wants to view this plant as part of a larger strategy, and the challenge facing management is the evaluation of this larger strategy. Let's look at the analysis first in isolation and then as part of an overall strategy.

Stand-Alone Project Analysis of the Initial Plant

Panel (a) of Table 13-1 presents Vespar's estimates of the revenues, expenses, and cash flows of the initial power plant. An analysis of the present value of the plant's cash flows based on an 8% cost of capital indicates that the plant should be valued at $320 million. However, the company's analysts have estimated that the cost of building the first plant is approximately $450 million, which means that the NPV of the initial plant turns out to be negative (i.e., −$130 million).

Panel (b) of Table 13-1 shows sensitivity analysis of the several key drivers of the project's NPV. This analysis suggests that very dramatic changes in the anticipated values of the key value drivers are needed to produce even a zero NPV for the plant. For example, the cost of capital would have to be reduced from 8% to 2.33% (about 71%) before the project would offer a zero NPV. Alternatively, a zero NPV can be achieved if the variable operating expenses are reduced to 93.47% of their expected value.

The key observation we can make at this point is the following: As a stand-alone project, the clean coal-fired plant is clearly unacceptable. But what if the project is viewed as the first stage of an investment strategy?

Analyzing Projects As Part of a Strategy

The Vespar executives proposing the plant argue that the firm should take the investment, despite its negative NPV, for *strategic* reasons. They maintain that by being an early mover with this technology, Vespar will achieve significant cost advantages relative to its competitors, and with these cost advantages, the firm will be very well positioned to generate significant profits in the future if market conditions change in a way that favors coal-generated electricity. The CEO finds this strategic argument somewhat convincing but is unwilling to invest several hundred million dollars based only on an analysis that, although it sounds plausible, is not backed up by hard numbers.

In response to the CEO's request, the managers proposing the project develop a more detailed strategic analysis. Specifically, they explicitly consider the possibility of constructing a series of power plants over the next four years, beginning with the initial plant this year. As the managers explain, each year can be viewed as a separate phase of the strategy's rollout because the firm will reevaluate its plans annually before launching the construction of more plants. The plan recognizes that at the end of each of the next four years, the firm has the option, but not the obligation, to continue with its strategy. As we will see, the value created by this strategy comes from these options.

Details of the Plan

When evaluating an investment strategy, analysts need to make a number of assumptions. For example, the analysts know that the costs of building the plants will decline significantly as they gain experience, but they do not know exactly how much the cost per plant will decline. They also know that they will be able to ramp up the building process, but this is also a function of unknown economic conditions that are difficult to predict. Having the judgment to make assumptions about these unknowns is the art of evaluating a strategy.

Vespar's executives must first make assumptions about the firm's ability to build these plants in the future. Specifically, based on discussions with their engineers, they assume that the engineering staff will have its hands full designing and constructing one plant in the first year (year 0) of the strategy. When this plant is completed, however,

Table 13-1 NPV Analysis of Building the First Coal-Fired Power Plant

Panel (a) Cash Flow Projections

	1	2	3	4	5	6	7	8	9	10
Revenues	$ 500,000,000	$ 507,500,000	$ 515,112,500	$ 522,839,188	$ 530,681,775	$ 538,642,002	$ 546,721,632	$ 554,922,456	$ 563,246,293	$ 571,694,988
Operating and maintenance (includes fuel)	(434,671,731)	(431,843,463)	(429,015,194)	(426,186,926)	(423,358,657)	(420,530,388)	(417,702,120)	(414,873,851)	(412,045,582)	(409,217,314)
Fixed operating expenses	(95,000,000)	(95,000,000)	(95,000,000)	(95,000,000)	(95,000,000)	(95,000,000)	(95,000,000)	(95,000,000)	(95,000,000)	(95,000,000)
Earnings before interest and taxes (EBIT)	$ (29,671,731)	$ (19,343,463)	$ (8,902,694)	$ 1,652,262	$ 12,323,118	$ 23,111,614	$ 34,019,512	$ 45,048,605	$ 56,200,711	$ 67,477,674
Less: taxes	8,901,519	5,803,039	2,670,808	(495,679)	(3,696,936)	(6,933,484)	(10,205,854)	(13,514,582)	(16,860,213)	(20,243,302)
Net operating profit after taxes (NOPAT)	$ (20,770,212)	$ (13,540,424)	$ (6,231,886)	$ 1,156,583	$ 8,626,183	$ 16,178,130	$ 23,813,659	$ 31,534,024	$ 39,340,498	$ 47,234,372
Plus: depreciation expense	45,000,000	45,000,000	45,000,000	45,000,000	45,000,000	45,000,000	45,000,000	45,000,000	45,000,000	45,000,000
Less: capital equipment (CAPEX)	(5,000,000)	(5,075,000)	(5,151,125)	(5,228,392)	(5,306,818)	(5,386,420)	(5,467,216)	(5,549,225)	(5,632,463)	(5,716,950)
Firm free cash flow (FCF)	$ 19,229,788	$ 26,384,576	$ 33,616,989	$ 40,928,191	$ 48,319,365	$ 55,791,710	$ 63,346,442	$ 70,984,799	$ 78,708,035	$ 86,517,422
Present value of firm free cash flows	$ 320,000,000									
Less: construction costs	(450,000,000)									
Net present value	$ (130,000,000)									

Panel (b) Breakeven Sensitivity Analysis

Value Driver (Variable)	Requisite Change to Make NPV = 0 (Holding All Else Constant)
Cost of capital (8%)	Reduce by 71% to 2.33%.
Operating and maintenance expenses	Decrease to 93.47% of projected totals.
Annual rate of decrease in operating and maintenance expenses	Increase the rate of decline in operating and maintenance expenses through time by a factor of 3.
Fixed operating expenses	Decrease by 26,131,521 million to $68,868,479 (a decrease of 27.5%).
Revenues	Increase the level of revenues across all years by 5%.

Table 13-2 Vespar's Power Plant Rollout Strategy

Rollout Phase of the Strategy (Construction Beginning in Year x)	Estimated Cost of Plant Construction (per Plant)	Number of Plants to Be Built
Phase I (year 0)	$450 million	1 plant
Phase II (year 1)	$375 million	2 plants
Phase III (year 2)	$350 million	2 plants
Phase IV (year 3)	$320 million	6 plants
Phase V (year 4)	$320 million	6 plants

the engineers believe that they can build two plants simultaneously in year 1, two more plants in year 2, and by year 3 they can ramp up to build six plants per year. Moreover, the analysts estimate that, with the benefit of their greater experience as well as economies of scale associated with building multiple plants, the cost of constructing each successive plant will decline over time. The assumed per-plant construction costs are summarized in Table 13-2.

Note that the cost estimates for the plants are based on the assumption that all plants are built in sequence. The learning that takes place during constructing and operating the early plants is what reduces the cost of construction over time.

The investment strategy described in the above table can be evaluated in terms of a sequence of options using the following four-step procedure:

Step 1	Use simulation to model the underlying uncertainty in power plant values (i.e., volatility).
Step 2	Use the estimated volatility to construct a binomial lattice of power plant values spanning the strategic planning horizon.
Step 3	Determine when the strategy should be abandoned and when it should be continued.
Step 4	Assess the value of the strategy.

Step 1: *Use simulation to model the underlying uncertainty in power plant values (i.e., volatility)*. The first step is to estimate how the values of power plants are expected to evolve over time. To do this, we will use simulations, as described in Chapter 3, to estimate distributions of possible power plant values. In our analysis, we assume that primary value drivers come from external forces that affect the value of a coal-fired electric power plant. Examples of these value drivers include (1) coal and alternative energy prices, (2) pollution laws that affect the costs of competing technologies, (3) economic conditions that affect the overall demand for electrical power, and (4) the entrance of potential competitors who might be developing similar technologies.

The goal of this exercise is to identify the value drivers, determine their volatility, and then determine how the volatility of the value drivers translates into the volatility of power plant values. Although the process used to simulate these values can be quite detailed, the general procedure can be summarized as follows.

First, we specify a model of power plant cash flows that incorporates consideration for the various sources of uncertainty. We then take the initial values of these uncertain variables and calculate the value of a power plant, as we have in our estimate of the first power plant in Table 13-1. We then simulate how these economic variables may change over time and the way in which these changes will affect how the value of the power plants evolves over the next four years. By running 10,000 iterations of the simulation experiment, we can estimate the volatility of the year-to-year changes in power plant values.

Step 2: *Use the estimated volatility to construct a binomial lattice of power plant values spanning the strategic planning horizon.* We use the volatility estimate and the procedure discussed in the appendix to Chapter 12 to construct a binomial lattice that summarizes the value of a power plant at the end of each year in the planning horizon. What we are doing is taking a relatively complex distribution of future values and summarizing it with a simpler distribution that will be easier to work with. The objective of our analysis at this point is to develop a binomial lattice that provides a reasonable representation of the uncertainty in the value of future power plants.

Step 3: *Determine when the strategy should be abandoned and when it should be continued*. We calculate the NPV of constructing a new plant at each node in the lattice as the difference between the value of a plant and the cost of constructing it. The value of continuing the strategy is the value of building the new plant plus the expected value of continuing the strategy until the next period. The expected value of continuing the strategy is never negative because the firm always has the option to abandon the strategy in the future if it has a negative value. This means that one will never turn down a positive NPV project for strategic reasons. The interesting cases that we will consider are ones where the current plants have negative NPVs but the strategy has a positive expected value.

Step 4: *Assess the value of the strategy*. Once we have analyzed each node in the decision tree to determine when it is optimal to abandon, we are ready to place a value on the investment strategy.

We will not provide the details of the simulation described in step 1 but will instead focus on the end product of this exercise, described in step 2, which consists of the expected present values of the power plant cash flows (i.e., estimated plant values) at each node in the binomial lattice. These estimates, described in panel (a) of Table 13-3, illustrate that these values are quite uncertain over the four-year planning horizon. For example, in the most favorable node in year 4, the present value of the expected cash flows generated from clean-coal plants is $467.93 million. However, this is clearly a very rosy picture, and nodes where power prices are low and the clean-coal plants have values less than $300 million are also quite possible.

A Naïve, Static Analysis of the Value of Vespar's Strategy

Before carrying out steps 3 and 4 of our valuation procedure, we first calculate the NPV of the strategy with the traditional (naïve) approach. This approach assumes that the strategy cannot be abandoned, which means that if it is initiated in year 0, it will be carried out at all nodes of the binomial lattice. The relevant cash flows in this NPV analysis are the average of the NPVs of the power plants that are built in each year (averaged across all possible nodes). Intuitively, we are valuing the strategy as if Vespar sells the power plants after they are built for the present values of their cash flows, thereby generating a cash flow to Vespar equal to the NPVs of the power plants. These cash flows are then discounted to the present to determine the NPV of the strategy in year 0.

Panel (b) of Table 13-3 calculates the NPVs of the power plants that are built in each node by subtracting the plant construction costs from the present values of the plant's future cash flows and multiplying this difference by the number of power plants built each year. Based on these numbers, we can calculate the NPV that we expect to generate in each year of the strategy. The expected NPVs in each year are calculated by weighting the NPVs of the power plants in each node by the probability of reaching that node and calculating the weighted average. We assume that, at each node, the probability of moving either up or down in value is 50% (see the second footnote in Table 13-3). For example, in year 1, the expected NPV is −\$98.25 million, which represents a probability-weighted average of the two possible NPV outcomes for that year.

From Table 13-3, we see that in the initial years of the strategy's rollout, the expected NPVs are negative. However, over time, as the cost of developing the plants declines, the NPVs become positive. Specifically, we see that the expected values in years 0 through 4 are −\$130 million, −\$98.25 million, −\$36.28 million, \$107.73 million, and \$144.96 million, respectively. In year 3, the NPV becomes positive. However, discounting these expected NPVs back to the present using the 8% cost of capital that Vespar uses for projects of this type yields an estimated value for the naïve strategy of negative \$60.01 million. This large negative NPV indicates that if the strategy is inflexible, as the above analysis assumes, the company should not undertake it.

An Option Pricing Approach for Evaluating Vespar's Strategy

We learned in Chapter 12 that the option to abandon an investment can provide an important source of value. The naïve analysis that we just did accounted for the fact that the scale of the project could be increased (in fact, it assumed that the scale increased regardless of the value of the plant in the future). However, the analysis ignored the possibility that the strategy could be abandoned in situations where the outlook was especially unfavorable. In this section, we will explicitly consider this abandonment option.

To value the option to abandon the strategy, we must first determine *when* the strategy should, in fact, be abandoned. Our analysis of this decision closely follows our analysis of the abandonment decision in Chapter 12. As a first step, we change the probabilities of reaching each node in the binomial tree found in panel (a) of Table 13-3 from the actual probabilities to the risk-adjusted (i.e., risk-neutral) probabilities so that we can calculate certainty-equivalent rather than expected cash flows. Assume specifically that the risk-neutral probability of the up state is 0.48 and that the probability of the down state is 0.52. Note that increasing the probability of the low state and decreasing the probability of the high state converts the expected cash flows to certainty-equivalent cash flows that should be discounted using the risk-free rate of interest of 5% rather than the 8% risk-adjusted rate that was used in the last section.

To value the strategy at the current date, we must first determine the value of the strategy at each node in the binomial lattice, as we did in Chapter 12, by solving the tree

Table 13-3 Naïve Analysis of Vespar's Investment Strategy

Panel (a) Present Values of Future Plant Cash Flows ($ Millions)

	Years 0	1	2	3	4
The number at each node represents the present value of the expected future cash flows resulting from building and operating a single power plant in that year.					$467.93
				$425.52	
			$386.96		398.74
		$351.89		362.61	
	$ 320.00		329.75		339.79
		299.86		308.99	
			280.99		289.55
				263.31	
					246.74

Panel (b) Net Present Values of Each Phase of the Investment Strategy* ($ Millions)

	Years 0	1	2	3	4
The number found at each node represents the sum of the NPVs of all the plants constructed in each year. The present values of the future cash flows for each plant in each phase are found in panel (a) above, and the number of plants built and the cost of each are found below—e.g., for the highest-value node in year 4:					$887.59
				$633.14	
			$ 73.92		472.47
		$(46.22)		255.65	
	$(130.00)		(40.51)		118.73
		(150.28)		(66.04)	
			(138.02)		(182.71)
$\text{NPV} = (\$467.93\text{ m} - \$320\text{ m}) \times 6$				(340.16)	
$= \$147.93\text{ m} \times 6 = \$887.59\text{ m}$					(439.58)
Number of plants to be built	1	2	2	6	6
Cost of constructing each plant	$ 450	$ 375	$ 350	$ 320	$ 320
Expected NPVs for each phase†	$(130.00)	$(98.25)	$(36.28)	$107.73	$144.96
PV (year 0) of annual expected NPVs‡	$(130.00)	$(90.97)	$(31.10)	$ 85.52	$106.55
Value (naïve estimate) of the strategy§	**$ (60.01)**				

backward, step by step. We start by calculating the values of the strategies at each of the nodes at the end of year 4 and work back to today. Panel (a) of Table 13-4 contains these values. For example, in year 4, the value of the strategy generated by the six power plants built in that year is simply the sum of the NPVs of the power plants built at that date if the NPV is positive and zero otherwise (because at the last date, negative NPV

Table 13-3 *continued*

*The NPV at each node in the tree is calculated as follows:

$$\text{NPV} = \left(\begin{array}{c}\text{Value of}\\ \text{Plant Future}\\ \text{Cash Flows}\end{array} - \begin{array}{c}\text{Cost of}\\ \text{Constructing}\\ \text{a Plant}\end{array}\right) \times \begin{array}{c}\text{Number of}\\ \text{Plants Built}\\ \text{in the Period}\end{array}$$

†The expected NPV for each year is calculated as a weighted average of the possible NPVs using the estimated probability of an up or down value for the future cash flows. In this instance, management estimates the probability of an up and down move in value of project cash flows to equal 50%. Thus, for year 2, the expected NPV $= .5 \times (\$46.22\text{ m}) + .5 \times (\$150.28\text{ m}) = (\$98.25\text{ m})$. The probabilities associated with each node in the tree are found below:

Years				
0	**1**	**2**	**3**	**4**
				6.25%
			12.50%	
		25.00%		25.00%
	50.00%		37.50%	
100.00%		50.00%		37.50%
	50.00%		37.50%	
		25.00%		25.00%
			12.50%	
				6.25%
100%	100%	100%	100%	100%

‡PV of the annual NPVs equals the present value today of the expected NPVs of the five phases of the investment strategy (e.g., for phase I, the present value is equal to $(\$98.25\text{ m})/(1.08)^1 = (\$90.97\text{ m})$.

§The value of the strategy is equal to the sum of the present values of all the NPVs for each of the five phases of the strategy rollout corresponding to years 0 through 4.

power plants will not be built). Hence, as we see in panel (a) of Table 13-4, the strategy generates positive values in the three highest-value nodes in year 4 but generates zero value in the two lower-value nodes in which the NPVs of constructing the plants are negative (panel [b] of Table 13-3). Given these year 4 values, we can now calculate the values of the strategy for each node in year 3.

Table 13-4 Dynamic Analysis of Vespar's Investment Strategy

Panel (a) Value of Continuing to Invest ($ Millions)

	Years				
	0	**1**	**2**	**3**	**4**
Each node contains the discounted value of investing in the subsequent period (weighted by the risk-neutral probability of each node) plus the NPV of investing in that current period.					$887.59
				$1,272.11	
			$916.97		472.47
		$472.15		530.10	
	$85.59		201.53		118.73
		0		0	
			0		0
				0	
					0

Panel (b) Net Present Values of Each Phase of the Investment Strategy* ($ Millions)

Phase of the strategy rollout	**I**	**II**	**III**	**IV**	**V**
Year	**0**	**1**	**2**	**3**	**4**
The value in each node is the NPV of investing in the plants built in that period or zero if continuing to invest is not optimal. The nodes in which the strategy is abandoned are determined in panel (a).					$887.59
				$633.14	
			$ 73.92		472.47
		($46.22)		255.65	
	($130.00)		(40.51)		118.73
		0		0	
			0		0
				0	
					0
Expected NPVs of initiated plants	($130.00)	($23.11)	($1.77)	$175.01	$218.11
PV of annual NPVs (year 0)*	(130.00)	(20.03)	(1.33)	113.91	123.04
Value of the strategy (year 0)	$ 85.59				

Panel (c) Sensitivity of the Value of the Investment Strategy to the Discount Rate

Discount Rate (k_{WACC})	Value of the Strategy in Year 0
10.0%	$127.99 million
15.0%	88.34 million
20.0%	55.97 million

*The discount rate used here is 15.39% and is calculated as the rate that, when used to discount the expected NPVs of all five phases of the strategy back to the present, results in a value of $85.59 (the value estimated using the binomial option valuation method). Because the discount rate cannot be known until we have estimated the value of the strategy using the option pricing approach, the DCF analysis is strictly a tool for presenting the strategy valuation to company executives using a methodology with which they are familiar.

The value of the strategy at each node in year 3 is equal to the sum of the NPVs of the plants built in year 3 plus the present value of the payoffs to the strategy in year 4. For example, consider the highest-value node in year 3, where the value of the strategy equals \$1,272.11 million. This value is calculated as follows:

$$\begin{array}{c}\text{Value of the Investment}\\ \text{Strategy in Highest-Value}\\ \text{Node of Year 3}\end{array} = \begin{pmatrix}\text{NPV of Plants}\\ \text{Built in}\\ \text{Year 3}\end{pmatrix} + \begin{pmatrix}\text{Present Value}\\ \text{of Certainty-Equivalent}\\ \text{Value of NPVs in Year 4}\end{pmatrix}$$

$$= \$633.14 \text{ million} + e^{-.05}(\$887.59 \text{ million} \times .48 + \$472.47 \text{ million} \times .52) = \$1{,}272.11 \text{ million}$$

Obviously, the investment in the six new plants *should* be made at the end of year 3 if the highest-value node is reached.

Let's now consider the lowest-value node found in year 3. In this node, the NPV of building six new plants (panel [b] of Table 13-3) is negative (that is, −\$340.16 million). Consequently, the only way that Vespar should build these plants is if the discounted value of the certainty-equivalent NPVs in year 4 is greater than \$340.16 million. However, the possible NPVs for investments in year 4, following a realization equal to the lowest-value node in year 3, are both negative. Consequently, Vespar should abandon the strategy if this low-value node is reached in year 3. One can similarly show that the strategy should be optimally abandoned in the second-to-lowest node in year 3 and, as a consequence of the abandonment in these two lowest nodes in year 3, the strategy should also be abandoned in the lowest node in year 2.

The middle node in year 2 deserves special attention. In this node, the NPV of the plants that are built in year 2 is negative \$40.51 million (panel [b] of Table 13-3). Because there is a possibility of building very high NPV plants in the future, however, the firm should not abandon the strategy in this situation. Following the procedure used earlier to analyze the highest-value node for year 3, we estimate the value of the strategy at this node (i.e., the NPV of the plant investments plus the present value of the certainty-equivalent value of the plant NPVs built in year 3) to be \$201.53 million (panel [a] of Table 13-4):

$$\begin{array}{c}\text{Value of the Investment}\\ \text{Strategy for Middle Node}\\ \text{in Year 2}\end{array} = \begin{pmatrix}\text{NPV of Plants}\\ \text{Built in}\\ \text{Year 2}\end{pmatrix} + \begin{pmatrix}\text{Present Value}\\ \text{of Certainty-Equivalent}\\ \text{Value of NPVs in Year 3}\end{pmatrix}$$

$$= (\$40.51 \text{ million}) + e^{-.05}(\$530.1 \text{ million} \times .48 + \$0 \text{ million} \times .52) = \$201.53 \text{ million}$$

After rolling back all the branches of the decision tree, we find that the value of the investment strategy at the current date (i.e., in the year 0 node) is \$85.59 million. Consequently, the strategy has significant value, even though the plants built today and in year 1 (phases I and II) all have negative NPVs. The negative NPVs associated with the initial investments can be viewed as the cost of buying an option to continue a strategy that can potentially create significant value in the future. The strategy will not generate positive NPV investments with certainty. In some future nodes, the NPVs are very negative and the strategy will be abandoned. Indeed, this option to abandon the strategy is what generates its positive value. Without the abandonment option, the strategy has a negative \$60.01 million value, as we calculated using the naïve or static analysis (shown in panel [b] of Table 13-3), but with the option, it has a positive value of \$85.59 million, calculated using the dynamic analysis (shown in Table 13-4).

Recapping the Analysis of the Vespar Strategy

It is useful to step back momentarily and reconsider the four-step procedure that we have just described. We started by simulating the cash flows under a wide variety of scenarios to estimate the volatility of future green coal-fired plant values. We then used this volatility estimate to create a binomial lattice that summarizes the future distribution of these values. Reducing the number of scenarios to those specified in the binomial lattice made it easier for us to describe the underlying uncertainty in the value of a coal-fired plant, which in turn allowed us to determine the scenarios in which it would be optimal to abandon the strategy. After determining the situations in which the strategy is abandoned, we worked back through the binomial tree to solve for the value of the strategy.

Using DCF Analysis to Estimate the Value of Vespar's Strategy

To clarify our analysis, it is generally useful to translate the options-based analysis of Vespar's strategy into the language of traditional DCF analysis. In addition to making it easier to communicate the analysis to other executives, it may facilitate a comparison with other strategies. To do this, we recommend that the analyst use the dynamic analysis as a guide to determine conditions under which the strategy should be abandoned. Given these prespecified abandonment nodes, we can then estimate the expected NPV of the power plants that are built in each year by computing the average of the NPVs found in each node where the strategy is not abandoned and setting the NPVs to zero in those nodes where the strategy is abandoned. Once the expected NPVs for each year have been calculated, we can estimate the value of the strategy by discounting them back to the present using an appropriate discount rate.

The DCF approach thus requires that an appropriate discount rate be specified. We suggested earlier that the appropriate cost of capital for building one power plant is 8% and used this same 8% to discount the cash flows of the naïve strategy. This assumes implicitly that the risks of the strategy and the individual power plants are equivalent, which is quite unlikely. Clearly, an investment strategy that involves building multiple plants over several years is much riskier than an 8% discount rate would suggest. For example, in panel (b) of Table 13-4, we see that the rollout of phases I and II of the strategy (in years 0 and 1) call for the commitment of \$1.2 billion for the construction of three power plants,[2] all of which have negative NPVs, in the hope that a favorable outcome will occur in year 2.

Panel (b) of Table 13-4 provides a DCF analysis of the proposed investment strategy, which assumes that management has specified that the investment strategy be abandoned *in exactly those nodes* where our option pricing analysis indicates that the strategy should optimally be abandoned. The expected NPV of the plants built in each phase of

[2] The plan calls for one plant in year 1 costing \$450 million and two plants in year 2 that cost \$375 million each, for a total of \$1.2 billion.

the strategy is found in panel (b) of Table 13-3. For example, these NPVs take on two values in year 1 (phase II)—($46.22) million and $0.00—each with a 50% probability, which implies that the expected NPV generated in phase II is ($23.11). Similarly, we can calculate the expected values generated in phases III through V as ($1.77 million), $175.01 million, and $218.11 million, respectively.

To calculate the NPV of the entire strategy, we must specify an appropriate discount rate. In panel (c) of Table 13-4, we calculate the NPV of the strategy using discount rates of 10%, 15%, and 20%. In each case, we find that the NPV of the strategy is significantly positive, indicating that the IRR of the strategy exceeds 20% In addition, we can calculate the discount rate that makes the discounted sum of the expected NPVs for each of the phases of the rollout of the strategy equal the $85.59 million value we estimated in panel (a) using the option valuation method. The discount rate that solves this problem is 15.39%, which means that the option pricing approach assumes implicitly that the appropriate discount rate for evaluating the strategy is 15.39%, which seems about right given the risk of the strategy.

The Anatomy of Vespar's Power Plant Strategy

Because this analysis required a number of assumptions, most executives would not approve the strategy based on the preceding analysis without considerable sensitivity analysis. Before doing the sensitivity analysis, however, it is useful to step back and consider the features of the power plant strategy that make it attractive. The strategy is clearly very risky, but Vespar has the flexibility to alter the strategy in ways that make the uncertainty an advantage rather than a disadvantage. First, the strategy can be abandoned in those unfavorable scenarios where present and future investment alternatives are not likely to be attractive. Second, the strategy is scalable. Because Vespar can scale up its development efforts and build up to six new power plants in those scenarios where it is attractive to do so, it generates very high NPVs in the most favorable nodes in years 4 and 5. We use sensitivity analysis to investigate the economic importance of these features.

Sensitivity Analysis of Vespar's Power Plant Strategy

Our analysis of Vespar's strategy for investing in clean-burning coal-fired power plants is based on a number of assumptions that ultimately determine whether the firm should proceed. Consequently, the next stage in the analysis involves an investigation of the impact of the individual assumptions on the final decision to commit to the investment strategy. We explore these assumptions in much the same way that we did earlier for the single-plant investment: Next, we perform breakeven sensitivity analysis for each of the key value drivers individually. We follow that with the construction and analysis of a simulation model that incorporates multiple sources of uncertainty simultaneously.

Sensitivity Analysis of the Strategy One Variable at a Time

The first driver to consider involves the *timing* of the investment strategy. What will happen if the planned ramp-up of the strategy cannot be accomplished in the four-year time frame?[3] Specifically, we will consider the possibility that Vespar reduces the number of plants that can be built in years 3 and 4 from six and six to three and four, respectively. If this is the case, the value of the strategy drops dramatically, from $85.59 million to a negative $9.71 million—a decline of $95.3 million![4] Obviously, it is critical that Vespar be able to achieve the planned number of new plants by years 3 and 4, when the strategy becomes value-enhancing.

A second consideration that is potentially very important to the analysis is the *cost* of constructing each new plant at each phase of the rollout process. Up until this point in our analysis, we treated these construction costs as if they were known. To gain some perspective on the importance of the uncertainty about these costs, we consider how big a cost overrun the strategy could withstand before the value of the strategy drops to zero. To do this, we consider the possibility that the cost of constructing plants throughout the rollout of the strategy is increased by 5%. When this is the case, the value of the strategy declines to negative $25.7 million. If we solve for the breakeven cost–overrun percentage, we find that the costs of construction for all of the plants can rise by only 3.98% before the value of the strategy becomes negative. Obviously, the value of the strategy is quite sensitive to the costs of constructing the new plants. Consequently, the expenditure of time and resources refining these estimates is probably warranted.

The remaining value driver we consider in our sensitivity analysis is the *distribution of future plant values,* which were described in the binomial lattice found in panel (a) of Table 13-3. Specifically, we consider how the value of the strategy changes if uncertainty about future plant values changes. The plant values specified in our original binomial tree reflect a volatility estimate of .08.[5] If this volatility drops to .0462, the NPV of the investment strategy drops to zero; if the volatility drops to .04, the value of the strategy declines to a negative $15.56 million. If the volatility of plant values is increased to .10, however, the value of the strategy rises to $139.64 million. The key insight here is that higher volatility significantly increases the upside potential for the investment strategy but, because of the option to abandon, has much less of an effect on the downside. Once again, the sensitivity of the strategy's value to the volatility measure suggests that significant time and energy be spent in evaluating this estimate.

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[3] Recall that the cost estimates for the plants deliberately assume that all plants are built in sequence because it is through the learning that takes place in constructing and operating the plants that the cost of construction is driven down over time and the costs of operations decline. If this were not the case, Vespar would reject the building of the initial plant or either of the plants in year 1 because all three plants have negative NPVs.

[4] This analysis assumes that Vespar undertakes the investment and discovers only at the end of the second year that it can build a maximum of three and four plants in the final two years of the strategy. Of course, if Vespar were aware today of the restrictions on the number of plants that could be built in years 3 and 4, then the valuation of the strategy would suggest that the plan be abandoned before any investments are made, thus producing a strategy valuation of zero.

[5] We assume a risk-free rate (r) of 5% and a convenience yield (δ) of 3.5%. Using the simulation procedure described in steps 1 and 2, we estimate the volatility parameter (σ) as 8%. Given these values, the up move is computed as $u = e^{r-\delta+\sigma} = 1.0997$ and the down move as $d = e^{r-\delta-\sigma} = 0.9370$. It follows that the risk-neutral probability given by

$$P = \frac{e^{(r-\delta)} - e^{[(r-\delta)-\sigma]}}{e^{[(r-\delta)+\sigma]} - e^{[(r-\delta)-\sigma]}},$$

is equal to 0.48 in the up state.

Simulation Analysis of the Strategy

We learned in Chapter 3 that breakeven sensitivity analysis is a useful tool for evaluating the importance of changes in key value drivers when taken one at a time. If we want to take a broader view of the underlying uncertainty of the outcome of the strategy, however, we need to construct a simulation model that captures simultaneously the uncertainties surrounding several value drivers.

Table 13-5 presents the underlying assumptions and forecasts used to construct a simulation model of the value of the strategy. Panel (a) of Table 13-5 defines the two value drivers (construction costs and the present value of future cash flows) and the assumptions that underlie the simulation. Briefly, to capture the uncertainty about the cost of constructing new plants, we consider a multiplicative cost-overrun factor, which is drawn from a triangular distribution with a most likely value of 1, indicating no cost overrun, as well as a minimum and a maximum value.[6] (The specific parameter values are described in panel [a] of Table 13-5.) The simulated cost-overrun factors are assumed to be positively correlated over time with a correlation coefficient equal to .90. This means that the simulation accounts for the fact that if there is a cost overrun for plants built in year 1, there is a very good chance that the costs in later years will also be higher than projected.

The value of the plants at each future date is modeled using the binomial lattice found in panel (a) of Table 13-3. As we noted in our breakeven sensitivity analysis, however, the uncertainty underlying these values is captured by the volatility of the returns to the plant investments, which we have assumed to be equal to .08. To incorporate the effects of uncertainty about this estimate, we use a triangular distribution with parameter values of .06, .08, and .15, representing the minimum, most likely, and maximum values of the distribution of the volatility measure, respectively.[7]

Each of the iterations of the simulation process calculates a value for the strategy, just as we did earlier using the option valuation method. However, with each iteration of the simulation process, we sample different values of each of the value drivers based on their assumed distributions as defined in panel (a) of Table 13-5, which leads to a different estimate of the value of the strategy.

The simulation focuses on the NPV of Vespar's strategy based on the assumption that Vespar commits to implementing the strategy by constructing the initial plant in year 0. Then, after one year, Vespar can decide whether it will construct the second plant, depending on market conditions (i.e., the estimated value of the plant cash flows at the end of year 1), and so forth.

Panel (b) of Table 13-5 contains the distribution of simulated values for the investment strategy based on 10,000 iterations. Note that a wide range of values for the strategy is generated with this simulation, and in over 73% of them, the value is positive. This, of course, means that in 26.26% of the simulation trials, the strategy generates a negative NPV, with the maximum negative NPV being −\$152 million. However, the maximum NPV of \$539.47 million is even more impressive. Again, the takeaway

[6] In other words, the cost of constructing a new plant in year t = estimated cost of constructing a plant in year $t \times (1 + \text{percentage cost overrun})$.

[7] Note that, because the volatility in power plant prices cannot be inferred from traded financial derivatives, we have to estimate it using other means. Because there is estimation error in the volatility measure, we incorporate this measure as one of the value drivers in the simulation analysis.

Table 13-5 Simulation Analysis of Vespar's Investment Strategy

Panel (a) Assumptions

Value Drivers	Assumptions Underlying the Simulation

Plant Construction Costs

Example: plant construction cost in year 0
$450 million × Cost-Overrun Factor

Cost-overrun factor has a triangular distribution with a minimum value of .99, a most likely value of 1.00, and a maximum value of 1.05.

Distribution of Cost-Overrun Factors

Assumption—triangular (parameters below)*

	Year 0	Year 1	Year 2	Year 3	Year 4
Min	0.99	0.95	0.92	0.90	0.87
Most Likely	1.00	1.00	1.00	1.00	1.00
Max	1.05	1.10	1.15	1.20	1.25

Value of Future Plant Cash Flows

The volatility of the annual rates of return to investing in the coal-fired power plants is the primary driver of the present value of future power plant cash flows.

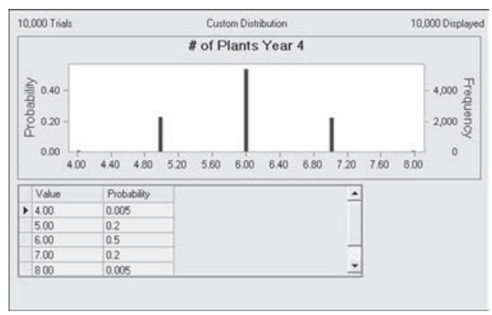
Distribution of Volatility

Assumption—triangular (parameters below)

Minimum = .06, most likely = .08, and maximum = .15

Distribution of the Number of Plants for Years 3 and 4

Assumption—Discrete (same for both years)†



*The cost-overrun factors are assumed to be highly correlated with a coefficient of .90 from year to year.

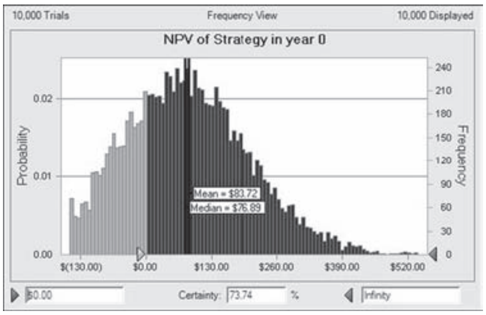
†The number of plants constructed in year 4 is assumed to be highly correlated (correlation = .90) with the number that can be built in year 3.

message from this analysis is that, although the NPV of the strategy is positive given our *best* assumptions, we can envision plausible sets of assumptions under which the strategy generates a negative NPV, as well as other plausible sets of assumptions under which the NPV is very large.

Panel (c) of Table 13-5 presents a tornado chart, the tool used for organizing information from a sensitivity analysis that we introduced in Chapter 3. The tool shows the sensitivity of the strategy's valuation to changes in each of the assumptions underlying the valuation. Specifically, the tornado chart contains estimates of the value of the strategy today (NPV in year 0), measured on the horizontal axis at the top of the chart, where each assumption or value driver (listed down the left-hand side of the chart) is set equal to its 10th- and 90th-percentile value from their own distributions, respectively. For example, if

Table 13-5 *continued*

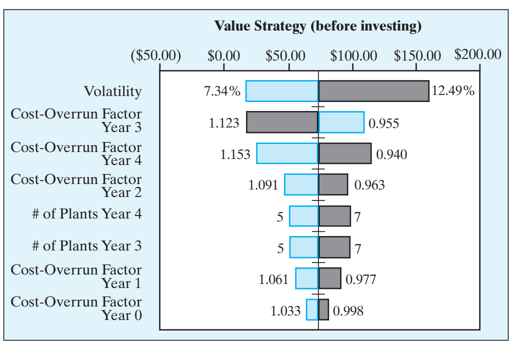
Panel (b) Simulated Distribution of Strategy Values for Today



The "certainty" box contains the percentage of the area under the distribution of NPV that lies above 0. Correspondingly, the likelihood that the NPV of the strategy would be negative is equal to 26.26% or (1 − 73.74%).

The mean NPV of the strategy is not equal to the value calculated earlier for two reasons: First, the simulation incorporates distributions for some value drivers whose expected values differ slightly from the expected values used in the prior analysis. Second, we incorporate consideration for correlation among the value drivers that was not incorporated into the earlier analysis.

Panel (c) Sensitivity Analysis—Tornado Chart



The tornado chart contains estimates of the value of the strategy today (NPV, year 0), where each assumption or value driver (listed down the left-hand side of the chart) is set equal to its 10th- and 90th-percentile value, respectively. The assumptions that have the greatest impact on the value of the strategy are placed at the top of the chart (e.g., the volatility metric), followed by each of the assumptions in decreasing order in terms of their effect on the value of the strategy.

the volatility measure equals its 90th-percentile value (which is 12.49%), while holding all other variable values constant, then the value of the strategy is equal to $159.88 million. Correspondingly, if the cost-overrun factor for year 3 were equal to its 10th-percentile value (which is .955), then the value of the strategy rises to $118.64 million. The next most influential variable in the analysis is the cost-overrun variable in year 4, and so forth.

Consequently, we can see from the tornado chart that the key value drivers in the analysis (based on the parameter estimates used by Vespar's analyst) are the volatility in the changes in the present value of plant cash flows, followed by the costs of building the plants in years 3 and 4, and so forth. This type of analysis can help managers determine where to focus their efforts—both in terms of forecasts made prior to undertaking the investment and in terms of monitoring efforts made after the investment strategy has been initiated.

13.4 Strategic Value When the Future Is Not Well Defined

The Vespar case provides an example where the future investments that comprise the strategy can be identified with a high degree of certainty. In cases such as this, we have shown that a quantitative options analysis can be very useful. In many cases, however, it is quite difficult to identify the relevant strategic options in advance—a fact that makes a quantitative valuation much more difficult. Who knew, for example, that when Apple Computer first began developing the iPod, it would lead to the iPhone and iPad?

The point here is that strategic investments often end up creating valuable future investment opportunities that are simply not knowable at the time the initial commitment to the strategy is made. What, then, can the analyst hope to do when looking for valuable strategic options? This is clearly a difficult question; however, we believe that there are some key value drivers that, if present, suggest an increased likelihood of valuable strategic options. Recognizing the situations where strategic options are likely to be found is the first step in attempting to incorporate consideration of their value into the analysis of new investment proposals.

Which Investments Generate Strategic Options?

To illustrate how strategic options can be both very valuable and difficult to define in advance, let's consider the move by Heinz Inc. into India in 1994. At the time, the market potential in India was expected to be large but highly uncertain and undeveloped. India had close to 350 million urban middle-class consumers, who were increasingly demanding more variety in processed food products. Only 2% of food output consisted of processed food at this time, suggesting that the country was ripe for more investments in food processing. Despite this potential, however, it was difficult to define precisely an initial investment project that could be viewed as having a positive NPV when viewed in isolation. Any particular project faced a high likelihood of failure, but with time and experience, Heinz's management felt confident that the initial investment would lead to valuable follow-on investment opportunities.

Heinz made its strategic entry into Indian markets by acquiring the consumer-products division of Glaxo (India). Although some of the acquired consumer-product brands were profitable, the strategy did not produce the market penetration in India that Heinz had hoped to achieve. Based on what it learned from its failures, however, Heinz changed its strategy to offer smaller package sizes called sachets that had low unit prices that appealed to lower-income buyers. This strategy was successful in helping attract new customers who had been unwilling to try the products earlier.

We can generalize from Heinz's initial experiences in the Indian market to identify three primary drivers of strategic option value:

Driver 1: High uncertainty combined with strategic flexibility is a potent formula for value creation. Heinz's entry into the Indian market offered highly uncertain but potentially very profitable results. This situation illustrates the following point. To the extent that higher uncertainty implies greater upside potential, it increases the value of a multistage investment strategy. Very simply, if the implementation of the strategy is flexible, the firm can limit the costs associated with bad outcomes and capitalize on the benefits of good outcomes.

Driver 2: The strategy creates relatively unique capabilities. Because projects with high NPVs can arise only when there is limited competition, firms should develop capabilities that distinguish them from their competitors. Heinz had an internationally recognized brand but needed to tailor it to local tastes. By getting into India early and developing a reputation for product quality, Heinz could expect to develop a brand within India that could be used in a wide range of products. In other words, developing a brand could be viewed as the first stage of an investment strategy that can lead to many positive NPV investments in the future.

Driver 3: The acquired capability leads to investment opportunities that are scalable. We have already stressed that uncertainty creates value only when it is linked to flexibility, and perhaps the most important flexibility is the flexibility to expand. Given the size and growth potential of the Indian market, it was clear that the Heinz investment was scalable.

How Does Corporate Structure Affect Strategic Option Value?

Up to this point in our discussion, we have focused on strategic investment opportunities without analyzing the firm itself. Indeed, positive NPV investment opportunities arise as a result of a marriage between opportunities and the firm's capability to capitalize on those opportunities. As we discuss next, capability is likely to be related to characteristics of the firm's financial structure, its workforce, and its past investment choices.

Choice 1: Financial flexibility. A good credit rating can enhance the value of a firm's strategic options for a couple of reasons. First, a firm with a good credit rating may be better positioned to take advantage of opportunities quickly, when they are presented, without having to find financial backers. Moreover, a firm with financial resources is less likely to be pressured to invest too soon, when the option to wait is valuable.

Although financial flexibility increases the value of a firm's strategic options, this does not mean that firms should not use debt financing. Indeed, as we discussed in Chapter 4, because of the tax deductibility of interest expenses, a firm's weighted average cost of capital (WACC) declines as it includes more debt in its capital structure. In addition, financial flexibility may allow a poorly managed firm to make bad choices that reduce the firm's value. Indeed, financial distress, which severely limits a firm's flexibility, can sometimes enforce a discipline on a firm that makes it more likely that the firm will exercise its options to abandon bad projects in a timely manner.

Choice 2: Workforce flexibility. Firms with more flexible labor forces can move quickly to capitalize on opportunities as they become available and can abandon underperforming investments more easily, when it is optimal to do so. Firms with highly flexible workforces will offer affirmative responses to the following questions: Do individuals rotate through different jobs as part of their training so that they can later be redeployed to where they can be of greatest value? Do employees have a broad education that allows them to pick up new skills, or do they tend to have relatively narrow skills that limit their flexibility? Does the firm have flexible work rules? Inflexible work rules imposed either by unions or government regulations are likely to limit a firm's ability to exercise its strategic options optimally. Along this dimension, a US firm, which generally has more flexible work rules, is likely to be better positioned to exercise strategic options than a French or an Italian firm, which is likely to be subject to more governmental and regulatory restrictions.

Choice 3: Diversification. A large and growing literature discusses the advantages and disadvantages of diversification. For the most part, this literature discusses a trade-off between the benefits of reducing risk through diversification and the costs associated with managers getting involved in investments that may be outside their areas of expertise. To the growing list of plusses and minuses of diversification, we would like to add the possibility that a diversified firm may have increased flexibility that allows its management to exercise valuable strategic options.

To illustrate the issues surrounding firm diversification and strategic options, consider the situation involved with both real estate and oil and gas investments. In these cases, diversification allows the firm to move resources to where they are most productive. The oil and gas firm will concentrate more of its efforts on producing oil when oil prices are high and more of its efforts on producing natural gas when gas prices are high. Similarly, a firm that develops real estate in both Dallas and Los Angeles has the option to concentrate its efforts in Dallas when the Dallas economy is doing well and then concentrate its efforts in Los Angeles when the Los Angeles economy is doing well. The manufacturing firm can also benefit from flexibility, by shifting production to those facilities that have the lowest costs; however, it will not want to shut down a high-cost facility completely because it will want to maintain the option to shift production back to the facility if the situation changes.

It should be stressed that these gains from diversification arise only when the businesses are closely enough related that resources can indeed be shifted between them. Unrelated diversification, such as Mobil Oil Corporation's acquisition of the department store Montgomery Ward, would be difficult to justify based on this type of analysis. It should also be stressed that the benefits of diversification require high-quality management with the incentives to exercise these options to shift resources optimally. Indeed, some have argued that diversification destroys value because of the tendency of management to exercise these options perversely, subsidizing badly performing businesses with the profits of the best performers.

Management Incentives, Psychology, and the Exercise of Strategic Options

In our earlier analysis, we assumed that managers exercise their strategic options optimally. In reality, however, managers may deviate from optimal exercise depending on their compensations, the organizational structure, and managerial psychology.[8]

Because the options to expand and abandon are so crucial to determining the value of an investment strategy, they deserve extra attention. Managers may be reluctant to

[8] Recall from our discussion in Chapter 12 that managers may have valid reasons for exercising too early even when the option to delay suggests otherwise. Similarly, managers may find it difficult to exercise the abandonment option for valid reasons or for reasons that are personally optimal but not necessarily best for the firm (recall our discussion of earnings management in Chapter 7).

abandon a strategy and may even want to expand a strategy prematurely. One reason is that a decision to expand or abandon a strategy may convey information to investors that will affect the firm's stock price. For example, the decision to abandon a strategy may convey negative information about a firm's outlook and can thus lead to a reduction in its stock price even when the decision itself is a good one that benefits shareholders. Because of this potential for a negative stock price reaction, management may be reluctant to abandon a value-destroying strategy.

Depending on its circumstances, a firm's management may be more or less concerned about the firm's stock price. For example, if the firm is likely to be raising external capital in the near future or if managers have stock options that are close to expiration, managers are likely to be very concerned about making announcements that could be viewed negatively. In these situations, they may be reluctant to abandon what may have initially looked like a good strategy but has turned sour.

The second reason for not exercising an abandonment option optimally is closely related to the first and arises because of the information it reveals within an organization. The problem arises when the individuals who originally approved a strategy are also responsible for determining when to abandon it. In this case, abandonment may be viewed as an admission that the original decision was a mistake. When the decision to abandon reflects poorly on the decision maker, perhaps influencing his or her promotion opportunities and bonus, the decision maker has a clear incentive to interpret market conditions much more favorably than warranted, in the hope that conditions will turn around in a way that makes the strategy profitable.

For example, in panel (a) of Table 13-4, we can see that it is optimal to abandon the strategy in the lowest-value node in year 2 (where the value of the strategy is negative). However, to protect his personal reputation, the project manager may argue that, if things turn around in year 3, it is still possible for the strategy to generate a positive NPV. Indeed, a sequence of two consecutive positive changes in the value of the plants in years 3 and 4 would make the value of the strategy \$118.73 million. If higher-level executives can be convinced that this is a likely event, then they may choose to allow the strategy to continue.

The final reason that managers sometimes do not optimally exercise the option to abandon a strategy is psychological and arises because of what psychologists call *cognitive dissonance,* which means that individuals tend to selectively observe information that supports their decisions. The basic idea is that individuals want to avoid information that makes them question their own abilities. The benefit of this psychological tendency is that it allows individuals to remain more confident about their abilities, even in the face of mistakes in judgment. Having confident managers is likely to have some benefits to the organization, but it has the obvious disadvantage of potentially generating bad decisions. In particular, one cannot rely on the project team that originally championed a strategy to objectively evaluate whether the strategy should be abandoned.

The important thing to note from the above discussion is that, even with the best of intentions, managers may not optimally exercise the abandonment option. This suggests that simply tinkering with compensation to encourage managers to recognize their mistakes may not be sufficient. It is very difficult to provide incentives for managers to "do the right thing" if managers already think they are doing the right thing. Hence, one might want to be cautious about implementing a strategy that has a value that is quite sensitive to exercising abandonment options optimally.

Behavioral Insight

Decision Making with Ambiguity—The Ellsberg Paradox

Daniel Ellsberg became famous during the Vietnam War for leaking sensitive government documents known as the Pentagon Papers. He is also known for identifying a very important attribute of human behavior that has come to be called the *Ellsberg Paradox*.* The idea behind the paradox is that people tend to be averse to making choices based on ambiguous information.

To illustrate this behavioral trait, Ellsberg asked participants in his experiment to select a ball from one of two urns, which each contained 100 balls. In one urn, we know that 50 balls are red and the rest are black. In the other urn, the number of red and black balls is unknown, that is, ambiguous. If the individual selects a red ball, he or she is paid $50, but he or she is paid nothing if a black ball is selected.

Ellsberg found that, when posed with this dilemma, individuals overwhelmingly chose the urn with the *known* proportions of red and black balls. If the individual chose the first urn, with known proportions, then the experimenter would state the following: "So you think that the likelihood of selecting a red ball from the 50-50 urn is higher than if you select from the urn with unknown proportions." The experimenter then asked the individual to draw another ball but was told that if a black ball was drawn from one of the two urns, he or she would receive $50. Faced with this new choice, the experimental subjects overwhelmingly selected the 50-50 urn again! Once again, the subjects of the experiment preferred the urn for which the probability of selecting a black or red ball was known (less ambiguous).

The natural bias against making decisions involving ambiguity provides a major challenge for managers evaluating investments with potential strategic value. There might be a reluctance to move forward with an investment based on future opportunities that are vague and difficult to quantify. Similarly, ambiguity aversion can lead managers to be too slow to exercise the option to abandon a strategy when the unfavorable information is vague and difficult to quantify. Indeed, some have speculated that Daniel Ellsberg believed that, because of a lack of concrete information, the United States was reluctant to exit Vietnam (i.e., we were slow to exercise our abandonment option), and he leaked the Pentagon Papers to provide additional clarity.

*Daniel Ellsberg, "Risk, Ambiguity, and the Savage Axioms," *Quarterly Journal of Economics* 75 (1961): 643–649.

The factors that make managers reluctant to abandon an investment strategy optimally are likely to be most relevant for strategies that are the most ambiguous to describe and evaluate. This bias against making decisions based on ambiguous information is a documented behavioral phenomenon known as the Ellsberg paradox (see the Behavioral Insight box).

To understand how ambiguity influences the abandonment choice, contrast the Vespar example in this chapter to the examples in Chapter 12, where the owner of an oil field has an option to develop the field within a set number of years. In the oil field example, the decision to abandon is based mainly on oil prices. Because oil prices are both easy to observe and known to be difficult to predict, the incentive and behavioral issues associated with the abandonment decision are likely to be less important. Specifically, the economics of the choice are relatively straightforward to analyze (the project should be abandoned if oil prices fall) and, because oil prices are difficult to predict, deterioration in the value of the oil property is less likely to be viewed as a negative reflection on the individual who originally chose to invest in the project.

The economics of the Vespar strategy, however, are much more ambiguous and thus more difficult for an outsider to evaluate. The initiation of the project must be based on a number of subjective variables that require managerial judgment. What this means is that the abandonment choice must also be based on subjective information and may thus reflect on management's prior judgment. This suggests that behavioral and incentive problems are more likely to influence the abandonment choice in the Vespar example.

13.5 Summary

Throughout this text, we have described approaches for evaluating individual investment projects. In this chapter, we stepped back from our focus on individual projects to think more broadly about a firm's investments as part of an overall strategy. From this analysis, we arrived at three important lessons. First, most major projects should be viewed as components of broader investment strategies and should be evaluated as such. Second, although the evaluation of a firm's business strategy rests heavily on the judgment of the firm's senior management, strategic choices do have financial consequences that should be estimated, even if imprecisely. The final lesson is that not all firms are created equally when it comes to an organization's ability to capitalize on strategic investment opportunities. Organizational structure, financial structure, and the way in which the firm has chosen to diversify all play roles in the firm's ability to exercise strategic options optimally.

An often-heard complaint about strategic options analysis is that it makes it too easy for a project sponsor to justify pet projects. The sponsor simply specifies a multitude of options that arise from the initial investment and argues that the project has "strategic value." When your vice president in charge of international development suggests an investment in a golf course in Tahiti because it creates options to do business throughout Asia, you may want to scrutinize his analysis. One should not lose sight of the fact that strategic options analysis, like any valuation model, is only as good as its inputs, and if the analysis is not executed within the context of a quantitative disciplined model, it will not necessarily lead to sensible decisions.

Throughout this text, we have made the case for taking a disciplined, quantitative approach to the evaluation of investment opportunities. In addition to bringing more-precise information to bear on the decision problem, a quantitative valuation process tends to take organizational politics out of the investment choice, making it easier to evaluate an investment based on its economic attributes rather than on the persuasiveness and power of the project sponsor. The advantage of using a more disciplined, quantitative approach is especially relevant for the evaluation of investment *strategies* because, by their very nature, investment strategies are much more ambiguous and hence more susceptible to the biases associated with organizational politics.

Because strategy tends to be ambiguous, it is much more difficult to apply a quantitative approach to the evaluation of investment strategies than to the escalation of individual investment projects. Although this is clearly a daunting task, real options analysis provides management with a framework as well as the necessary tools for quantifying strategic value. Managers will note that the suggested approach requires that the analyst make numerous assumptions. However, if managers are not making the assumptions explicitly in a quantitative analysis, they are, by default, making them implicitly by using more-qualitative forms of analysis. Indeed, although real option analysis still requires considerable managerial judgment, it allows managers to apply their intuition and judgment in a disciplined way. For example, with a real option approach, the analyst can conduct a sensitivity analysis to determine how each assumption affects the valuation of the investment strategy, thereby allowing the analyst to home in on the assumptions that are most important to the success of the strategy.

A final point to stress is that the approach presented here goes beyond the valuation of investment strategy and into the realm of optimal implementation. To be more precise, we have introduced an approach that not only values options but also provides guidance about when these options should be exercised optimally. For example, our approach can be used to determine when a strategy should be expanded (Should we build five rather than three power plants?), as well as when a strategy should be abandoned. In addition, our approach provides some insights about how firms should be organized to extract the most value from their investment strategies. The key word here is *flexibility*. When firms design their organizations and determine their financial structures, it is critical that they be mindful of the benefits of being flexible in an uncertain environment.

Exercises

13-1 OPTIONALITY AND STRATEGIC VALUE You have been retained by a major entertainment company to evaluate the purchase of land near one of its new amusement parks in Australia. The land will not be developed immediately, but it will be developed later for either high-density or low-density hotels, depending on the success of the amusement park.

Describe a strategy for developing the land and the approach you would take to value the strategy. Comment on the merits of this approach to evaluating the value of the land (no computations required).

13-2 ANALYZING A STRATEGY USING OPTION ANALYSIS Reliable Industries is considering the construction of a power plant investment in India. Reliable's analysts calculate that the cost of building the plant is $600 million, and the internal rate of return (IRR) of the plant is 13%. The analysts also estimate that, given the experience of building the first plant, a second plant can be built for $550 million, and additional plants can be built for about $500 million each. The cost of capital is 16%.

a. How would you evaluate whether or not to build this power plant in India?
b. Are you evaluating a project or a strategy?
c. How does the risk associated with the power plant strategy compare with the risk associated with the individual power plants?

13-3 THOUGHT EXERCISE Many financial analysts are very skeptical of the use of strategic considerations to justify a project. This opinion is largely based on the observation that some of the biggest investment disasters were undertaken based on a "strategic" rationale. However, this type of mind-set can lead to a form of managerial myopia in which the only projects that can survive the firm's acceptance hurdle are those for which future cash flows can be identified and forecast easily. Do you agree with the managerial myopia argument? Why or why not?

PROBLEMS

13-4 VALUING A BUSINESS STRATEGY Vespar's senior management team was poised to undertake the clean-coal power plants when they received a call from the chief engineer for the contractor who had been selected to build the initial plant. The engineer had the following proposed change to the plan: Instead of building two power plants each in years 1 and 2, the engineer suggested that the firm consider building only one plant per year and that additional funds be spent on R&D so that the learning that was expected to be accomplished by the building of multiple plants could be accomplished. The cost of plants plus the increased cost of R&D in years 1 and 2 would rise to $400 million and $385 million, respectively. Vespar's management found the proposal intriguing and decided to revisit the economic analysis based on the reduced number of plants and higher total cost per plant.

When Vespar's financial analyst in charge of the original strategy evaluation was told of the need to reanalyze the strategy, he noted that this was probably a good idea because of recent events in the energy market. In fact, he felt that the volatility of the coal-fired strategy was substantially higher than when the original analysis was done. He estimated that the present values of the individual plants ($ millions) built over the next four years would now be as follows:

		Years		
0	**1**	**2**	**3**	**4**
				$534.30
			$450.77	
		$449.58		395.82
	$379.30		394.78	
$320.00		333.06		346.65
	280.99		292.46	
		246.74		256.81
			216.66	
				190.25

All the other information regarding the strategy remains the same except that the risk-neutral probability of a positive shift in the value of a new plant is now estimated to be 46.26%. (The actual probabilities remain 50-50.) The decision tree above assumes an up factor of 1.1853 and a down factor of .8781

a. What is the expected value of the investment strategy in which the abandonment option is ignored and all the plants are built, regardless of their NPV? For the purposes of this analysis, assume that the appropriate discount rate for the strategy is 13.77%.

b. What is the expected value of the investment strategy in which the option to abandon is exercised optimally?

c. How much more can the plants cost in years 1 and 2 before the revised strategy is no longer preferred to the initial strategy? Assume that the same cost inflation factor applies to each plant in years 1 and 2 and that the net present value lattice applies.

13-5 SIMPLE INVESTMENT STRATEGY—STAGED INVESTMENTS You have been retained to evaluate a major investment for a technology company. The cost of the project is \$100 million. If the project is successful, it will generate expected profits of \$15 million per year forever, which has a present value of \$150 million. However, there is a 50% chance that the project will be a complete failure, in which case it will generate no cash flows. If the project is successful, there will be a follow-on project that can be initiated the following year. The follow-on project will have a cost of \$1 billion, and if all goes well (probability of 50%), it will generate expected cash flows of \$150 million per year that will last forever and will result in a value of \$1.5 billion (in year 1 dollars). If the follow-on project is not successful, it will result in a stream of cash flows with a present value of \$900 million. Should the initial project be undertaken? Explain your recommendation in commonsense terms to your boss, who is not a technology person.

Epilogue

In preparing to write this book, we reviewed the academic literature on valuation theory, corporate finance, and behavioral economics and interviewed corporate managers, consultants, and investment bankers. This dual-track process not only helped solidify our understanding of valuation theory and industry practice, but also identified a number of situations where there is a substantial disconnect between the two. To conclude the book, we will revisit these disconnects along with our explanations for why each exists. In addition, we will use this recap as an opportunity to discuss how we think industry practice is likely to evolve in the future.

Estimating Future Cash Flows

The first source of disconnect that we observe relates to the tendency of managers to provide cash flow forecasts that are biased estimates of expected cash flows. These biases, depending on the situation, can be either positive or negative. For example, positive biases tend to arise from the fact that cash flow estimates are frequently based on what the analyst believes is a *likely* scenario. These estimates tend to be optimistic rather than expected cash flows, because there is a tendency for optimistic project champions to focus on scenarios in which the project succeeds. However, this focus on likely scenarios may also result in a downward bias, because it can lead the analyst to ignore the benefits of project flexibility. This downward bias becomes especially important when the investment presents opportunities for scaling up when it is doing well and scaling down when it is doing poorly.

It should also be noted that, in practice, cash flow forecasts are often used for more than project evaluation. A venture capitalist, for example, is generally quite happy to fund an entrepreneur based on the entrepreneur's optimistic cash flow forecasts. To understand why, you should first note that venture capitalists can address the entrepreneur's optimistic cash flow forecasts by requiring very high rates of return. Consequently, the ultimate investment decision is not necessarily biased. You should also note that the venture capitalist uses the entrepreneur's cash flow forecasts as cash flow targets for the entrepreneur. As a result, the optimistic cash flow estimates provide higher targets that may serve to motivate the entrepreneur and provide the venture capitalist with bargaining power in the future, if realized cash flows fail to meet the entrepreneur's projections.

As we noted above, cash flow estimates are biased downward if significant sources of project flexibility are unrecognized. The fact that analysts often ignore the effects of project flexibility may simply be due to the complexity associated with accounting for the inherent flexibility of most projects. Indeed, our chapters on real options and the valuation of flexibility are probably the most complex in this book. For a variety of reasons, executives tend to shy away from complex problems. Complexity can lead to mistakes because complicated problems are more difficult to solve than simple problems, and may require hidden assumptions that the financial analyst does not completely understand. In addition, as we discuss in Chapter 5, internal political problems (what we call *influence costs*) in more-complex decision problems can provide decision makers with the leeway to make assumptions that make their pet projects look more favorable. When more-complicated valuation approaches are used, project champions who are cleverer, more articulate, and politically more adept are more likely to get their projects approved, even though the projects they champion may not necessarily be the best ones for the firm.

Estimating Discount Rates

Anecdotal evidence suggests that firms tend to use hurdle rates that are substantially higher than what most academics would consider to be appropriate risk-adjusted discount rates, and, more importantly, firms often use the same discount rate to evaluate investments with very different levels of risk. As we mentioned above, the higher discount rate may be used to offset overly optimistic cash flow forecasts, and it may also serve to motivate project sponsors to bargain for the best deals possible with suppliers, employees, etc. The use of a single discount rate rather than more-appropriate risk-adjusted discount rates tailored to each project is probably a function of the complexity of the task and the role that influence costs play.

Earnings Dilution and Accretion

Perhaps the most important disconnect between theory and practice that we have identified has to do with the importance of reported accounting earnings. Most valuation textbooks provide very little discussion of the accounting implications of project selection; however, in practice, managers often devote as much time evaluating whether an investment is earnings accretive or earnings dilutive as they spend on estimating the NPV of the project. As we discuss in Chapter 7, managers are likely to be concerned about the earnings impact of an investment project as long as their performance and the overall performance of the firm are evaluated on the basis of accounting earnings.

Narrowing the Gap—Future Directions

Although we believe that the gap between theory and practice will never be eliminated entirely, it is narrowing over time and should continue to shrink in the future. This will partly come about as theory changes to account for the realities of operating in a diverse business organization that is populated by managers with multiple objectives and recognized behavioral biases. More importantly, business practice is changing as managers come to recognize the costs associated with failures to adjust properly for optimism bias, to account for project flexibility, and to use an appropriate discount rate.

As the magnitude of these costs becomes more apparent, we expect firms to make changes that counter the organizational difficulties that arise when firms implement more-complex valuation tools suggested by theory. We believe that these organizational difficulties can be substantially mitigated if firms set up truly independent control groups, whose sole purpose is the evaluation of major investment projects and which have no incentive to either accept or reject investments. Because of their unbiased nature, these groups can reduce incentive problems, which in turn will allow the firm to use more-sophisticated valuation approaches. From our casual observations, we find that firms with such evaluation groups do tend to use more-sophisticated valuation approaches; however, this may reflect the more-sophisticated nature of the organizations themselves.

Finally, we believe that the gap between theory and practice will narrow with time as valuation approaches that initially appear to be very complex begin to appear more intuitive. The development of valuation software will contribute to this trend by making the somewhat-more-complicated academic solutions easier to implement in practice. Indeed, we hope that this book plays a role in hastening this process as well.

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