Chapter Summaries

CHAPTER 1: A NEW PARADIGM?

Introduction

This chapter looks at the issues of new decision-making challenges and provides an introduction to real options analysis as the solution to these new challenges. The chapter briefly defines real options analysis and its many forms, when it is used, who has used it in the past, and why it is used. Examples provided come from multiple industries, including oil and gas exploration and production, pharmaceutical research and development, e-commerce valuation, IT infrastructure investment justification, prioritization of venture capital investments, mergers and acquisitions, research and development, Internet start-up valuation, structuring of venture capital contracts, timing of investments, parallel portfolio development, profitability profiling, and so forth. The chapter also profiles the types of options, defines real options analysis, and introduces several sample business cases of how real options are used as well as quotations of what the experts are saying. Finally, actual business cases from industry are provided in the appendixes. These appendixes are contributed by major corporations detailing the applications of real options in their respective companies.

A Paradigm Shift

The new economy provides a challenge for the corporate decision-maker. Corporate valuation may no longer depend on traditional fundamentals but rather on future expectations. Investment strategies with high risks and uncertainty or irreversible corporate decisions coupled with managerial flexibility provide the best candidates for real options. In this chapter, the reader will find that real options analysis is indeed a new way of thinking rather than simply the application of advanced analytical procedures.

Sample Business Cases Where Traditional Approaches Break Down

These sections introduce the issues, concerns, and problems of traditional methods, issues that are addressed using a real options framework. The sections also introduce several business cases requiring the use of real options analysis. These cases include IT investments in a new operating system, prioritizing e-commerce strategies, pharmaceutical research and development, oil and gas exploration, manufacturing contractual decisions, valuation of different venture capital opportunities, capital structuring and valuation of an Internet start-up firm, and selecting capital investment projects within the context of a portfolio. In each of these cases, the reader delves into the minds of people closest to the analysis and decision-making process, and examines their thinking and analytical approach.

The Real Options Solution and Issues to Consider

These two sections detail the use of real options in terms of thinking strategically, identifying strategic optionalities, valuing and prioritizing strategies, optimizing and timing strategies, as well as the overall management of strategies. In addition, they describe where real options value comes from and why in certain cases the true value of a project may be less than its option value.

Industry Leaders Embracing Real Options

This section details actual corporate cases and Fortune 500 firms embracing this new valuation concept. Firms highlighted include General Motors, HP-Compaq, Boeing, and AT&T. Included are consulting success stories of how these firms have looked at business decisions through the lens of real options. More industry cases are provided in the appendixes.

What the Experts Are Saying

This section details what the experts are saying in terms of the uses of real options, including quotations from the *Wall Street Journal, Business Week, Harvard Business Review, CFO,* and others. The upshot is that firms are fast embracing this new hot valuation approach, which has the potential of being the next new business breakthrough. It would seem apparent from the brief excerpts that real options analysis is not simply a financial fad but the methodology is here to stay for the long-term.

CHAPTER 2: TRADITIONAL VALUATION APPROACHES

Introduction

This chapter introduces the pitfalls of using only traditional discounted cash flow analysis and how a real options process framework captures the strategic valuation a traditional approach cannot. A brief overview of traditional analyses includes the income approach, the market approach, and the cost approach. In addition, the chapter focuses on the issues and concerns regarding the discounted cash flow analysis. The chapter concludes with two appendixes discussing the details of financial statement analysis and the calculation of an appropriate discount rate.

The Traditional Views

Traditional analysis includes the income, cost, and market approaches, which involve using forecast profit and loss statements, comparable multiples, ratio analysis, common sizing, and so forth. The traditional approaches view risk and return on investment in a very static view. However, not all uncertainty is risk, and not all risk is bad. Real options view capital investments in terms of a dynamic approach and view upside risk as an ally that can be capitalized on.

Practical Issues Using Traditional Valuation Methodologies

This section highlights the pitfalls of the three fundamental approaches: income approach, cost approach, and market approach. These pitfalls include the incorrect use of discount rates, risk-free rates, terminal value calculations, and others.

CHAPTER 3: REAL OPTIONS ANALYSIS

Introduction

This chapter introduces the fundamental concepts of real options through several simple examples showing why an options framework provides much better insights than traditional valuation approaches do. In order to compare the results from different approaches, a simplified example is presented, starting

with traditional analyses. The example continues with the application of Monte Carlo simulation and ends with the use of real options analysis.

The Fundamental Essence of Real Options

This section starts with the example of how an analyst would perform a financial analysis for the purpose of project selection. It then shows the virtues of using simulation to capture uncertainties rather than using simple single-point estimates. The analysis is complicated further by using active and passive waiting strategies. Finally, this section demonstrates how real options can be applied to more accurately assess a project's value by better defining the variables underlying a project and its potential value creation.

The Basics of Real Options, and a Simplified Example of Real Options in Action

A simple example illustrates the power of real options through the execution of an option to wait. The option to defer the execution of a second-phase clinical trial until receiving updated news of market demand adds value to a pharmaceutical research and development division's project in general. The example uses a simple discounted cash flow model to make the case.

Advanced Approaches to Real Options, and Why Are Real Options Important?

These two sections show the importance of looking at decision-making processes as a series of dynamic options and describe the types of generic options that exist in corporate investment strategies. In addition, several advanced real options techniques are introduced. Some of these techniques—for example, the use of binomial lattices, Monte Carlo simulation, partial-differential equations, and closed-form exotic options analysis—are also discussed briefly.

Comparing Traditional Approaches with Real Options

A protracted example is provided on a sample business case. The example starts from a simple static discounted cash flow analysis and proceeds with sensitivity analysis. Then an additional layer of sophistication is introduced, with the application of Monte Carlo simulation. Finally, real options analysis is applied to the problem. The results are then compared, starting with a static discounted cash flow approach, to the simulation results, as well as to the real options results.

CHAPTER 4: THE REAL OPTIONS PROCESS

Introduction and Critical Steps in Performing Real Options Analysis

This chapter introduces the eight phases in a real options process framework as developed by the author. The first phase starts with the qualification of projects through management screening, which weeds out the projects that management wishes to evaluate. The second phase starts with the construction of a traditional discounted cash flow model under the base case condition. Next, Monte Carlo simulation is applied, and the results are in turn inserted directly into the real options analysis. This phase covers the identification of strategic options that exist for a particular project under review. Based on the type of problem framed, the relevant real options models are chosen and executed. Depending on the number of projects as well as management-set constraints, portfolio optimization is performed. The efficient allocation of resources is the outcome of this analysis. The next phase involves creating reports and explaining to management the analytical results. This step is critical in that an analytical process is only as good as its expositional ease. Finally, the last phase involves updating the analysis over time. Real options analysis adds tremendous value to projects with uncertainty, but when uncertainty becomes resolved through the passage of time, old assumptions and forecasts have now become historical facts. Therefore, existing models must be updated to reflect new facts and data. This continual improvement and monitoring is vital in making clear, precise, and definitive decisions over time.

CHAPTER 5: REAL OPTIONS, FINANCIAL OPTIONS, MONTE CARLO SIMULATION, AND OPTIMIZATION

Introduction

This chapter explains the differences between financial options and real options by first describing the fundamentals of financial options theory. The chapter then goes into the importance of Monte Carlo simulation for financial analysis and ends with the application of portfolio optimization and the efficient allocation of resources.

Real Options versus Financial Options

This section details the basics of financial options and how they relate to real options. For instance, the underlying asset in most real options analysis is

nontradable—that is, there usually exists no liquid market for the asset or project in question. Nonetheless, there exist many similarities between the two, and the underlying analytics of financial options may be applicable, with a few exceptions and modifications.

Monte Carlo Simulation

How are simulation techniques important in real options analysis? This discussion explains how certain key variables are obtained through the use of Monte Carlo simulation. An example depicts the error of means and why simulation should be used when uncertainty abounds. Further examples show the different strategies that would have been executed otherwise without the use of real options.

CHAPTER 6: BEHIND THE SCENES

This chapter introduces the reader to some common types of real options analytics. The two main methods introduced are closed-form differential equations and binomial lattices through the use of risk-neutral probabilities. The advantages and disadvantages of each are discussed in detail. In addition, the theoretical underpinnings surrounding the binomial equations are demystified here, leading the reader through a set of simplified discussions on how certain binomial equations are derived.

Real Options: Behind the Scenes

This section introduces the reader to the use of binomial models and closed-form solutions, which are the two mainstream approaches, used in solving real options problems. The section also discusses the advantages and disadvantages of using each approach, while demonstrating that the results from both methods approach each other at the limit.

Binomial Lattices

The binomial lattice is introduced here, complete with the application of risk-neutral probabilities, time-steps, and jump sizes.

The Look and Feel of Uncertainty, and a Firm's Real Options Provide Value in the Face of Uncertainty

The idea of uncertainty in cash flow predictions is presented in these two sections. With the use of Monte Carlo simulation, these uncertainties can be easily captured and quantified. However, if there are strategic options in

these projects, there may be value in these uncertainties, which Monte Carlo simulation alone cannot capture. The upside and downside options can be better quantified using real options analysis.

Binomial Lattices as a Discrete Simulation of Uncertainty, Risk versus Uncertainty, Hard Options versus Soft Options, and Granularity Leads to Precision

The cone of uncertainty is explained through the idea of increasing uncertainty over time. This cone of uncertainty can be captured using stochastic simulation methods, such as the use of Brownian Motions. Then a discussion contrasting risk and uncertainty is provided and the linkage among risk, uncertainty, volatility, probability, and discount rate is further explored. The section continues with the discussion of how a binomial lattice approximates the simulation of stochastic processes. Indeed, the binomial lattice is a discrete simulation and, at the limit, approaches the results generated using continuous stochastic process simulation techniques, which can be solved using closed-form approaches.

An Intuitive Look at Binomial Equations, and Frolicking in a Risk-Neutral World

These sections look at the binomial equations and how they can be explained intuitively, without the need for difficult and high-level mathematics. The equations include the use of up and down jump-steps as well as the use of risk-neutral probabilities.

CHAPTER 7: REAL OPTIONS MODELS

This chapter looks at the different types of strategic real options, providing a step-by-step methodology in solving these options. The options covered include the options to abandon, expand, contract, and choose. In addition, compound options, changing strike options, changing volatility options, and sequential compound options are discussed. These basic option types provide the building blocks in analyzing more complex real options as discussed in the following chapters, including building more sophisticated real options models such as those included in the CD-ROM.

These different real options sections walk the reader through calculating by hand the various real options models. These models include using the binomial lattices and closed-form approaches. Examples of options calculated include the option to expand, contract, barrier, salvage, switch, and so on. There are also several technical appendixes on the derivation of the

appropriate volatility estimate, a discussion of the Black-Scholes model, the use of path-dependent valuation using market-replicating portfolios, an example static binomial model, sensitivity models, reality checks, and trinomial lattices.

CHAPTER 8: ADDITIONAL ISSUES IN REAL OPTIONS

The additional issues in real options are discussed here, including exit and abandonment options, timing options, compound options, and the use of stochastic optimization. A discussion of the inappropriate use of decision trees is also included. Three technical appendixes follow the chapter, providing insights into different stochastic processes, differential equations, and a barrage of exotic options models.

The options models start from a simple European Black-Scholes model and extend to Black-Scholes with dividend outflows, chooser options, complex options, compound options, floating strike options, fixed strike options, forward start options, jump-diffusion options, spread options, discrete time switch options, and two correlated asset options. The approaches for estimating American-type options are also discussed.

CHAPTER 9: INTRODUCTION TO THE REAL OPTIONS VALUATION'S SUPER LATTICE SOLVER SOFTWARE AND RISK SIMULATOR SOFTWARE

This chapter introduces the readers to the author's Super Lattice Solver (SLS) and Risk Simulator software, trial versions of which are included in the CD-ROM.

The SLS software comprises several different modules. The Single Asset SLS is used for solving simple to complex and customized American, Bermudan, and European financial and real options with one underlying asset. The types of options solved include among others, the abandonment, American, barrier, Bermudan, chooser, contraction, deferment, European, expansion, and plain-vanilla options. The Multiple Asset SLS is used for solving options with multiple underlying assets and/or multiple-phased options. The types of options solved include multistaged sequential compound options, complex custom sequential options, multiple asset simultaneous compound options, options with multiple underlying assets, and switching options. The Multinomial SLS is used to solve mean-reverting options using trinomial lattices, jump-diffusion options using quadranomial lattices, and dual-asset rainbow options using pentanomial lattices. Excel-based SLS functions are also shown, where real options can be solved in existing Excel models (this allows

Monte Carlo simulation and optimization to be run on the results), as well as sample audit sheets generated by the SLS software.

The author's own Risk Simulator software is also introduced. This software is used to perform Monte Carlo simulation, time-series forecasting, and stochastic optimization within the Excel spreadsheet environment. Step-by-step getting started illustrations are presented in this chapter. It is also used for running regular simulations, nonparametric simulations, multivariate regressions, nonlinear extrapolations, stochastic processes, time-series analysis, sensitivity analysis, tornado and spider charts, bootstrapping, hypothesis testing, and many other methodologies.

CHAPTER 10: REAL OPTIONS VALUATION APPLICATION CASES

In this chapter, American, Bermudan, European, and Customized options are introduced and solved using the author's Super Lattice Solver software. The types of options introduced and solved include:

- American, European, Bermudan, and Customized Abandonment Options
- American, European, Bermudan, and Customized Contraction Options
- American, European, Bermudan, and Customized Expansion Options
- Contraction, Expansion, and Abandonment Options
- American, European, Bermudan, and Customized Call and Put Options
- Exotic Chooser Options
- Multiphased Complex Sequential Compound Options
- Multiphased Simultaneous Compound Options
- Mean-Reverting Options
- Jump-Diffusion Options
- Dual-Asset Rainbow Options
- Barrier Options (Upper, Lower, and Double-Barrier Options)
- Employee Stock Options (with Suboptimal Exercise Behavior Multiples, Forfeitures, Vesting, and Blackout Periods)

Other topics discussed include optimal timing and optimal trigger values in real options: path dependent, path independent, mutually exclusive, nonmutually exclusive, and complex nested options, as well as dominant and dominated options. Additional student exercises are included in this chapter.

CHAPTER 11: REAL OPTIONS CASE STUDIES

This chapter provides many solved case studies in various industries using real options and financial options. The cases are solved by illustrating the

use of real options framing exercises. The cases show how the real or financial options are first framed in strategy trees and then solved using the Super Lattice Solver software. The cases introduced in this chapter include:

- High-tech manufacturing: Build or buy decision with real options.
- Financial options: Convertible warrants with a vesting period and put protection.
- Pharmaceutical development: Value of perfect information and trigger values.
- Oil and gas: Farm outs, options to defer, and value of information.
- Valuing employee stock options under 2004 FAS 123.
- Integrated risk modeling: Applying simulation, forcasting, and optimization on real options.
- Biopharmaceutical industry: Valuing strategic manufacturing flexibility.
- Real estate: Alternative use and development.
- United States Navy: Strategic flexibility in mission control centers.

CHAPTER 12: RESULTS INTERPRETATION AND PRESENTATION

This chapter walks the reader through the results and sample reports that should be generated by a real options analyst. The chapter includes information to help the reader in interpreting the results and being able to bring the results from the analyst's desktop to the desktop of the CEO.

How do you broach the subject of real options to management? What are the links between traditional approaches versus more advanced analytical approaches? Will management "bet the farm" based on a single number generated through a fancy mathematical model the analyst can't even interpret? This chapter provides a step-by-step methodology in presenting and explaining to management a highly complicated set of analyses through the eyes of an analyst. Complete with graphical displays, charts, tables, and process flows, this chapter provides a veritable cookbook of sorts, for the exposition of the results from a real options analysis.

The results interpretation and presentation proceed through 13 steps. The steps include comparing real options analysis with traditional financial analysis, comparing their similarities, and highlighting their differences. Next, the presentation shows where traditional analyses end and where the new analytics begin, through a simple-to-understand structured evaluation process. Then the results summary is presented, where different projects with different sized investments and returns are compared. This comparison is made on the basis of returns as well as risk structures. The final prognosis is

presented as an impact to the bottom line for the company as a consequence of selecting different projects. A critical success factor analysis is also presented, together with its corresponding sensitivity analyses. A Monte Carlo simulation analysis is then presented as a means of identifying and measuring risks inherent in the analysis. Finally, the assumptions and results stemming from a real options analysis are discussed, as are its corresponding risk analyses.