

Tools and Techniques for Valuing Strategic Investments and Decisions

Second Edition

JOHNATHAN MUN



John Wiley & Sons, Inc.

List of Figures	xxi
Chapter Summaries	1
Chapter 1: A New Paradigm?	1
Chapter 2: Traditional Valuation Approaches	3
Chapter 3: Real Options Analysis	3
Chapter 4: The Real Options Process	5
Chapter 5: Real Options, Financial Options, Monte Carlo	
Simulation, and Optimization	5
Chapter 6: Behind the Scenes	6
Chapter 7: Real Options Models	7
Chapter 8: Additional Issues in Real Options	. 8
Chapter 9: Introduction to the Real Options Valuation's Super	
Lattice Solver Software and Risk Simulator Software	8
Chapter 10: Real Options Valuation Application Cases	9
Chapter 11: Real Options Case Studies	9
Chapter 12: Results Interpretation and Presentation	10
	~
PART ONE	
Theory	
CHAPTER 1	
A New Paradigm?	15
Introduction	15
A Paradigm Shift	15
Expansion and Compound Options: The Case of the	
Operating System	17
Expansion Options: The Case of the E-Business Initiative	20
Expansion and Sequential Options: The Case of the	
Pharmaceutical R&D	22
Expansion and Switching Options: The Case of the	
Oil and Gas Exploration and Production	23
Abandonment Ontions: The Case of the Manufacturer	26

Expansion and Barrier Options: The Case of the Lost	
Venture Capitalist	27
Compound Expansion Options: The Case of the Internet Start-Up	29
The Real Options Solution	30
Issues to Consider	31
Industry Leaders Embracing Real Options	32
What the Experts Are Saying	36
Criticisms, Caveats, and Misunderstandings in Real Options	38
Summary	40
Chapter 1 Questions	40
Appendix 1A The Timken Company on Real Options in	
R&D and Manufacturing	41
Appendix 1B Schlumberger on Real Options in Oil and Gas	44
Appendix 1C Intellectual Property Economics on Real Options	
in Patent and Intangible Valuation	50
Appendix 1D Gemplus on Real Options in High-Tech R&D	53
Appendix 1E Sprint on Real Options in Telecommunications	5 7
CMAPTER 2	
Traditional Valuation Approaches	88
Introduction	63
The Traditional Views	63
Practical Issues Using Traditional Valuation Methodologies	65
Summary	73
Chapter 2 Questions	74
Appendix 2A Financial Statement Analysis	76
Free Cash Flow Calculations	76
Free Cash Flow to a Firm	77
Levered Free Cash Flow	77
Inflation Adjustment	77
Terminal Value	78
Price-to-Earnings Multiples Approach	78
Discounting Conventions	80
Appendix 2B Discount Rate versus Risk-Free Rate	84
The CAPM versus the Multifactor Asset-Pricing Model	85
CHAPTER 3	
Real Options Analysis	87
Introduction	87
The Fundamental Essence of Real Options	87
The Basics of Real Options	89
A Simplified Example of Real Options in Action	89
Advanced Approaches to Real Options	91

Why Are Real Options Important?	92
Comparing Traditional Approaches with Real Options	95
Summary	102
Chapter 3 Questions	102
CHAPTER 4	
The Real Options Process	103
Introduction	103
Critical Steps in Performing Real Options Analysis	103
Summary	106
Chapter 4 Questions	108
CHAPTER 5	
Real Options, Financial Options, Monte Carlo Simulation,	400
and Optimization	109
Introduction	109
Real Options versus Financial Options	109
Monte Carlo Simulation	112
Summary Change 5 Occasions	119
Chapter 5 Questions	119
PART TWO	
Application	
CHAPTER 6	
Behind the Scenes	123
Introduction	123
Real Options: Behind the Scenes	123
Binomial Lattices	127
The Look and Feel of Uncertainty	13 1
A Firm's Real Options Provide Value in the Face of Uncertainty	134
Binomial Lattices as a Discrete Simulation of Uncertainty	136
Risk Versus Uncertainty, Volatility versus Discount Rates	139
Granularity Leads to Precision	146
An Intuitive Look at the Binomial Equations	151
Frolicking in a Risk-Neutral World	156
Summary .	161
Chapter 6 Questions	162
CHAPTER 7	400
Real Options Models	183
Introduction Option to Abandon	163 163

Option to Expand	167
Option to Contract	170
Option to Choose	174
Simultaneous Compound Options	177
Changing Strikes	180
Changing Volatility	182
Sequential Compound Option	184
Extension to the Binomial Models	187
Summary	188
Chapter 7 Questions	188
Appendix 7A Volatility Estimates	190
Logarithmic Cash Flow Returns Stock Price Returns	
Approach	191
Logarithmic Present Value Returns Approach	197
GARCH Approach	203
Management Assumption Approach	204
Market Proxy Approach	211
Volatility versus Probability of Technical Success	211
Appendix 7B Black-Scholes in Action	213
Appendix 7C Binomial Path-Dependent and	
Market-Replicating Portfolios	215
Appendix 7D Single-State Static Binomial Example	221
Differential Equations	221
Optimal Trigger Values	225
Appendix 7E Sensitivity Analysis with Delta, Gamma, Rho,	
Theta, Vega, and Xi	227
Call Delta	228
Call Gamma	229
Call Rbo	229
Call Theta	229
Call Vega	230
Call Xi	231
Appendix 7F Reality Checks	232
Theoretical Ranges for Options	[*] 232
SMIRR and SNPV Consistency	232
, Minimax Approach	233
Implied Volatility Test	233
Appendix 7G Applying Monte Carlo Simulation to Solve	
Real Options	235
Applying Monte Carlo Simulation to Obtain a	
Real Options Result	235
Applying Monte Carlo Simulation to Obtain a Range of	
Real Options Values	239

۸.,		-4-
υOI	Пe	nts

41	-

Appendix 7H Trinomial Lattices	242
Appendix 7I Nonrecombining Lattices	244
CHAPTER 8	
Additional Issues in Real Options	255
Introduction	255
Project Ranking, Valuation, and Selection	255
Decision Trees	256
Exit and Abandonment Options	259
Compound Options	260
Timing Options	260
Solving Timing Options Calculated Using	
Stochastic Optimization	262
Switching Options	267
Summary	271
Chapter 8 Questions	271
Appendix 8A Stochastic Processes	272
Summary Mathematical Characteristics of	-/-
Geometric Brownian Motions	272
Summary Mathematical Characteristics of	-,-
Mean-Reversion Processes	273
Summary Mathematical Characteristics of	2, 3
Barrier Long-Run Processes	273
Summary Mathematical Characteristics of	2,3
Jump-Diffusion Processes	274
Appendix 8B Differential Equations for a Deterministic	/
Case	275
Appendix 8C Exotic Options Formulae	278
Black and Scholes Option Model—European Version	278
Black and Scholes with Drift (Dividend)—	270
European Version	279
Black and Scholes with Future Payments—	2.,,
European Version	279
Chooser Options (Basic Chooser)	280
Complex Chooser	281
Compound Options on Options	282
Exchange Asset for Asset Option	283
Fixed Strike Look-Back Option	284
Floating Strike Look-Back Options	285
Forward Start Options	287
Generalized Black-Scholes Model	287
Options on Futures	288
Spread Option	289

XVIII CONTENTS

Discrete Time Switch Options	290
Two-Correlated-Assets Option	290
PART THREE	
Software Applications	
CHAPTER 9	
Introduction to the Real Options Valuation's Super Lattice	
Software and Risk Simulator Software	285
Introduction to the Super Lattice Solver Software	296
Single Super Lattice Solver	297
Multiple Super Lattice Solver	305
Multinomial Lattice Solver	307
SLS Excel Solution (SSLS, MSLS, and Changing Volatility	
Models in Excel)	309
SLS Functions	311
Lattice Maker	314
Introduction to the Risk Simulator Software	315
Monte Carlo Simulation	316
Forecasting	331
Optimization	343
Appendix 9A Financial Options	348
Definitions	348
Black-Scholes Model	349
Other Key Points	349
Appendix 9B Probability Distributions for	
Monte Carlo Simulation	351
Understanding Probability Distributions	351
Selecting a Probability Distribution	353
Monte Carlo Simulation	353
Probability Density Functions, Cumulative Distribution	
Functions, and Probability Mass Functions	354
Discrete Distributions	355
Continuous Distributions	362
Appendix 9C Forecasting	375
Time-Series Forecasting	375
Multiple Linear Regression	376
Appendix 9D Optimization	377
What Is an Optimization Model?	377
Decision Variables	380
Constraints	380
Objective	381
Requirements	382
Types of Optimization Models	383

Contents xix

CHAPTER 10	
Real Options Valuation Application Cases	385
American, European, Bermudan, and Customized	
Abandonment Option	386
American, European, Bermudan, and Customized	
Contraction Option	396
American, European, Bermudan, and Customized	
Expansion Option	403
Contraction, Expansion, and Abandonment Option	409
Basic American, European, and Bermudan Call Options	414
Basic American, European, and Bermudan Put Options	415
Exotic Chooser Options	419
Sequential Compound Options	421
Multiple-Phased Sequential Compound Option	424
Customized Sequential Compound Options	426
Path-Dependent, Path-Independent, Mutually Exclusive,	
Nonmutually Exclusive, and Complex Combinatorial	
Nested Options	428
Simultaneous Compound Option	430
American and European Options Using Trinomial Lattices	432
American and European Mean-Reversion Option Using	
Trinomial Lattices	434
Jump-Diffusion Option Using Quadranomial Lattices	436
Dual-Variable Rainbow Option Using Pentanomial Lattices	438
American and European Lower Barrier Options	440
American and European Upper Barrier Option	443
American and European Double Barrier Options	
and Exotic Barriers	4 46
American ESO with Vesting Period	449
Changing Volatilities and Risk-free Rates Options	449
American ESO with Suboptimal Exercise Behavior	452
American ESO with Vesting and Suboptimal Exercise Behavior	453
American ESO with Vesting, Suboptimal Exercise Behavior,	
Blackout Periods, and Forfeiture Rate	455
·	,,,,
CHAPTER 11	
Real Options Case Studies	459
Case 1: High-Tech Manufacturing— Build or Buy Decision	
with Real Options	459
Case 2: Financial Options—Convertible Warrants with a	.57
Vesting Period and Put Protection	467
Case 3: Pharmaceutical Development—Value of Perfect	,
Information and Ontimal Trigger Values	473

Case 4: Oil and Gas—Farm Outs, Options to Defer, and	
Value of Information	476
Case 5: Valuing Employee Stock Options Under 2004 FAS 123	478
Case 6: Integrated Risk Analysis Model—How to Combine	
Simulation, Forecasting, Optimization, and Real Options	
Analysis into a Seamless Risk Model	527
Case 7: Biopharmaceutical Industry—Valuing Strategic	
Manufacturing Flexibility	547
Case 8: Alternative Uses for a Proposed Real Estate	
Development—A Strategic Value Appraisal	557
Case 9: Naval Special Warfare Group One's Mission	
Support Center Case	568
CHAPTER 12	
Results Interpretation and Presentation	581
Introduction	581
Comparing Real Options Analysis with Traditional	
Financial Analysis	582
The Evaluation Process	585
Summary of the Results	588
Comparing across Different-Sized Projects	589
Comparing Risk and Return of Multiple Projects	590
Impact to Bottom Line	594
Critical Success Factors and Sensitivity Analysis	595
Risk Analysis and Simulation on NPV	596
Break-Even Analysis and Payback Periods	597
Discount Rate Analysis	598
Real Options Analysis Assumptions	599
Real Options Analysis	600
Real Options Risk Analysis	602
The Next Steps	602
Summary	604
Chapter 12 Questions	604
Appendix 12A: Summary of Articles	606
Case Studies and Problems in Real Options	615
Answer to Chapter Questions	825
Notes	633
About the CD-ROM	645
Index	649