

# An Introduction to Derivatives Sc Risk Management

## Don M. Chance

Louisiana State University



SOUTHWESTERN

Australia • Canada • Me<sub>xico</sub> • Singapore • Spain • United Kingdom • United St,

<sup>\*</sup>F?,; t^r<sup>7</sup>?\*:

#### CONTENTS

#### Preface xi

#### Chapter 1

Introduction 1 Derivative Markets and Instruments 2 Options 2 Forward Contracts 3 Futures Contracts 3 Options on Futures 4 Swaps and Other Derivatives 4 The Underlying Asset 5 Some Important Concepts in Financial and Derivative Markets 5 Risk Preference 5 Short Selling 6 Return and Risk 6 Market Efficiency and Theoretical Fair Value Fundamental Linkages between Spot and Derivative Markets 9 Arbitrage and the Law of One Price 10 The Storage Mechanism: Spreading Consumption across Time 11 Delivery and Settlement 11 The Role of Derivative Markets 12 Risk Management 12 Price Discovery 12 **Operational Advantages** 13 Market Efficiency 13 Criticisms of Derivative Markets 14 Misuses of Derivatives 14 Derivatives and Your Career 15 Sources of Information on Derivatives 15 Summary 16 Key Terms 16 Further Reading 17 Questions and Problems 17

## PART

#### Options 19

#### Chapter 2

#### The Structure of Options Markets 20 The Development of Options Markets 21

Call Options22Put Options23The Over-the-Counter Options Market23Organized Options Trading25Listing Requirements25Contract Size26Exercise Prices26Expiration Dates27Position and Exercise Limits28Options Exchanges and Trading Activity28

Option Traders 29 The Market Maker 30 The Floor Broker 30 The Order Book Official 31 Other Option Trading Systems 31 Off Floor Option Traders 32 Cost and Profitability of Exchange Membership 32 The Mechanics of Trading 33 Placing an Opening Order 33 The Role of the Clearinghouse 33 Placing an Offsetting Order 35 Exercising an Option 36 Option Price Quotations 37 Types of Options - 38 Stock Options -38 Index Options 38 Currency Options 40 Other Types of Traded Options 40 Real Options 41 Transaction Costs in Option Trading 42 Floor Trading and Clearing Fees 42 Commissions 42 Bid-Ask Spread 43 Other Transaction Costs 43 The Regulation of Options Markets 44 Summary 45 Key Terms 46 Further Reading 46 Questions and Problems 47 Appendix 2.A: Margin Requirements 49 Margin Requirements on Stock Transactions 49 Margin Requirements on Option Purchases 49 Margin Requirements on the Uncovered Sale of Options 49 Margin Requirements on Covered Calls 50 Questions and Problems 50 Appendix 2.B: Taxation of Option Transactions 51 Taxation of Long Call Transactions 51 Taxation of Short Call Transactions 51 Taxation of Long Put Transactions 52 Taxation of Short Put Transactions 52 Taxation of Non-Equity Options 53 Wash and Constructive Sales -53 Questions and Problems - 53

#### Chapter 3

#### Principles of Option Pricing 55

Basic Notation and Terminology 56 Principles of Call Option Pricing 58 The Minimum Value of a Call 58 The Maximum Value of a Call 60 The Value of a Call at Expiration 61 The Effect of Time to Expiration 62 The Effect of Exercise Price 64 The Lower Bound of a European Call 67 American Call Versus European Call 70

The Early Exercise of American Calls on Dividend-Paving Stocks 71 The Effect of Interest Rates 72 The Effect of Stock Volatility 72 Principles of Put Option Pricing 73 The Minimum Value of a Put 73 The Maximum Value of a Put 75 The Value of a Put at Expiration 76 The Effect of Time to Expiration 77 The Effect of Exercise Price 78 The Lower Bound of a European Put 80 American Put Versus European Put 83 The Early Exercise of American Puts 83 Put-Call Parity 83 The Effect of Interest Rates 86 The Effect of Stock Volatility 87 Summary 88 Key Terms 90 Further Reading 90 Questions and Problems 91 Appendix 3: The Dynamics of Option Boundary Conditions: A Learning Exercise 94

#### Chapter 4

#### *Option Pricing Models: The Binomial Model* 96

The One-Period Binomial Model 97 An Illustrative Example 100 A Hedge Portfolio 101 An Overpriced Call 103 An Underpriced Call 104 The Two-Period Binomial Model 104 An Illustrative Example 107 A Hedge Portfolio 108 A Mispriced Call in the Two-Period World 110 Extensions of the Binomial Model 110 Pricing Put Options 110 American Puts and Early Exercise 113 Dividends, European Calls, American Calls, and Early Exercise 113 Extending the Binomial Model to n Periods 118 The Behavior of the Binomial Model for a Large n and a Fixed Option Life 120 Alternative Specifications of the Binomial Model 121

SOFTWARE DEMONSTRATION 4.1 Calculating the Binomial Price with the Excel Spreadsheet: bsbin3.xls 124

Summary 125 Key Terms 126 Further Reading 126 Questions and Problems 127

#### Chapter 5

Option Pricing Models: The Black-Scholes Model 129

Origins of the Black-Scholes Formula 129

The Black-Scholes Model as the Limit of the Binomial Model 130 The Assumptions of the Model 133 Stock Prices Behave Randomly and Evolve According to a Lognormal Distribution 134 The Risk-Free Rate and Volatility of the Log Return on the Stock Are Constant throughout the Option's Life 136 There Are No Taxes or Transaction Costs 137 The Stock Pays No Dividends 137 The Options Are European 138 A Nobel Formula 138 A Digression on Using the Normal Distribution 139 A Numerical Example 140 SOFTWARE DEMONSTRATION 5.1 Calculating the Black-Scholes Price with the Excel Spreadsheet: bsbin3.xls 142 Characteristics of the Black-Scholes Formula 143 The Variables in the Black-Scholes Model 147 The Stock Price 147 The Exercise Price 152 The Risk-Free Rate 153 The Volatility or Standard Deviation 155 The Time to Expiration 157 The Black-Scholes Model When the Stock Pays Dividends 159 Known Discrete Dividends 150 Known Continuous Dividend Yield 160 The Black-Scholes Model and Some Insights into American Call Options 162 Estimating the Volatility 163 Historical Volatility 163 SOFTWARE DEMONSTRATION 5.2 Calculating the Historical Volatility with the Excel Spreadsheet: hisv2.xls 164 Implied Volatility 165 Put Option Pricing Models 173 Managing the Risk of Options 176 Summary 181 Key Terms 182 Further Reading 183 Questions and Problems 184 Appendix 5.A: A Shortcut to the Calculation of Implied Volatility 187 Appendix 5.B: The BSBWIN2.2 Windows Software 189

#### Chapter 6

#### Basic Option Strategies 193

Terminology and Notation 194 *The Profit Equations 194 Different Holding Periods 196 Assumptions 197* Stock Transactions 197 *Buy Stock 197 Sell Short Stock 197* Call Option Transactions 198 *Buy a Call 198 Write a Call 203*  Put Option Transactions 205 Buy a Put 205 Write a Put 209 Calls and Stock: The Covered Call 211 Some General Considerations with Covered Calls 218 Puts and Stock: The Protective Put 219 Synthetic Puts and Calls 223

SOFTWARE DEMONSTRATION 6.1 Analyzing Option Strategies with the Excel Spreadsheet: stratlyz3.xls 227

Summary 229 Key Terms 230 Questions and Problems 230

#### Chapter 7

#### Advanced Option Strategies 233

Option Spreads: Basic Concepts 234 Why Investors Use Option Spreads 234 Notation 235 Money Spreads 236 236 **Bull Spreads** Bear Spreads 240 A Word about Call Bear Spreads and Put Bull Spreads 241 Collars 242 Butterfly Spreads 246 Calendar Spreads 252 Time Value Decay 254 Ratio Spreads 256 Straddles 257 Box Spreads 262 Summary 265 Key Terms 265 Questions and Problems 266

## PART II

#### Forwards, Futures, and Swaps 269

#### Chapter 8

#### The Structure of Forward and Futures Markets 270

The Development of Forward and Futures Markets271Chicago Futures Markets271The Development of Financial Futures272The Development of Options on Futures Markets273The Parallel Development of Over-the-Counter Markets274Organized Futures Trading275Contract Development276Contract Terms and Conditions276Delivery Terms277Daily Price Limits and Trading Halts277Other Exchange Responsibilities278

Futures Exchanges 278 Futures Traders 280 General Classes of Futures Traders 280 Classification by Trading Strategy 280 Classification by Trading Style 281 Off-Floor Futures Traders 282 The Cost and Profitability of Exchange Membership 282 Forward Market Traders 283 The Mechanics of Futures Trading 284 Placing an Order 284 The Role of the Clearinghouse 284 Daily Settlement 285 Delivery and Cash Settlement 288 Futures Price Quotations 289 Types of Futures Contracts 290 290 Agricultural Commodities Natural Resources 200 Miscellaneous Commodities 291 Foreign Currencies 291 291 Treasury Bills and Eurodollars Treasury Notes and Bonds 291 Equities 292 294 Managed Funds Hedge Funds 294 **Options on Futures** 295 Transaction Costs in Forward and Futures Trading 295 Commissions 295 Bid-Ask Spread 295 Delivery Costs 296 The Regulation of Futures and Forward Markets 296 Summary 297 Key Terms 298 Further Reading 298 **Questions and Problems** 299 Appendix 8: Taxation of Futures Transactions in the United States 301

#### Chapter 9

#### Principles of Pricing Forwards, Futures, and Options on Futures 303

Properties of Forward and Futures Prices 304 The Concept of Price versus Value 304 The Value of a Forward Contract 304 The Value of a Futures Contract 306 Forward versus Futures Prices 309 A Forward and Futures Pricing Model 310 Spot Prices, Risk Premiums, and the Cost of Carry for Generic Assets 311 The Theoretical Fair Price 312 Futures Prices and Risk Premia 317 Forward and Futures Pricing When the Underlying Generates Cash Flows 322 Another Look at Valuation of Forward Contracts 326 Pricing Foreign Currency Forward and Futures Contracts: Interest Rate Parity 326

Prices of Futures Contracts of Different Expirations 329 Put-Call-Forward/Futures Parity 329 Pricing Options on Futures 331 The Intrinsic Value of an American Option on Futures 331 The Lower Bound of a European Option on Futures 332 Put-Call Parity of Options on Futures 334 Early Exercise of Call and Put Options on Futures 335 The Black Option on Futures Pricing Model 336 Summary 340 Key Terms 341 Further Reading 341 Questions and Problems 342

#### Chapter 10

Forward and Futures Hedging 345 *Strategies* Why Hedge? 346 Hedging Concepts 347 Short Hedge and Long Hedge 347 The Basis 348 Some Risks of Hedging 352 Contract Choice 353 Margin Requirements and Marking to Market 355 Determination of the Hedge Ratio 357 Minimum Variance Hedge Ratio 357 Price Sensitivity Hedge Ratio 359 Stock Index Futures Hedging 361 Tailing the Hedge 362 Hedging Strategies 363 Foreign Currency Hedges 363 Intermediate- and Long-Term Interest Rate Hedges 365 Stock Market Hedges 371 Summary 375 Key Terms 376 Further Reading 376 Ouestions and Problems 376 Appendix 10.A: Derivation of the Hedge Ratio 380 Minimum Variance Hedge Ratio 380 Price Sensitivity Hedge Ratio 380 Appendix 10.B:Taxation of Hedging 381

#### Chapter 11

#### Advanced Futures Strategies 383

Short-Term Interest Rate Futures Strategies 384 Treasury Bill Cash-and-Carry/Implied Repo 384 Eurodollar Arbitrage 386
Intermediate- and Long-Term Interest Rate Futures
Strategies 387 Determining the Cheapest-to-Deliver Bond on the Treasury Bond Futures Contract 390 Delivery Options 392

SOFTWARE DEMONSTRATION 11.1 Identifying the Cheapest-to-Deliver Bond with the Excel Spreadsheet: ctd3.xls 394

Implied Repo/Cost of Carry 397

A Treasury Bond Futures Spread 398 Treasury Bond Spread/Implied Repo Rate 400 Intermarket Spreads 401 Bond Market Timing with Futures 402 Stock Index Futures Strategies 404 Stock Index Arbitrage 404 Alpha Capture 409 Stock Market Timing with Futures 410 Tactical Asset Allocation Using Stock and Bond Futures 413 Summary 416 Key Terms 416 Further Reading 417 **Ouestions and Problems** 417 Appendix 11.A: Determining the CBOT Treasury Bond Conversion Factor 421 SOFTWARE DEMONSTRATION 11.2

Determining the CBOT Conversion Factor with the Excel Spreadsheet: cf2.xls 422

Appendix II.B: Derivation of the Hedge Ratio for Adjusting Duration with Treasury Bond Futures 423

#### Chapter 12

Swaps 424

Interest Rate Swaps 427 The Structure of a Typical Interest Rate Swap 427 The Pricing and Valuation of Interest Rate Swaps 429 Interest Rate Swap Strategies 435 Currency Swaps 439 The Structure of a Typical Currency Swap 440 The Pricing and Valuation of Currency Swaps 442 Currency Swap Strategies 446 Equity Swaps 449 The Structure of a Typical Equity Swap 450 Pricing and Valuation of Equity Swaps 451 Equity Swap Strategies 455 Some Final Words about Swaps 457 Summary 458 Key Terms 458 Further Reading 459 Ouestions and Problems 459

## PART III

#### Advanced Topics 463

#### Chapter 13

Interest Rate Forwards and Options 465

Forward Rate Agreements 466
The Structure and Use of a Typical FRA 467
The Pricing and Valuation ofFRAs 469
Applications ofFRAs 471
Interest Rate Options 474
The Structure and Use of a Typical Interest Rate
Option 475
Pricing and Valuation of Interest Rate Options 476

Interest Rate Option Strategies 477 Interest Rate Caps, Floors, and Collars 482 Interest Rate Options, FRAs, and Swaps 488 Interest Rate Swaptions and Forward Swaps 489 The Structure of a Typical Interest Rate Swaption 489 The Equivalence of Swaptions and Options on Bonds 492 Pricing Swaptions 493 Forward Swaps 493 Applications of Swaptions and Forward Swaps 495 Summary 495 Key Terms 496 Further Reading 496 Questions and Problems 497

#### Chapter 14

#### Advanced Derivatives and Strategies 500

Advanced Equity Derivatives and Strategies 501 Portfolio Insurance 501 Equity Forwards 506 Equity Warrants 510 Equity-Linked Debt 511 Advanced Interest Rate Derivatives 512 Structured Notes 512 Mortgage-Backed Securities 514 Exotic Options 519 Digital and Chooser Options 519 Path-Dependent Options 522 Other Exotic Options 529 Some Important New Derivatives 530 Electricity Derivatives 530 530 Weather Derivatives Summary 532 Key Terms 532 Further Reading 533 Questions and Problems 534 Appendix 14.A: Derivation of the Dynamic Hedge Ratio for Portfolio Insurance 537 Stock-Futures Dynamic Hedge 537 Stock-T-Bill Dynamic Hedge 538 Appendix 14.B: Monte Carlo Simulation 539

#### Chapter 15

#### *Financial Risk Management Techniques and Applications* 542

Why Practice Risk Management? 543 The Impetus for Risk Management 543 The Benefits of Risk Management 543 Managing Market Risk 545 Delta Hedging 546 Gamma Hedging 548 Vega Hedging 550 Value at Risk (VAR) 552

A Comprehensive Calculation of VAR 558 Benefits and Criticisms of VAR 560 Extensions of VAR 561 Managing Credit Risk 562 Option Pricing Theory and Credit Risk 563 The Credit Risk of Derivatives 565 Netting 568 Credit Derivatives 569 Other Types of Risks 572 Summary 576 Key Terms 576 Further Reading 577 Questions and Problems 577

#### Chapter 16

#### Managing Risk in an Organization 580

The Structure of the Risk Management Industry 581 End Users 581 Dealers 582 Other Participants in the Risk Management Industry 583 Organizing the Risk Management Function in a Company 584 Risk Management Accounting 587 Fair Value Hedges 588 Cash Flow Hedges 589 Foreign Investment Hedges 591 Speculation 591 Some Problems in the Application of FAS 133 591 Disclosure 592 Avoiding Derivatives Losses 592 MetaUgeseUschafi: To Hedge or Not to Hedge ? 594 Orange County, California: Playing the Odds 596 Barings PLC: How One Man Blew Up a Bank 597 Procter & Gamble: Going Up in Suds 599 Risk Management Industry Standards 600 Responsibilities of Senior Management 606 Summary 607 Key Terms 607 Further Reading 608 Questions and Problems 608

#### Appendix A

List of Formulas 611

#### Appendix B

References620Glossary640Index663