

# Contents

|                   |                                                     |              |
|-------------------|-----------------------------------------------------|--------------|
|                   | <b>List of Business Snapshots.....</b>              | <b>xvii</b>  |
|                   | <b>List of Technical Notes.....</b>                 | <b>xviii</b> |
|                   | <b>Preface .....</b>                                | <b>xix</b>   |
| <b>Chapter 1.</b> | <b>Introduction .....</b>                           | <b>1</b>     |
|                   | 1.1 Exchange-traded markets .....                   | 2            |
|                   | 1.2 Over-the-counter markets .....                  | 3            |
|                   | 1.3 Forward contracts.....                          | 5            |
|                   | 1.4 Futures contracts .....                         | 7            |
|                   | 1.5 Options.....                                    | 7            |
|                   | 1.6 Types of traders.....                           | 9            |
|                   | 1.7 Hedgers.....                                    | 10           |
|                   | 1.8 Speculators .....                               | 13           |
|                   | 1.9 Arbitrageurs.....                               | 15           |
|                   | 1.10 Dangers .....                                  | 16           |
|                   | Summary.....                                        | 16           |
|                   | Further reading .....                               | 18           |
|                   | Practice questions.....                             | 18           |
|                   | Further questions.....                              | 20           |
| <b>Chapter 2.</b> | <b>Mechanics of futures markets.....</b>            | <b>22</b>    |
|                   | 2.1 Background .....                                | 22           |
|                   | 2.2 Specification of a futures contract.....        | 24           |
|                   | 2.3 Convergence of futures price to spot price..... | 26           |
|                   | 2.4 The operation of margins.....                   | 27           |
|                   | 2.5 OTC markets .....                               | 30           |
|                   | 2.6 Market quotes.....                              | 33           |
|                   | 2.7 Delivery .....                                  | 36           |
|                   | 2.8 Types of traders and types of orders.....       | 37           |
|                   | 2.9 Regulation .....                                | 38           |
|                   | 2.10 Accounting and tax.....                        | 39           |
|                   | 2.11 Forward vs. futures contracts.....             | 41           |
|                   | Summary.....                                        | 42           |
|                   | Further reading .....                               | 43           |
|                   | Practice questions.....                             | 43           |
|                   | Further questions.....                              | 45           |
| <b>Chapter 3.</b> | <b>Hedging strategies using futures.....</b>        | <b>47</b>    |
|                   | 3.1 Basic principles.....                           | 47           |
|                   | 3.2 Arguments for and against hedging .....         | 49           |
|                   | 3.3 Basis risk.....                                 | 52           |
|                   | 3.4 Cross hedging .....                             | 56           |

|                   |                                                         |            |
|-------------------|---------------------------------------------------------|------------|
| 3.5               | Stock index futures.....                                | 60         |
| 3.6               | Stack and roll.....                                     | 65         |
|                   | Summary.....                                            | 67         |
|                   | Further reading.....                                    | 68         |
|                   | Practice questions.....                                 | 69         |
|                   | Further questions.....                                  | 71         |
|                   | Appendix: Capital asset pricing model.....              | 73         |
| <b>Chapter 4.</b> | <b>Interest rates.....</b>                              | <b>75</b>  |
| 4.1               | Types of rates.....                                     | 75         |
| 4.2               | Measuring interest rates.....                           | 77         |
| 4.3               | Zero rates.....                                         | 80         |
| 4.4               | Bond pricing.....                                       | 80         |
| 4.5               | Determining Treasury zero rates.....                    | 82         |
| 4.6               | Forward rates.....                                      | 84         |
| 4.7               | Forward rate agreements.....                            | 86         |
| 4.8               | Duration.....                                           | 89         |
| 4.9               | Convexity.....                                          | 92         |
| 4.10              | Theories of the term structure of interest rates.....   | 93         |
|                   | Summary.....                                            | 96         |
|                   | Further reading.....                                    | 97         |
|                   | Practice questions.....                                 | 97         |
|                   | Further questions.....                                  | 99         |
| <b>Chapter 5.</b> | <b>Determination of forward and futures prices.....</b> | <b>101</b> |
| 5.1               | Investment assets vs. consumption assets.....           | 101        |
| 5.2               | Short selling.....                                      | 102        |
| 5.3               | Assumptions and notation.....                           | 103        |
| 5.4               | Forward price for an investment asset.....              | 104        |
| 5.5               | Known income.....                                       | 107        |
| 5.6               | Known yield.....                                        | 109        |
| 5.7               | Valuing forward contracts.....                          | 109        |
| 5.8               | Are forward prices and futures prices equal?.....       | 111        |
| 5.9               | Futures prices of stock indices.....                    | 112        |
| 5.10              | Forward and futures contracts on currencies.....        | 114        |
| 5.11              | Futures on commodities.....                             | 117        |
| 5.12              | The cost of carry.....                                  | 120        |
| 5.13              | Delivery options.....                                   | 121        |
| 5.14              | Futures prices and the expected future spot price.....  | 121        |
|                   | Summary.....                                            | 123        |
|                   | Further reading.....                                    | 125        |
|                   | Practice questions.....                                 | 125        |
|                   | Further questions.....                                  | 127        |
| <b>Chapter 6.</b> | <b>Interest rate futures.....</b>                       | <b>129</b> |
| 6.1               | Day count and quotation conventions.....                | 129        |
| 6.2               | Treasury bond futures.....                              | 132        |
| 6.3               | Eurodollar futures.....                                 | 137        |
| 6.4               | Duration-based hedging strategies using futures.....    | 142        |
| 6.5               | Hedging portfolios of assets and liabilities.....       | 143        |
|                   | Summary.....                                            | 144        |
|                   | Further reading.....                                    | 145        |
|                   | Practice questions.....                                 | 145        |
|                   | Further questions.....                                  | 147        |

|                                                                      |            |
|----------------------------------------------------------------------|------------|
| <b>Chapter 7. Swaps</b> .....                                        | <b>148</b> |
| 7.1 Mechanics of interest rate swaps .....                           | 148        |
| 7.2 Day count issues.....                                            | 154        |
| 7.3 Confirmations .....                                              | 155        |
| 7.4 The comparative-advantage argument .....                         | 156        |
| 7.5 The nature of swap rates.....                                    | 158        |
| 7.6 Determining the LIBOR/swap zero rates .....                      | 159        |
| 7.7 Valuation of interest rate swaps.....                            | 160        |
| 7.8 Overnight indexed swaps.....                                     | 164        |
| 7.9 Currency swaps .....                                             | 165        |
| 7.10 Valuation of currency swaps .....                               | 168        |
| 7.11 Credit risk .....                                               | 171        |
| 7.12 Other types of swaps.....                                       | 173        |
| Summary.....                                                         | 175        |
| Further reading .....                                                | 176        |
| Practice questions.....                                              | 176        |
| Further questions.....                                               | 178        |
| <b>Chapter 8. Securitization and the Credit Crisis of 2007</b> ..... | <b>180</b> |
| 8.1 Securitization .....                                             | 180        |
| 8.2 The US housing market.....                                       | 184        |
| 8.3 What went wrong? .....                                           | 188        |
| 8.4 The aftermath .....                                              | 190        |
| Summary.....                                                         | 191        |
| Further reading .....                                                | 192        |
| Practice questions.....                                              | 193        |
| Further questions.....                                               | 193        |
| <b>Chapter 9. Mechanics of options markets</b> .....                 | <b>194</b> |
| 9.1 Types of options.....                                            | 194        |
| 9.2 Option positions.....                                            | 196        |
| 9.3 Underlying assets.....                                           | 198        |
| 9.4 Specification of stock options .....                             | 199        |
| 9.5 Trading .....                                                    | 203        |
| 9.6 Commissions.....                                                 | 204        |
| 9.7 Margins .....                                                    | 205        |
| 9.8 The options clearing corporation.....                            | 206        |
| 9.9 Regulation .....                                                 | 207        |
| 9.10 Taxation.....                                                   | 207        |
| 9.11 Warrants, employee stock options, and convertibles .....        | 209        |
| 9.12 Over-the-counter markets.....                                   | 210        |
| Summary.....                                                         | 210        |
| Further reading .....                                                | 211        |
| Practice questions.....                                              | 211        |
| Further questions.....                                               | 213        |
| <b>Chapter 10. Properties of stock options</b> .....                 | <b>214</b> |
| 10.1 Factors affecting option prices .....                           | 214        |
| 10.2 Assumptions and notation .....                                  | 218        |
| 10.3 Upper and lower bounds for option prices.....                   | 218        |
| 10.4 Put–call parity .....                                           | 221        |
| 10.5 Calls on a non-dividend-paying stock .....                      | 225        |
| 10.6 Puts on a non-dividend-paying stock .....                       | 226        |
| 10.7 Effect of dividends .....                                       | 229        |

|                                                              |                                                                                                      |            |
|--------------------------------------------------------------|------------------------------------------------------------------------------------------------------|------------|
|                                                              | Summary .....                                                                                        | 230        |
|                                                              | Further reading.....                                                                                 | 231        |
|                                                              | Practice questions.....                                                                              | 231        |
|                                                              | Further questions.....                                                                               | 233        |
| <b>Chapter 11. Trading strategies involving options.....</b> |                                                                                                      | <b>234</b> |
| 11.1                                                         | Principal-protected notes .....                                                                      | 234        |
| 11.2                                                         | Trading an option and the underlying asset .....                                                     | 236        |
| 11.3                                                         | Spreads.....                                                                                         | 238        |
| 11.4                                                         | Combinations .....                                                                                   | 246        |
| 11.5                                                         | Other payoffs.....                                                                                   | 249        |
|                                                              | Summary .....                                                                                        | 249        |
|                                                              | Further reading.....                                                                                 | 250        |
|                                                              | Practice questions.....                                                                              | 250        |
|                                                              | Further questions .....                                                                              | 252        |
| <b>Chapter 12. Binomial trees .....</b>                      |                                                                                                      | <b>253</b> |
| 12.1                                                         | A one-step binomial model and a no-arbitrage argument .....                                          | 253        |
| 12.2                                                         | Risk-neutral valuation.....                                                                          | 257        |
| 12.3                                                         | Two-step binomial trees .....                                                                        | 259        |
| 12.4                                                         | A put example .....                                                                                  | 262        |
| 12.5                                                         | American options.....                                                                                | 263        |
| 12.6                                                         | Delta.....                                                                                           | 264        |
| 12.7                                                         | Matching volatility with $u$ and $d$ .....                                                           | 265        |
| 12.8                                                         | The binomial tree formulas.....                                                                      | 267        |
| 12.9                                                         | Increasing the number of steps .....                                                                 | 268        |
| 12.10                                                        | Using DerivaGem .....                                                                                | 269        |
| 12.11                                                        | Options on other assets.....                                                                         | 269        |
|                                                              | Summary .....                                                                                        | 272        |
|                                                              | Further reading.....                                                                                 | 273        |
|                                                              | Practice questions.....                                                                              | 274        |
|                                                              | Further questions .....                                                                              | 275        |
|                                                              | Appendix: Derivation of the Black–Scholes–Merton option-pricing<br>formula from a binomial tree..... | 276        |
| <b>Chapter 13. Wiener processes and Itô’s lemma .....</b>    |                                                                                                      | <b>280</b> |
| 13.1                                                         | The Markov property .....                                                                            | 280        |
| 13.2                                                         | Continuous-time stochastic processes.....                                                            | 281        |
| 13.3                                                         | The process for a stock price .....                                                                  | 286        |
| 13.4                                                         | The parameters.....                                                                                  | 289        |
| 13.5                                                         | Correlated processes .....                                                                           | 290        |
| 13.6                                                         | Itô’s lemma .....                                                                                    | 291        |
| 13.7                                                         | The lognormal property .....                                                                         | 292        |
|                                                              | Summary .....                                                                                        | 293        |
|                                                              | Further reading.....                                                                                 | 294        |
|                                                              | Practice questions.....                                                                              | 294        |
|                                                              | Further questions.....                                                                               | 295        |
|                                                              | Appendix: Derivation of Itô’s lemma .....                                                            | 297        |
| <b>Chapter 14. The Black–Scholes–Merton model.....</b>       |                                                                                                      | <b>299</b> |
| 14.1                                                         | Lognormal property of stock prices .....                                                             | 300        |
| 14.2                                                         | The distribution of the rate of return .....                                                         | 301        |
| 14.3                                                         | The expected return.....                                                                             | 302        |
| 14.4                                                         | Volatility.....                                                                                      | 303        |
| 14.5                                                         | The idea underlying the Black–Scholes–Merton differential equation.....                              | 307        |

|                    |                                                                                       |            |
|--------------------|---------------------------------------------------------------------------------------|------------|
| 14.6               | Derivation of the Black–Scholes–Merton differential equation .....                    | 309        |
| 14.7               | Risk-neutral valuation .....                                                          | 311        |
| 14.8               | Black–Scholes–Merton pricing formulas .....                                           | 313        |
| 14.9               | Cumulative normal distribution function .....                                         | 315        |
| 14.10              | Warrants and employee stock options .....                                             | 316        |
| 14.11              | Implied volatilities.....                                                             | 318        |
| 14.12              | Dividends .....                                                                       | 320        |
|                    | Summary.....                                                                          | 323        |
|                    | Further reading .....                                                                 | 324        |
|                    | Practice questions.....                                                               | 325        |
|                    | Further questions.....                                                                | 328        |
|                    | Appendix: Proof of Black–Scholes–Merton formula using risk-neutral<br>valuation ..... | 329        |
| <b>Chapter 15.</b> | <b>Employee stock options.....</b>                                                    | <b>332</b> |
| 15.1               | Contractual arrangements.....                                                         | 332        |
| 15.2               | Do options align the interests of shareholders and managers?.....                     | 334        |
| 15.3               | Accounting issues .....                                                               | 335        |
| 15.4               | Valuation.....                                                                        | 336        |
| 15.5               | Backdating scandals .....                                                             | 341        |
|                    | Summary.....                                                                          | 342        |
|                    | Further reading .....                                                                 | 343        |
|                    | Practice questions.....                                                               | 343        |
|                    | Further questions.....                                                                | 344        |
| <b>Chapter 16.</b> | <b>Options on stock indices and currencies .....</b>                                  | <b>345</b> |
| 16.1               | Options on stock indices.....                                                         | 345        |
| 16.2               | Currency options .....                                                                | 347        |
| 16.3               | Options on stocks paying known dividend yields .....                                  | 350        |
| 16.4               | Valuation of European stock index options.....                                        | 352        |
| 16.5               | Valuation of European currency options.....                                           | 355        |
| 16.6               | American options .....                                                                | 356        |
|                    | Summary.....                                                                          | 357        |
|                    | Further reading .....                                                                 | 357        |
|                    | Practice questions.....                                                               | 358        |
|                    | Further questions.....                                                                | 360        |
| <b>Chapter 17.</b> | <b>Futures options.....</b>                                                           | <b>361</b> |
| 17.1               | Nature of futures options.....                                                        | 361        |
| 17.2               | Reasons for the popularity of futures options .....                                   | 364        |
| 17.3               | European spot and futures options.....                                                | 364        |
| 17.4               | Put–call parity .....                                                                 | 365        |
| 17.5               | Bounds for futures options.....                                                       | 366        |
| 17.6               | Valuation of futures options using binomial trees .....                               | 367        |
| 17.7               | Drift of a futures prices in a risk-neutral world .....                               | 369        |
| 17.8               | Black’s model for valuing futures options.....                                        | 370        |
| 17.9               | American futures options vs. American spot options.....                               | 372        |
| 17.10              | Futures-style options .....                                                           | 372        |
|                    | Summary.....                                                                          | 373        |
|                    | Further reading .....                                                                 | 374        |
|                    | Practice questions.....                                                               | 374        |
|                    | Further questions.....                                                                | 376        |
| <b>Chapter 18.</b> | <b>The Greek letters.....</b>                                                         | <b>377</b> |
| 18.1               | Illustration .....                                                                    | 377        |

|                    |                                                                                           |            |
|--------------------|-------------------------------------------------------------------------------------------|------------|
| 18.2               | Naked and covered positions .....                                                         | 378        |
| 18.3               | A stop-loss strategy .....                                                                | 378        |
| 18.4               | Delta hedging .....                                                                       | 380        |
| 18.5               | Theta .....                                                                               | 387        |
| 18.6               | Gamma .....                                                                               | 389        |
| 18.7               | Relationship between delta, theta, and gamma.....                                         | 392        |
| 18.8               | Vega .....                                                                                | 393        |
| 18.9               | Rho .....                                                                                 | 395        |
| 18.10              | The realities of hedging.....                                                             | 396        |
| 18.11              | Scenario analysis.....                                                                    | 397        |
| 18.12              | Extension of formulas.....                                                                | 397        |
| 18.13              | Portfolio insurance .....                                                                 | 400        |
| 18.14              | Stock market volatility .....                                                             | 402        |
|                    | Summary .....                                                                             | 402        |
|                    | Further reading.....                                                                      | 404        |
|                    | Practice questions.....                                                                   | 404        |
|                    | Further questions.....                                                                    | 406        |
|                    | Appendix: Taylor series expansions and hedge parameters.....                              | 408        |
| <b>Chapter 19.</b> | <b>Volatility smiles .....</b>                                                            | <b>409</b> |
| 19.1               | Why the volatility smile is the same for calls and puts .....                             | 409        |
| 19.2               | Foreign currency options.....                                                             | 411        |
| 19.3               | Equity options.....                                                                       | 414        |
| 19.4               | Alternative ways of characterizing the volatility smile.....                              | 415        |
| 19.5               | The volatility term structure and volatility surfaces.....                                | 416        |
| 19.6               | Greek letters.....                                                                        | 417        |
| 19.7               | The role of the model.....                                                                | 418        |
| 19.8               | When a single large jump is anticipated.....                                              | 419        |
|                    | Summary .....                                                                             | 420        |
|                    | Further reading.....                                                                      | 421        |
|                    | Practice questions.....                                                                   | 421        |
|                    | Further questions.....                                                                    | 423        |
|                    | Appendix: Determining implied risk-neutral distributions from<br>volatility smiles .....  | 424        |
| <b>Chapter 20.</b> | <b>Basic numerical procedures .....</b>                                                   | <b>427</b> |
| 20.1               | Binomial trees.....                                                                       | 427        |
| 20.2               | Using the binomial tree for options on indices, currencies, and futures<br>contracts..... | 435        |
| 20.3               | Binomial model for a dividend-paying stock.....                                           | 437        |
| 20.4               | Alternative procedures for constructing trees .....                                       | 442        |
| 20.5               | Time-dependent parameters .....                                                           | 445        |
| 20.6               | Monte Carlo simulation .....                                                              | 446        |
| 20.7               | Variance reduction procedures.....                                                        | 452        |
| 20.8               | Finite difference methods.....                                                            | 455        |
|                    | Summary .....                                                                             | 466        |
|                    | Further reading.....                                                                      | 466        |
|                    | Practice questions.....                                                                   | 467        |
|                    | Further questions.....                                                                    | 469        |
| <b>Chapter 21.</b> | <b>Value at risk .....</b>                                                                | <b>471</b> |
| 21.1               | The VaR measure .....                                                                     | 471        |
| 21.2               | Historical simulation.....                                                                | 474        |
| 21.3               | Model-building approach .....                                                             | 478        |

|                    |                                                             |            |
|--------------------|-------------------------------------------------------------|------------|
| 21.4               | Linear model .....                                          | 481        |
| 21.5               | Quadratic model .....                                       | 486        |
| 21.6               | Monte Carlo simulation.....                                 | 488        |
| 21.7               | Comparison of approaches .....                              | 489        |
| 21.8               | Stress testing and back testing.....                        | 490        |
| 21.9               | Principal components analysis.....                          | 490        |
|                    | Summary.....                                                | 494        |
|                    | Further reading .....                                       | 494        |
|                    | Practice questions.....                                     | 495        |
|                    | Further questions.....                                      | 497        |
| <b>Chapter 22.</b> | <b>Estimating volatilities and correlations .....</b>       | <b>498</b> |
| 22.1               | Estimating volatility .....                                 | 498        |
| 22.2               | The exponentially weighted moving average model.....        | 500        |
| 22.3               | The GARCH (1,1) model .....                                 | 502        |
| 22.4               | Choosing between the models.....                            | 503        |
| 22.5               | Maximum likelihood methods.....                             | 504        |
| 22.6               | Using GARCH (1,1) to forecast future volatility .....       | 509        |
| 22.7               | Correlations .....                                          | 512        |
| 22.8               | Application of EWMA to four-index example.....              | 515        |
|                    | Summary.....                                                | 517        |
|                    | Further reading .....                                       | 517        |
|                    | Practice questions.....                                     | 518        |
|                    | Further questions.....                                      | 519        |
| <b>Chapter 23.</b> | <b>Credit risk.....</b>                                     | <b>521</b> |
| 23.1               | Credit ratings .....                                        | 521        |
| 23.2               | Historical default probabilities .....                      | 522        |
| 23.3               | Recovery rates .....                                        | 523        |
| 23.4               | Estimating default probabilities from bond prices .....     | 524        |
| 23.5               | Comparison of default probability estimates.....            | 526        |
| 23.6               | Using equity prices to estimate default probabilities ..... | 530        |
| 23.7               | Credit risk in derivatives transactions.....                | 531        |
| 23.8               | Credit risk mitigation .....                                | 534        |
| 23.9               | Default correlation.....                                    | 536        |
| 23.10              | Credit VaR .....                                            | 540        |
|                    | Summary.....                                                | 542        |
|                    | Further reading .....                                       | 543        |
|                    | Practice questions.....                                     | 543        |
|                    | Further questions.....                                      | 545        |
| <b>Chapter 24.</b> | <b>Credit derivatives .....</b>                             | <b>547</b> |
| 24.1               | Credit default swaps.....                                   | 548        |
| 24.2               | Valuation of credit default swaps .....                     | 551        |
| 24.3               | Credit indices .....                                        | 555        |
| 24.4               | The use of fixed coupons .....                              | 556        |
| 24.5               | CDS forwards and options.....                               | 557        |
| 24.6               | Basket credit default swaps.....                            | 558        |
| 24.7               | Total return swaps .....                                    | 558        |
| 24.8               | Collateralized debt obligations .....                       | 559        |
| 24.9               | Role of correlation in a basket CDS and CDO .....           | 561        |
| 24.10              | Valuation of a synthetic CDO.....                           | 562        |
| 24.11              | Alternatives to the standard market model.....              | 569        |
|                    | Summary.....                                                | 570        |

|                                                                 |                                                  |            |
|-----------------------------------------------------------------|--------------------------------------------------|------------|
|                                                                 | Further reading.....                             | 571        |
|                                                                 | Practice questions.....                          | 571        |
|                                                                 | Further questions.....                           | 573        |
| <b>Chapter 25. Exotic options .....</b>                         |                                                  | <b>574</b> |
| 25.1                                                            | Packages.....                                    | 574        |
| 25.2                                                            | Nonstandard American options.....                | 575        |
| 25.3                                                            | Gap options.....                                 | 575        |
| 25.4                                                            | Forward start options.....                       | 576        |
| 25.5                                                            | Cliquet options.....                             | 577        |
| 25.6                                                            | Compound options.....                            | 577        |
| 25.7                                                            | Chooser options.....                             | 578        |
| 25.8                                                            | Barrier options.....                             | 579        |
| 25.9                                                            | Binary options.....                              | 581        |
| 25.10                                                           | Lookback options.....                            | 582        |
| 25.11                                                           | Shout options.....                               | 584        |
| 25.12                                                           | Asian options.....                               | 584        |
| 25.13                                                           | Options to exchange one asset for another.....   | 586        |
| 25.14                                                           | Options involving several assets.....            | 587        |
| 25.15                                                           | Volatility and variance swaps.....               | 588        |
| 25.16                                                           | Static options replication.....                  | 591        |
|                                                                 | Summary.....                                     | 593        |
|                                                                 | Further reading.....                             | 594        |
|                                                                 | Practice questions.....                          | 594        |
|                                                                 | Further questions.....                           | 596        |
| <b>Chapter 26. More on models and numerical procedures.....</b> |                                                  | <b>599</b> |
| 26.1                                                            | Alternatives to Black–Scholes–Merton.....        | 600        |
| 26.2                                                            | Stochastic volatility models.....                | 605        |
| 26.3                                                            | The IVF model.....                               | 607        |
| 26.4                                                            | Convertible bonds.....                           | 608        |
| 26.5                                                            | Path-dependent derivatives.....                  | 611        |
| 26.6                                                            | Barrier options.....                             | 615        |
| 26.7                                                            | Options on two correlated assets.....            | 618        |
| 26.8                                                            | Monte Carlo simulation and American options..... | 621        |
|                                                                 | Summary.....                                     | 625        |
|                                                                 | Further reading.....                             | 626        |
|                                                                 | Practice questions.....                          | 627        |
|                                                                 | Further questions.....                           | 628        |
| <b>Chapter 27. Martingales and measures.....</b>                |                                                  | <b>630</b> |
| 27.1                                                            | The market price of risk.....                    | 631        |
| 27.2                                                            | Several state variables.....                     | 634        |
| 27.3                                                            | Martingales.....                                 | 635        |
| 27.4                                                            | Alternative choices for the numeraire.....       | 636        |
| 27.5                                                            | Extension to several factors.....                | 640        |
| 27.6                                                            | Black’s model revisited.....                     | 641        |
| 27.7                                                            | Option to exchange one asset for another.....    | 642        |
| 27.8                                                            | Change of numeraire.....                         | 643        |
|                                                                 | Summary.....                                     | 644        |
|                                                                 | Further reading.....                             | 645        |
|                                                                 | Practice questions.....                          | 645        |
|                                                                 | Further questions.....                           | 647        |



|                                                                                |            |
|--------------------------------------------------------------------------------|------------|
| <b>Chapter 28. Interest rate derivatives: The standard market models .....</b> | <b>648</b> |
| 28.1 Bond options .....                                                        | 648        |
| 28.2 Interest rate caps and floors.....                                        | 653        |
| 28.3 European swap options.....                                                | 659        |
| 28.4 Generalizations.....                                                      | 663        |
| 28.5 Hedging interest rate derivatives.....                                    | 663        |
| Summary.....                                                                   | 664        |
| Further reading .....                                                          | 665        |
| Practice questions.....                                                        | 665        |
| Further questions.....                                                         | 666        |
| <b>Chapter 29. Convexity, timing, and quanto adjustments .....</b>             | <b>668</b> |
| 29.1 Convexity adjustments .....                                               | 668        |
| 29.2 Timing adjustments.....                                                   | 672        |
| 29.3 Quantos .....                                                             | 674        |
| Summary.....                                                                   | 677        |
| Further reading .....                                                          | 677        |
| Practice questions.....                                                        | 678        |
| Further questions.....                                                         | 679        |
| Appendix: Proof of the convexity adjustment formula .....                      | 681        |
| <b>Chapter 30. Interest rate derivatives: models of the short rate .....</b>   | <b>682</b> |
| 30.1 Background .....                                                          | 682        |
| 30.2 Equilibrium models.....                                                   | 683        |
| 30.3 No-arbitrage models.....                                                  | 689        |
| 30.4 Options on bonds.....                                                     | 694        |
| 30.5 Volatility structures .....                                               | 695        |
| 30.6 Interest rate trees .....                                                 | 696        |
| 30.7 A general tree-building procedure.....                                    | 698        |
| 30.8 Calibration.....                                                          | 707        |
| 30.9 Hedging using a one-factor model.....                                     | 709        |
| Summary.....                                                                   | 710        |
| Further reading .....                                                          | 710        |
| Practice questions.....                                                        | 711        |
| Further questions.....                                                         | 713        |
| <b>Chapter 31. Interest rate derivatives: HJM and LMM .....</b>                | <b>715</b> |
| 31.1 The Heath, Jarrow, and Morton model.....                                  | 715        |
| 31.2 The LIBOR market model.....                                               | 718        |
| 31.3 Agency mortgage-backed securities.....                                    | 728        |
| Summary.....                                                                   | 730        |
| Further reading .....                                                          | 731        |
| Practice questions.....                                                        | 731        |
| Further questions.....                                                         | 732        |
| <b>Chapter 32. Swaps Revisited.....</b>                                        | <b>733</b> |
| 32.1 Variations on the vanilla deal .....                                      | 733        |
| 32.2 Compounding swaps .....                                                   | 735        |
| 32.3 Currency swaps .....                                                      | 736        |
| 32.4 More complex swaps.....                                                   | 737        |
| 32.5 Equity swaps.....                                                         | 740        |
| 32.6 Swaps with embedded options .....                                         | 742        |
| 32.7 Other swaps.....                                                          | 744        |
| Summary.....                                                                   | 745        |
| Further reading .....                                                          | 746        |

|                                                                             |                                                                    |            |
|-----------------------------------------------------------------------------|--------------------------------------------------------------------|------------|
|                                                                             | Practice questions.....                                            | 746        |
|                                                                             | Further questions.....                                             | 747        |
| <b>Chapter 33. Energy and commodity derivatives.....</b>                    |                                                                    | <b>748</b> |
| 33.1                                                                        | Agricultural commodities.....                                      | 748        |
| 33.2                                                                        | Metals.....                                                        | 749        |
| 33.3                                                                        | Energy products.....                                               | 750        |
| 33.4                                                                        | Modeling commodity prices.....                                     | 752        |
| 33.5                                                                        | Weather derivatives.....                                           | 758        |
| 33.6                                                                        | Insurance derivatives.....                                         | 759        |
| 33.7                                                                        | Pricing weather and insurance derivatives.....                     | 760        |
| 33.8                                                                        | How an energy producer can hedge risks.....                        | 761        |
|                                                                             | Summary.....                                                       | 762        |
|                                                                             | Further reading.....                                               | 762        |
|                                                                             | Practice questions.....                                            | 763        |
|                                                                             | Further question.....                                              | 764        |
| <b>Chapter 34. Real options.....</b>                                        |                                                                    | <b>765</b> |
| 34.1                                                                        | Capital investment appraisal.....                                  | 765        |
| 34.2                                                                        | Extension of the risk-neutral valuation framework.....             | 766        |
| 34.3                                                                        | Estimating the market price of risk.....                           | 768        |
| 34.4                                                                        | Application to the valuation of a business.....                    | 769        |
| 34.5                                                                        | Evaluating options in an investment opportunity.....               | 769        |
|                                                                             | Summary.....                                                       | 776        |
|                                                                             | Further reading.....                                               | 776        |
|                                                                             | Practice questions.....                                            | 777        |
|                                                                             | Further questions.....                                             | 777        |
| <b>Chapter 35. Derivatives mishaps and what we can learn from them.....</b> |                                                                    | <b>779</b> |
| 35.1                                                                        | Lessons for all users of derivatives.....                          | 779        |
| 35.2                                                                        | Lessons for financial institutions.....                            | 783        |
| 35.3                                                                        | Lessons for nonfinancial corporations.....                         | 788        |
|                                                                             | Summary.....                                                       | 790        |
|                                                                             | Further reading.....                                               | 790        |
| <b>Chapter 36. Derivatives markets in developing countries.....</b>         |                                                                    | <b>791</b> |
| 36.1                                                                        | China's markets.....                                               | 791        |
| 36.2                                                                        | India's markets.....                                               | 793        |
| 36.3                                                                        | Other developing countries.....                                    | 794        |
|                                                                             | Summary.....                                                       | 794        |
|                                                                             | Further reading.....                                               | 795        |
|                                                                             | <b>Glossary of terms.....</b>                                      | <b>797</b> |
|                                                                             | <b>DerivaGem software.....</b>                                     | <b>818</b> |
|                                                                             | <b>Major exchanges trading futures and options.....</b>            | <b>823</b> |
|                                                                             | <b>Table for <math>N(x)</math> when <math>x \leq 0</math>.....</b> | <b>824</b> |
|                                                                             | <b>Table for <math>N(x)</math> when <math>x \geq 0</math>.....</b> | <b>825</b> |
|                                                                             | <b>Author index.....</b>                                           | <b>826</b> |
|                                                                             | <b>Subject index.....</b>                                          | <b>830</b> |