

CONTENTS

<i>Preface</i>	xix
1. Introduction	1
1.1 Exchange-traded markets.....	1
1.2 Over-the-counter markets	2
1.3 Forward contracts.....	2
1.4 Futures contracts.....	5
1.5 Options	6
1.6 Types of traders	10
1.7 Other derivatives	14
Summary.....	15
Questions and problems	16
Assignment questions	17
2. Mechanics of futures markets	19
2.1 Trading futures contracts.....	19
2.2 Specification of the futures contract	20
2.3 Convergence of futures price to spot price.....	23
2.4 Operation of margins.....	24
2.5 Newspaper quotes.....	27
2.6 Keynes and Hicks.....	31
2.7 Delivery.....	31
2.8 Types of traders	32
2.9 Regulation	33
2.10 Accounting and tax.....	35
2.11 Forward contracts vs. futures contracts.....	36
Summary.....	37
Suggestions for further reading	38
Questions and problems	38
Assignment questions	40
3. Determination of forward and futures prices	41
3.1 Investment assets vs. consumption assets	41
3.2 Short selling	41
3.3 Measuring interest rates	42
3.4 Assumptions and notation	44
3.5 Forward price for an investment asset	45
3.6 Known income.....	47
3.7 Known yield.....	49
3.8 Valuing forward contracts.....	49
3.9 Are forward prices and futures prices equal?.....	51
3.10 Stock index futures	52
3.11 Forward and futures contracts on currencies.....	55
3.12 Futures on commodities.....	58

3.13	Cost of carry	60
3.14	Delivery options	60
3.15	Futures prices and the expected future spot price.....	61
	Summary	63
	Suggestions for further reading	64
	Questions and problems	65
	Assignment questions	67
	Appendix 3A: Proof that forward and futures prices are equal when interest rates are constant	68
4.	Hedging strategies using futures	70
4.1	Basic principles	70
4.2	Arguments for and against hedging	72
4.3	Basis risk	75
4.4	Minimum variance hedge ratio	78
4.5	Stock index futures	82
4.6	Rolling the hedge forward	86
	Summary	87
	Suggestions for further reading	88
	Questions and problems	88
	Assignment questions	90
	Appendix 4A: Proof of the minimum variance hedge ratio formula	92
5.	Interest rate markets	93
5.1	Types of rates	93
5.2	Zero rates	94
5.3	Bond pricing	94
5.4	Determining zero rates	96
5.5	Forward rates	98
5.6	Forward rate agreements	100
5.7	Theories of the term structure	102
5.8	Day count conventions	102
5.9	Quotations	103
5.10	Treasury bond futures	104
5.11	Eurodollar futures	110
5.12	The LIBOR zero curve	111
5.13	Duration	112
5.14	Duration-based hedging strategies	116
	Summary	118
	Suggestions for further reading	119
	Questions and problems	120
	Assignment questions	123
6.	Swaps	125
6.1	Mechanics of interest rate swaps	125
6.2	The comparative-advantage argument	131
6.3	Swap quotes and LIBOR zero rates	134
6.4	Valuation of interest rate swaps	136
6.5	Currency swaps	140
6.6	Valuation of currency swaps	143
6.7	Credit risk	145
	Summary	146
	Suggestions for further reading	147
	Questions and problems	147
	Assignment questions	149

7. Mechanics of options markets.....	151
7.1 Underlying assets.....	151
7.2 Specification of stock options	152
7.3 Newspaper quotes.....	155
7.4 Trading	157
7.5 Commissions	157
7.6 Margins.....	158
7.7 The options clearing corporation.....	160
7.8 Regulation	161
7.9 Taxation	161
7.10 Warrants, executive stock options, and convertibles.....	162
7.11 Over-the-counter markets	163
Summary.....	163
Suggestions for further reading	164
Questions and problems	164
Assignment questions	165
8. Properties of stock options.....	167
8.1 Factors affecting option prices.....	167
8.2 Assumptions and notation.....	170
8.3 Upper and lower bounds for option prices	171
8.4 Put–call parity	174
8.5 Early exercise: calls on a non-dividend-paying stock	175
8.6 Early exercise: puts on a non-dividend-paying stock	177
8.7 Effect of dividends.....	178
8.8 Empirical research	179
Summary.....	180
Suggestions for further reading	181
Questions and problems	182
Assignment questions	183
9. Trading strategies involving options.....	185
9.1 Strategies involving a single option and a stock.....	185
9.2 Spreads	187
9.3 Combinations	194
9.4 Other payoffs.....	197
Summary.....	197
Suggestions for further reading.....	198
Questions and problems	198
Assignment questions	199
10. Introduction to binomial trees.....	200
10.1 A one-step binomial model.....	200
10.2 Risk-neutral valuation	203
10.3 Two-step binomial trees	205
10.4 A put example	208
10.5 American options	209
10.6 Delta	210
10.7 Matching volatility with u and d	211
10.8 Binomial trees in practice	212
Summary.....	213
Suggestions for further reading.....	214
Questions and problems	214
Assignment questions	215

11. A model of the behavior of stock prices	216
11.1 The Markov property	216
11.2 Continuous-time stochastic processes	217
11.3 The process for stock prices	222
11.4 Review of the model	223
11.5 The parameters	225
11.6 Itô's lemma	226
11.7 The lognormal property	227
Summary	228
Suggestions for further reading	229
Questions and problems	229
Assignment questions	230
Appendix 11A: Derivation of Itô's lemma	232
12. The Black-Scholes model.....	234
12.1 Lognormal property of stock prices	234
12.2 The distribution of the rate of return	236
12.3 The expected return.....	237
12.4 Volatility.....	238
12.5 Concepts underlying the Black-Scholes-Merton differential equation	241
12.6 Derivation of the Black-Scholes-Merton differential equation	242
12.7 Risk-neutral valuation	244
12.8 Black-Scholes pricing formulas.....	246
12.9 Cumulative normal distribution function.....	248
12.10 Warrants issued by a company on its own stock	249
12.11 Implied volatilities	250
12.12 The causes of volatility	251
12.13 Dividends	252
Summary	256
Suggestions for further reading	257
Questions and problems	258
Assignment questions	261
Appendix 12A: Proof of Black-Scholes-Merton formula	262
Appendix 12B: Exact procedure for calculating the values of American calls on dividend-paying stocks	265
Appendix 12C: Calculation of cumulative probability in bivariate normal distribution	266
13. Options on stock indices, currencies, and futures.....	267
13.1 Results for a stock paying a known dividend yield	267
13.2 Option pricing formulas.....	268
13.3 Options on stock indices	270
13.4 Currency options	276
13.5 Futures options	278
13.6 Valuation of futures options using binomial trees	284
13.7 Futures price analogy	286
13.8 Black's model for valuing futures options	287
13.9 Futures options vs. spot options	288
Summary	289
Suggestions for further reading	290
Questions and problems	291
Assignment questions	294
Appendix 13A: Derivation of differential equation satisfied by a derivative dependent on a stock providing a dividend yield	295

Appendix 13B: Derivation of differential equation satisfied by a derivative dependent on a futures price	297
14. The Greek letters	299
14.1 Illustration	299
14.2 Naked and covered positions	300
14.3 A stop-loss strategy	300
14.4 Delta hedging	302
14.5 Theta	309
14.6 Gamma	312
14.7 Relationship between delta, theta, and gamma	315
14.8 Vega	316
14.9 Rho	318
14.10 Hedging in practice	319
14.11 Scenario analysis	319
14.12 Portfolio insurance	320
14.13 Stock market volatility	323
Summary	323
Suggestions for further reading	324
Questions and problems	326
Assignment questions	327
Appendix 14A: Taylor series expansions and hedge parameters	329
15. Volatility smiles	330
15.1 Put–call parity revisited	330
15.2 Foreign currency options	331
15.3 Equity options	334
15.4 The volatility term structure and volatility surfaces	336
15.5 Greek letters	337
15.6 When a single large jump is anticipated	338
15.7 Empirical research	339
Summary	341
Suggestions for further reading	341
Questions and problems	343
Assignment questions	344
Appendix 15A: Determining implied risk-neutral distributions from volatility smiles	345
16. Value at risk	346
16.1 The VaR measure	346
16.2 Historical simulation	348
16.3 Model-building approach	350
16.4 Linear model	352
16.5 Quadratic model	356
16.6 Monte Carlo simulation	359
16.7 Comparison of approaches	359
16.8 Stress testing and back testing	360
16.9 Principal components analysis	360
Summary	364
Suggestions for further reading	364
Questions and problems	365
Assignment questions	366
Appendix 16A: Cash-flow mapping	368
Appendix 16B: Use of the Cornish–Fisher expansion to estimate VaR	370

17. Estimating volatilities and correlations.....	372
17.1 Estimating volatility	372
17.2 The exponentially weighted moving average model.....	374
17.3 The GARCH(1, 1) model	376
17.4 Choosing between the models.....	377
17.5 Maximum likelihood methods	378
17.6 Using GARCH(1, 1) to forecast future volatility	382
17.7 Correlations.....	385
Summary	388
Suggestions for further reading	388
Questions and problems	389
Assignment questions	391
18. Numerical procedures.....	392
18.1 Binomial trees.....	392
18.2 Using the binomial tree for options on indices, currencies, and futures contracts.....	399
18.3 Binomial model for a dividend-paying stock	402
18.4 Extensions to the basic tree approach.....	405
18.5 Alternative procedures for constructing trees.....	406
18.6 Monte Carlo simulation.....	410
18.7 Variance reduction procedures	414
18.8 Finite difference methods.....	418
18.9 Analytic approximation to American option prices	427
Summary	427
Suggestions for further reading	428
Questions and problems	430
Assignment questions	432
Appendix 18A: Analytic approximation to American option prices of MacMillan and of Barone-Adesi and Whaley	433
19. Exotic options.....	435
19.1 Packages.....	435
19.2 Nonstandard American options	436
19.3 Forward start options.....	437
19.4 Compound options	437
19.5 Chooser options	438
19.6 Barrier options.....	439
19.7 Binary options	441
19.8 Lookback options.....	441
19.9 Shout options	443
19.10 Asian options	443
19.11 Options to exchange one asset for another	445
19.12 Basket options	446
19.13 Hedging issues	447
19.14 Static options replication	447
Summary	449
Suggestions for further reading	449
Questions and problems	451
Assignment questions	452
Appendix 19A: Calculation of the first two moments of arithmetic averages and baskets	454
20. More on models and numerical procedures	456
20.1 The CEV model.....	456
20.2 The jump diffusion model.....	457

20.3	Stochastic volatility models	458
20.4	The IVF model	460
20.5	Path-dependent derivatives	461
20.6	Lookback options	465
20.7	Barrier options	467
20.8	Options on two correlated assets	472
20.9	Monte Carlo simulation and American options	474
	Summary	478
	Suggestions for further reading	479
	Questions and problems	480
	Assignment questions	481
21.	Martingales and measures	483
21.1	The market price of risk	484
21.2	Several state variables	487
21.3	Martingales	488
21.4	Alternative choices for the numeraire	489
21.5	Extension to multiple independent factors	492
21.6	Applications	493
21.7	Change of numeraire	495
21.8	Quantos	497
21.9	Siegel's paradox	499
	Summary	500
	Suggestions for further reading	500
	Questions and problems	501
	Assignment questions	502
	Appendix 21A: Generalizations of Itô's lemma	504
	Appendix 21B: Expected excess return when there are multiple sources of uncertainty	506
22.	Interest rate derivatives: the standard market models	508
22.1	Black's model	508
22.2	Bond options	511
22.3	Interest rate caps	515
22.4	European swap options	520
22.5	Generalizations	524
22.6	Convexity adjustments	524
22.7	Timing adjustments	527
22.8	Natural time lags	529
22.9	Hedging interest rate derivatives	530
	Summary	531
	Suggestions for further reading	531
	Questions and problems	532
	Assignment questions	534
	Appendix 22A: Proof of the convexity adjustment formula	536
23.	Interest rate derivatives: models of the short rate	537
23.1	Equilibrium models	537
23.2	One-factor equilibrium models	538
23.3	The Rendleman and Bartter model	538
23.4	The Vasicek model	539
23.5	The Cox, Ingersoll, and Ross model	542
23.6	Two-factor equilibrium models	543
23.7	No-arbitrage models	543
23.8	The Ho and Lee model	544
23.9	The Hull and White model	546

23.10	Options on coupon-bearing bonds.....	549
23.11	Interest rate trees	550
23.12	A general tree-building procedure.....	552
23.13	Nonstationary models.....	563
23.14	Calibration.....	564
23.15	Hedging using a one-factor model.....	565
23.16	Forward rates and futures rates.....	566
	Summary.....	566
	Suggestions for further reading.....	567
	Questions and problems	568
	Assignment questions	570
24.	Interest rate derivatives: more advanced models.....	571
24.1	Two-factor models of the short rate.....	571
24.2	The Heath, Jarrow, and Morton model	574
24.3	The LIBOR market model.....	577
24.4	Mortgage-backed securities	586
	Summary.....	588
	Suggestions for further reading.....	589
	Questions and problems	590
	Assignment questions	591
	Appendix 24A: The $A(t, T)$, σ_P , and $\theta(t)$ functions in the two-factor Hull–White model	593
25.	Swaps revisited.....	594
25.1	Variations on the vanilla deal.....	594
25.2	Compounding swaps	595
25.3	Currency swaps	598
25.4	More complex swaps	598
25.5	Equity swaps	601
25.6	Swaps with embedded options	602
25.7	Other swaps	605
25.8	Bizarre deals.....	605
	Summary.....	606
	Suggestions for further reading.....	606
	Questions and problems	607
	Assignment questions	607
	Appendix 25A: Valuation of an equity swap between payment dates	609
26.	Credit risk	610
26.1	Bond prices and the probability of default	610
26.2	Historical data	619
26.3	Bond prices vs. historical default experience	619
26.4	Risk-neutral vs. real-world estimates	620
26.5	Using equity prices to estimate default probabilities	621
26.6	The loss given default.....	623
26.7	Credit ratings migration	626
26.8	Default correlations.....	627
26.9	Credit value at risk	630
	Summary.....	633
	Suggestions for further reading.....	633
	Questions and problems	634
	Assignment questions	635
	Appendix 26A: Manipulation of the matrices of credit rating changes.....	636

27. Credit derivatives	637
27.1 Credit default swaps	637
27.2 Total return swaps	644
27.3 Credit spread options	645
27.4 Collateralized debt obligations	646
27.5 Adjusting derivative prices for default risk	647
27.6 Convertible bonds	652
Summary	655
Suggestions for further reading	655
Questions and problems	656
Assignment questions	658
28. Real options	660
28.1 Capital investment appraisal	660
28.2 Extension of the risk-neutral valuation framework	661
28.3 Estimating the market price of risk	665
28.4 Application to the valuation of a new business	666
28.5 Commodity prices	667
28.6 Evaluating options in an investment opportunity	670
Summary	675
Suggestions for further reading	676
Questions and problems	676
Assignment questions	677
29. Insurance, weather, and energy derivatives	678
29.1 Review of pricing issues	678
29.2 Weather derivatives	679
29.3 Energy derivatives	680
29.4 Insurance derivatives	682
Summary	683
Suggestions for further reading	684
Questions and problems	684
Assignment questions	685
30. Derivatives mishaps and what we can learn from them	686
30.1 Lessons for all users of derivatives	686
30.2 Lessons for financial institutions	690
30.3 Lessons for nonfinancial corporations	693
Summary	694
Suggestions for further reading	695
<i>Glossary of notation</i>	697
<i>Glossary of terms</i>	700
<i>DerivaGem software</i>	715
<i>Major exchanges trading futures and options</i>	720
<i>Table for $N(x)$ when $x \leq 0$</i>	722
<i>Table for $N(x)$ when $x \geq 0$</i>	723
<i>Author index</i>	725
<i>Subject index</i>	729