

EIGHTH EDITION

OPTIONS, FUTURES, AND OTHER DERIVATIVES

GLOBAL EDITION

John C. Hull

*Maple Financial Group Professor of Derivatives and Risk Management
Joseph L. Rotman School of Management
University of Toronto*



Boston Columbus Indianapolis New York San Francisco Upper Saddle River
Amsterdam Cape Town Dubai London Madrid Milan Munich Paris Montreal Toronto
Delhi Mexico City Sao Paulo Sydney Hong Kong Seoul Singapore Taipei Tokyo

Contents

	List of Business Snapshots.....	xvii
	List of Technical Notes.....	xviii
	Preface.....	xix
Chapter 1.	Introduction.....	1
	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
Chapter 2.	Mechanics of futures markets.....	22
	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
Chapter 3.	Hedging strategies using futures.....	47
	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
Chapter 4.	Interest rates.....	75
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
i	Practice questions.....	97
	Further questions.....	99
Chapter 5.	Determination of forward and futures prices.....	101
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
Chapter 6.	Interest rate futures.....	129
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

Chapter 7. Swaps.....	148
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
Chapter 8. Securitization and the Credit Crisis of 2007.....	180
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
Chapter 9. Mechanics of options markets.....	194
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
Chapter 10. Properties of stock options.....	214
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
Chapter 11. Trading strategies involving options.....		234
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
Chapter 12. Binomial trees.....		253
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 formula from a binomial tree.....	276
Chapter 13. Wiener processes and Ito's lemma.....		280
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	Ito's lemma.....	291
13.7	The lognormal property.....	292
	Summary.....	293
	Further reading.....	294
	Practice questions.....	294
	Further questions.....	295
	Appendix: Derivation of Ito's lemma.....	297
Chapter 14. The Black-Scholes-Merton model.....		299
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 valuation.....	329
Chapter 15.	Employee stock options.....	332
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
Chapter 16.	Options on stock indices and currencies.....	345
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
Chapter 17.	Futures options.....	361
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
Chapter 18.	The Greek letters.....	377
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
Chapter 19.	Volatility smiles.....	409
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 volatility smiles.....	424
Chapter 20.	Basic numerical procedures.....	427
20.1	Binomial trees.....	427
20.2	Using the binomial tree for options on indices, currencies, and futures contracts.....	43
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
Chapter 21.	Value at risk.....	471
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
Chapter 22.	Estimating volatilities and correlations.....	498
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
Chapter 23.	Credit risk.....	521
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
Chapter 24.	Credit derivatives.....	547
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
Chapter 25. Exotic options.....		574
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
Chapter 26. More on models and numerical procedures.....		599
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
Chapter 27. Martingales and measures.....		630
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

Chapter 28. Interest rate derivatives: The standard market models.....	648
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
Chapter 29. Convexity, timing, and quanto adjustments.....	668
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
Chapter 30. Interest rate derivatives: models of the short rate.....	682
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
Chapter 31. Interest rate derivatives: HJM and LMM.....	715
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
Chapter 32. Swaps Revisited.....	733
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
Chapter 33. Energy and commodity derivatives.....	748
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
Chapter 34. Real options.....	765
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
Chapter 35. Derivatives mishaps and what we can learn from them.....	779
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
Chapter 36. Derivatives markets in developing countries.....	791
36.1 China's markets.....	791
36.2 India's markets.....	793
36.3 Other developing countries.....	794
Summary.....	794
Further reading.....	795
Glossary of terms.....	797
DerivaGem software.....	818
Major exchanges trading futures and options.....	823
Table for $N(x)$ when $x \rightarrow 0$.....	824
Table for $N'(x)$ when $x \rightarrow 0$.....	825
Author index.....	826
Subject index.....	830