NINTH EDITION GLOBAL EDITION

OPTIONS, FUTURES, AND OTHER DERIVATIVES

John C. Hull

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



Harlow, England London New York Boston San Francisco Toronto Sydney Dubai Singapore Hong Kong Tokyo Seoul Taipei New Delhi Cape Town São Paulo Mexico City Madrid Amsterdam Munich Paris Milan

Contents

	List of Business Snapshots	17
	List of Technical Notes	18
	Preface	19
Chapter 1.	Introduction 1.1 Exchange-traded markets 1.2 Over-the-counter markets 1.3 Forward contracts 1.4 Futures contracts 1.5 Options 1.6 Types of traders 1.7 Hedgers 1.8 Speculators 1.9 Arbitrageurs	23 24 25 28 30 30 33 33 33 36 38
	1.10 Dangers Summary Further reading Practice questions Further questions	40 41 41 43
Chapter 2.	Mechanics of futures markets. 2.1 Background 2.2 Specification of a futures contract. 2.3 Convergence of futures price to spot price 2.4 The operation of margin accounts 2.5 OTC markets 2.6 Market quotes 2.7 Delivery 2.8 Types of traders and types of orders 2.9 Regulation 2.10 Accounting and tax. 2.11 Forward vs. futures contracts. Summary. Further reading . Practice questions. Further questions.	46 48 50 51 54 57 60 61 62 63 65 66 67 67
Chapter 3.	Hedging strategies using futures. 3.1 Basic principles. 3.2 Arguments for and against hedging . 3.3 Basis risk	71 71 73 76

	3.5	Stock index futures	
	3.6	Stack and roll	
		Summary	
		Further reading	
		Practice questions	
		Further questions	
		Appendix: Capital asset pricing model	97
Chapter 4.	Intere	est rates	99
-	4.1	Types of rates	99
	4.2	Measuring interest rates	101
	4.3	Zero rates	104
	4.4	Bond pricing	
	4.5	Determining Treasury zero rates	
	4.6	Forward rates	
	4.7	Forward rate agreements	
	4.8	Duration	
	4.9	Convexity	
	4.10	Theories of the term structure of interest rates	
		Summary	
		Further reading	
		Practice questions	
		Further questions	
Chanton 5	Data	mination of forward and futures prices	
Chapter 5.	5.1		
	5.1 5.2	Investment assets vs. consumption assets	
	5.2	Assumptions and notation	
	5.5 5.4	Forward price for an investment asset	
	5.4 5.5	Known income	
	5.6		
	5.0 5.7	Known yield Valuing forward contracts	
	5.8	Are forward prices and futures prices equal?	
	5.8 5.9	Futures prices of stock indices	
	5.10	Forward and futures contracts on currencies	
	5.10	Futures on commodities	
	5.11	The cost of carry.	
	5.12	•	
	5.15	Delivery options.	
	3.14	Futures prices and expected future spot prices	
		Further reading.	
		Practice questions	
		Further questions	
Chapter 6.	Intere	est rate futures	
	6.1	Day count and quotation conventions	
	6.2	Treasury bond futures	
	6.3	Eurodollar futures	
	6.4	Duration-based hedging strategies using futures	
	6.5	Hedging portfolios of assets and liabilities	
		Summary	
		Further reading	
		Practice questions	170
		Further questions	172

Cont	ents

Chapter 7.	Swaps		. 174
1	7.1	Mechanics of interest rate swaps	
	7.2	Day count issues	
	7.3	Confirmations	. 181
	7.4	The comparative-advantage argument	
	7.5	The nature of swap rates	
	7.6	Determining LIBOR/swap zero rates	
	7.7	Valuation of interest rate swaps	
	7.8	Term structure effects	
	7.9	Fixed-for-fixed currency swaps	
	7.10	Valuation of fixed-for-fixed currency swaps	
	7.11	Other currency swaps	
	7.12	Credit risk	
	7.13	Other types of swaps	
		Summary	
		Further reading	
		Practice questions	
		Further questions	
		•	
Chapter 8.		tization and the credit crisis of 2007	
	8.1	Securitization	
	8.2	The US housing market	
	8.3	What went wrong?	
	8.4	The aftermath	
		Summary	
		Further reading	
		Practice questions	
		Further questions	
Chapter 9.	OIS d	iscounting, credit issues, and funding costs	
	9.1	The risk-free rate	
	9.2	The OIS rate	
	9.3	Valuing swaps and FRAs with OIS discounting	
	9.4	OIS vs. LIBOR: Which is correct?	
	9.5	Credit risk: CVA and DVA	
	9.6	Funding costs	
		Summary	
		Further reading	. 233
		Practice questions	
		Further questions	. 234
Chanter 10	Mech	anics of options markets	235
		Types of options	
	10.2	Option positions	
	10.2	Underlying assets	
	10.5	Specification of stock options	
	10.5	Trading	
	10.6	Commissions	
	10.0	Margin requirements	
	10.7	The options clearing corporation	
	10.8	Regulation	
	10.10	Taxation	
	10.10	Warrants, employee stock options, and convertibles	
		Over-the-counter options markets	
	· · · · · -		

		Summary	252
		Further reading	253
		Practice questions	
		Further questions	
Chapter 11.	Prope	rties of stock options	256
-	11.1	Factors affecting option prices	256
	11.2	Assumptions and notation	
	11.3	Upper and lower bounds for option prices	
	11.4	Put-call parity	263
	11.5	Calls on a non-dividend-paying stock	
	11.6	Puts on a non-dividend-paying stock	
	11.7	Effect of dividends	
		Summary	
		Further reading	
		Practice questions	
		Further questions	
Chapter 12.	Tradir	ng strategies involving options	276
	12.1	Principal-protected notes	276
	12.2	Trading an option and the underlying asset	278
	12.3	Spreads	280
	12.4	Combinations	
	12.5	Other payoffs	
		Summary	292
		Further reading	293
		Practice questions	293
		Further questions	. 294
		•	
Chapter 13.	Binon	nial trees	. 296
Chapter 13.	Binom 13.1	hial trees	296 296
Chapter 13.		nial trees	296 296 300
Chapter 13.	13.1 13.2 13.3	nial trees	296 296 300 302
Chapter 13.	13.1 13.2 13.3 13.4	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation Two-step binomial trees A put example	296 296 300 302 305
Chapter 13.	13.1 13.2 13.3 13.4 13.5	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation Two-step binomial trees A put example American options.	296 296 300 302 305 305
Chapter 13.	13.1 13.2 13.3 13.4 13.5 13.6	hial trees	296 296 300 302 305 306 307
Chapter 13.	13.1 13.2 13.3 13.4 13.5 13.6 13.7	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation Two-step binomial trees A put example American options Delta Matching volatility with u and d	296 296 300 302 305 305 306 307 308
Chapter 13.	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation Two-step binomial trees A put example American options Delta Matching volatility with u and d The binomial tree formulas American options	296 296 300 302 305 305 306 307 308 310
Chapter 13.	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8 13.9	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation Two-step binomial trees A put example American options Delta Matching volatility with u and d The binomial tree formulas Increasing the number of steps	296 296 300 302 305 306 307 308 310 310
Chapter 13.	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8 13.9 13.10	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation Two-step binomial trees A put example American options Delta Matching volatility with u and d The binomial tree formulas Increasing the number of steps Using DerivaGem	 296 296 300 302 305 306 307 308 310 310 311
Chapter 13.	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8 13.9	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation Two-step binomial trees A put example American options Delta Matching volatility with u and d The binomial tree formulas Increasing the number of steps Using DerivaGem Options on other assets	 296 296 300 302 305 306 307 308 310 310 311 312
Chapter 13.	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8 13.9 13.10	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation. Two-step binomial trees A put example. American options. Delta. Matching volatility with u and d The binomial tree formulas. Increasing the number of steps Using DerivaGem Options on other assets. Summary	 296 296 300 302 305 306 307 308 310 310 311 312 315
Chapter 13.	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8 13.9 13.10	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation. Two-step binomial trees A put example. American options. Delta. Matching volatility with u and d The binomial tree formulas. Increasing the number of steps Using DerivaGem Options on other assets. Summary Further reading.	296 296 300 302 305 306 307 308 310 310 311 312 315 316
Chapter 13.	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8 13.9 13.10	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation. Two-step binomial trees A put example. American options. Delta. Matching volatility with u and d The binomial tree formulas. Increasing the number of steps Using DerivaGem Options on other assets. Summary Further reading. Practice questions	296 296 300 302 305 306 307 308 310 311 312 315 316 317
Chapter 13.	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8 13.9 13.10	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation. Two-step binomial trees A put example. American options. Delta. Matching volatility with u and d. The binomial tree formulas. Increasing the number of steps Using DerivaGem Options on other assets. Summary Further reading. Practice questions	296 296 300 302 305 306 307 308 310 311 312 315 316 317
Chapter 13.	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8 13.9 13.10	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation Two-step binomial trees A put example American options Delta Matching volatility with u and d The binomial tree formulas Increasing the number of steps Using DerivaGem Options on other assets Summary Further reading Practice questions Further questions Appendix: Derivation of the Black–Scholes–Merton option-pricing	296 296 300 302 305 306 307 308 310 311 312 315 316 317 318
	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8 13.9 13.10 13.11	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation. Two-step binomial trees A put example. American options. Delta. Matching volatility with u and d. The binomial tree formulas. Increasing the number of steps Using DerivaGem Options on other assets. Summary Further reading. Practice questions Further questions Appendix: Derivation of the Black–Scholes–Merton option-pricing formula from a binomial tree.	296 296 300 302 305 306 307 308 310 311 312 315 316 317 318 317 318
	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8 13.9 13.10 13.11	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation Two-step binomial trees A put example American options Delta Matching volatility with u and d The binomial tree formulas Increasing the number of steps Using DerivaGem Options on other assets Summary Further reading Practice questions Appendix: Derivation of the Black–Scholes–Merton option-pricing formula from a binomial tree	 296 296 300 3022 305 306 307 308 310 311 3122 315 316 317 318 320 324
	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8 13.9 13.10 13.11	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation Two-step binomial trees A put example American options Delta Matching volatility with u and d The binomial tree formulas Increasing the number of steps Using DerivaGem Options on other assets Summary Further reading Practice questions Appendix: Derivation of the Black–Scholes–Merton option-pricing formula from a binomial tree The Markov property	 296 296 300 3022 305 306 307 308 310 311 312 315 316 317 318 320 324 324
	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8 13.9 13.10 13.11	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation. Two-step binomial trees A put example. A merican options. Delta. Matching volatility with u and d. The binomial tree formulas. Increasing the number of steps Using DerivaGem Options on other assets. Summary Further reading. Practice questions Further questions Appendix: Derivation of the Black–Scholes–Merton option-pricing formula from a binomial tree. The Markov property Continuous-time stochastic processes Continuous-time stochastic processes	 296 296 300 3022 305 306 307 308 310 311 3122 315 316 317 318 320 324 325
	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8 13.9 13.10 13.11	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation. Two-step binomial trees A put example. American options Delta. Delta. Matching volatility with u and d The binomial tree formulas. Increasing the number of steps Using DerivaGem Options on other assets Summary Further reading. Practice questions Further questions Appendix: Derivation of the Black–Scholes–Merton option-pricing formula from a binomial tree er processes and Itô's lemma The Markov property Continuous-time stochastic processes The process for a stock price	 296 296 300 3022 305 306 307 308 310 311 312 315 316 317 318 320 324 325 330
	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8 13.9 13.10 13.11 • Wiene 14.1 14.2 14.3 14.4	iial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation. Two-step binomial trees A put example. American options. Delta. Matching volatility with u and d. The binomial tree formulas. Increasing the number of steps. Using DerivaGem Options on other assets. Summary. Further reading. Practice questions. Further questions. Appendix: Derivation of the Black–Scholes–Merton option-pricing formula from a binomial tree. er processes and Itô's lemma The Markov property Continuous-time stochastic processes. The parameters	 296 296 300 3022 305 306 307 308 310 311 312 315 316 317 318 320 324 325 330 333
	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8 13.9 13.10 13.11	hial trees A one-step binomial model and a no-arbitrage argument Risk-neutral valuation. Two-step binomial trees A put example. American options Delta. Delta. Matching volatility with u and d The binomial tree formulas. Increasing the number of steps Using DerivaGem Options on other assets Summary Further reading. Practice questions Further questions Appendix: Derivation of the Black–Scholes–Merton option-pricing formula from a binomial tree er processes and Itô's lemma The Markov property Continuous-time stochastic processes The process for a stock price	 296 296 300 3022 305 306 307 308 310 311 312 315 316 317 318 320 324 325 330 334

	14.7	The lognormal property	336
		Summary	337
		Further reading	338
		Practice questions	338
		Further questions	
		Appendix: Derivation of Itô's lemma	341
Chapter 15.	The B	lack–Scholes–Merton model	343
1	15.1	Lognormal property of stock prices	
	15.2	The distribution of the rate of return	
	15.3	The expected return	
	15.4	Volatility	347
	15.5	The idea underlying the Black-Scholes-Merton differential equation	
	15.6	Derivation of the Black-Scholes-Merton differential equation	
	15.7	Risk-neutral valuation	
	15.8	Black-Scholes-Merton pricing formulas	
	15.9	Cumulative normal distribution function	
	15.10	Warrants and employee stock options	
		Implied volatilities	
		Dividends	
		Summary	
		Further reading	
		Practice questions	
		Further questions	
		Appendix: Proof of Black–Scholes–Merton formula using risk-neutral	
		valuation	374
Chapter 16.	Emplo	vee stock options	376
Chapter 16.	Emplo 16.1	yee stock options Contractual arrangements	
Chapter 16.	-	Contractual arrangements	376
Chapter 16.	16.1	Contractual arrangements Do options align the interests of shareholders and managers?	376 378
Chapter 16.	16.1 16.2	Contractual arrangements	376 378 379
Chapter 16.	16.1 16.2 16.3	Contractual arrangements Do options align the interests of shareholders and managers? Accounting issues Valuation	376 378 379 380
Chapter 16.	16.1 16.2 16.3 16.4	Contractual arrangements. Do options align the interests of shareholders and managers? Accounting issues Valuation. Backdating scandals	376 378 379 380 385
Chapter 16.	16.1 16.2 16.3 16.4	Contractual arrangements. Do options align the interests of shareholders and managers? Accounting issues Valuation. Backdating scandals Summary.	376 378 379 380 385 386
Chapter 16.	16.1 16.2 16.3 16.4	Contractual arrangements Do options align the interests of shareholders and managers? Accounting issues Valuation Backdating scandals Further reading	376 378 379 380 385 386 387
Chapter 16.	16.1 16.2 16.3 16.4	Contractual arrangements. Do options align the interests of shareholders and managers? Accounting issues Valuation. Backdating scandals Summary.	376 378 379 380 385 386 387 387
	16.1 16.2 16.3 16.4 16.5	Contractual arrangements Do options align the interests of shareholders and managers? Accounting issues Valuation Backdating scandals Further reading Further reading Further questions Further questions	376 378 379 380 385 386 387 387 388
	16.1 16.2 16.3 16.4 16.5	Contractual arrangements Do options align the interests of shareholders and managers? Accounting issues Valuation Backdating scandals Summary Further reading Practice questions Further questions Further questions so on stock indices and currencies	376 378 379 380 385 386 387 387 388
	16.1 16.2 16.3 16.4 16.5 Option 17.1	Contractual arrangements Do options align the interests of shareholders and managers? Accounting issues Valuation Backdating scandals Summary Further reading Practice questions Further questions Further questions options on stock indices	376 378 379 380 385 386 387 388 389 389
	16.1 16.2 16.3 16.4 16.5 Option 17.1 17.2	Contractual arrangements Do options align the interests of shareholders and managers? Accounting issues Valuation Backdating scandals Backdating scandals Further reading Further reading Practice questions Further questions Further questions Options on stock indices Currency options	376 378 379 380 385 386 387 388 388 389 389 391
	16.1 16.2 16.3 16.4 16.5 Option 17.1 17.2 17.3	Contractual arrangements Do options align the interests of shareholders and managers? Accounting issues Valuation Backdating scandals Backdating scandals Further reading Further reading Practice questions Further questions Further questions Options on stock indices Options on stock indices Options on stock spaying known dividend yields	376 378 379 380 385 387 387 389 389 391 394
	16.1 16.2 16.3 16.4 16.5 Option 17.1 17.2 17.3 17.4	Contractual arrangements Do options align the interests of shareholders and managers? Accounting issues Valuation Backdating scandals Summary Further reading Practice questions Further questions Further questions Options on stock indices Options on stock indices Options on stock spaying known dividend yields Valuation of European stock index options	376 378 379 380 385 386 387 387 389 389 391 394 396
	16.1 16.2 16.3 16.4 16.5 Option 17.1 17.2 17.3 17.4 17.5	Contractual arrangements Do options align the interests of shareholders and managers? Accounting issues Valuation Backdating scandals Summary Further reading Practice questions Further questions Further questions options on stock indices Options on stock indices Options on stock paying known dividend yields Valuation of European stock index options Valuation of European currency options	376 378 380 385 386 387 387 389 389 391 394 399
	16.1 16.2 16.3 16.4 16.5 Option 17.1 17.2 17.3 17.4	Contractual arrangements Do options align the interests of shareholders and managers? Accounting issues Valuation Backdating scandals Summary Further reading Practice questions Further questions Further questions options on stock indices Options on stock indices Options on stocks paying known dividend yields Valuation of European stock index options Valuation of European currency options American options	376 379 380 385 386 387 387 388 389 391 394 394 399 400
	16.1 16.2 16.3 16.4 16.5 Option 17.1 17.2 17.3 17.4 17.5	Contractual arrangements Do options align the interests of shareholders and managers? Accounting issues Valuation Backdating scandals Backdating scandals Summary Further reading Further reading Practice questions Further questions Further questions Son stock indices and currencies Options on stock indices Currency options Options on stocks paying known dividend yields Valuation of European stock index options Valuation of European currency options American options Summary	376 378 380 385 386 387 387 387 389 391 394 394 399 399 400 401
	16.1 16.2 16.3 16.4 16.5 Option 17.1 17.2 17.3 17.4 17.5	Contractual arrangements Do options align the interests of shareholders and managers? Accounting issues	376 378 380 385 386 387 387 387 389 391 394 394 399 399 400 401 401
	16.1 16.2 16.3 16.4 16.5 Option 17.1 17.2 17.3 17.4 17.5	Contractual arrangements Do options align the interests of shareholders and managers? Accounting issues Valuation Backdating scandals Summary Further reading Practice questions Further questions Further questions Son stock indices and currencies Options on stock indices Currency options Options on stocks paying known dividend yields Valuation of European stock index options Valuation of European currency options American options Summary Further reading Practice questions	376 378 380 385 386 387 387 387 389 391 394 394 394 394 396 399 400 401 401 402
Chapter 17.	16.1 16.2 16.3 16.4 16.5 Optio 17.1 17.2 17.3 17.4 17.5 17.6	Contractual arrangements Do options align the interests of shareholders and managers? Accounting issues Valuation Backdating scandals Summary Further reading Practice questions Further questions ns on stock indices and currencies Options on stock indices Options on stock indices Currency options Options on stocks paying known dividend yields Valuation of European stock index options Valuation of European currency options American options Summary Further reading Further reading Practice questions Further questions Further questions	376 378 380 385 386 387 387 388 389 391 394 394 396 399 400 401 401 402 404
Chapter 17.	16.1 16.2 16.3 16.4 16.5 Option 17.1 17.2 17.3 17.4 17.5 17.6 Future	Contractual arrangements Do options align the interests of shareholders and managers? Accounting issues Valuation Backdating scandals Summary Further reading Practice questions Further questions options on stock indices and currencies Options on stock indices Currency options Options on stocks paying known dividend yields Valuation of European stock index options Valuation of European currency options. Summary Further reading Practice questions Further reading Further reading Further reading Further reading Further reading Further questions Further questions Further questions	376 378 379 380 385 386 387 387 388 389 389 391 394 394 396 399 400 401 401 402 405
Chapter 17.	16.1 16.2 16.3 16.4 16.5 Option 17.1 17.2 17.3 17.4 17.5 17.6 Future 18.1	Contractual arrangements. Do options align the interests of shareholders and managers? Accounting issues Valuation. Backdating scandals Summary. Further reading Practice questions. Further questions. Further questions. Options on stock indices Currency options Options on stocks paying known dividend yields Valuation of European stock index options. Valuation of European currency options. American options Summary. Further reading Practice questions. Further reading Practice questions. Further reading Practice questions. Nature of futures options.	376 378 379 380 385 386 387 387 388 389 389 391 394 394 394 396 399 400 401 401 405 405
Chapter 17.	16.1 16.2 16.3 16.4 16.5 Option 17.1 17.2 17.3 17.4 17.5 17.6 Future 18.1 18.2	Contractual arrangements. Do options align the interests of shareholders and managers? Accounting issues Valuation. Backdating scandals Summary. Further reading Practice questions. Further questions. Further questions. options on stock indices and currencies Currency options Options on stocks paying known dividend yields Valuation of European stock index options. Valuation of European currency options. American options Summary. Further reading Practice questions. Summary. Further reading Practice questions. Summary. Further reading Practice questions. Further questions. Summary. Further options Summary. Further options. Summary. Further questions. Further questions. Summary. Further questions. Summary. Further of futures options. Nature of futures options. Reasons for the popularity of futures options	376 378 379 380 385 386 387 387 388 389 389 391 394 394 394 394 395 401 401 405 405 408
Chapter 17.	16.1 16.2 16.3 16.4 16.5 Option 17.1 17.2 17.3 17.4 17.5 17.6 Future 18.1	Contractual arrangements. Do options align the interests of shareholders and managers? Accounting issues Valuation. Backdating scandals Summary. Further reading Practice questions. Further questions. Further questions. Options on stock indices Currency options Options on stocks paying known dividend yields Valuation of European stock index options. Valuation of European currency options. American options Summary. Further reading Practice questions. Further reading Practice questions. Further reading Practice questions. Nature of futures options.	376 378 379 380 385 386 387 387 387 387 389 391 394 394 396 399 400 401 401 402 404 405 408 408

	18.5 18.6 18.7 18.8	Bounds for futures options	411 413 414
	18.9	American futures options vs. American spot options	
	18.10	Futures-style options	
		Further reading	
		Practice questions	
		Further questions	
Chanter 19.	The G	reek letters	421
Chapter 15.	19.1	Illustration	
	19.2	Naked and covered positions	
	19.3	A stop-loss strategy	
	19.4	Delta hedging	
	19.5	Theta	
	19.6	Gamma	
	19.7	Relationship between delta, theta, and gamma	
	19.8 19.9	Vega Rho	
		The realities of hedging	
		Scenario analysis	
		Extension of formulas	
		Portfolio insurance	
		Stock market volatility	
		Summary	
		Further reading	
		Practice questions	
		Further questions	450
		Appendix: Taylor series expansions and hedge parameters	
Chapter 20.	Volati	lity smiles	453
	20.1	Why the volatility smile is the same for calls and puts	
	20.2	Foreign currency options	
	20.3	Equity options	458
	20.4 20.5	The volatility term structure and volatility surfaces	
	20.5	Greek letters	
	20.0	The role of the model	
	20.8	When a single large jump is anticipated	
	-0.0	Summary	
		Further reading	465
		Practice questions	
		Further questions	467
		Appendix: Determining implied risk-neutral distributions from volatility smiles	
Chapter 21.		numerical procedures	
	21.1	Binomial trees.	472
	21.2	Using the binomial tree for options on indices, currencies, and futures	480
	21.3	contracts Binomial model for a dividend-paying stock	
	21.5	Alternative procedures for constructing trees	
	41.4	memative procedures for constructing frees	107

	21.5	Time-dependent parameters	490
	21.6	Monte Carlo simulation	491
	21.7	Variance reduction procedures	497
	21.8	Finite difference methods	500
		Summary	
		Further reading	511
		Practice questions	512
		Further questions	. 514
Chapter 22.	Value	at risk	.516
	22.1	The VaR measure	
	22.2	Historical simulation	
	22.3	Model-building approach	
	22.4	The linear model	
	22.5	The quadratic model	
	22.6	Monte Carlo simulation	
	22.7	Comparison of approaches	
	22.8	Stress testing and back testing	
	22.9	Principal components analysis	
		Summary	
		Further reading	
		Practice questions	
		Further questions	
~ ~ ~		-	
Chapter 23.		ting volatilities and correlations	.545
	23.1	Estimating volatility	
	23.2	The exponentially weighted moving average model	
	23.3	The GARCH (1,1) model	
	23.4	Choosing between the models	
	23.5	Maximum likelihood methods.	
	23.6	Using GARCH (1,1) to forecast future volatility	
	23.7	Correlations	
	23.8	Application of EWMA to four-index example	
		Summary	
		Further reading	
		Practice questions	
		Further questions	
Chapter 24.		risk	
	24.1	Credit ratings	
	24.2	Historical default probabilities	
	24.3	Recovery rates	
	24.4	Estimating default probabilities from bond yield spreads	
	24.5	Comparison of default probability estimates	. 572
	24.6	Using equity prices to estimate default probabilities	. 575
	24.7	Credit risk in derivatives transactions	
	24.8	Default correlation	
	24.9	Credit VaR	
		Summary	
		Further reading	
		Practice questions	
		Further questions	. 591

Chapter 25.	Credit	derivatives	593
•	25.1	Credit default swaps	
	25.2	Valuation of credit default swaps	
	25.3	Credit indices	601
	25.4	The use of fixed coupons	602
	25.5	CDS forwards and options	603
	25.6	Basket credit default swaps	603
	25.7	Total return swaps	603
	25.8	Collateralized debt obligations	
	25.9	Role of correlation in a basket CDS and CDO	607
		Valuation of a synthetic CDO	
	25.11	Alternatives to the standard market model	614
		Summary	
		Further reading	6 16
		Practice questions	617
		Further questions	618
Chanter 26	Exotic	options	620
Chapter 20.	26.1	Packages	
	26.2	Perpetual American call and put options	
	26.3	Nonstandard American options	
	26.4	Gap options	
	26.5	Forward start options	
	26.6	Cliquet options	
	26.7	Compound options	
	26.8	Chooser options	
	26.9	Barrier options	
	26.10	Binary options	
		Lookback options	
		Shout options	
		Asian options	
		Options to exchange one asset for another	
	26.15	Options involving several assets	634
	26.16	Volatility and variance swaps	635
	26.17	Static options replication	638
		Summary	640
		Further reading	641
		Practice questions	
		Further questions	643
Chanter 27	More	on models and numerical procedures	646
Chapter 27.	27.1	Alternatives to Black–Scholes–Merton	647
	27.2	Stochastic volatility models	
	27.3	The IVF model	
	27.4	Convertible bonds	
	27.5	Path-dependent derivatives	
	27.6	Barrier options	
	27.7	Options on two correlated assets	
	27.8	Monte Carlo simulation and American options	
		Summary	
		Further reading	
		Practice questions	
		Further questions	

Chapter 28.	Martin	ngales and measures	. 677
-	28.1	The market price of risk	
	28.2	Several state variables	681
	28.3	Martingales	
	28.4	Alternative choices for the numeraire	
	28.5	Extension to several factors	
	28.6	Black's model revisited	
	28.7	Option to exchange one asset for another	689
	28.8	Change of numeraire	
		Summary	
		Further reading	
		Practice questions	
		Further questions	694
Chapter 29.	Interes	st rate derivatives: The standard market models	695
F	29.1	Bond options	
	29.2	Interest rate caps and floors	
	29.3	European swap options	
	29.4	OIS discounting	
	29.5	Hedging interest rate derivatives	
		Summary	
		Further reading	
		Practice questions	
		Further questions	
Chapter 30	Convo	xity, timing, and quanto adjustments	
Chapter 50.	30.1	Convexity adjustments	715
	30.2	Timing adjustments	.719
	30.3	Quantos	
	50.5	Summary	
		Further reading	
		Practice questions	
		Further questions	
		Appendix: Proof of the convexity adjustment formula	. 727
Chanten 21	Intono	st rate derivatives: Models of the short rate	
Chapter 31.	31.1	Background	
	31.1	Equilibrium models	
	31.3	No-arbitrage models	
	31.4	Options on bonds	
	31.5	Volatility structures	
	31.6	Interest rate trees	
	31.7	A general tree-building procedure	
	31.8	Calibration	
	31.9	Hedging using a one-factor model	
	51.9	Summary	
		Further reading	
		Practice questions	
		Further questions	
~		•	
Chapter 32.		, LMM, and multiple zero curves	.762
	32.1	The Heath, Jarrow, and Morton model	
	32.2	The LIBOR market model	
	32.3	Handling multiple zero curves	
	32.4	Agency mortgage-backed securities	. ///

		Summary	779
		Further reading	
		Practice questions	780
		Further questions	781
Chapter 33.	Swaps	Revisited	782
•	33.1	Variations on the vanilla deal	
	33.2	Compounding swaps	
	33.3	Currency swaps	785
	33.4	More complex swaps	
	33.5	Equity swaps	
	33.6	Swaps with embedded options	
	33.7	Other swaps	
		Summary	
		Further reading	
		Practice questions	
		Further questions	796
Chapter 34.	Energy	y and commodity derivatives	797
-	34.1	Agricultural commodities	797
	34.2	Metals	798
	34.3	Energy products	799
	34.4	Modeling commodity prices	
	34.5	Weather derivatives	
	34.6	Insurance derivatives	
	34.7	Pricing weather and insurance derivatives	
	34.8	How an energy producer can hedge risks	
		Summary	
		Further reading	
		Practice questions	
		Further questions	
Chapter 35.	Real o	options	814
	35.1	Capital investment appraisal	814
	35.2	Extension of the risk-neutral valuation framework	
	35.3	Estimating the market price of risk	
	35.4	Application to the valuation of a business	818
	35.5	Evaluating options in an investment opportunity	
		Summary	
		Further reading	
		Practice questions	
		Further questions	
Chapter 36.	Deriva	atives mishaps and what we can learn from them	
	36.1	Lessons for all users of derivatives	
	36.2	Lessons for financial institutions	
	36.3	Lessons for nonfinancial corporations	
		Summary	
		Further reading	
		ary of terms	
		aGem software	
		exchanges trading futures and options	
		s for $N(x)$	
		r index	
	Subjec	et index	8/4