

Contents

Preface to the Second Edition	xi
Preface to the First Edition	xiii
I Option Pricing	1
1 Derivatives	3
1.1 Recommended Literature	10
2 Introduction to Option Management	11
2.1 Arbitrage Relations	11
2.2 Portfolio Insurance	23
2.3 Binary One-Period Model	30
2.4 Recommended Literature	35
3 Basic Concepts of Probability Theory	37
3.1 Real Valued Random Variables	37
3.2 Expectation and Variance	39
3.3 Skewness and Kurtosis	41
3.4 Random Vectors, Dependence, Correlation	42
3.5 Conditional Probabilities and Expectations	43
3.6 Recommended Literature	45
4 Stochastic Processes in Discrete Time	47
4.1 Binomial Processes	47
4.2 Trinomial Processes	51
4.3 General Random Walks	53
4.4 Geometric Random Walks	54
4.5 Binomial Models with State Dependent Increments	55
4.6 Recommended Literature	56
5 Stochastic Integrals and Differential Equations	57
5.1 Wiener Process	57
5.2 Stochastic Integration	61

5.3	Stochastic Differential Equations	63
5.4	The Stock Price as a Stochastic Process	66
5.5	Itô's Lemma	69
5.6	Recommended Literature	72
6	Black–Scholes Option Pricing Model	73
6.1	Black–Scholes Differential Equation	73
6.2	Black–Scholes Formula for European Options	80
6.2.1	Numerical Approximation	84
6.3	Simulation	87
6.3.1	Linear Congruential Generator	88
6.3.2	Fibonacci Generators	93
6.3.3	Inversion Method	94
6.3.4	Box-Muller Method	95
6.3.5	Variant of Marsaglia Method	97
6.4	Risk Management and Hedging	98
6.4.1	Delta Hedging	101
6.4.2	Gamma and Theta	104
6.4.3	Rho and Vega	107
6.4.4	Volga and Vanna	108
6.4.5	Historical and Implied Volatility	110
6.4.6	Realised Volatility	114
6.5	Recommended Literature	115
7	Binomial Model for European Options	117
7.1	Cox–Ross–Rubinstein Approach to Option Pricing	118
7.2	Discrete Dividends	122
7.2.1	Dividends as a Percentage of the Stock Price	123
7.2.2	Dividends as a Fixed Amount of Money	124
7.3	Recommended Literature	127
8	American Options	129
8.1	Arbitrage Relationship for American Options	129
8.2	The Trinomial Model for American Options	136
8.3	Recommended Literature	141
9	Exotic Options	143
9.1	Compound Options, Option on Option	143
9.2	Chooser Options or “As You Wish” Options	146
9.3	Barrier Options	146
9.4	Asian Options	148
9.5	Lookback Options	150
9.6	Cliquet Options	152

9.7	Recommended Literature	153
10	Models for the Interest Rate and Interest Rate Derivatives	155
10.1	Bond Value with Known Time Dependent Interest Rate . . .	155
10.2	Stochastic Interest Rate Model	156
10.3	The Bond Valuation Equation	157
10.4	Solving the Zero Bond Valuation Equation	159
10.5	Valuation of Bond Options	160
10.6	Recommended Literature	161
II	Statistical Models of Financial Time Series	163
11	Introduction: Definitions and Concepts	165
11.1	Some Definitions	166
11.2	Statistical Analysis of German Stock Returns	173
11.3	Expectations and Efficient Markets	175
11.4	Econometric Models: A Brief Summary	181
11.4.1	Stock Prices: the CAPM	181
11.4.2	Exchange Rate: Theory of the Interest Rate Parity . .	182
11.4.3	Term Structure: The Cox-Ingersoll-Ross Model	184
11.4.4	Options: The Black-Scholes Model	186
11.4.5	The Market Price of Risk	188
11.5	The Random Walk Hypothesis	191
11.6	Unit Root Tests	193
11.6.1	Dickey-Fuller Tests	194
11.6.2	The KPSS Test of Stationarity	196
11.6.3	Variance Ratio Tests	198
11.7	Recommended Literature	200
12	ARIMA Time Series Models	203
12.1	Moving Average Processes	204
12.2	Autoregressive Process	205
12.3	ARMA Models	209
12.4	Partial Autocorrelation	211
12.5	Estimation of Moments	214
12.5.1	Estimation of the Mean Function	215
12.5.2	Estimation of the Covariance Function	216
12.5.3	Estimation of the ACF	217
12.6	Portmanteau Statistics	218
12.7	Estimation of AR(p) Models	219
12.8	Estimation of MA(q) and ARMA(p, q) Models	220

12.9 Recommended Literature	225
13 Time Series with Stochastic Volatility	227
13.1 ARCH and GARCH Models	229
13.1.1 ARCH(1): Definition and Properties	231
13.1.2 Estimation of ARCH(1) Models	239
13.1.3 ARCH(q): Definition and Properties	242
13.1.4 Estimation of an ARCH(q) Model	244
13.1.5 Generalised ARCH (GARCH)	245
13.1.6 Estimation of GARCH(p, q) Models	248
13.2 Extensions of the GARCH Model	252
13.2.1 Exponential GARCH	252
13.2.2 Threshold ARCH Models	254
13.2.3 Risk and Returns	255
13.2.4 Estimation Results for the DAX Returns	256
13.3 Shortfalls of GARCH	258
13.3.1 Recent Challenges to GARCH Models	258
13.3.2 Next-Day Volatility Forecasting for DAX Returns	265
13.4 Multivariate GARCH Models	268
13.4.1 The Vec Specification	268
13.4.2 The BEKK Specification	271
13.4.3 The CCC Model	272
13.4.4 The DCC Model	272
13.4.5 An Empirical Illustration	273
13.5 Recommended Literature	277
14 Non-parametric Concepts for Financial Time Series	279
14.1 Nonparametric Regression	280
14.2 Construction of the Estimator	283
14.3 Asymptotic Normality	286
14.4 Recommended Literature	301
III Selected Financial Applications	303
15 Pricing Options with Flexible Volatility Estimators	305
15.1 Pricing Options with ARCH-Models	305
15.2 A Monte Carlo Study	312
15.3 Application to the Valuation of DAX Calls	315
15.4 Recommended Literature	319
16 Value at Risk and Backtesting	321
16.1 Forecast and VaR Models	323

16.2	Backtesting with Expected Shortfall	325
16.3	Backtesting in Action	326
16.4	Recommended Literature	331
17	Copulae and Value at Risk	333
17.1	Copulae	335
17.1.1	Gaussian Copula	339
17.1.2	Student's t -Copula	341
17.1.3	Archimedean Copulae	342
17.1.4	Multivariate Archimedean Copulae	343
17.1.5	Distributions Constructed with Copulae	345
17.1.6	Monte Carlo Simulation	345
17.2	Copula Estimation	349
17.2.1	Maximum Likelihood Estimation	351
17.2.2	IFM - Inference for Margins	351
17.2.3	CML - Canonical Maximum Likelihood	351
17.2.4	Gaussian Copula Estimation	352
17.2.5	t -Copula Estimation	353
17.3	Value-at-Risk and Copulae	354
17.3.1	Value-at-Risk	354
17.3.2	VaR Estimation with Copulae	355
17.3.3	Time-Varying Copulae and Backtesting	356
17.4	Empirical Results	356
17.4.1	An Exchange Rate Portfolio	356
17.4.2	5-dimensional Exchange Rate Portfolio	361
17.5	Recommended Literature	368
18	Statistics of Extreme Risks	371
18.1	Limit Behaviour of Maxima	371
18.2	Statistics of Extreme Events	380
18.2.1	The POT (Peaks-Over-Threshold) Method	382
18.2.2	The Hill Estimator	388
18.3	Estimators for Risk Measurements	390
18.4	Extreme Value Theory for Time Series	392
18.5	Recommended Literature	396
19	Neural Networks	399
19.1	From Perceptron to Non-linear Neuron	400
19.2	Back Propagation	409
19.3	Neural Networks in Non-parametric Regression Analysis	411
19.4	Forecasts of Financial Time Series with Neural Networks	418
19.5	Quantifying Risk with Neural Networks	422

19.6 Recommended Literature	427
20 Volatility Risk of Option Portfolios	429
20.1 Description of the Data	430
20.2 Principal Component Analysis of the VDAX's Dynamics . . .	434
20.3 Stability Analysis of the VDAX's Dynamics	437
20.4 Measure of the Implied Volatility's Risk	438
20.5 Recommended Literature	441
21 Nonparametric Estimators for the Probability of Default	443
21.1 Logistic Regression	443
21.2 Semi-parametric Model for Credit Rating	445
21.3 Credit Ratings with Neural Networks	449
22 Credit Risk Management	451
22.1 Basic Concepts	451
22.2 The Bernoulli Model	453
22.3 The Poisson Model	454
22.4 The Industrial Models	455
22.5 One Factor Models	460
22.6 Copulae and Loss Distributions	462
A Technical Appendix	467
Appendix	467
A.1 Integration Theory	467
A.2 Portfolio Strategies	472
Frequently Used Notations	479
Bibliography	481
Index	497