

Contents

Contributors	9
Preface to the second edition	11
Preface	13
Frequently used notation	17
I Finance	19
1 Models for heavy-tailed asset returns	21
<i>Szymon Borak, Adam Misiorek, and Rafał Weron</i>	
1.1 Introduction	21
1.2 Stable distributions	22
1.2.1 Definitions and basic properties	22
1.2.2 Computation of stable density and distribution functions	25
1.2.3 Simulation of stable variables	28
1.2.4 Estimation of parameters	29
1.3 Truncated and tempered stable distributions	34
1.4 Generalized hyperbolic distributions	36
1.4.1 Definitions and basic properties	36
1.4.2 Simulation of generalized hyperbolic variables	40
1.4.3 Estimation of parameters	42
1.5 Empirical evidence	44
2 Expected shortfall	57
<i>Simon A. Broda and Marc S. Paoletta</i>	
2.1 Introduction	57
2.2 Expected shortfall for several asymmetric, fat-tailed distributions	58
2.2.1 Expected shortfall: definitions and basic results	58
2.2.2 Student's t and extensions	60

2.2.3	ES for the stable Paretian distribution	65
2.2.4	Generalized hyperbolic and its special cases	67
2.3	Mixture distributions	70
2.3.1	Introduction	70
2.3.2	Expected shortfall for normal mixture distributions . . .	71
2.3.3	Symmetric stable mixture	72
2.3.4	Student's t mixtures	73
2.4	Comparison study	73
2.5	Lower partial moments	76
2.6	Expected shortfall for sums	82
2.6.1	Saddlepoint approximation for density and distribution	83
2.6.2	Saddlepoint approximation for expected shortfall	84
2.6.3	Application to sums of skew normal	85
2.6.4	Application to sums of proper generalized hyperbolic . .	87
2.6.5	Application to sums of normal inverse Gaussian	90
2.6.6	Application to portfolio returns	92
3	Modelling conditional heteroscedasticity in nonstationary series	101
	<i>Pavel Čížek</i>	
3.1	Introduction	101
3.2	Parametric conditional heteroscedasticity models	103
3.2.1	Quasi-maximum likelihood estimation	104
3.2.2	Estimation results	105
3.3	Time-varying coefficient models	108
3.3.1	Time-varying ARCH models	109
3.3.2	Estimation results	111
3.4	Pointwise adaptive estimation	114
3.4.1	Search for the longest interval of homogeneity	116
3.4.2	Choice of critical values	118
3.4.3	Estimation results	119
3.5	Adaptive weights smoothing	123
3.5.1	The AWS algorithm	124
3.5.2	Estimation results	127
3.6	Conclusion	127
4	FX smile in the Heston model	133
	<i>Agnieszka Janek, Tino Kluge, Rafał Weron, and Uwe Wystup</i>	
4.1	Introduction	133
4.2	The model	134

4.3	Option pricing	136
4.3.1	European vanilla FX option prices and Greeks	138
4.3.2	Computational issues	140
4.3.3	Behavior of the variance process and the Feller condition	142
4.3.4	Option pricing by Fourier inversion	144
4.4	Calibration	149
4.4.1	Qualitative effects of changing the parameters	149
4.4.2	The calibration scheme	150
4.4.3	Sample calibration results	152
4.5	Beyond the Heston model	155
4.5.1	Time-dependent parameters	155
4.5.2	Jump-diffusion models	158
5	Pricing of Asian temperature risk	163
	<i>Fred Espen Benth, Wolfgang Karl Härdle, and Brenda Lopez Cabrera</i>	
5.1	The temperature derivative market	165
5.2	Temperature dynamics	167
5.3	Temperature futures pricing	170
5.3.1	CAT futures and options	171
5.3.2	CDD futures and options	173
5.3.3	Inferring the market price of temperature risk	175
5.4	Asian temperature derivatives	177
5.4.1	Asian temperature dynamics	177
5.4.2	Pricing Asian futures	188
6	Variance swaps	201
	<i>Wolfgang Karl Härdle and Elena Silyakova</i>	
6.1	Introduction	201
6.2	Volatility trading with variance swaps	202
6.3	Replication and hedging of variance swaps	203
6.4	Constructing a replication portfolio in practice	209
6.5	3G volatility products	211
6.5.1	Corridor and conditional variance swaps	213
6.5.2	Gamma swaps	214
6.6	Equity correlation (dispersion) trading with variance swaps	216
6.6.1	Idea of dispersion trading	216
6.7	Implementation of the dispersion strategy on DAX index	219

7	Learning machines supporting bankruptcy prediction	225
	<i>Wolfgang Karl Härdle, Linda Hoffmann, and Rouslan Moro</i>	
7.1	Bankruptcy analysis	226
7.2	Importance of risk classification and Basel II	237
7.3	Description of data	238
7.4	Calculations	239
7.5	Computational results	240
7.6	Conclusions	245
8	Distance matrix method for network structure analysis	251
	<i>Janusz Miśkiewicz</i>	
8.1	Introduction	251
8.2	Correlation distance measures	252
8.2.1	Manhattan distance	253
8.2.2	Ultrametric distance	253
8.2.3	Noise influence on the time series distance	254
8.2.4	Manhattan distance noise influence	255
8.2.5	Ultrametric distance noise influence	257
8.2.6	Entropy distance	262
8.3	Distance matrices analysis	263
8.4	Examples	265
8.4.1	Structure of stock markets	265
8.4.2	Dynamics of the network	268
8.5	Summary	279
II	Insurance	291
9	Building loss models	293
	<i>Krzysztof Burnecki, Joanna Janczura, and Rafał Weron</i>	
9.1	Introduction	293
9.2	Claim arrival processes	294
9.2.1	Homogeneous Poisson process (HPP)	295
9.2.2	Non-homogeneous Poisson process (NHPP)	297
9.2.3	Mixed Poisson process	300
9.2.4	Renewal process	301
9.3	Loss distributions	302
9.3.1	Empirical distribution function	303
9.3.2	Exponential distribution	304
9.3.3	Mixture of exponential distributions	305

9.3.4	Gamma distribution	307
9.3.5	Log-Normal distribution	309
9.3.6	Pareto distribution	311
9.3.7	Burr distribution	313
9.3.8	Weibull distribution	314
9.4	Statistical validation techniques	315
9.4.1	Mean excess function	315
9.4.2	Tests based on the empirical distribution function . . .	318
9.5	Applications	321
9.5.1	Calibration of loss distributions	321
9.5.2	Simulation of risk processes	324
10	Ruin probability in finite time	329
	<i>Krzysztof Burnecki and Marek Teuerle</i>	
10.1	Introduction	329
10.1.1	Light- and heavy-tailed distributions	331
10.2	Exact ruin probabilities in finite time	333
10.2.1	Exponential claim amounts	334
10.3	Approximations of the ruin probability in finite time	334
10.3.1	Monte Carlo method	335
10.3.2	Segerdahl normal approximation	335
10.3.3	Diffusion approximation by Brownian motion	337
10.3.4	Corrected diffusion approximation	338
10.3.5	Diffusion approximation by α -stable Lévy motion	338
10.3.6	Finite time De Vylder approximation	340
10.4	Numerical comparison of the finite time approximations	342
11	Property and casualty insurance pricing with GLMs	349
	<i>Jan Iwanik</i>	
11.1	Introduction	349
11.2	Insurance data used in statistical modeling	350
11.3	The structure of generalized linear models	351
11.3.1	Exponential family of distributions	352
11.3.2	The variance and link functions	353
11.3.3	The iterative algorithm	353
11.4	Modeling claim frequency	354
11.4.1	Pre-modeling steps	355
11.4.2	The Poisson model	355
11.4.3	A numerical example	356

11.5	Modeling claim severity	356
11.5.1	Data preparation	357
11.5.2	A numerical example	358
11.6	Some practical modeling issues	360
11.6.1	Non-numeric variables and banding	360
11.6.2	Functional form of the independent variables	360
11.7	Diagnosing frequency and severity models	361
11.7.1	Expected value as a function of variance	361
11.7.2	Deviance residuals	361
11.7.3	Statistical significance of the coefficients	363
11.7.4	Uniformity over time	364
11.7.5	Selecting the final models	365
11.8	Finalizing the pricing models	366
12	Pricing of catastrophe bonds	371
	<i>Krzysztof Burnecki, Grzegorz Kukla, and David Taylor</i>	
12.1	Introduction	371
12.1.1	The emergence of CAT bonds	372
12.1.2	Insurance securitization	374
12.1.3	CAT bond pricing methodology	375
12.2	Compound doubly stochastic Poisson pricing model	377
12.3	Calibration of the pricing model	379
12.4	Dynamics of the CAT bond price	381
13	Return distributions of equity-linked retirement plans	393
	<i>Nils Detering, Andreas Weber, and Uwe Wystup</i>	
13.1	Introduction	393
13.2	The displaced double-exponential jump diffusion model	395
13.2.1	Model equation	395
13.2.2	Drift adjustment	398
13.2.3	Moments, variance and volatility	398
13.3	Parameter estimation	399
13.3.1	Estimating parameters from financial data	399
13.4	Interest rate curve	401
13.5	Products	401
13.5.1	Classical insurance strategy	401
13.5.2	Constant proportion portfolio insurance	402
13.5.3	Stop loss strategy	404
13.6	Payments to the contract and simulation horizon	405
13.7	Cost structures	406

13.8 Results without costs	407
13.9 Impact of costs	409
13.10 Impact of jumps	411
13.11 Summary	412
Index	415