

Financial Risk Modelling and Portfolio Optimization with R

Second Edition

Bernhard Pfaff

WILEY

Contents

Preface to the Second Edition	xi
Preface	xiii
Abbreviations	xv
About the Companion Website	xix
PART I MOTIVATION	1
1 Introduction	3
Reference	5
2 A brief course in R	6
2.1 Origin and development	6
2.2 Getting help	7
2.3 Working with R	10
2.4 Classes, methods, and functions	12
2.5 The accompanying package FRAPO	22
References	28
3 Financial market data	29
3.1 Stylized facts of financial market returns	29
3.1.1 Stylized facts for univariate series	29
3.1.2 Stylized facts for multivariate series	32
3.2 Implications for risk models	35
References	36
4 Measuring risks	37
4.1 Introduction	37
4.2 Synopsis of risk measures	37
4.3 Portfolio risk concepts	42
References	44
5 Modern portfolio theory	46
5.1 Introduction	46

5.2	Markowitz portfolios	47
5.3	Empirical mean-variance portfolios	50
	References	52

PART II RISK MODELLING 55

6	Suitable distributions for returns	57
6.1	Preliminaries	57
6.2	The generalized hyperbolic distribution	57
6.3	The generalized lambda distribution	60
6.4	Synopsis of R packages for GHD	66
6.4.1	The package fBasics	66
6.4.2	The package GeneralizedHyperbolic	67
6.4.3	The package ghyp	69
6.4.4	The package QRM	70
6.4.5	The package SkewHyperbolic	70
6.4.6	The package VarianceGamma	71
6.5	Synopsis of R packages for GLD	71
6.5.1	The package Davies	71
6.5.2	The package fBasics	72
6.5.3	The package gld	73
6.5.4	The package lmomco	73
6.6	Applications of the GHD to risk modelling	74
6.6.1	Fitting stock returns to the GHD	74
6.6.2	Risk assessment with the GHD	77
6.6.3	Stylized facts revisited	80
6.7	Applications of the GLD to risk modelling and data analysis	82
6.7.1	VaR for a single stock	82
6.7.2	Shape triangle for FTSE 100 constituents	84
	References	86
7	Extreme value theory	89
7.1	Preliminaries	89
7.2	Extreme value methods and models	90
7.2.1	The block maxima approach	90
7.2.2	The r th largest order models	91
7.2.3	The peaks-over-threshold approach	92
7.3	Synopsis of R packages	94
7.3.1	The package evd	94
7.3.2	The package evdbayes	95
7.3.3	The package evir	96
7.3.4	The packages extRemes and in2extRemes	98

7.3.5	The package fExtremes	99
7.3.6	The package ismev	101
7.3.7	The package QRM	101
7.3.8	The packages Renext and RenextGUI	102
7.4	Empirical applications of EVT	103
7.4.1	Section outline	103
7.4.2	Block maxima model for Siemens	103
7.4.3	r -block maxima for BMW	107
7.4.4	POT method for Boeing	110
	References	115
8	Modelling volatility	116
8.1	Preliminaries	116
8.2	The class of ARCH models	116
8.3	Synopsis of R packages	120
8.3.1	The package bayesGARCH	120
8.3.2	The package ccgarch	121
8.3.3	The package fGarch	122
8.3.4	The package GEVStableGarch	122
8.3.5	The package gogarch	123
8.3.6	The package lgarch	123
8.3.7	The packages rugarch and rmgarch	125
8.3.8	The package tseries	127
8.4	Empirical application of volatility models	128
	References	130
9	Modelling dependence	133
9.1	Overview	133
9.2	Correlation, dependence, and distributions	133
9.3	Copulae	136
9.3.1	Motivation	136
9.3.2	Correlations and dependence revisited	137
9.3.3	Classification of copulae	139
9.4	Synopsis of R packages	142
9.4.1	The package BLCOP	142
9.4.2	The package copula	144
9.4.3	The package fCopulae	146
9.4.4	The package gumbel	147
9.4.5	The package QRM	148
9.5	Empirical applications of copulae	148
9.5.1	GARCH–copula model	148
9.5.2	Mixed copula approaches	155
	References	157

PART III	PORTFOLIO OPTIMIZATION APPROACHES	161
10	Robust portfolio optimization	163
10.1	Overview	163
10.2	Robust statistics	164
10.2.1	Motivation	164
10.2.2	Selected robust estimators	165
10.3	Robust optimization	168
10.3.1	Motivation	168
10.3.2	Uncertainty sets and problem formulation	168
10.4	Synopsis of R packages	174
10.4.1	The package covRobust	174
10.4.2	The package fPortfolio	174
10.4.3	The package MASS	175
10.4.4	The package robustbase	176
10.4.5	The package robust	176
10.4.6	The package rrcov	178
10.4.7	Packages for solving SOCPs	179
10.5	Empirical applications	180
10.5.1	Portfolio simulation: robust versus classical statistics	180
10.5.2	Portfolio back test: robust versus classical statistics	186
10.5.3	Portfolio back-test: robust optimization	190
	References	195
11	Diversification reconsidered	198
11.1	Introduction	198
11.2	Most-diversified portfolio	199
11.3	Risk contribution constrained portfolios	201
11.4	Optimal tail-dependent portfolios	204
11.5	Synopsis of R packages	207
11.5.1	The package cccp	207
11.5.2	The packages DEoptim , DEoptimR , and RcppDE	207
11.5.3	The package FRAPO	210
11.5.4	The package PortfolioAnalytics	211
11.6	Empirical applications	212
11.6.1	Comparison of approaches	212
11.6.2	Optimal tail-dependent portfolio against benchmark	216
11.6.3	Limiting contributions to expected shortfall	221
	References	226
12	Risk-optimal portfolios	228
12.1	Overview	228
12.2	Mean-VaR portfolios	229
12.3	Optimal CVaR portfolios	234
12.4	Optimal draw-down portfolios	238

12.5	Synopsis of R packages	241
12.5.1	The package fPortfolio	241
12.5.2	The package FRAPO	243
12.5.3	Packages for linear programming	245
12.5.4	The package PerformanceAnalytics	249
12.6	Empirical applications	251
12.6.1	Minimum-CVaR versus minimum-variance portfolios	251
12.6.2	Draw-down constrained portfolios	254
12.6.3	Back-test comparison for stock portfolio	260
12.6.4	Risk surface plots	265
	References	272
13	Tactical asset allocation	274
13.1	Overview	274
13.2	Survey of selected time series models	275
13.2.1	Univariate time series models	275
13.2.2	Multivariate time series models	281
13.3	The Black–Litterman approach	289
13.4	Copula opinion and entropy pooling	292
13.4.1	Introduction	292
13.4.2	The COP model	292
13.4.3	The EP model	293
13.5	Synopsis of R packages	295
13.5.1	The package BLCOP	295
13.5.2	The package dse	297
13.5.3	The package fArma	300
13.5.4	The package forecast	301
13.5.5	The package MSBVAR	302
13.5.6	The package PortfolioAnalytics	304
13.5.7	The packages urca and vars	304
13.6	Empirical applications	307
13.6.1	Black–Litterman portfolio optimization	307
13.6.2	Copula opinion pooling	313
13.6.3	Entropy pooling	318
13.6.4	Protection strategies	324
	References	334
14	Probabilistic utility	339
14.1	Overview	339
14.2	The concept of probabilistic utility	340
14.3	Markov chain Monte Carlo	342
14.3.1	Introduction	342
14.3.2	Monte Carlo approaches	343
14.3.3	Markov chains	347
14.3.4	Metropolis–Hastings algorithm	349

14.4	Synopsis of R packages	354
14.4.1	Packages for conducting MCMC	354
14.4.2	Packages for analyzing MCMC	358
14.5	Empirical application	362
14.5.1	Exemplary utility function	362
14.5.2	Probabilistic versus maximized expected utility	366
14.5.3	Simulation of asset allocations	369
	References	375
Appendix A Package overview		378
A.1	Packages in alphabetical order	378
A.2	Packages ordered by topic	382
	References	386
Appendix B Time series data		391
B.1	Date/time classes	391
B.2	The <code>ts</code> class in the base package <code>stats</code>	395
B.3	Irregularly spaced time series	395
B.4	The package <code>timeSeries</code>	397
B.5	The package <code>zoo</code>	399
B.6	The packages <code>tframe</code> and <code>xts</code>	401
	References	404
Appendix C Back-testing and reporting of portfolio strategies		406
C.1	R packages for back-testing	406
C.2	R facilities for reporting	407
C.3	Interfacing with databases	407
	References	408
Appendix D Technicalities		411
	Reference	411
	Index	413