

Measuring Market Risk

Second Edition

Kevin Dowd

UNIVERSITÄT
LIECHTENSTEIN
Bibliothek



John Wiley & Sons, Ltd

Contents

Preface to the Second Edition	xiii
Acknowledgements	xix
1 The Rise of Value at Risk	1
1.1 The emergence of financial risk management	2
1.2 Market risk measurement	4
1.3 Risk measurement before VaR	5
1.3.1 Gap analysis	5
1.3.2 Duration analysis	5
1.3.3 Scenario analysis	6
1.3.4 Portfolio theory	7
1.3.5 Derivatives risk measures	8
1.4 Value at risk	9
1.4.1 The origin and development of VaR	9
1.4.2 Attractions of VaR	11
1.4.3 Criticisms of VaR	13
Appendix: Types of Market Risk	15
2 Measures of Financial Risk	19
2.1 The mean-variance framework for measuring financial risk	20
2.2 Value at risk	27
2.2.1 Basics of VaR	27
2.2.2 Determination of the VaR parameters	29
2.2.3 Limitations of VaR as a risk measure	31
2.3 Coherent risk measures	32
2.3.1 The coherence axioms and their implications	32
2.3.2 The expected shortfall	35
2.3.3 Spectral risk measures	37

2.3.4	Scenarios as coherent risk measures	42
2.4	Conclusions	44
Appendix 1: Probability Functions		45
Appendix 2: Regulatory Uses of VaR		52
Estimating Market Risk Measures: An Introduction and Overview		53
3.1	Data	53
3.1.1	Profit/loss data	53
3.1.2	Loss/profit data	54
3.1.3	Arithmetic return data	54
3.1.4	Geometric return data	54
3.2	Estimating historical simulation VaR	56
3.3	Estimating parametric VaR	57
3.3.1	Estimating VaR with normally distributed profits/losses	57
3.3.2	Estimating VaR with normally distributed arithmetic returns	59
3.3.3	Estimating lognormal VaR	61
3.4	Estimating coherent risk measures	64
3.4.1	Estimating expected shortfall	64
3.4.2	Estimating coherent risk measures	64
3.5	Estimating the standard errors of risk measure estimators	69
3.5.1	Standard errors of quantile estimators	69
3.5.2	Standard errors in estimators of coherent risk measures	72
3.6	The core issues: an overview	73
Appendix 1: Preliminary Data Analysis		75
Appendix 2: Numerical Integration Methods		80
Non-parametric Approaches		83
4.1	Compiling historical simulation data	84
4.2	Estimation of historical simulation VaR and ES	84
4.2.1	Basic historical simulation	84
4.2.2	Bootstrapped historical simulation	85
4.2.3	Historical simulation using non-parametric density estimation	86
4.2.4	Estimating curves and surfaces for VAR and ES	88
4.3	Estimating confidence intervals for historical simulation VaR and ES	89
4.3.1	An order-statistics approach to the estimation of confidence intervals for HS VaR and ES	89
4.3.2	A bootstrap approach to the estimation of confidence intervals for HS VaR and ES	90
4.4	Weighted historical simulation	92
4.4.1	Age-weighted Historical simulation	93
4.4.2	Volatility-weighted historical simulation	94
4.4.3	Correlation-weighted historical simulation	95
4.4.4	Filtered historical simulation	96

4.5	Advantages and disadvantages of non-parametric methods	99
4.5.1	Advantages	99
4.5.2	Disadvantages	100
4.6	Conclusions	101
Appendix 1: Estimating Risk Measures with Order Statistics		102
Appendix 2: The Bootstrap		105
Appendix 3: Non-parametric Density Estimation		111
Appendix 4: Principal Components Analysis and Factor Analysis		118
Forecasting Volatilities, Covariances and Correlations		127
5.1	Forecasting volatilities	127
5.1.1	Defining volatility	127
5.1.2	Historical volatility forecasts	128
5.1.3	Exponentially weighted moving average volatility	129
5.1.4	GARCH models	131
5.1.5	Implied volatilities	136
5.2	Forecasting covariances and correlations	137
5.2.1	Defining covariances and correlations	137
5.2.2	Historical covariances and correlations	138
5.2.3	Exponentially weighted moving average covariances	140
5.2.4	GARCH covariances	140
5.2.5	Implied covariances and correlations	141
5.2.6	Some pitfalls with correlation estimation	141
5.3	Forecasting covariance matrices	142
5.3.1	Positive definiteness and positive semi-definiteness	142
5.3.2	Historical variance-covariance estimation	142
5.3.3	Multivariate EWMA	142
5.3.4	Multivariate GARCH	142
5.3.5	Computational problems with covariance and correlation matrices	143
Appendix: Modelling Dependence: Correlations and Copulas		145
Parametric Approaches (I)		151
6.1	Conditional vs unconditional distributions	152
6.2	Normal VaR and ES	154
6.3	The f-distribution	159
6.4	The lognormal distribution	161
6.5	Miscellaneous parametric approaches	165
6.5.1	Levy approaches	165
6.5.2	Elliptical and hyperbolic approaches	167
6.5.3	Normal mixture approaches	167
6.5.4	Jump diffusion	168

Contents	
6.5.5 Stochastic volatility approaches	169
6.5.6 The Cornish-Fisher approximation	171
6.6 The multivariate normal variance-covariance approach	173
6.7 Non-normal variance-covariance approaches	176
6.7.1 Multivariate χ^2 -distributions	176
6.7.2 Multivariate elliptical distributions	177
6.7.3 The Hull-White transformation-into-normality approach	177
6.8 Handling multivariate return distributions with copulas	178
6.8.1 Motivation	178
6.8.2 Estimating VaR with copulas	179
6.9 Conclusions	182
Appendix: Forecasting Longer-term Risk Measures	184
Parametric Approaches (II): Extreme Value	189
7.1 Generalised extreme-value theory	190
7.1.1 Theory	190
7.1.2 A short-cut EV method	194
7.1.3 Estimation of EV parameters	195
7.2 The peaks-over-threshold approach: the generalised Pareto distribution	201
7.2.1 Theory	201
7.2.2 Estimation	203
7.2.3 GEV vs POT	204
7.3 Refinements to EV approaches	204
7.3.1 Conditional EV	204
7.3.2 Dealing with dependent (or non-iid) data	205
7.3.3 Multivariate EVT	206
7.4 Conclusions	206
Monte Carlo Simulation Methods	209
8.1 Uses of Monte Carlo simulation	210
8.2 Monte Carlo simulation with a single risk factor	213
8.3 Monte Carlo simulation with multiple risk factors	215
8.4 Variance-reduction methods	217
8.4.1 Antithetic variables	218
8.4.2 Control variates	218
8.4.3 Importance sampling	219
8.4.4 Stratified sampling	220
8.4.5 Moment matching	223
8.5 Advantages and disadvantages of Monte Carlo simulation	225
8.5.1 Advantages	225
8.5.2 Disadvantages	225
8.6 Conclusions	225
Applications of Stochastic Risk Measurement Methods	227
9.1 Selecting stochastic processes	227
9.2 Dealing with multivariate stochastic processes	230

9.2.1	Principal components simulation	230
9.2.2	Scenario simulation	232
9.3	Dynamic risks	234
9.4	Fixed-income risks	236
9.4.1	Distinctive features of fixed-income problems	237
9.4.2	Estimating fixed-income risk measures	237
9.5	Credit-related risks	238
9.6	Insurance risks	240
9.6.1	General insurance risks	241
9.6.2	Life insurance risks	242
9.7	Measuring pensions risks	244
9.7.1	Estimating risks of defined-benefit pension plans	245
9.7.2	Estimating risks of defined-contribution pension plans	246
9.8	Conclusions	248
10	Estimating Options Risk Measures	249
10.1	Analytical and algorithmic solutions for options VaR	249
10.2	Simulation approaches	253
10.3	Delta-gamma and related approaches	256
10.3.1	Delta-normal approaches	257
10.3.2	Delta-gamma approaches	258
10.4	Conclusions	264
11	Incremental and Component Risks	265
11.1	Incremental VaR	265
11.1.1	Interpreting Incremental VaR	265
11.1.2	Estimating IVaR by brute force: the 'before and after' approach	266
11.1.3	Estimating IVaR using analytical solutions	267
11.2	Component VaR	271
11.2.1	Properties of component VaR	271
11.2.2	Uses of component VaR	274
11.3	Decomposition of coherent risk measures	277
12	Mapping Positions to Risk Factors * •	279
12.1	Selecting core instruments	280
12.2	Mapping positions and VaR estimation	281
12.2.1	Basic building blocks	281
12.2.2	More complex positions	287
13	Stress Testing	291
13.1	Benefits and difficulties of stress testing	293
13.1.1	Benefits of stress testing	293
13.1.2	Difficulties with stress tests	295
13.2	Scenario analysis	297
13.2.1	Choosing scenarios	297
13.2.2	Evaluating the effects of scenarios	300

Contents

13.3	Mechanical stress testing	303
13.3.1	Factor push analysis	303
13.3.2	Maximum loss optimisation	305
13.3.3	CrashMetrics	305
13.4	Conclusions	306
14	Estimating Liquidity Risks	309
14.1	Liquidity and liquidity risks	309
14.2	Estimating liquidity-adjusted VaR	310
14.2.1	The constant spread approach	311
14.2.2	The exogenous spread approach	312
14.2.3	Endogenous-price approaches	314
14.2.4	The liquidity discount approach	315
14.3	Estimating liquidity at risk (LaR)	316
14.4	Estimating liquidity in crises	319
15	Backtesting Market Risk Models	321
15.1	Preliminary data issues	321
15.2	Backtests based on frequency tests	323
15.2.1	The basic frequency backtest	324
15.2.2	The conditional testing (Christoffersen) backtest	329
15.3	*Backtests based on tests of distribution equality	331
15.3.1	Tests based on the Rosenblatt transformation	331
15.3.2	Tests using the Berkowitz transformation	333
15.3.3	Overlapping forecast periods	335
15.4	Comparing alternative models	336
15.5	Backtesting with alternative positions and data	339
15.5.1	Backtesting with alternative positions	340
15.5.2	Backtesting with alternative data	340
15.6	Assessing the precision of backtest results	340
15.7	Summary and conclusions	342
	Appendix: Testing Whether Two Distributions are Different	343
16	Model Risk	351
16.1	Models and model risk	351
16.2	Sources of model risk	353
16.2.1	Incorrect model specification	353
16.2.2	Incorrect model application	354
16.2.3	Implementation risk	354
16.2.4	Other sources of model risk	355
16.3	Quantifying model risk	357
16.4	Managing model risk	359
16.4.1	Managing model risk: some guidelines for risk practitioners	359
16.4.2	Managing model risk: some guidelines for senior managers	360

16.4.3 Institutional methods to manage model risk	361
16.5 Conclusions	363
Bibliography	365
Index	379

CD content has been moved to website - please see www.wiley.com/go/dowd