Contents

Preface xi
About the Authors xv

CHAPTER 1
Introduction 1
Quantitative Techniques in the Investment Management Industry 1
Central Themes of This Book 9
Overview of This Book 12

PART ONE
Portfolio Allocation: Classical Theory and Extensions 15

CHAPTER 2
Mean-Variance Analysis and Modern Portfolio Theory 17
The Benefits of Diversification 18
Mean-Variance Analysis: Overview 21
Classical Framework for Mean-Variance Optimization 24
The Capital Market Line 35
Selection of the Optimal Portfolio When There Is a Risk-Free Asset 41
More on Utility Functions: A General Framework for Portfolio Choice 45
Summary 50

CHAPTER 3
Advances in the Theory of Portfolio Risk Measures 53
Dispersion and Downside Measures 54
Portfolio Selection with Higher Moments through Expansions of Utility 70
Polynomial Goal Programming for Portfolio Optimization with Higher Moments 78
Some Remarks on the Estimation of Higher Moments 80
The Approach of Malevergne and Sornette 81
Summary 86
## CONTENTS

### CHAPTER 4
**Portfolio Selection in Practice** 87
- Portfolio Constraints Commonly Used in Practice 88
- Incorporating Transaction Costs in Asset-Allocation Models 101
- Multiaccount Optimization 106
- Summary 111

### PART TWO
**Robust Parameter Estimation** 113

### CHAPTER 5
**Classical Asset Pricing** 115
- Definitions 115
- Theoretical and Econometric Models 117
- Random Walk Models 118
- General Equilibrium Theories 131
- Capital Asset Pricing Model (CAPM) 132
- Arbitrage Pricing Theory (APT) 136
- Summary 137

### CHAPTER 6
**Forecasting Expected Return and Risk** 139
- Dividend Discount and Residual Income Valuation Models 140
- The Sample Mean and Covariance Estimators 146
- Random Matrices 157
- Arbitrage Pricing Theory and Factor Models 160
- Factor Models in Practice 168
- Other Approaches to Volatility Estimation 172
- Application to Investment Strategies and Proprietary Trading 176
- Summary 177

### CHAPTER 7
**Robust Estimation** 179
- The Intuition behind Robust Statistics 179
- Robust Statistics 181
- Robust Estimators of Regressions 192
- Confidence Intervals 200
- Summary 206
CHAPTER 8
Robust Frameworks for Estimation: Shrinkage,
Bayesian Approaches, and the Black-Litterman Model 207
Practical Problems Encountered in Mean-Variance Optimization 208
Shrinkage Estimation 215
Bayesian Approaches 229
Summary 253

PART THREE
Optimization Techniques 255

CHAPTER 9
Mathematical and Numerical Optimization 257
Mathematical Programming 258
Necessary Conditions for Optimality for Continuous Optimization Problems 267
Optimization Duality Theory 269
How Do Optimization Algorithms Work? 272
Summary 288

CHAPTER 10
Optimization under Uncertainty 291
Stochastic Programming 293
Dynamic Programming 308
Robust Optimization 312
Summary 332

CHAPTER 11
Implementing and Solving Optimization Problems in Practice 333
Optimization Software 333
Practical Considerations When Using Optimization Software 340
Implementation Examples 346
Specialized Software for Optimization Under Uncertainty 358
Summary 360
## CONTENTS

### PART FOUR

Robust Portfolio Optimization 361

#### CHAPTER 12
Robust Modeling of Uncertain Parameters in Classical Mean-Variance Portfolio Optimization 363
Portfolio Resampling Techniques 364
Robust Portfolio Allocation 367
Some Practical Remarks on Robust Portfolio Allocation Models 392
Summary 393

#### CHAPTER 13
The Practice of Robust Portfolio Management: Recent Trends and New Directions 395
Some Issues in Robust Asset Allocation 396
Portfolio Rebalancing 410
Understanding and Modeling Transaction Costs 413
Rebalancing Using an Optimizer 422
Summary 435

#### CHAPTER 14
Quantitative Investment Management Today and Tomorrow 439
Using Derivatives in Portfolio Management 440
Currency Management 442
Benchmarks 445
Quantitative Return-Forecasting Techniques and Model-Based Trading Strategies 447
Trade Execution and Algorithmic Trading 456
Summary 460

#### APPENDIX A
Data Description: The MSCI World Index 463

INDEX 473