# Contents

**Acknowledgments** **v**

**Preface** **xiii**

**Part I. Asset Pricing Theory** **1**

**1 Consumption-Based Model and Overview** *$*
1.1 Basic Pricing Equation . . . . . 4
1.2 Marginal Rate of Substitution/Stochastic Discount Factor 6
1.3 Prices, Payoffs, and Notation . . . . . 8
1.4 Classic Issues in Finance . . . . . 10
1.5 Discount Factors in Continuous Time . . . . . 25
Problems . . . . . 31

**2 Applying the Basic Model** **35**
2.1 Assumptions and Applicability . . . . . 35
2.2 General Equilibrium . . . . . 37
2.3 Consumption-Based Model in Practice . . . . . 41
2.4 Alternative Asset Pricing Models: Overview . . . . . 43
Problems . . . . . 45

**3 Contingent Claims Markets** **49**
3.1 Contingent Claims . . . . . 49
3.2 Risk-Neutral Probabilities . . . . . 51
3.3 Investors Again . . . . . 53
3.4 Risk Sharing . . . . . 54
3.5 State Diagram and Price Function . . . . . 56

**4 The Discount Factor** **61**
4.1 Law of One Price and Existence of a Discount Factor .... 62
4.2 No Arbitrage and Positive Discount Factors . . . . . 6V

4,3 An Alternative Formula, and $x^*$ in Continuous Time: . . . 72
Problems . . . 7.i

**5 Mean-Variance Frontier and Beta Representations 77**
5.1 Expected Return-Beta Representations . . . 78
5.2 Mean-Variance Frontier: Intuition and Lagnmgian Characterization . . . 81
5.3 An Orthogonal Characterization of the Mean-Variance Frontier . . . 84
5.4 Spanning the Mean-Variance Frontier . . . 88
5.5 A Compilation of Properties of $R^*$, $R^e$\ and $x^*$ . . . 81)
5.6 Mean-Variance Frontiers for Discount Factors: Tht: Hansen-Jagannathan Bounds . . . 92
Problems . . . 1)7

**6 Relation between Discount Factors, Betas, and Mean-Variance Frontiers 99**
6.1 From Discount Factors to Beta Representations . . . 100
6.2 From Mean-Variance Frontier to a Discount Factor and Beta Representation . . . 1{):)
6.3 Factor Models and Discount Factors . . . 100
6.4 Discount Factors and Beta Models to Mean-Variance Frontier . . . 110
6.5 Three Risk-Free Rate Analogues . . . I11
6.6 Mean-Variance Special Cases with No Risk-Free Rate . . . 117
Problems . . . 120

**7 Implications of Existence and Equivalence Theorems 121**

**8 Conditioning Information 131**
8.1 Scaled Payoffs . . . {32
8.2 Sufficiency of Adding Scaled Returns . . . 134
8.3 Conditional and Unconditional Models . . . 13(j
8.4 Scaled Factors: A Partial Solution . . . ] 44
8.5 Summary . . . jA^
Problems . . . ^\{\

**9 Factor Pricing Models 149**
9.1 Capital Asset Pricing Model (CAPM) . . . \%%
9.2 Intertemporal Capital Asset Pricing Model (IGAPM) . . . 105
9.3 Comments on the CAPM and ICAPM . . . 1C7
9.4 Arbitrage Pricing Theory (APT) . . . 17<i

9.5 APT vs. ICAPM . . . 182

Problems . . . 183

**Part II. Estimating and Evaluating Asset Pricing Models 185**

**10 GMM in Explicit Discount Factor Models 189**

10.1 The Recipe . . . 190
10.2 Interpreting the GMM Procedure . . . 192
10.3 Applying GMM . . . 196

**11 GMM: General Formulas and Applications 201**

11.1 General GMM Formulas . . . 202
11.2 Testing Moments . . . 206
11.3 Standard Errors of Anything by Delta Method . . . 207
11.4 Using GMM for Regressions . . . 207
11.5 Prespecified Weighting Matrices and Moment Conditions 210
11.6 Estimating on One Group of Moments, Testing on Another . . . 218
11.7 Estimating the Spectral Density Matrix . . . 219
Problems . . . 227

**12 Regression-Based Tests of Linear Factor Models 229**

12.1 Time-Series Regressions . . . 280
12.2 Gross-Sectional Regressions . . . 235
12.3 Fama-MacBeth Procedure . . . 245
Problems . . . 251

**13 GMM for Linear Factor Models in Discount Factor Form 253**

13.1 GMM on the Pricing Errors Gives a Gross-Sectional Regression . . . 253
13.2 The Gase of Excess Returns . . . 256
13.3 Horse Races . . . 259
13.4 Testing for Priced Factors: Lambdas or //s? . . . 260
13.5 Mean-Variance Frontier and Performance Evaluation . . . . 262
13.6 Testing for Characteristics . . . 264
Problems . . . 265

**14 Maximum Likelihood 267**

14.1 Maximum Likelihood . . . 268
14.2 ML is GMM on the Scores . . . 270
14.3 When Factors Are Returns, MI, Prescribes a Time-Series Regression . . . 272

14.4 When Factors Are Not Excess Returns, ML Prescribes a Cross-Sectional Regression . . . 275
Problems . . . A "

**15 Time-Series, Cross-Section, and GMM/DF Tests of Linear Factor Models** **279**
15.1 Three Approaches to the CAPM in Size Portfolios . . . 280
15.2 Monte Carlo and Bootstrap . . . 280

**16 Which Method?** **293**

**Part III. Bonds and Options** 309

**17 Option Pricing** 3*3
17.1 Background . . . 3 13
17.2 Black-Scholes Formula . . . 320
Problems . . . 320

**18 Option Pricing without Perfect Replication** 327
18.1 On the Edges of Arbitrage . . . 327
18.2 One-Period Good-Deal Bounds . . . 329
18.3 Multiple Periods and Continuous Time . . . 330
18.4 Extensions, Other Approaches, and Bibliography . . . 345
Problems . . . 347

**19 Term Structure of Interest Rates** **349**
19.1 Definitions and Notation . . . 349
19.2 Yield Curve and Expectations Hypothesis . . . 355
19.3 Term Structure Models—A Discrete-Time Introduction . . , 357
19.4 Continuous-Time Term Structure Models . . . 3(52
19.5 Three Linear Term Structure Models . . . 3()H
19.6 Bibliography and Comments . . . H79
Problems . . . 382

**Part IV. Empirical Survey** **385**

**20 Expected Returns in the Time Series and Cross Section** 389
20.1 Time-Series Predictability . . . 3<;)J
20.2 The Cross Section: CAPM and Multifactor Models . . . 435
20.3 Summary and Interpretation . . . 449
Problems . . . 453

**21 Equity Premium Puzzle and Consumption-Based Models** 455
21.1 Equity Premium Puzzles . . . 456
21.2 New Models . . . 465
21.3 Bibliography . . . 481
Problems . . . 485

**Part V. Appendix** **487**

**Appendix. Continuous Time** **489**
A. 1 Brownian Motion . . . 489
A.2 Diffusion Model . . . 491
A.3 Ito's Lemma . . . 494
Problems . . . 495

**References** **497**

**Author Index** **513**

**Subject Index** **517**