Contents

Preface xiii
Preface to the First Edition xv

Part I Introduction

1 Background and Overview 3
1.1 Background 3
1.2 Overview 4

2 Casting Models in Canonical Form 9
2.1 Notation 9
2.1.1 Log-Linear Model Representations 11
2.1.2 Nonlinear Model Representations 11
2.2 Linearization 12
2.2.1 Taylor Series Approximation 12
2.2.2 Log-Linear Approximations 14
2.2.3 Example Equations 15

3 DSGE Models: Three Examples 18
3.1 Model I: A Real Business Cycle Model 20
3.1.1 Environment 20
3.1.2 The Nonlinear System 23
3.1.3 Log-Linearization 26
3.2 Model II: Monopolistic Competition and Monetary Policy 28
3.2.1 Environment 28
3.2.2 The Nonlinear System 33
3.2.3 Log-Linearization 34
3.3 Model III: Asset Pricing 38
3.3.1 Single-Asset Environment 38
3.3.2 Multi-Asset Environment 39
3.3.3 Alternative Preference Specifications 40

Part II Model Solution Techniques

4 Linear Solution Techniques 51
4.1 Homogeneous Systems 52
4.2 Example Models 54
4.2.1 The Optimal Consumption Model 54
4.2.2 Asset Pricing with Linear Utility 55
4.2.3 Ramsey's Optimal Growth Model 56

4.3 Blanchard and Kahn's Method 57
4.4 Sims' Method 61
4.5 Klein's Method 64
4.6 An Undetermined Coefficients Approach 66

5 Nonlinear Solution Techniques 69
5.1 Projection Methods 71
5.1.1 Overview 71
5.1.2 Finite Element Methods 72
5.1.3 Orthogonal Polynomials 73
5.1.4 Implementation 74
5.1.5 Extension to the l-dimensional Case 78
5.1.6 Application to the Optimal Growth Model 79
5.2 Iteration Techniques: Value-Function and Policy-Function Iterations 87
5.2.1 Dynamic Programming 87
5.2.2 Value-Function Iterations 89
5.2.3 Policy-Function Iterations 94
5.3 Perturbation Techniques 95
5.3.1 Notation 95
5.3.2 Overview 97
5.3.3 Application to DSGE Models 99
5.3.4 Application to an Asset-Pricing Model 105

Part III Data Preparation and Representation

6 Removing Trends and Isolating Cycles 113
6.1 Removing Trends 115
6.2 Isolating Cycles 120
6.2.1 Mathematical Background 120
6.2.2 Cramér Representations 124
6.2.3 Spectra 125
6.2.4 Using Filters to Isolate Cycles 126
6.2.5 The Hodrick-Prescott Filter 128
6.2.6 Seasonal Adjustment 130
6.2.7 Band Pass Filters 131
6.3 Spuriousness 134

7 Summarizing Time Series Behavior When All Variables Are Observable 138
7.1 Two Useful Reduced-Form Models 139
7.1.1 The ARMA Model 139
7.1.2 Allowing for Heteroskedastic Innovations 145
7.1.3 The VAR Model 147

7.2 Summary Statistics 149
7.2.1 Determining Lag Lengths 157
7.2.2 Characterizing the Precision of Measurements 159
7.3 Obtaining Theoretical Predictions of Summary Statistics 162

8 State-Space Representations 166
8.1 Introduction 166
8.1.1 ARMA Models 167
8.2 DSGE Models as State-Space Representations 169
8.3 Overview of Likelihood Evaluation and Filtering 171
8.4 The Kalman Filter 173
8.4.1 Background 173
8.4.2 The Sequential Algorithm 175
8.4.3 Smoothing 178
8.4.4 Serially Correlated Measurement Errors 181
8.5 Examples of Reduced-Form State-Space Representations 182
8.5.1 Time-Varying Parameters 182
8.5.2 Stochastic Volatility 185
8.5.3 Regime Switching 186
8.5.4 Dynamic Factor Models 187

Part IV Monte Carlo Methods

9 Monte Carlo Integration: The Basics 193
9.1 Motivation and Overview 193
9.2 Direct Monte Carlo Integration 196
9.2.1 Model Simulation 198
9.2.2 Posterior Inference via Direct Monte Carlo Integration 201
9.3 Importance Sampling 202
9.3.1 Achieving Efficiency: A First Pass 206
9.4 Efficient Importance Sampling 211
9.5 Markov Chain Monte Carlo Integration 215
9.5.1 The Gibbs Sampler 216
9.5.2 Metropolis-Hastings Algorithms 218

10 Likelihood Evaluation and Filtering in State-Space Representations Using Sequential Monte Carlo Methods 221
10.1 Background 221
10.2 Unadapted Filters 224
10.3 Conditionally Optimal Filters 228
10.4 Unconditional Optimality: The EIS Filter 233
10.4.1 Degenerate Transitions 235
10.4.2 Initializing the Importance Sampler 236
10.4.3 Example 239

10.5 Application to DSGE Models 241
10.5.1 Initializing the Importance Sampler 243
10.5.2 Initializing the Filtering Density 245
10.5.3 Application to the RBC Model 246

Part V Empirical Methods

11 Calibration 253
11.1 Historical Origins and Philosophy 253
11.2 Implementation 258
11.3 The Welfare Cost of Business Cycles 261
11.4 Productivity Shocks and Business Cycle Fluctuations 268
11.5 The Equity Premium Puzzle 273
11.6 Critiques and Extensions 276
11.6.1 Critiques 276
11.6.2 Extensions 279

12 Matching Moments 285
12.1 Overview 285
12.2 Implementation 286
12.2.1 The Generalized Method of Moments 286
12.2.2 The Simulated Method of Moments 294
12.2.3 Indirect Inference 297
12.3 Implementation in DSGE Models 300
12.3.1 Analyzing Euler Equations 300
12.3.2 Analytical Calculations Based on Linearized Models 301
12.3.3 Simulations Involving Linearized Models 306
12.3.4 Simulations Involving Nonlinear Approximations 307
12.4 Empirical Application: Matching RBC Moments 308

13 Maximum Likelihood 314
13.1 Overview 314
13.2 Introduction and Historical Background 316
13.3 A Primer on Optimization Algorithms 318
13.3.1 Simplex Methods 319
13.3.2 Derivative-Based Methods 328
13.4 Ill-Behaved Likelihood Surfaces: Problems and Solutions 330
13.4.1 Problems 330
13.4.2 Solutions 331
13.5 Model Diagnostics and Parameter Stability 334
13.6 Empirical Application: Identifying Sources of Business Cycle Fluctuations 337

14 Bayesian Methods 351
14.1 Overview of Objectives 351
14.2 Preliminaries 352

14.3 Using Structural Models as Sources of Prior Information for Reduced-Form Analysis 355
14.4 Implementing Structural Models Directly 360
14.5 Model Comparison 361
14.6 Using an RBC Model as a Source of Prior Information for Forecasting 364
14.7 Estimating and Comparing Asset-Pricing Models 373
14.7.1 Estimates 380
14.7.2 Model Comparison 384

References 387
Index 401