

CONTENTS

PREFACE v

ABOUT THE AUTHOR viii

Chapter 1 DIFFERENCE EQUATIONS 1

Introduction 1

1. Time-Series Models 1
2. Difference Equations and Their Solutions 7
3. Solution by Iteration 10
4. An Alternative Solution Methodology 14
5. The Cobweb Model 18
6. Solving Homogeneous Difference Equations 22
7. Particular Solutions for Deterministic Processes 31
8. The Method of Undetermined Coefficients 33
9. Lag Operators 39
10. Summary 42

Questions and Exercises 43

Endnotes 45

Appendix 1.1: Imaginary Roots and de Moivre's Theorem 45

Appendix 1.2: Characteristic Roots in Higher-Order Equations 47

Chapter 2 STATIONARY TIME-SERIES MODELS 49

1. Stochastic Difference Equation Models 49
2. ARMA Models 52
3. Stationarity 53
4. Stationarity Restrictions for an ARMA(p, q) Model 57
5. The Autocorrelation Function 62
6. The Partial Autocorrelation Function 65
7. Sample Autocorrelations of Stationary Series 69
8. Box-Jenkins Model Selection 78
9. Properties of Forecasts 81
10. A Model of the Interest Rate Spread 89

CONTENTS

11. Seasonality	97
12. Parameter Instability and Structural Change	103
13. Summary and Conclusions	110
Questions and Exercises	110
Endnotes	116
Appendix 2.1: Estimation of an MA(1) Process	116
Appendix 2.2: Model Selection Criteria	118

Chapter 3 *MODELING VOLATILITY* **121**

1. Economic Time Series: The Stylized Facts	121
2. ARCH Processes	125
3. ARCH and GARCH Estimates of Inflation	132
4. Two Examples of GARCH Models	136
5. A GARCH Model of Risk	141
6. The ARCH-M Model	143
7. Additional Properties of GARCH Processes	146
8. Maximum-Likelihood Estimation of GARCH Models	152
9. Other Models of Conditional Variance	154
10. Estimating the NYSE International 100 Index	158
11. Multivariate GARCH	165
12. Summary and Conclusions	170
Questions and Exercises	172
Endnotes	176
Appendix 3.1: Multivariate GARCH Models	176

Chapter 4 *MODELS WITH TREND* **181**

1. Deterministic and Stochastic Trends	181
2. Removing the Trend	189
3. Unit Roots and Regression Residuals	195
4. The Monte Carlo Method	200
5. Dickey–Fuller Tests	206
6. Examples of the Dickey–Fuller Test	209
7. Extensions of the Dickey–Fuller Test	215
8. Structural Change	227
9. Power and the Deterministic Regressors	234
10. Tests with More Power	239
11. Panel Unit Root Tests	244
12. Trends and Univariate Decompositions	247

13. Summary and Conclusions	257
Questions and Exercises	258
Endnotes	262
Appendix 4.1: The Bootstrap	263
Appendix 4.2: Determination of the Deterministic Regressors	267

Chapter 5 *MULTIEQUATION TIME-SERIES MODELS* **272**

1. Intervention Analysis	273
2. Transfer Function Models	280
3. Estimating a Transfer Function	290
4. Limits to Structural Multivariate Estimation	294
5. Introduction to VAR Analysis	297
6. Estimation and Identification	303
7. The Impulse Response Function	307
8. Testing Hypotheses	315
9. Example of a Simple VAR: Terrorism and Tourism in Spain	321
10. Structural VARs	325
11. Examples of Structural Decompositions	329
12. The Blanchard–Quah Decomposition	338
13. Decomposing Real and Nominal Exchange Rates: An Example	344
14. Summary and Conclusions	347
Questions and Exercises	349
Endnotes	354

Chapter 6 *COINTEGRATION AND ERROR-CORRECTION MODELS* **356**

1. Linear Combinations of Integrated Variables	357
2. Cointegration and Common Trends	363
3. Cointegration and Error Correction	365
4. Testing for Cointegration: The Engle–Granger Methodology	373
5. Illustrating the Engle–Granger Methodology	377
6. Cointegration and Purchasing Power Parity	382
7. Characteristic Roots, Rank, and Cointegration	385
8. Hypothesis Testing	393
9. Illustrating the Johansen Methodology	401
10. Error-Correction and ADL Tests	405
11. Comparing the Three Methods	409

CONTENTS

Summary and Conclusions	412
Questions and Exercises	413
Endnotes	418
Appendix 6.1: Characteristic Roots, Stability, and Rank	419
Appendix 6.2: Inference on a Cointegrating Vector	425
Chapter 7 <i>NONLINEAR TIME-SERIES MODELS</i>	428

1. Linear Versus Nonlinear Adjustment	428
2. Simple Extensions of the ARMA Model	431
3. Pretesting in Nonlinearity	434
4. Threshold Autoregressive Models	439
5. Extensions of the TAR Model	445
6. Three Threshold Models	451
7. Smooth-Transition Models	457
8. Other Regime Switching Models	462
9. Estimates of STAR Models	466
10. Generalized Impulse Responses and Forecasting	470
11. Unit Roots and Nonlinearity	477
12. Summary and Conclusions	482
Questions and Exercises	483
Endnotes	486

STATISTICAL TABLES **488**

A. Empirical Cumulative Distribution of the τ	488
B. Empirical Distribution of ϕ	489
C. Critical Values for the Engle–Granger Cointegration Test	490
D. Residual-Based Cointegration Test with $I(1)$ and $I(2)$ Variables	491
E. Empirical Distributions of the λ_{\max} and λ_{trace} Statistics	492
F. Critical Values for $\beta_1 = 0$ in the Error-correction Model	493
G. Critical Values for Threshold Unit Roots	494

REFERENCES **495**

SUBJECT INDEX **503**