Contents

List of Figures *page* xiii

List of Tables xv

Preface to the Fourth Edition xviii

1 Introduction 1
- 1.1 Introduction 1
- 1.2 Advantages of Panel Data 4
- 1.3 Challenges to Panel Data Analysis 8
- 1.4 Outline of the Monograph 12

2 Linear Static Models with Additive Effects 15
- 2.1 Introduction 15
- 2.2 Fixed-Effects Models: Dummy-Variable Approach 18
- 2.3 Random-Effects Models: Variance-Components Models 22
- 2.4 Fixed Effects or Random Effects 29
- 2.5 Tests for Misspecification 37
- 2.6 Models with Time- and/or Individual-Invariant Explanatory Variables and both Individual- and Time-Specific Effects 38
- 2.7 Analysis of Covariance Tests for the Presence of Individual- or Time- Specific Effects 43
- 2.8 Heteroscedasticity and Autocorrelation 50
- 2.9 Models with Arbitrary Error Structure: Chamberlain π-Approach 54

Appendix 2A: Consistency and Asymptotic Normality of the Minimum-Distance Estimator 59

Appendix 2B: Characteristic Vectors and the Inverse of the Variance-Covariance Matrix of a Three-Component Model 61

3 Dynamic Models with Additive Specific Effects 63
- 3.1 Introduction 63
- 3.2 The Least Squares and the Least Squares Dummy Variable (Covariance) Estimator 64
- 3.3 Method of Moments Estimator 67
- 3.4 The Quasi-Likelihood Approach for Random-Effects Models 75
- 3.5 The Likelihood Approach-Fixed-Effects Models 85

3.6 Relations between the Likelihood Based Estimator and the GMM 89
3.7 Estimation of Dynamic Models with Arbitrary Serial Correlations in the Residuals 95
3.8 Models with Both Individual- and Time-Specific Additive Effects 96
Appendix 3A: Derivation of the Asymptotic Covariance Matrix of the Feasible MDE 101
Appendix 3B: Large N and T Asymptotics 102

4 Simultaneous-Equations Models 107
4.1 Introduction 107
4.2 Joint Generalized Least Squares Estimation Technique 110
4.3 Estimation of Structural Equations 114
4.4 Triangular System 121
Appendix 4A: The Determinant and Inverse of the Triangular System Covariance Matrix 131

5 Dynamic System 133
5.1 Introduction 133
5.2 Panel Vector Autoregressive Models 134
5.3 Cointegrated Panel Models and Vector Error Correction 142
5.4 Unit Root and Cointegration Tests 148
5.5 Dynamic Simultaneous Equation Models 157

6 Discrete Data 165
6.1 Introduction 165
6.2 Qualitative Response Models for Cross-Sectional Data 165
6.3 Panel Parametric Approach to Static Models with Heterogeneity 170
6.4 Semiparametric Approach to Static Models 180
6.5 Dynamic Models 183
6.6 Alternative Approaches for Identifying Dynamic Dependence 203

7 Limited Dependent and Sample Selection Models 214
7.1 Cross-Sectional Data Approach 214
7.2 A Sample Selection Example: Nonrandomly Missing Data in a Panel 223
7.3 Tobit Models with Random Individual Effects 229
7.4 Fixed-Effects Estimator 230
7.5 An Example: Housing Expenditure 241
7.6 Dynamic Tobit Models 244

8 Some Nonlinear Models 251
8.1 Duration Model 251
8.2 Count Data Model 262
8.3 Nonparametric Models 268

9 Miscellaneous Topics 273
9.1 Quantile Regression Analysis 273

- ? F > < ? 2 5 6 5 C C @ B + ! ! F F F 4 2 = 3 A : 5 8 6

9.2 Simulation Methods 276
9.3 Data with Multilevel Structures 281
9.4 Errors of Measurement 283
9.5 Estimating Distributed Lags in Short Panels 288
9.6 Rotating or Randomly Missing Data 297
9.7 Pseudo Panels (or Repeated Cross-Sectional Data) 302
9.8 Discretizing Unobserved Heterogeneity 305

10 Interactive Effects Models 307
10.1 Introduction 307
10.2 Fixed-Effects Linear Static Models 309
10.3 Fixed-Effects Linear Dynamic Models 315
10.4 Models with Mixed Fixed and Random Effects 323
10.5 Quantile Models 328
10.6 Factor Dimension Determination 330

11 Spatial Models and Tests for Cross-Sectional Dependence 339
11.1 Introduction – Weak or Strong Cross-Correlations 339
11.2 The Basic Formulation on Spatial Weight Matrix and Spatial (Dependence) Coefficients 341
11.3 Spatial Error Models 343
11.4 Spatial Regressive Models 346
11.5 Some Extensions 348
11.6 Mixed Spatial and Factor Process 351
11.7 Cross-Sectional Dependence Tests 354

12 Program Evaluation Using Panel Data 361
12.1 Introduction 361
12.2 Cross-Sectional Data Approach 362
12.3 Panel Data Approach 368
12.4 Some Examples 374
12.5 Multiple Treated Units 381
12.6 Simulating or Ranking Program Outcomes with Different Policy Options 384

13 Variable Coefficients Models 389
13.1 Introduction 389
13.2 Coefficients that Vary over Cross-Sectional Units 391
13.3 Coefficients that Vary over Time and Cross-Sectional Units 401
13.4 A Mixed Fixed- and Random-Coefficients Model 407
13.5 Dynamic Random-Coefficients Models 414
13.6 An Example: Liquidity Constraints and Firm Investment Expenditure 418
13.7 Coefficients that Vary over Time 422
13.8 Coefficients that Are Functions of Other Exogenous Variables 428
13.9 Correlated Random-Coefficients Models 431
Appendix 13A: Combination of Two Normal Distributions 438

14 Big Data Analytics 440
14.1 Machine Learning Algorithms 440
14.2 Inference with High-Dimensional Data 442
14.3 Inference for Low-Dimensional Parameters in the Presence of High-Dimensional Data 446
14.4 Prediction 453
References 469
Author Index 498
Subject Index 502

- ? F > < ? 2 5 6 9 C C @ A ? = ! ! F F F 4 2 = 3 A 6 5 8 B G < E 2 > 4 2 A 0 C 2 9 C 6 1 2 G E 5 ' A 5 ' C 2 C B D ; 6 4 9 C + 5 C & C 9 6 , 2 = 3 A : 5 8 6 ,
9 C C @ B + ! ! F F F 4 2 = 3 A : 5 8 6 C @ A 8 ! 4 5 A 6 ! C 6 A 8 = B " # " # (! * ( ) # " " * " ' ((& '