Contents

List of Figures xxvi
List of Tables xxviii
Preface xxvii
Acknowledgements xxx

Part I Statistical Background and Basic Data Handling 1

1 Fundamental Concepts 3
   Introduction 4
   A simple example 4
   A statistical framework 6
   Properties of the sampling distribution of the mean 7
   Hypothesis testing and the central limit theorem 8
   Central limit theorem 10
   Conclusion 13

2 The Structure of Economic Data and Basic Data Handling 14
   Learning objectives 14
   The structure of economic data 15
     Cross-sectional data 15
     Time series data 15
     Panel data 16
   Basic data handling 17
     Looking at raw data 17
     Graphical analysis 17
     Summary statistics 19

Part II The Classical Linear Regression Model 27

3 Simple Regression 29
   Learning objectives 29
   Introduction to regression: the classical linear regression model (CLRM) 30
     Why do we do regressions? 30
     The classical linear regression model 30

ix
## Contents

The Ordinary Least Squares (OLS) method of estimation 32
- Alternative expressions for $\hat{\beta}$ 34

The assumptions of the CLRM 35
- General 35
- The assumptions 36
- Violations of the assumptions 37

Properties of the OLS estimators 38
- Linearity 38
- Unbiasedness 39
- Efficiency and BLUEness 40
- Consistency 42

The overall goodness of fit 43
- Problems associated with $R^2$ 44

Hypothesis testing and confidence intervals 45
- Testing the significance of the OLS coefficients 46
- Confidence intervals 47

How to estimate a simple regression in EViews and Stata 48
- Simple regression in EViews 48
- Simple regression in Stata 48
- Reading the Stata simple regression results output 49
- Reading the EViews simple regression results output 49

Presentation of regression results 50

Economic theory applications 50
- Application 1: the demand function 50
- Application 2: the production function 51
- Application 3: Okun's law 52
- Application 4: the Keynesian consumption function 52

Computer example: the Keynesian consumption function 53
- Solution 53

Questions and exercises 58

## 4 Multiple Regression 62

Learning objectives 62

Introduction 64

Derivation of multiple regression coefficients 64
- The three-variable model 64
- The $k$-variables case 65
- Derivation of the coefficients with matrix algebra 66
- The structure of the $X'X$ and $X'Y$ matrices 67
- The assumptions of the multiple regression model 68
- The variance-covariance matrix of the errors 69

Properties of multiple regression model OLS estimators 69
- Linearity 69
- Unbiasedness 70
- Consistency 70
- BLUEness 70

$R^2$ and adjusted $R^2$ 72

General criteria for model selection 73
Multiple regression estimation in EViews and Stata
  Multiple regression in EViews 74
  Multiple regression in Stata 74
  Reading the EViews multiple regression results output 75
Hypothesis testing 75
  Testing individual coefficients 75
  Testing linear restrictions 75
The $F$-form of the Likelihood Ratio test 77
Testing the joint significance of the $X$s 78
  $F$-test for overall significance in EViews 78
Adding or deleting explanatory variables 79
  Omitted and redundant variables test in EViews 79
  How to perform the Wald test in EViews 80
The $t$ test (a special case of the Wald procedure) 80
The Lagrange Multiplier (LM) test 81
  The LM test in EViews 82
Computer example: Wald, omitted and redundant variables tests 82
  A Wald test of coefficient restrictions 83
  A redundant variable test 83
  An omitted variable test 84
  Computer example: commands for Stata 84
Financial econometrics application: the Capital Asset Pricing Model
  in action 87
  A few theoretical remarks regarding the CAPM 87
  The empirical application of the CAPM 89
  EViews programming and the CAPM application 90
  Advanced EViews programming and the CAPM application 96
Questions and exercises 97

Part III  Violating the Assumptions of the CLRM 101

5  Multicollinearity 103
  Learning objectives 103
  Introduction 104
  Perfect multicollinearity 104
  Consequences of perfect multicollinearity 105
  Imperfect multicollinearity 106
  Consequences of imperfect multicollinearity 107
  Detecting problematic multicollinearity 109
    Simple correlation coefficient 109
    $R^2$ from auxiliary regressions 109
  Computer examples 110
    Example 1: induced multicollinearity 110
    Example 2: with the use of real economic data 112
Questions and exercises 115
6 Heteroskedasticity 117
Learning objectives 117
Introduction: what is heteroskedasticity? 118
Consequences of heteroskedasticity for OLS estimators 120
A general approach 120
A mathematical approach 121
Detecting heteroskedasticity 124
The informal way 124
The Breusch–Pagan LM test 125
The Glesjer LM test 128
The Harvey–Godfrey LM test 130
The Park LM test 131
Criticism of the LM tests 133
The Goldfeld–Quandt test 133
White’s test 135
Computer example: heteroskedasticity tests 137
The Breusch–Pagan test 138
The Glesjer test 140
The Harvey–Godfrey test 140
The Park test 141
The Goldfeld–Quandt test 142
White’s test 144
Commands for the computer example in Stata 144
Engle’s ARCH test 146
Computer example of the ARCH-LM test 147
Resolving heteroskedasticity 148
Generalized (or weighted) least squares 148
Computer example: resolving heteroskedasticity 150
Questions and exercises 153

7 Autocorrelation 156
Learning objectives 156
Introduction: what is autocorrelation? 157
What causes autocorrelation? 157
First- and higher-order autocorrelation 158
Consequences of autocorrelation for the OLS estimators 159
A general approach 159
A more mathematical approach 160
Detecting autocorrelation 162
The graphical method 162
Example: detecting autocorrelation using the graphical method 162
The Durbin–Watson test 164
Computer example of the DW test 166
The Breusch–Godfrey LM test for serial correlation 167
Computer example of the Breusch–Godfrey test 168
Durbin’s $h$ test in the presence of lagged dependent variables 170
Computer example of Durbin’s $h$ test 171
<table>
<thead>
<tr>
<th>Contents</th>
<th>xiii</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolving autocorrelation</td>
<td>172</td>
</tr>
<tr>
<td>When $\rho$ is known</td>
<td>173</td>
</tr>
<tr>
<td>Computer example of the generalized differencing approach</td>
<td>173</td>
</tr>
<tr>
<td>When $\rho$ is unknown</td>
<td>175</td>
</tr>
<tr>
<td>Computer example of the iterative procedure</td>
<td>176</td>
</tr>
<tr>
<td>Resolving autocorrelation in Stata</td>
<td>178</td>
</tr>
<tr>
<td>Questions and exercises</td>
<td>178</td>
</tr>
<tr>
<td>Appendix</td>
<td>178</td>
</tr>
<tr>
<td>8 Misspecification: Wrong Regressors, Measurement Errors and Wrong Functional Forms</td>
<td>180</td>
</tr>
<tr>
<td>Learning objectives</td>
<td>180</td>
</tr>
<tr>
<td>Introduction</td>
<td>181</td>
</tr>
<tr>
<td>Omitting influential or including non-influential explanatory variables</td>
<td>181</td>
</tr>
<tr>
<td>Consequences of omitting influential variables</td>
<td>181</td>
</tr>
<tr>
<td>Including a non-influential variable</td>
<td>182</td>
</tr>
<tr>
<td>Omission and inclusion of relevant and irrelevant variables at the same time</td>
<td>183</td>
</tr>
<tr>
<td>The plug-in solution in the omitted variable bias</td>
<td>183</td>
</tr>
<tr>
<td>Various functional forms</td>
<td>185</td>
</tr>
<tr>
<td>Introduction</td>
<td>185</td>
</tr>
<tr>
<td>Linear-log functional form</td>
<td>185</td>
</tr>
<tr>
<td>Reciprocal functional form</td>
<td>186</td>
</tr>
<tr>
<td>Polynomial functional form</td>
<td>186</td>
</tr>
<tr>
<td>Functional form including interaction terms</td>
<td>187</td>
</tr>
<tr>
<td>Log-linear functional form</td>
<td>188</td>
</tr>
<tr>
<td>The double-log functional form</td>
<td>188</td>
</tr>
<tr>
<td>The Box–Cox transformation</td>
<td>189</td>
</tr>
<tr>
<td>Measurement errors</td>
<td>190</td>
</tr>
<tr>
<td>Measurement error in the dependent variable</td>
<td>191</td>
</tr>
<tr>
<td>Measurement error in the explanatory variable</td>
<td>191</td>
</tr>
<tr>
<td>Tests for misspecification</td>
<td>193</td>
</tr>
<tr>
<td>Normality of residuals</td>
<td>193</td>
</tr>
<tr>
<td>The Ramsey RESET test for general misspecification</td>
<td>195</td>
</tr>
<tr>
<td>Tests for non-nested models</td>
<td>197</td>
</tr>
<tr>
<td>Computer example: the Box–Cox transformation in EViews</td>
<td>199</td>
</tr>
<tr>
<td>Approaches in choosing an appropriate model</td>
<td>202</td>
</tr>
<tr>
<td>The traditional view: average economic regression</td>
<td>202</td>
</tr>
<tr>
<td>The Hendry ‘general to specific approach’</td>
<td>203</td>
</tr>
<tr>
<td>Questions and Exercises</td>
<td>204</td>
</tr>
</tbody>
</table>

Part IV Topics in Econometrics | 207 |

9 Dummy Variables | 209 |
| Learning objectives | 209 |
| Introduction: the nature of qualitative information | 210 |
The use of dummy variables
  Intercept dummy variables 210
  Slope dummy variables 212
  The combined effect of intercept and slope dummies 214
Computer example of the use of dummy variables 215
  Using a constant dummy 216
  Using a slope dummy 216
  Using both dummies together 217
Special cases of the use of dummy variables 218
  Using dummy variables with multiple categories 218
  Using more than one dummy variable 220
  Using seasonal dummy variables 221
Computer example of dummy variables with multiple categories 222
Financial econometrics application: the January effect in emerging stock markets 224
Tests for structural stability 227
  The dummy variable approach 227
  The Chow test for structural stability 227
Financial econometrics application: the day-of-the-week effect in action 228
Questions 230

10 Dynamic Econometric Models 231
Learning objectives 231
Introduction 232
Distributed lag models 232
  The Koyck transformation 233
  The Almon transformation 235
  Other models of lag structures 236
Autoregressive models 236
  The partial adjustment model 236
  A computer example of the partial adjustment model 237
  The adaptive expectations model 239
  Tests of autocorrelation in autoregressive models 241
Exercises 241

11 Simultaneous Equation Models 243
Learning objectives 243
Introduction: basic definitions 244
Consequences of ignoring simultaneity 245
The identification problem 245
  Basic definitions 245
  Conditions for identification 246
  Example of the identification procedure 247
  A second example: the macroeconomic model of a closed economy 247
Contents

12 Limited Dependent Variable Regression Models 254
   Learning objectives 254
   Introduction 255
   The linear probability model 255
   Problems with the linear probability model 256
      \( \hat{D}_i \) is not bounded by the (0,1) range 256
      Non-normality and heteroskedasticity of the disturbances 257
      The coefficient of determination as a measure of overall fit 257
   The logit model 258
      A general approach 258
      Interpretation of the estimates in logit models 259
      Goodness of fit 260
      A more mathematical approach 261
   The probit model 263
      A general approach 263
      A more mathematical approach 264
      Multinomial and ordered logit and probit models 265
      Multinomial logit and probit models 266
      Ordered logit and probit models 266
   The Tobit model 267
   Computer example: probit and logit models in EViews and Stata 267
      Logit and probit models in EViews 267
      Logit and probit models in Stata 270

Part V Time Series Econometrics 273

13 ARIMA Models and the Box-Jenkins Methodology 275
   Learning objectives 275
   An introduction to time series econometrics 276
   ARIMA models 276
   Stationarity 277
   Autoregressive time series models 277
      The AR(1) model 277
      The AR(p) model 279
      Properties of the AR models 281
   Moving average models 282
      The MA(1) model 282
      The MA(q) model 282
      Invertibility in MA models 283
      Properties of the MA models 284
   ARMA models 285
Contents

Integrated processes and the ARIMA models
  An integrated series 285
  Example of an ARIMA model 286
Box-Jenkins model selection
  Identification 287
  Estimation 288
  Diagnostic checking 288
  The Box-Jenkins approach step by step 289
Computer example: the Box–Jenkins approach 289
  The Box–Jenkins approach in EViews 289
  The Box–Jenkins approach in Stata 293
Questions and exercises 295

14 Modelling the Variance: ARCH–GARCH Models 297
Learning objectives 297
Introduction 298
The ARCH model
  The ARCH(1) model 300
  The ARCH(q) model 300
  Testing for ARCH effects 301
  Estimation of ARCH models by iteration 301
  Estimating ARCH models in EViews 302
  A more mathematical approach 306
The GARCH model
  The GARCH(\(p, q\)) model 309
  The GARCH(1, 1) model as an infinite ARCH process 309
  Estimating GARCH models in EViews 310
Alternative specifications
  The GARCH in mean or GARCH-M model 312
  Estimating GARCH-M models in EViews 313
  The threshold GARCH (TGARCH) model 316
  Estimating TGARCH models in EViews 316
  The exponential GARCH (EGARCH) model 317
  Estimating EGARCH models in EViews 318
  Adding explanatory variables in the mean equation 319
  Adding explanatory variables in the variance equation 319
  Estimating ARCH/GARCH-type models in Stata 320
  Advanced EViews programming for the estimation of GARCH-type models 322
  Application: a GARCH model of UK GDP and the effect of socio-political instability 326
Questions and exercises 330

15 Vector Autoregressive (VAR) Models and Causality Tests 333
Learning objectives 333
Vector autoregressive (VAR) models
  The VAR model 334
  Pros and cons of the VAR models 335
Causality tests
  The Granger causality test
  The Sims causality test

Financial econometrics application: financial development and economic growth – what is the causal relationship?

Estimating VAR models and causality tests in EViews and Stata
  Estimating VAR models in EViews
  Estimating VAR models in Stata

16 Non-Stationarity and Unit-Root Tests

Learning objectives

Introduction
  Unit roots and spurious regressions
    What is a unit root?
    Spurious regressions
    Explanation of the spurious regression problem
  Testing for unit roots
    Testing for the order of integration
    The simple Dickey-Fuller (DF) test for unit roots
    The augmented Dickey-Fuller (ADF) test for unit roots
    The Phillips-Perron (PP) test
  Unit-root tests in EViews and Stata
    Performing unit-root tests in EViews
    Performing unit-root tests in Stata
  Application: unit-root tests on various macroeconomic variables
  Financial econometrics application: unit-root tests for the financial development and economic growth case

Questions and exercises

17 Cointegration and Error-Correction Models

Learning objectives

Introduction: what is cointegration?
  Cointegration: a general approach
  Cointegration: a more mathematical approach
  Cointegration and the error-correction mechanism (ECM): a general approach
    The problem
    Cointegration (again)
    The error-correction model (ECM)
    Advantages of the ECM
  Cointegration and the error-correction mechanism: a more mathematical approach
    A simple model for only one lagged term of $X$ and $Y$
    A more general model for large numbers of lagged terms
  Testing for cointegration
    Cointegration in single equations: the Engle-Granger approach
    Drawbacks of the EG approach
    The EG approach in EViews and Stata
    Cointegration in multiple equations and the Johansen approach
    Advantages of the multiple-equation approach
## Contents

The Johansen approach (again) 381  
The steps of the Johansen approach in practice 382  
The Johansen approach in EViews and Stata 387  
Financial econometrics application: cointegration tests for the financial development and economic growth case 392  
Monetization ratio 393  
Turnover ratio 396  
Claims and currency ratios 396  
A model with more than one financial development proxy variable 398  
Questions and exercises 400

### 18 Identification in Standard and Cointegrated Systems 402  
#### Learning objectives 402  
#### Introduction 403  
#### Identification in the standard case 403  
#### The order condition 405  
#### The rank condition 406  
#### Identification in cointegrated systems 406  
#### A worked example 408  
#### Computer example of identification 410  
#### Conclusion 412

### 19 Solving Models 413  
#### Learning objectives 413  
#### Introduction 414  
#### Solution procedures 414  
#### Model add factors 416  
#### Simulation and impulse responses 417  
#### Stochastic model analysis 418  
#### Setting up a model in EViews 420  
#### Conclusion 423

### 20 Time-Varying Coefficient Models: A New Way of Estimating Bias-Free Parameters 424  
#### Learning objectives 424  
#### Introduction 425  
#### TVC estimation 426  
#### Theorem 1 427  
#### Coefficient drivers 428  
#### Assumption 1 (auxiliary information) 428  
#### Assumption 2 428  
#### Choosing coefficient drivers 429  
#### First requirement: selecting the complete driver set 429  
#### Second requirement: splitting the driver set 430  
#### Financial econometrics application: rating agencies’ decisions and the sovereign bond spread between Greece and Germany 433  
#### Conclusion 438
Part VI  Panel Data Econometrics  439

21  Traditional Panel Data Models  441
  Learning objectives  441
  Introduction: the advantages of panel data  442
  The linear panel data model  443
  Different methods of estimation
    The common constant method  443
    The fixed effects method  444
    The random effects method  445
    The Hausman test  446
  Computer examples with panel data
    Inserting panel data in EViews  447
    Estimating a panel data regression in EViews  451
    The Hausman test in EViews  452
  Inserting panel data into Stata
    Estimating a panel data regression in Stata  455
    The Hausman test in Stata  456

22  Dynamic Heterogeneous Panels  457
  Learning objectives  457
  Introduction  458
  Bias in dynamic panels
    Bias in the simple OLS estimator  458
    Bias in the fixed effects model  459
    Bias in the random effects model  459
  Solutions to the bias problem (caused by the dynamic nature of the panel)  459
  Bias of heterogeneous slope parameters  460
  Solutions to heterogeneity bias: alternative methods of estimation
    The mean group (MG) estimator  461
    The pooled mean group (PMG) estimator  462
  Application: the effects of uncertainty in economic growth and investment
    Evidence from traditional panel data estimation  464
    Mean group and pooled mean group estimates  465

23  Non-Stationary Panels  467
  Learning objectives  467
  Introduction  468
  Panel unit-root tests
    The Levin and Lin (LL) test  469
    The Im, Pesaran and Shin (IPS) test  470
    The Maddala and Wu (MW) test  471
    Computer examples of panel unit-root tests  471
  Panel cointegration tests
    Introduction  473
    The Kao test  474
    The McCoskey and Kao test  475
    The Pedroni tests  476
    The Larsson et al. test  477
  Computer examples of panel cointegration tests  478
Contents

Part VII  Using Econometric Software  483

24 Practicalities of Using EViews and Stata  485
   About EViews  486
      Starting up with EViews  486
      Creating a workfile and importing data  488
      Copying and pasting data  488
      Verifying and saving the data  489
      Examining the data  489
      Commands, operators and functions  490
   About Stata  491
      Starting up with Stata  491
      The Stata menu and buttons  492
      Creating a file when importing data  493
      Copying/pasting data  493
   Cross-sectional and time series data in Stata  494
      First way – time series data with no time variable  494
      Second way – time series data with time variable  495
      Time series – daily frequency  495
      Time series – monthly frequency  496
      All frequencies  497
   Saving data  497
      Basic commands in Stata  497
      Understanding command syntax in Stata  499

Appendix: Statistical Tables  501

Bibliography  507

Index  513