

Phoebus Dhrymes

Introductory Econometrics

With Contributions by John Guerard

 Springer

Contents

| | | |
|----------|---|----|
| 1 | The General Linear Model I | 1 |
| 1 | Introduction | 1 |
| 1.1 | Generalities | 1 |
| 1.2 | Models and Their Uses | 2 |
| 2 | Model Specification and Estimation | 3 |
| 2.1 | Notation, Basic Concepts, and Assumptions | 3 |
| 2.2 | The General Linear Model Defined | 7 |
| 2.3 | Estimation of Parameters: Assumptions | 8 |
| 2.4 | Properties of the OLS Estimator of β | 10 |
| 2.5 | Estimation of σ^2 | 15 |
| 3 | Goodness of Fit | 17 |
| 3.1 | Properties of the Vector of Residuals; the Coefficient of Determination of Multiple Regression | 17 |
| 3.2 | The GLM Without a Constant Term | 23 |
| | Appendix: A Geometric Interpretation of the GLM: The Multiple Correlation Coefficient | 28 |
| | The Geometry of the GLM | 28 |
| | A Measure of Correlation Between a Scalar and a Vector | 32 |
| 2 | The General Linear Model II | 37 |
| 1 | Generalities | 37 |
| 2 | Distribution of the Estimator of β | 38 |
| 2.1 | Equivalence of OLS and ML Procedures | 38 |
| 2.2 | Distribution of the ML Estimator of β | 40 |
| 2.3 | Distribution of Quadratic Forms in Normal Variables | 41 |
| 2.4 | Tests of Significance in the GLM with Normal Errors | 46 |
| 2.5 | Formal Tests of Goodness of Fit | 54 |

| | | |
|----------|---|------------|
| 3 | General Linear Restriction: Estimation and Tests | 56 |
| 4 | The Information Content in Residuals and Outliers? | 70 |
| 5 | Mixed Estimators and the Bayesian Approach | 73 |
| | Appendix | 81 |
| | Noncentral Chi Square | 82 |
| | Noncentral F-Distributions | 86 |
| | Multiple Comparison Tests | 93 |
| | Geometric Preliminaries | 95 |
| | Multiple Comparison Tests—The S-Method | 104 |
| 3 | The General Linear Model III | 115 |
| 1 | Generalities | 115 |
| 2 | Violation of Standard Error Process Assumptions | 116 |
| 2.1 | Nonzero Mean | 116 |
| 2.2 | Nonscalar Covariance Matrix | 118 |
| 2.3 | Heteroskedasticity | 130 |
| 2.4 | Autocorrelated Errors | 131 |
| 2.5 | Tests for First-Order Autoregression: | |
| | Durbin–Watson Theory | 151 |
| 2.6 | Systems of GLM | 162 |
| | Appendix | 174 |
| | Durbin–Watson Theory | 174 |
| | Gaps in Data | 205 |
| 3 | Tables for Testing Hypotheses on the Autoregressive Structure of the Errors in a GLM | 220 |
| 4 | The General Linear Model IV | 229 |
| 1 | Multicollinearity: Failure of the Rank Condition | 230 |
| 1.1 | Definition of the Problem | 230 |
| 1.2 | Recognition of Multicollinearity and Proposed Remedies | 235 |
| 2 | Analysis of Variance: Categorical Explanatory Variables | 255 |
| 3 | Analysis of Covariance: Some Categorical and Some Continuous Explanatory Variables | 265 |
| 4 | Case Study of Returns, Risk, Portfolio Selection and Evaluation | 267 |
| 4.1 | Expected Returns Modeling and Stock Selection Models: Recent Evidence | 268 |
| 4.2 | Evaluation of Portfolio Performance: Origins | 283 |
| 4.3 | Portfolio Simulation Results with the USER and GLER Models and a USER Model Update | 285 |
| 5 | Conclusions | 289 |
| | Appendix: Modern Regression Analysis, the Case of Least Angle Regression | 289 |

- 5 Misspecification Analysis and Errors in Variables** 293
 - 1 Introduction 293
 - 2 Misspecification Analysis 296
 - 2.1 General Theory in the Context of the GLM 296
 - 2.2 Proxy Variables and Their Use 305
 - 2.3 Near Collinearity 310
 - 3 Errors in Variables (EIV): Bivariate Model 321
 - 3.1 Inconsistency of the OLS Estimator 321
 - 3.2 Wald and ML Estimators 325
 - 4 Errors in Variables (EIV): General Model 331
 - 4.1 Derivation of the Estimator 331
 - 4.2 Asymptotic Properties 337
 - 5 Misspecification Error Analysis for EIV Models 343
 - 5.1 The General Case 343

- 6 Systems of Simultaneous Equations** 353
 - 1 Introduction 353
 - 2 The Simultaneous Equations Model (SEM): Definitions, Conventions, and Notation 354
 - 2.1 The Nature of the Problem 354
 - 2.2 Definition of GLSEM 355
 - 2.3 Basic Conditions Under Which the GLSEM Is Estimated 357
 - 3 The Identification Problem 362
 - 4 Estimation of the GLSEM 373
 - 4.1 Failure of OLS Methods 373
 - 4.2 Two Stage Least Squares (2SLS) 376
 - 4.3 Three Stage Least Squares (3SLS) 380
 - 4.4 Asymptotic Properties of 2SLS and 3SLS 383
 - 5 Prediction from the GLSEM 390
 - 6 The GLSEM and Undersized Samples 401
 - 7 Maximum Likelihood (ML) Estimators 406

- 7 Time Series Modeling** 415
 - 1 Basic Statistical Properties of Economic Series 416
 - 1.1 Stationarity of Economic Series 417
 - 2 ARMA Model Identification in Practice 426
 - 3 Time Series Modeling of Real GDP Analysis, 1947–2015Q2 430
 - 4 Automatic Time Series Model Selection 436
 - 5 Transfer Functions using Leading Economic Indicators (LEI) to Forecast Real GDP Analysis, 1959-2015Q2 440
 - 6 Testing for Causality 461
 - 7 Summary 473
- Appendix: Advanced Time Series Modeling 473

| | | |
|-----------|--|-----|
| 8 | Forecasting: Accuracy and Evaluation | 477 |
| 1 | Measuring Forecast Accuracy and Establishing Benchmarks | 478 |
| 2 | Forecast Rationality | 479 |
| 2.1 | Absolute and Relative Forecast Accuracy | 486 |
| 3 | An Equally-Weighted Forecast | 488 |
| 4 | GNP Forecasts: Is Equal-Weighting of Forecasts Optimal and Can Time Series Models Beat Experts? | 493 |
| 5 | Leading Economic Indicators (LEI) and Real GDP Analysis: Reviewing the Statistical Evidence, 1970–2002, and an Update, 2003–6/2016 | 497 |
| 6 | Forecasting Unemployment | 500 |
| 7 | Forecasts, Forecast Revisions, and the Applicability of Analysts Forecasts in Financial Markets | 502 |
| 8 | Forecasting Recessions | 508 |
| 9 | Summary | 514 |
| | Appendix A: Exponential Smoothing | 514 |
| | Appendix B: The Theta Model | 517 |
| | Appendix C: Automatic Modeling of the Unemployment Rate | 519 |
| 9 | Discrete Choice Models: Logit and Probit Analysis | 527 |
| 1 | Introduction | 527 |
| 2 | The Nature of Discrete Choice Models | 528 |
| 3 | Formulation of Dichotomous Choice Models | 529 |
| 4 | A Behavioral Justification for the Dichotomous Choice Model | 533 |
| 5 | Inapplicability of OLS Procedures | 535 |
| 6 | Maximum Likelihood Estimation | 538 |
| 7 | Inference for Discrete Choice Models | 540 |
| 8 | Polytomous Choice Models | 543 |
| 8.1 | General Discussion | 543 |
| 8.2 | Estimation | 544 |
| | Appendix | 545 |
| | A Random Choice Motivation for the Logistic Model | 545 |
| | Convexity of the Likelihood Function | 550 |
| | Convexity of the Likelihood Function in the Polytomous Logistic Case | 554 |
| 10 | Statistical and Probabilistic Background | 561 |
| 1 | Multivariate Density and Distribution Functions | 561 |
| 1.1 | Introduction | 561 |
| 1.2 | Multivariate Distributions | 561 |
| 1.3 | Expectation and Covariance Operators | 564 |
| 1.4 | A Mathematical Digression | 568 |

- 2 The Multivariate Normal Distribution 570
 - 2.1 Joint, Marginal, and Conditional Density Functions 570
 - 2.2 The Moment Generating Function 579
- 3 Point Estimation 587
- 4 Elements of Bayesian Inference 598
 - 4.1 Prior and Posterior Distributions 598
 - 4.2 Inference in a Bayesian Context 605
- References** 613