

Contents

| | |
|----------------------------------------------------------|------------------|
| <i>Preface</i> | <i>page xiii</i> |
| 1 Regression and the Normal Distribution | 1 |
| 1.1 What Is Regression Analysis? | 1 |
| 1.2 Fitting Data to a Normal Distribution | 3 |
| 1.3 Power Transforms | 7 |
| 1.4 Sampling and the Role of Normality | 8 |
| 1.5 Regression and Sampling Designs | 10 |
| 1.6 Actuarial Applications of Regression | 12 |
| 1.7 Further Reading and References | 13 |
| 1.8 Exercises | 14 |
| 1.9 Technical Supplement – Central Limit Theorem | 18 |
| | |
| Part I Linear Regression | |
| 2 Basic Linear Regression | 23 |
| 2.1 Correlations and Least Squares | 23 |
| 2.2 Basic Linear Regression Model | 29 |
| 2.3 Is the Model Useful? Some Basic Summary Measures | 32 |
| 2.4 Properties of Regression Coefficient Estimators | 35 |
| 2.5 Statistical Inference | 37 |
| 2.6 Building a Better Model: Residual Analysis | 41 |
| 2.7 Application: Capital Asset Pricing Model | 46 |
| 2.8 Illustrative Regression Computer Output | 51 |
| 2.9 Further Reading and References | 54 |
| 2.10 Exercises | 54 |
| 2.11 Technical Supplement – Elements of Matrix Algebra | 62 |
| | |
| 3 Multiple Linear Regression – I | 70 |
| 3.1 Method of Least Squares | 70 |
| 3.2 Linear Regression Model and Properties of Estimators | 76 |
| 3.3 Estimation and Goodness of Fit | 81 |
| 3.4 Statistical Inference for a Single Coefficient | 85 |
| 3.5 Some Special Explanatory Variables | 92 |
| 3.6 Further Reading and References | 100 |
| 3.7 Exercises | 101 |

| | | |
|--------------------------------------|------------------------------------------------------------|------------|
| 4 | Multiple Linear Regression – II | 107 |
| 4.1 | The Role of Binary Variables | 107 |
| 4.2 | Statistical Inference for Several Coefficients | 113 |
| 4.3 | One Factor ANOVA Model | 120 |
| 4.4 | Combining Categorical and Continuous Explanatory Variables | 126 |
| 4.5 | Further Reading and References | 133 |
| 4.6 | Exercises | 133 |
| 4.7 | Technical Supplement – Matrix Expressions | 138 |
| 5 | Variable Selection | 148 |
| 5.1 | An Iterative Approach to Data Analysis and Modeling | 148 |
| 5.2 | Automatic Variable Selection Procedures | 149 |
| 5.3 | Residual Analysis | 153 |
| 5.4 | Influential Points | 160 |
| 5.5 | Collinearity | 165 |
| 5.6 | Selection Criteria | 171 |
| 5.7 | Heteroscedasticity | 175 |
| 5.8 | Further Reading and References | 179 |
| 5.9 | Exercises | 180 |
| 5.10 | Technical Supplements for Chapter 5 | 182 |
| 6 | Interpreting Regression Results | 189 |
| 6.1 | What the Modeling Process Tells Us | 190 |
| 6.2 | The Importance of Variable Selection | 196 |
| 6.3 | The Importance of Data Collection | 198 |
| 6.4 | Missing Data Models | 205 |
| 6.5 | Application: Risk Managers' Cost-Effectiveness | 209 |
| 6.6 | Further Reading and References | 218 |
| 6.7 | Exercises | 219 |
| 6.8 | Technical Supplements for Chapter 6 | 222 |
| Part II Topics in Time Series | | |
| 7 | Modeling Trends | 227 |
| 7.1 | Introduction | 227 |
| 7.2 | Fitting Trends in Time | 229 |
| 7.3 | Stationarity and Random Walk Models | 236 |
| 7.4 | Inference Using Random Walk Models | 238 |
| 7.5 | Filtering to Achieve Stationarity | 243 |
| 7.6 | Forecast Evaluation | 245 |
| 7.7 | Further Reading and References | 248 |
| 7.8 | Exercises | 249 |
| 8 | Autocorrelations and Autoregressive Models | 251 |
| 8.1 | Autocorrelations | 251 |
| 8.2 | Autoregressive Models of Order One | 254 |

Cambridge University Press

978-0-521-13596-2 - Regression Modeling with Actuarial and Financial Applications

Edward W. Frees

Table of Contents

[More information](#)

| | |
|----------------------------------------------------------|------------|
| <i>Contents</i> | ix |
| 8.3 Estimation and Diagnostic Checking | 256 |
| 8.4 Smoothing and Prediction | 258 |
| 8.5 Box-Jenkins Modeling and Forecasting | 260 |
| 8.6 Application: Hong Kong Exchange Rates | 265 |
| 8.7 Further Reading and References | 269 |
| 8.8 Exercises | 270 |
| 9 Forecasting and Time Series Models | 273 |
| 9.1 Smoothing with Moving Averages | 273 |
| 9.2 Exponential Smoothing | 275 |
| 9.3 Seasonal Time Series Models | 278 |
| 9.4 Unit Root Tests | 284 |
| 9.5 ARCH/GARCH Models | 285 |
| 9.6 Further Reading and References | 288 |
| 10 Longitudinal and Panel Data Models | 289 |
| 10.1 What Are Longitudinal and Panel Data? | 289 |
| 10.2 Visualizing Longitudinal and Panel Data | 291 |
| 10.3 Basic Fixed Effects Models | 293 |
| 10.4 Extended Fixed Effects Models | 296 |
| 10.5 Random Effects Models | 299 |
| 10.6 Further Reading and References | 301 |
| Part III Topics in Nonlinear Regression | |
| 11 Categorical Dependent Variables | 305 |
| 11.1 Binary Dependent Variables | 305 |
| 11.2 Logistic and Probit Regression Models | 307 |
| 11.3 Inference for Logistic and Probit Regression Models | 312 |
| 11.4 Application: Medical Expenditures | 315 |
| 11.5 Nominal Dependent Variables | 318 |
| 11.6 Ordinal Dependent Variables | 325 |
| 11.7 Further Reading and References | 328 |
| 11.8 Exercises | 329 |
| 11.9 Technical Supplements – Likelihood-Based Inference | 337 |
| 12 Count Dependent Variables | 343 |
| 12.1 Poisson Regression | 343 |
| 12.2 Application: Singapore Automobile Insurance | 348 |
| 12.3 Overdispersion and Negative Binomial Models | 352 |
| 12.4 Other Count Models | 354 |
| 12.5 Further Reading and References | 359 |
| 12.6 Exercises | 360 |
| 13 Generalized Linear Models | 362 |
| 13.1 Introduction | 362 |
| 13.2 GLM Model | 364 |

| x | <i>Contents</i> |
|---------------------------------------------------|-----------------|
| 13.3 Estimation | 367 |
| 13.4 Application: Medical Expenditures | 371 |
| 13.5 Residuals | 374 |
| 13.6 Tweedie Distribution | 375 |
| 13.7 Further Reading and References | 376 |
| 13.8 Exercises | 377 |
| 13.9 Technical Supplements – Exponential Family | 378 |
| 14 Survival Models | 383 |
| 14.1 Introduction | 383 |
| 14.2 Censoring and Truncation | 385 |
| 14.3 Accelerated Failure Time Model | 390 |
| 14.4 Proportional Hazards Model | 392 |
| 14.5 Recurrent Events | 395 |
| 14.6 Further Reading and References | 397 |
| 15 Miscellaneous Regression Topics | 399 |
| 15.1 Mixed Linear Models | 399 |
| 15.2 Bayesian Regression | 403 |
| 15.3 Density Estimation and Scatterplot Smoothing | 406 |
| 15.4 Generalized Additive Models | 409 |
| 15.5 Bootstrapping | 410 |
| 15.6 Further Reading and References | 412 |
| Part IV Actuarial Applications | |
| 16 Frequency-Severity Models | 417 |
| 16.1 Introduction | 417 |
| 16.2 Tobit Model | 418 |
| 16.3 Application: Medical Expenditures | 421 |
| 16.4 Two-Part Model | 424 |
| 16.5 Aggregate Loss Model | 427 |
| 16.6 Further Reading and References | 429 |
| 16.7 Exercises | 432 |
| 17 Fat-Tailed Regression Models | 433 |
| 17.1 Introduction | 433 |
| 17.2 Transformations | 434 |
| 17.3 Generalized Linear Models | 437 |
| 17.4 Generalized Distributions | 442 |
| 17.5 Quantile Regression | 446 |
| 17.6 Extreme Value Models | 448 |
| 17.7 Further Reading and References | 449 |
| 17.8 Exercises | 451 |

| | |
|------------------------------------------------------------------|------------|
| <i>Contents</i> | xi |
| 18 Credibility and Bonus-Malus | 452 |
| 18.1 Risk Classification and Experience Rating | 452 |
| 18.2 Credibility | 453 |
| 18.3 Credibility and Regression | 458 |
| 18.4 Bonus-Malus | 464 |
| 18.5 Further Reading and References | 465 |
| 19 Claims Triangles | 467 |
| 19.1 Introduction | 467 |
| 19.2 Regression Using Functions of Time as Explanatory Variables | 471 |
| 19.3 Using Past Developments | 475 |
| 19.4 Further Reading and References | 477 |
| 19.5 Exercises | 478 |
| 20 Report Writing: Communicating Data Analysis Results | 481 |
| 20.1 Overview | 481 |
| 20.2 Methods for Communicating Data | 482 |
| 20.3 How to Organize | 486 |
| 20.4 Further Suggestions for Report Writing | 490 |
| 20.5 Case Study: Swedish Automobile Claims | 491 |
| 20.6 Further Reading and References | 503 |
| 20.7 Exercises | 504 |
| 21 Designing Effective Graphs | 505 |
| 21.1 Introduction | 506 |
| 21.2 Graphic Design Choices Make a Difference | 508 |
| 21.3 Design Guidelines | 513 |
| 21.4 Empirical Foundations for Guidelines | 520 |
| 21.5 Concluding Remarks | 526 |
| 21.6 Further Reading and References | 526 |
| <i>Brief Answers to Selected Exercises</i> | 529 |
| <i>Appendix 1: Basic Statistical Inference</i> | 547 |
| <i>Appendix 2: Matrix Algebra</i> | 551 |
| <i>Appendix 3: Probability Tables</i> | 554 |
| <i>Index</i> | 559 |