国外实用统计丛书

应用线性统计模型

下册（英文影印版·原书第5版）

Applied Linear Statistical Models

[美] 迈克尔 H.库特纳（Michael H.Kutner）
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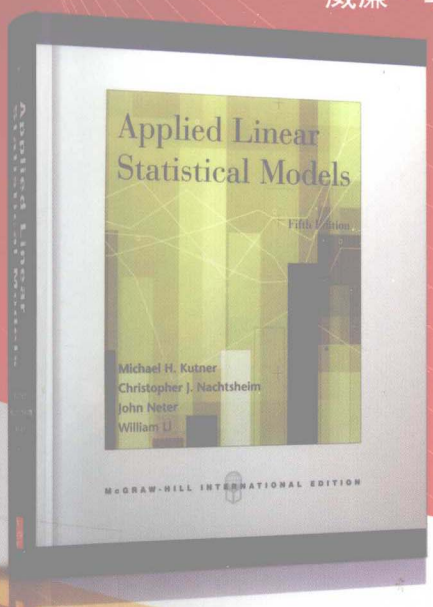

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本书续接上册第 4 ~ 7 部分：第 4 部分单因子研究的分析和设计，内容涉及试验和观测研究的设计引入、单因子研究、因子水平平均数分析、ANOVA 诊断和修正测度等；第 5 部分多因子研究，内容涉及具有相等样本量的双因子研究、随机完全区组设计、协方差分析、具有不相等样本量的双因子研究、多因子研究、随机和混合效应模型等；第 6 部分专业化的设计，内容涉及：重复和相关设计，平衡不完全区组、拉丁方和相关设计，探索性试验，二阶析因设计和分式析因设计，响应面方法论等。全书例子涉及各个应用领域，比较突出地介绍了统计思想。

本书可作为高等院校统计学专业和理工科各专业本科生和研究生的教材使用。

Michael H. Kutner , Christopher J. Nachtsheim , John Neter ,William Li

Applied Linear Statistical Models

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TABLE B.2
(*concluded*)
Percentiles of the t Distribution.

	A						
ν	.98	.985	.99	.9925	.995	.9975	.9995
1	15.895	21.205	31.821	42.434	63.657	127.322	636.590
2	4.849	5.643	6.965	8.073	9.925	14.089	31.598
3	3.482	3.896	4.541	5.047	5.841	7.453	12.924
4	2.999	3.298	3.747	4.088	4.604	5.598	8.610
5	2.757	3.003	3.365	3.634	4.032	4.773	6.869
6	2.612	2.829	3.143	3.372	3.707	4.317	5.959
7	2.517	2.715	2.998	3.203	3.499	4.029	5.408
8	2.449	2.634	2.896	3.085	3.355	3.833	5.041
9	2.398	2.574	2.821	2.998	3.250	3.690	4.781
10	2.359	2.527	2.764	2.932	3.169	3.581	4.587
11	2.328	2.491	2.718	2.879	3.106	3.497	4.437
12	2.303	2.461	2.681	2.836	3.055	3.428	4.318
13	2.282	2.436	2.650	2.801	3.012	3.372	4.221
14	2.264	2.415	2.624	2.771	2.977	3.326	4.140
15	2.249	2.397	2.602	2.746	2.947	3.286	4.073
16	2.235	2.382	2.583	2.724	2.921	3.252	4.015
17	2.224	2.368	2.567	2.706	2.898	3.222	3.965
18	2.214	2.356	2.552	2.689	2.878	3.197	3.922
19	2.205	2.346	2.539	2.674	2.861	3.174	3.883
20	2.197	2.336	2.528	2.661	2.845	3.153	3.849
21	2.189	2.328	2.518	2.649	2.831	3.135	3.819
22	2.183	2.320	2.508	2.639	2.819	3.119	3.792
23	2.177	2.313	2.500	2.629	2.807	3.104	3.768
24	2.172	2.307	2.492	2.620	2.797	3.091	3.745
25	2.167	2.301	2.485	2.612	2.787	3.078	3.725
26	2.162	2.296	2.479	2.605	2.779	3.067	3.707
27	2.158	2.291	2.473	2.598	2.771	3.057	3.690
28	2.154	2.286	2.467	2.592	2.763	3.047	3.674
29	2.150	2.282	2.462	2.586	2.756	3.038	3.659
30	2.147	2.278	2.457	2.581	2.750	3.030	3.646
40	2.123	2.250	2.423	2.542	2.704	2.971	3.551
60	2.099	2.223	2.390	2.504	2.660	2.915	3.460
120	2.076	2.196	2.358	2.468	2.617	2.860	3.373
∞	2.054	2.170	2.326	2.432	2.576	2.807	3.291

英文影印版序

本书是在美国大学中广泛使用的教材，已经再版至第5版，不仅深受广大师生的欢迎，而且有很大的影响，已逐步成为经典。

由于篇幅较大，故其英文影印版分为上、下两册。本书深入地介绍了“应用线性统计模型”这门课程中几乎所有的关键知识，但是读起来并不艰深晦涩。书中用深入浅出的方式来讲解相关概念，同时配有大量的例题、习题以及实际案例帮助学生理解知识点。同时在帮助学生独立地解决实际问题方面，本书给人留下很深刻的印象。

本书图文并茂，许多例子和习题都是经过精心挑选的，来源于生活和工程实践，丰富的数据也都取材于实际案例。因此，本书不仅适用于统计专业，也可作为商业、计量经济学等专业的参考书。

本书叙述比较详尽，内容比国内教材丰富，篇幅较大，因此作为教材时可适当选取主要内容讲授，其余可作为学生自学使用。

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Preface

Linear regression models are widely used today in business administration, economics, engineering, and the social, health, and biological sciences. Successful applications of these models require a sound understanding of both the underlying theory and the practical problems that are encountered in using the models in real-life situations. While *Applied Linear Regression Models,* Fourth Edition, is basically an applied book, it seeks to blend theory and applications effectively, avoiding the extremes of presenting theory in isolation and of giving elements of applications without the needed understanding of the theoretical foundations.

The fourth edition differs from the third in a number of important respects.

1. We have reorganized the chapters for better clarity and flow of topics. Material from the old Chapter 15 on normal correlation models has been integrated throughout the text where appropriate. Much of the material is now found in an expanded Chapter 2, which focuses on inference in regression analysis. Material from the old Chapter 7 pertaining to polynomial and interaction regression models and from old Chapter 11 on qualitative predictors has been integrated into a new Chapter 8 called, "Regression Models for Quantitative and Qualitative Predictors." Material on model validation from old Chapter 10 is now fully integrated with updated material on model selection in a new Chapter 9 entitled, "Building the Regression Model I: Model Selection and Validation."
2. We have added material on important techniques for data mining, including regression trees and neural network models, in Chapters 11 and 13, respectively.
3. We have made extensive revisions to the problem material. Problem data sets are generally larger and more challenging, and we have included a large number of new case data sets in Appendix C. In addition, we have added a new category of chapter exercises, called Case Studies. These are open-ended problems that require students, given an overall objective, to carry out complete analyses of the various case data sets in Appendix C. They are distinct from the material in the Problems and Projects sections, which frequently ask students to simply carry out specific analytical procedures.
4. The chapter on logistic regression (Chapter 14) has been extensively revised and expanded to include a more thorough treatment of logistic, probit, and complementary log-log models, logistic regression residuals, model selection, model assessment, logistic regression diagnostics, and goodness of fit tests. We have also developed new material on polytomous (multicategory) nominal logistic regression models and polytomous ordinal logistic regression models.
5. We have expanded the discussion of model selection methods and criteria. The Akaike information criterion and Schwarz Bayesian criterion have been added, and a greater emphasis is placed on the use of cross-validation for model selection and validation.
6. We have substantially expanded the amount of graphic presentation, including much greater use of scatter plot matrices, three-dimensional rotating plots, three-dimensional response surface and contour plots, and conditional effects plots.
7. Throughout the text, we have made extensive revisions in the exposition on the basis of classroom experience to improve the clarity of the presentation.

We have included in this book not only the more conventional topics in regression, but also topics that are frequently slighted, though important in practice. We devote three chapters (Chapter 9–11) to the model-building process for regression, including computer-assisted selection procedures for identifying good subsets of predictor variables and validation of the chosen regression model. Two chapters (Chapters 8 and 14) are devoted to indicator variables, covering both response and predictor indicator variables. The use of residual analysis and other diagnostics for examining the appropriateness of a regression model is a recurring theme throughout this book. So is the use of remedial measures that may be helpful when the model is not appropriate. In the analysis of the results of a study, we give greater emphasis to the use of estimation procedures than to significance tests, because estimation is often more meaningful in practice. Also, since practical problems seldom are concerned with a single inference, we stress the use of simultaneous inference procedures.

Theoretical ideas are presented to the degree needed for good understanding in making sound applications. Proofs are given in those instances where we feel they serve to demonstrate an important method of approach. Emphasis is placed on a thorough understanding of the regression models, particularly the meaning of the model parameters, since such understanding is basic to proper applications. A wide variety of examples and cases is presented to illustrate the use of the theoretical principles, to show the great diversity of applications of regression models, and to demonstrate how analyses are carried out for different problems.

We use "Comments" sections in each chapter to present additional discussion and matters related to the mainstream of development. In this way, the basic ideas in a chapter are presented concisely and without distraction.

Applications of regression models frequently require extensive computations. We take the position that a computer is available in most applied work and that almost every computer user has access to program packages for regression analysis. Hence, we explain the basic mathematical steps in fitting a regression model but do not dwell on computational details. This approach permits us to avoid many complex formulas and enables us to focus on basic principles. We make extensive use in this text of computer capabilities for performing computations and preparing graphic plots, and we illustrate a variety of computer printouts and plots and explain how they are used for analysis.

A selection of problems is provided at the end of each chapter. Here readers can reinforce their understanding of the methodology and use the concepts learned to analyze data. We have been careful to supply data-analysis problems that typify genuine applications. In most problems the calculations are best handled on a computer. To facilitate data entry, a compact disk is provided with the text that includes the data sets for all examples, problems, exercises, projects, and case studies, as well as for the data sets in Appendix C. The README.TXT file on the compact disk provides information about the identification of the data sets.

We assume that the reader of *Applied Linear Regression Models,* Fourth Edition, has had an introductory course in statistical inference, covering the material outlined in Appendix A. Should some gaps in the reader's background exist, the relevant portions of an introductory text can be studied, or the instructor of the class may use supplemental materials for covering the missing segments. Appendix A is primarily intended as a reference of basic statistical results for continuing use as the reader progresses through the book.

Calculus is not required for reading *Applied Linear Regression Models,* Fourth Edition. In a number of instances, we use calculus to demonstrate how some important results are obtained, but these demonstrations are confined to supplementary comments and can

be omitted without any loss of continuity. Readers who do know calculus will find these comments in natural sequence so that the benefits of the mathematical developments are obtained in their immediate context. Some basic elements of matrix algebra are needed for multiple regression. Chapter 5 introduces these elements of matrix algebra in the context of simple regression for easy learning.

Applied Linear Regression Models, Fourth Edition, is intended for use in undergraduate and graduate courses in regression analysis and in second courses in applied statistics. The extent to which material presented in this text is used in a particular course depends upon the amount of time available and the objectives of the course. The basic elements of regression are covered in Chapters 1, 2, 3, 4 (Sections 4.1–4.3), 5, 6, 7, 8, 9, and 10. Chapters 11, 12, 13, and 14 can be covered as time permits and interests dictate.

This book can also be used for self-study by persons engaged in the fields of business administration, economics, engineering, and the social, health, and biological sciences who desire to obtain competence in the application of regression models.

An *Instructor Solutions Manual,* containing detailed solutions to all numerical problems and analytical exercises, is available from the publisher, McGraw-Hill/Irwin, for use by instructors.

A *Student Solutions Manual* is included on the compact disk for use by students. The Student Solutions Manual provides intermediate and final numerical results for easy self-checking of solutions for selected problems. We use an asterisk (*) in front of the problem number to designate the problems for which the solutions appear in the Student Solutions Manual.

Available new for this Fourth Edition is a *SAS and SPSS Program Solution Manual* for examples contained in the text. The manual was prepared by Dr. William Replogle and Dr. William Johnson, both of the University of Mississippi Medical School. The manual uses data files to present solutions, output, and discussion of necessary steps for students to solve examples selected from the book using SAS and SPSS.

The *Student Solutions Manual* and all of the data files on the compact disk can also be downloaded from the book's website at: www.mhhe.com/KutnerALRM4e. A list of errata for the book as well as some useful, related links will also be maintained at this address.

A book such as this cannot be written without substantial assistance from numerous persons. We are indebted to the many contributors who have developed the theory and practice discussed in this book. We also would like to acknowledge appreciation to our students, who helped us in a variety of ways to fashion the method of presentation contained herein. We are grateful to the many users of *Applied Linear Statistical Models* and *Applied Linear Regression Models,* who have provided us with comments and suggestions based on their teaching with these texts. We are also indebted to Professors James E. Holstein, University of Missouri, and David L. Sherry, University of West Florida, for their review of *Applied Linear Statistical Models,* First Edition; to Professors Samuel Kotz, University of Maryland at College Park, Ralph P. Russo, University of Iowa, and Peter F. Thall, The George Washington University, for their review of *Applied Linear Regression Models,* First Edition; to Professors John S. Y Chiu, University of Washington, James A. Calvin, University of Iowa, and Michael F. Driscoll, Arizona State University, for their review of *Applied Linear Statistical Models,* Second Edition; to Professor Richard Anderson-Sprecher, University of Wyoming, for his review of *Applied Linear Regression Models,* Second Edition; and to Professors Alexander von Eye, The Pennsylvania State University, Samuel Kotz, University of

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In addition, valuable assistance was provided by Professors Richard K. Burdick, Arizona State University, R. Dennis Cook, University of Minnesota, W. J. Conover, Texas Tech University, Mark E. Johnson, University of Central Florida, Dick DeVeaux, Williams College, and by Drs. Richard I. Beckman, Los Alamos National Laboratory, Ronald L. Iman, Sandia National Laboratories, and Brad Jones, SAS Institute. We are most appreciative of their willing help. We are also indebted to the 88 participants in a survey concerning *Applied Linear Regression Models,* Second Edition, the 76 participants in a survey concerning *Applied Linear Statistical Models,* Third Edition, and the 73 participants in a survey concerning *Applied Linear Regression Models,* Third Edition, or *Applied Linear Statistical Models,* Fourth Edition. Helpful suggestions were received in these surveys, for which we are thankful.

Weiyong Zhang and Vincent Agboto assisted us in the development of new problem material, and Lexin Li and Yingwen Dong prepared the revised *Instructor Solutions Manual* and *Student Solutions Manual* under considerable time pressure. Amy Hendrickson provided much-needed LaTeX expertise. We are most grateful to these individuals for their invaluable help and assistance. We also wish to thank the various members of the Carlson Executive MBA Program classes of 2003 and 2004, notably Mike Ohmes, Trevor Bynum, Baxter Stephenson, Zakir Salyani, Sanders Marvin, Trent Spurgeon, Nate Ogzawalla, David Mott, Preston McKenzie, Bruce DeJong, and Tim Kensok, for their contributions of interesting and relevant case study data and materials.

Finally, our families bore patiently the pressures caused by our commitment to complete this revision. We are appreciative of their understanding.

Michael H. Kutner

Christopher J. Nachtsheim

John Neter

William Li

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