5. The book's applications chapter needs to be more detailed so that it can be used as a guide for novice data analysts in this area.

Overall, at this price, I wish I could have left out conclusions 4 and 5. In addition, some fully worked out (with software) real examples are needed. As I found out long ago, being able to prove theorems does not mean that one can apply them. The novice (e.g., someone like me) needs training in both. However, one good thing is that there are many references with authors that both chemists and statisticians will recognize. Hopefully, that helps. If you are faced with this type of data, perhaps this book is a reasonable place to start. I know of no others.

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Generalized Least Squares, by Takeaki KARIYA and Hiroshi KURATA, West Sussex, U.K.: Wiley, 2004, ISBN 0-471-86697-7, xiii + 289 pp., $149.95.

Regression analysis provides a major statistical tool for building functional relationship between response variables and explanatory variables. In linear regression analysis, the well-known Gauss–Markov theorem plays a central role, which says that the least squares estimator is the minimum variance linear unbiased estimator among all linear unbiased estimators, under several conventional assumptions. In applications, however, these conventional assumptions may not all be valid. For instance, quite often the observations are correlated at different design points and the true covariance matrix of the observations is unknown. In such cases the assumption of independent observations is violated, and it is interesting to know how to estimate the model coefficients properly. This book provides a systematic discussion about statistical methods and theory for handling linear regression analysis when such conventional model assumptions are violated.

This book is decently written. All concepts and terminologies are carefully defined and explained, and description of the major results is concise and mathematically rigorous. Although in some places in the book the English can be improved, I did not have much difficulty understanding the authors' description when reading through the book.

The book covers quite complete topics related to linear regression analysis when conventional model assumptions are violated, in the unified framework of generalized least squares estimation. It comprises nine chapters.

Chapter 1 describes concepts and basic properties of the multivariate normal distributions, Wishart distributions, elliptically symmetric distributions, and group-invariant transformations. These distributions and transformations constitute the theoretical background of generalized least squares estimation. Chapter 2 gives a formulation of generalized linear regression models and generalized least squares estimators (GLSEs). Several commonly used generalized linear regression models, including the AR(1) model, equicorrelated model, heteroscedastic model, and seemingly unrelated regression (SUR) model, are introduced in detail. Two empirical examples related to CO_2 emission data and bond price data are also discussed.

Chapters 3–6 constitute the main body of the book. Chapter 3 introduces generalized least squares prediction, a nonlinear version of the Gauss–Markov theorem in prediction, a nonlinear version of the Gauss–Markov theorem in estimation, and generalized least squares estimation with iterated residuals. Chapter 4 first discusses efficiency of a GLSE by deriving an effective upper bound for the covariance matrix of the GLSE, then derives corresponding GLSEs and their efficiency results in cases of the SUR model and heteroscedastic model, and finally demonstrates the results using the CO_2 emission data. The efficiency problem in the case of a serial correlation model is discussed in Chapter 5, and the major results are demonstrated using an automobile data. In applications, it is natural to approximate the distributions of generalized least squares predictors (GLSPs) and GLSEs by the distributions of their Gauss–Markov counterparts, which are normal if the random error terms in the model are normally distributed. Chapter 6 derives uniform bounds for differences between the distributions of GLSPs and GLSEs and their normal approximations. These uniform bounds are given for both probability density functions and cumulative distribution functions.

Chapters 7–9 make some extensions and generalizations of the results discussed in Chapters 3–6. More specifically, Chapter 7 specifies the maximal class of error distributions under which the Gauss–Markov estimator is optimal in a conventional sense. Based on this result, the nonlinear version of the Gauss–Markov theorem discussed in Chapter 3 is further improved. Chapter 8 discusses three topics. First, it shows that under some regularity conditions, the Gauss–Markov estimator maximizes, among a class of GLSEs, the probability that the bias of the estimator lies in any symmetric convex set. Then it extends some results in Chapter 4 by replacing the normal distribution assumption with the assumption that the error distribution is elliptically symmetric. Finally, it proves that the distribution of the difference between a GLSE and the corresponding Gauss–Markov estimator is degenerate in certain circumstances. Chapter 9 discusses generalized least squares estimation in the case of a growth curve model.

The mathematical level required for reading this book is kept low. Readers with some background in linear algebra, calculus through integration and differentiation, and introductory statistics can easily understand the materials in the book. This book can be used as a primary textbook for a one-semester graduate-level course on generalized least squares estimation. It can also be used as a supplemental textbook for graduate-level courses on linear regression analysis and longitudinal data analysis.

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Applied Bayesian Modeling and Causal Inference From Incomplete-Data Perspectives, edited by Andrew GELMAN and Xiao-Li MENG, West Sussex, U.K.: Wiley, ISBN 0-470-09043-X, xix + 407 pp., $110.00.

This book comprises 4 parts and 31 chapters covering such topics as causal inference, missing-data modeling, statistical modeling and computation, and applied Bayesian inference. Although it includes several chapters that do not really discuss Bayesian issues, the book's title gives the impression that this is a complete applied Bayesian volume. I prefer the alternative title, which is more eye-catching—"Blue-Label Statistics (60 years): Sipping With Donald Rubin"—as it was at least considered by the editors.

This book contains most of the topics that Rubin either originally initiated or has worked on during his career thus far. In part one, causal inference from observational studies is discussed in the first nine chapters. Propensity score method is heavily discussed, with applications in public health and economics, followed by discussions of the method of instrumental variables. Part two contains seven chapters on the topic of missing-data modeling, one of Rubin's signature contributions in the statistical world. This part starts with a review chapter and proceeds with three chapters on multiple imputation and then missing-data problems in design and estimation. Part three is a collection of eight chapters investigating statistical modeling and computation. In this part, various computational techniques, including EM algorithm and Markov chain Monte Carlo (MCMC) simulation, are investigated. There also is a chapter dealing with the robust "robit" regression models. Finally, part four contains seven chapters on the topic of applied Bayesian inference. This part begins with an overview of applied Bayesian inference written by Brad Carlin (2004) that is very interesting and should be read by any one wishing to use applied Bayesian inference. In this part, applications are more focused in natural and social sciences.

Many people, including myself, would expect this book to be very "applied" after reading the title. However, quite a few chapters are still somewhat too much theory-oriented. Nonetheless, this book contains much current important work that may attract the readers of *Technometrics*.

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REFERENCE

Carlin, B. (2004), "Whither Applied Bayesian Inference?" in *Applied Bayesian Modeling and Causal Inference From Incomplete-Data Perspectives*, eds. A. Gelman and X. L. Meng, New York: Wiley, pp. 279–282.

Skew-Elliptical Distributions and Their Applications: A Journey Beyond Normality, edited by Marc G. GENTON, Boca Raton, FL: Chapman & Hall/CRC, 2004, ISBN 1-58488-431-2, xx + 396 pp., $89.95.

In describing random phenomenon pertaining to a skewed distribution, a skew-normal (SN) distribution offers a natural and smooth transition from the normal distribution. Mathematical tractability of the statistical inference associated with SN triggered much research in the area of modeling skewed distributions in the past two decades. The book under review is an edited volume that documents a substantial portion of this research.

The book contains 20 chapters distributed over two parts. The first part, consisting of nine chapters, describes in detail the theory and statistical inference issues of skew-elliptical distributions. The second part of the book covers applications of skew-elliptical distributions in a wide range of areas including finance, economics, engineering, oceanography, astronomy, and biomedical sciences, among others. Such a balance between theory and applications is a particular strength of this monograph, because it provides something for both theoreticians and practitioners.

Chapter 1 introduces the basic SN random variable, which in its standardized form assumes the pdf

$$g(z;\alpha) = 2\phi(z)\Phi(\alpha z), \qquad -\infty < z < \infty, \tag{1}$$

where ϕ and Φ in (1) denote the standard normal pdf and cdf and the real number α is the tuning parameter for skewness. The distributional properties of SN and associated statistical inference results are detailed. Particular emphasis is placed on describing its connection to the symmetric two-parameter normal variates corresponding to $\alpha = 0$.

Different multivariate extensions of SN have been considered in the literature. Of these, the multivariate closed skew-normal (CSN) distribution described in Chapter 2 seems to be quite attractive due to its closure properties. The term “closed” owes to the fact that CSN is closed under linear transformations. Further, it admits a linear combination of components characterization similar to a multivariate normal. Closure under joint distribution and convolution of independent CSN variables are also demonstrated in this chapter.

Several multivariate extensions of SN in a direction different from the foregoing are explained in Chapter 3. These extensions have their roots in a broad class of distributions called elliptically contoured (EC) distributions. Different constructions of multivariate skew-elliptical distributions are considered. Various statistical properties, such as moment-generating functions, distributions of quadratic forms, and different closure properties, are discussed in detail.

Chapters 4 and 5 focus on the class of generalized skew-elliptical (GSE) distribution defined by the pdf

$$2f(\mathbf{z};\boldsymbol{\epsilon},\boldsymbol{\Omega})\pi(\mathbf{z}-\boldsymbol{\epsilon}), \tag{2}$$

where f is an elliptically contoured pdf with location parameter $\boldsymbol{\epsilon}$ and scale matrix parameter $\boldsymbol{\Omega}$, and the skewing function π satisfies $0 \le \pi(\mathbf{z}) = 1 - \pi(-\mathbf{z}) \le 1$. The motivation behind defining such a class came from the need for modeling multimodality, which the traditional skew-normal distributions are incapable. Chapter 4 discusses the statistical properties, inference results, and diagnostic issues for the special GSE distribution where f in (2) corresponds to a multivariate normal pdf. A noteworthy point in this context is the inability of traditional diagnostic tests to distinguish between samples from a generalized SN and a regular “symmetric” normal distribution. Chapter 5 generalizes GSE to the class of skew-symmetric distributions where f in (2) is taken to be any continuous pdf symmetric around 0. It is shown that by taking the skewing function π to be a polynomial of odd order several features of a distribution, such as multimodality and heavy tails, can be captured. A stochastic representation and an invariance property of skew-symmetric distributions are discussed at length.

The main contribution of Chapter 6 is the stochastic representation of SN and other multivariate skewed distributions through a hidden truncation argument. In the univariate case, hidden truncation can be conceived through a pair of dependent random variables, say (X_1, X_2), where X_1 is observed only if X_2 is above a threshold, say $X_2 > c$. The conditional distribution of X_1 given $X_2 > c$ then yields SN when the parent pair (X_1, X_2) conforms to a bivariate normal. Extension to the case of skew-elliptical and general multivariate skewed distributions are presented in detail.

Chapter 7 presents a unified approach to generating skewed distributions starting from a given family of symmetric distributions. Emphasis is on stochastic representations associated with certain groups of transformations that are intimately connected to symmetry or lack of it (skewness).

In contrast to the other chapters in Part 1, the context of discussion in Chapters 8 and 9 is Bayesian. Chapter 8 is an exposition on skewed link models in connection with categorical outcomes. These models differ from the class of distributions discussed in earlier chapters in that the skewness is introduced via a link function for the probability, rather than through a direct manipulation of the pdf. Correlated multinomial as well as discrete choice models are discussed, in addition to the traditional nonclustered categorical response. Bayesian inference is recommended primarily for the flexibility of model selection, as well as for the availability of powerful computational techniques.

Chapter 9 discusses the role of skew-elliptical distributions in Bayesian inference. A discourse on skewed prior distributions for location parameters is followed by a treatment of (Bayesian) inferential aspects of a distribution with a skew-elliptical sampling distribution. This chapter also provides interesting insights into some pathologies encountered in the likelihood-based frequentist approach to analyzing SN distributions and contrasts it with an objective Bayesian one.

Each of the 11 chapters in Part 2 discusses an application area that uses a skewed model. The application areas range from traditional medical topics to finance, climatology, astronomy, and pattern recognition. Chapter 10 uses multivariate regression with a skewed error to model firm sizes (measured by market value, tangible assets, and sales) as a function of investment and research and development effort. The analysis is undertaken under a Bayesian framework. Comparison of models is carried out under different prior specifications as well as two different choices of skewed multivariate errors.

The old topic of returns on financial asset is revisited in Chapter 11. Borrowing the mean structure from the well-accepted capital asset pricing model, returns of risky assets are modeled using an SN distribution. The resulting model is applied to constituents of a certain index that has available price information covering 17 years.

Chapter 12 introduces a GARCH-type model to describe volatility of small capitalized markets characterized by short term influence exerted by the U.S. stock exchange. The implemented structure incorporates both an endogenous and an exogenous component and models both domestic (U.S.) and foreign returns simultaneously. The interest is in describing the foreign returns which, under the GARCH structure, is subject to “shocks” from the domestic component. Under standard normal distributions on the shocks and the specific functional relationship imposed between foreign returns and lagged exogenous shocks, the distribution of the foreign returns is SN when conditioned on the volatility and sign of the lagged U.S. return. The model is implemented to analyzing returns of the Swiss, Italian, and Dutch markets.

Chapter 13 introduces skew-normality in the error structure of a regression model in the context of stochastic frontier analysis encountered in economic applications. The error is decomposed into two components, one representing traditional measurement error and the other called an efficiency/inefficiency component. Unlike usual regression analysis, where regression coefficients in the mean model are of primary interest, here the focus is on estimating the efficiency component. To counter the identifiability issue, it is proposed to estimate the expectation of the efficiency component conditional on the total error. Simulation results are presented for a particular error structure.

Chapter 14 describes a case study dealing with projection of coastal flooding from a time series of sea level data. The sea level observations, corrected for tide, are modeled by multivariate skew-t distribution with a seasonally varying parameter. The detailed analysis demonstrates how the estimated distribution can be used to detect trends as well as predict the times of extreme level rise.

Chapter 15 describes skewed Kalman filter modeling of a spatiotemporal time series. The CSN distribution is used to model the skewness and is applied to a data arising from climatology.

A further paleoclimatic context of predicting rainfall is explored in Chapter 16, which specifically focuses on modeling spatial processes with SN distributions. A Bayesian framework is adopted, and the popular MCMC is used to estimate the posterior quantities of interest.

Chapter 17 discusses an interesting approach to learning and modeling shapes using the class of flexible skew-symmetric (FSS) distributions. The topic of interest is planar shapes characterized by a random trace of points in two dimensions. Detailed modeling of the polar representation of the points is described, with the radial distances (from the identified centroid) formulated using the FSS. Nonuniform modeling of the angular distribution is pursued in view of the irregularity of shapes. The proposed models are implemented to “learn” different shapes, including those of a star, brain, heart, and a car.

Linear regression with SN error is the model under consideration in Chapter 18, which specializes in determining astronomical distance of a class of stars, called Cepheids, exploiting their period–luminosity relationship.

Chapters 19 and 20 comprise generalizations of well-known application areas using skewed distributions. Specifically, Chapter 19 deals with a clustered regression framework for survival data which are traditionally modeled with an unobserved frailty parameter. It is shown how a log-skew-t distribution for frailty provides a more flexible choice compared with the widely used gamma or stable distributions. The framework adopted is fully Bayesian, and details are provided for the posterior updating steps via MCMC.

Finally Chapter 20 deals with the well-studied linear mixed-effects regression formulation, where the random effects are modeled using a class of GSE distributions introduced earlier in Chapter 5. The likelihood inference is implemented via an EM algorithm. Simulation results are presented to assess the performance of the proposed models and methods, followed by an application to a well-known longitudinal study of cholesterol levels.

Overall, this is an outstanding monograph on current research on skew-elliptical models and its generalizations. Contributed by several experts in this area, the book does an excellent job presenting the depth of methodological research as well as the breath of application regimes. It will clearly be an extremely useful resource for researchers in pursuit of modeling skewness.

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Atmospheric Modeling, Data Assimilation, and Predictability, by Eugenia KALNAY, Cambridge, U.K.: Cambridge University Press, 2003, ISBN 0-521-79179-0, xxii + 341 pp., $120.00.

With increasing concerns about potential climate change and its associated impacts, questions of uncertainty in climate prediction are becoming paramount. Naturally, such concerns about uncertainty suggest the need for statistical expertise. In addition, statisticians interested in problems in the environmental sciences (e.g., meteorology, oceanography, ecology) are incorporating deterministic dynamical models (e.g., partial differential equations) in their statistical models for spatiotemporal processes. Because it is relatively uncommon for statisticians to receive training in dynamical systems and partial differential equations (PDEs) in their formal academic courses, there is a need for a concise, yet thorough book that describes the critical aspects of these subjects, at least those related to environmental processes. This book does exactly that.

In essence, this book is an overview of modern numerical weather forecasting. After an accessible historical overview in Chapter 1, Chapter 2 provides a summary of the continuous system of equations that describe the state of the atmosphere. Although somewhat terse for a statistician with no previous exposure to the governing equations of the atmosphere, it is an excellent overview of atmospheric dynamics. Chapter 3 then describes the numerical solution of such systems of PDEs. This is an excellent chapter and would be a nice reference for statisticians interested in numerical solutions of PDEs, as well as those interested in the connection between PDEs and difference equations. Chapter 4 is a very short introduction to the parameterization of subgrid-scale processes that are necessary in atmospheric models as a result of the discretization limits imposed on the continuous system. Such parameterizations are critically important in weather forecasting and climate modeling, yet are rarely considered from a statistical perspective (either in terms of estimation of free model parameters or in terms of the uncertainty in the model specification).

Chapters 5 and 6 are more directly relevant to statistics. Chapter 5 gives a comprehensive overview of "data assimilation," which involves combining uncertain observations with deterministic (or quasi-deterministic) dynamical models to obtain an estimate of the state of the system (and its uncertainty). For numerical weather forecasting, this is critical. To initialize the discretized deterministic weather forecasting model, one must have an estimate of the system state variables at each grid location (in three-dimensional space). Obviously, atmospheric observations do not occur at such resolution, so one must effectively interpolate the observations to obtain the initial state. The problem is complicated by the presence of large gaps of missing data and the fact that the initial state must be in some sort of dynamical balance (i.e., must be a physically realistic representation of the system state). This requires using a dynamical model to help fill in the missing information. Statisticians are familiar with these ideas in the context of spatial prediction (i.e., kriging). More generally, data assimilation can be posed from a Bayesian perspective in which one has a prior distribution for the state process that might be obtained from a numerical weather prediction model. The "likelihood" is then the distribution of the data conditional on this true process. One of the biggest challenges with this procedure is obtaining the "prior" covariance matrix. In the case of normal assumptions for both the prior and "likelihood," both the state vector and the associated covariance matrix can be obtained via the Kalman filter. However, with the high-dimensional state vectors common to atmospheric systems (on the order of millions!), and the nonlinearity of the dynamical evolution equations, standard Kalman filter methods are not practical. This book presents the outline of so-called "ensemble" Kalman filters, which overcome many of these problems and are currently the focus of intense research and development because of their outstanding potential for practical assimilation problems.

Chapter 6 is concerned with atmospheric predictability and ensemble forecasting. From a statistical perspective, this chapter provides a very nice and concise review of the basics of chaotic systems and such important concepts as singular vectors and Lyapunov vectors. The growth of errors in nonlinear dynamical systems is critical for prediction, and these concepts provide a fundamental way to evaluate predictability. There is also a discussion of the necessity of accounting for the uncertainty in the initial state for nonlinear prediction models due to chaos. This leads to the idea of ensemble forecasting, which is closely tied to the ensemble methods for data assimilation presented in Chapter 5.

In summary, this book is an excellent reference for statisticians interested in dynamical systems and/or spatiotemporal processes in the environment. The technical level is reasonable for statisticians with advanced degrees. Although a few token exercises are included, to use this book as a textbook the instructor would need to provide supplemental problems.

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Computational Methods in Statistics and Econometrics, by Hisashi TANIZAKI, New York: Marcel Dekker, 2004, ISBN 0-8247-4804-2, xix + 494 pp. + CD, $99.95.

Statistical computing is a rapidly developing area in statistics. It has many applications in different disciplines including economics, health sciences, geology, psychology, and many others. This book covers some basic statistical computation techniques, with an emphasis on applications in economics. The book has an attractive layout and includes a useful companion CD–ROM displaying all source codes used in the book in Fortran 77 and sometimes in C languages.

The book comprises three main sections: Monte Carlo Statistical Methods, Selected Applications of Monte Carlo Methods, and Nonparametric Statistical Methods. Chapter 1 provides a concise introduction to mathematical statistics and statistical inference. It also introduces the basic mathematical techniques that are required in the book.

The first section of the book consists of two chapters. Chapters 2 and 3 discuss the generation of random numbers from different statistical distributions. Some commonly used random number generation methods, the inverse transform method for continuous and discrete distributions, the composition method, the rejection method, and the ratio-of-uniforms method are presented. Three random number generation procedures that use the sampling density—rejection sampling, importance resampling and the Metropolis–Hastings algorithm—are discussed. Justifications and illustrative examples are provided for each of the methods described in these chapters. Random number generators are compared in terms of CPU time and precision of the estimates of moments.

The book's second part presents three applications of the Monte Carlo methods in statistics and econometrics. These applications focus mainly on time series analysis and modeling. Chapter 4 discusses Bayesian analysis, with applications to multiplicative heteroscedasticity model and autocorrelation model in detail. Chapter 5 demonstrates some computational intensive bias-reduction techniques with the application of reducing bias for the ordinary least squares estimates of autoregressive models. Chapter 6 presents the estimation, filtering, and smoothing procedures for nonlinear non-Gaussian state–space models, using a stock market example to illustrate the methodologies.

The book's final section is devoted to nonparametric methods and nonparametric statistical tests. Chapter 7 discusses the nonparametric score tests and Fisher's randomization test for dealing with the two-sample problem and derives their asymptotic relative efficiencies. Chapter 8 considers the nonparametric tests for independence between two samples by testing the correlation coefficient or the regression coefficient. Monte Carlo simulations are used to compare the performance of different nonparametric and parametric procedures. Although the nonparametric procedures described in Chapters 7 and 8 are well known in the nonparametric statistics literature, the extensive Monte Carlo simulation studies for comparing the test procedures provide useful insight into picking the appropriate statistical test procedure in practice.

This book will be of use for practitioners who use Monte Carlo methods and simulations, Bayesian analysis, state-space modeling, or nonparametric statis-