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Book Reviews

Books for review are to be sent to the Book Review Editor Jan Wretman, Statistical Research Unit, Statistics Sweden, S–115 81 Stockholm, Sweden.

Duncan, O.D., Notes on Social Measurement: Historical and Critical. Russell Sage Foundation, New York, 1984. ISBN 0–87154–219–6. 272 pp.

In reviewing this book I have kept in mind that it has not been the author's intention to develop a systematic theory of social measurement. Instead, he covers an unusually broad range of historical material and considerable critical material as well. This means that the volume can be read casually and at leisure, and the many interesting historical examples can be easily appreciated.

Chapter 1 begins with the early history of social measurement with the first example being the Greeks' invention of voting. A quick history of the long and complicated history of the theory of voting is given. Chapter 2, which is concerned with historical metrology, contrasts systems of physical measurement and systems of social measurement. I give two examples of the wealth of unusual historical material discussed. One is the medieval system of English field measurement, another is the early concern with the theory and practice of measuring and weighing in the United States in the early part of the 19th century. I was surprised to learn, for example, that John Quincy Adams wrote a substantial report on weights and measures in 1821.

The much more substantial third chapter is concerned with the invention of methods of social measurement. Here too many examples are considered to list them all. A couple of unusual ones are the defining and labeling of social ranks or degrees, provisions for which are found in early Greek and Roman documents, and much interesting material on the ancient history of the Olympic Games and Chinese examinations, both of which go back to very early times. (To give the spirit of this volume it should be emphasized that the author is quite clear that he is not claiming to have done original research on the history of these matters but has given an overview based on wide reading of the secondary literature.)

Chapter 4 is on the more classical measurement topic of scales. The author examines in some detail the history of the theory of scales and scale types beginning with the 1946 proposal by S.S. Stevens. Among other things he is concerned with the incompleteness of Stevens's classification.

Chapter 5 is entitled "Measurement: The Real Thing." The author is mainly concerned to contrast the very developed state of quantitative measurement in the physical sciences with the relatively primitive developments in the social sciences. The author is rightly uncertain in my judgment as to whether the development of the interaction between measurement and theory will take the same course in the social sciences that it has taken in physics.

Chapter 6 is concerned with psychophysics, one of the areas in which measurement theory and practice have been developed to a serious level in psychology. In a way the chapter is mistitled, for the author does not really survey in any systematic way the now extraordinarily large literature of psychophysics concerned with measurement. To a large extent he is as much concerned to examine the possibility of true ratio scales in sociology, e.g., for social values and attitudes. Chapter 7 is concerned with psychometrics and here the classical methods of Thurstone, as well as the more recent models of Rasch, are discussed, although again the relevant theory is not really laid out in any technical detail.

Chapter 8, the final one, is entitled "Social Measurement: Predicaments and Practices." This chapter is meant to offer a broad overview. It considers for example the special features of social measurement such as dependence on results from other sciences, the importance of population concepts, and the resultant need for statistical models that include both variability and measurement error. The author ends his chapter by asking if we might end up with more measurements than we want in the sense that we learn more than we want to know about our society. He does not examine in any detail the classical political or normative conflict between the individual's right to privacy and society's need for data.

As can be seen from a summary of the chapters, the author covers a very large number of topics, and in the process of traversing the many topics he makes interesting and extended historical excursions. The book must be appreciated and read for what it is. It is Duncan's own personal view of the history and the present state of social measurement, taken in a very broad sense. It is not a systematic treatise and it makes no pretense to give a technical development of any of the topics it covers. In a book of this kind there are naturally many points of detail with which a reviewer could quarrel, but it does not seem appropriate to pursue such specific criticisms about very particular points. Taken for what it is, almost any reader will learn something about topics he or she has not encountered before and will be lead to further references he or she did not know about.

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Glymour, C., Scheines, R., Spirtes, P., and Kelly, K., Discovering Causal Structure: Artificial Intelligence, Philosophy of Science, and Statistical Modeling. Academic Press, Inc., Orlando, FL, 1987. ISBN 0-12-286961-3. xvii + 394 pp., $39.50.

The logic of causal analysis with nonexperimental statistical designs has been around for a long time. Although its philosophical roots are embedded in the earliest development of statistics (since many of the early applications of statistical reasoning were to problems of causal inference), the widespread use of causal analysis in the social and behavioral sciences has been relatively recent. Due largely to the influence of Paul Lazarsfeld, causal inference strategies have been prevalent among analysts of sample survey data since the

1940s, but it was not until the early 1960s that there was a general infusion of techniques of causal modeling into the research methods of these disciplines (economics, sociology, psychology, political science, and allied fields). Of course, path analysis was invented before 1920 by the great geneticist Sewall Wright, but his contributions were not appreciated by social and behavioral scientists (including psychometricians and econometricians) until much later. Wright developed path models as *deductive* systems for deriving correlations of genetic traits among relatives of stated degree. He also used the method inductively to model complex economic and social processes using correlation data. Psychometricians (Spearman, for example) had dealt with causal models involving latent variables that could be understood in Wright's path analysis framework, but Spearman and others who developed common factor models were unfamiliar with Wright's work. None of the early psychometricians recognized the possibility of causal relationships among the latent variables of their models, or for that matter among the indicators.

In 1954 Herbert Simon discovered that in some simple three-variable causal models, certain partial correlations could serve as a "test" of the assumptions of the model, and Hubert Blalock popularized and extended these ideas. These developments, and Otis Dudley Duncan's introduction of path analysis to sociologists and Karl Jöreskog's maximum-likelihood solution to the problem of estimating parameters of over-identified structural equation models, which both were published within one year of one another, did much to "revolutionize" the analysis of data from nonexperimental designs. Soon thereafter, students of measurement began using causal models to conceptualize "errors in variables," and one class of psychometric models specifying latent variables (namely common factor models) was rediscovered (see Costner (1969)) and became integrated with the structural equation approaches from biometrics and econometrics. The use of these models was spurred on by the availability of computer programs for readily estimating causal structures for "latent variables" measured by "multiple indicators." From the early 1970s Jöreskog and van Thillo's (and later Jöreskog and Sörbom's) maximum-likelihood methods for estimating over-identified structural equation models (LISREL) have been accessible. There are now alternative computer programs (e.g., Bentler's EQS, McDonald's COSAN, and Schoenberg's MILS), which all do basically the same thing, but none is as popular as Jöreskog and Sörbom's LISREL.

Discovering Causal Structure is about causal analysis using linear structural equation models, or what I prefer to call LISREL-type models. It is best understood against the background of the traditions of causal modeling referred to above, although it departs from its roots in several key respects. *Discovering's* primary focus is on the use of a new computer program called TETRAD, the purpose of which is to "search" for alternative causal specifications of the relationships among the latent and observed variables in structural equation models. This program, intended for use in conjunction with other programs, such as LISREL (Jöreskog and Sörbom (1986)) or EQS (Bentler (1985)), is not in itself an approach to statistical estimation. Rather, its stated purpose is to use artificial intelligence techniques to assist the investigator perform a search for alternative causal models, using the data and existing models at hand. TETRAD uses as input the covariance (or correlation) matrix for the variables along with a causal model, and with these in hand it inductively searches for causal structure by attempting to find one or more alternative causal models that are consistent with a set of data. TETRAD's major objective is not just to evaluate the fit of models, which represent alternatives to the one or ones hypothesized on the basis of empirically-based theoretical knowledge, but to discover such alternative models. In this sense the TETRAD program goes a step further than all other approaches to model specification, in that it examines patterns of lack of fit to the data to determine alternative causal structures, that is, it deter-

mines causal priority from the data. TETRAD makes suggestions about what set of directional causal parameters might be added to a model to better satisfy certain predesignated criteria of statistical fit. This, of course, violates the first principles of the tradition of causal modeling referred to above, in that it was always assumed that one had to bring a set of causal assumptions to the data and that the data by themselves could only in rare instances reveal anything about the causal ordering of the variables.

The authors of the book argue that current uses of causal modeling techniques are imprecise because of the combination of two problems: (a) the "psychological" problem that science itself is by and large too difficult for human cognitive capacities, and (b) the astronomically high number of distinct alternative models that might be consistent with the data, but which are never tried. They do not claim they want to find the "one unique correct theory," but only want to reduce uncertainty by coming up with a handful of possibilities. They think that when social and behavioral scientists apply "substantive knowledge" of the domain, they are mostly "whistling in the dark." Even the best researchers, the authors argue, tend to indulge their prejudices rather than their knowledge and are known to simply make "wild guesses" most of the time.

The problem, they argue, is that the practice of model-building in the social and behavioral sciences often looks very much like "irrational judgement under uncertainty." This book, and the TETRAD program it presents, propose a "new solution," by first considering the formal aspects of scientific explanations by comparing alternative models, and second by using artificial intelligence techniques to help search for models that will provide the best explanation of the data. The authors rely on Herbert Simon's notions of "heuristic search," based on a "satisficing" strategy, which amounts to settling for what is feasible and good enough rather than insisting on what is optimal, but infeasible. Such a "data-driven" approach to model-building represents a somewhat radical departure from the more "theoretically-driven" approaches seemingly in current use. But the authors claim that "researchers with TETRAD will do better science than researchers without it" (p. 123).

Relying on the same logic used by Spearman (and Kepler before him), Glymour and colleagues reason that "the best explanation is one which generates constraints found in the population measures without having to assume special values for its parameters," that is, the explanation which is robust over changes in the values of free parameters (p. 236). The TETRAD approach is a modern-day extension of Spearman's famous tetrad equations, which involve products of correlations among a set of four measured variables (thus the name tetrad). Tetrad equations say that one product of covariances (or correlations) is equal to another such product. For four variables there are three possible tetrad equations, any two of which are independent, and a given causal model implies a particular set of such equations. These tretrad equations amount to "over-identifying constraints," since they are equations that must be satisfied in the population if the causal model is correct.

There is an algorithm (see pp. 265–267 of *Discovering*), employed by TETRAD, for deriving the tetrad equations implied by any acyclic directed graph. The authors argue that TETRAD's algorithm finds only (and all) tetrad equations and vanishing partial correlations strongly implied by an acyclic stochastic linear causal theory. In order to fully appreciate the mathematical foundations of the TETRAD approach, it helps to be familiar with the principles of formal mathematical logic and the language of graph theory, which most users of TETRAD will not be.

The bulk of the book is devoted to the presentation of the TETRAD program, justifying its use, and telling about what it will do. Implementing the program is relatively straightforward, although most readers will neither be familiar with the methods used in the TETRAD program nor their statistical justification. The basic idea behind the TETRAD algorithm is that a given population causal model implies a set of tetrad

equations, which can be compared against a sample covariance or correlation structure, and that one is justified in searching the data to find the range of causal models that provide a better approximation to the sample data. The program itself, intended for use on the PC, is an interactive command-driven program, which can be used with or without a mathematical coprocessor chip. The user of TETRAD begins with a "skeletal" model and a matrix of correlations (covariances), and the program will generate a list of possible causal models that can be estimated with LISREL or EQS and compared with one another, after it has systematically ransacked the implied tetrad equations for all possible pairs of four variables in the model.

The authors of *Discovering* present a strong case for their approach, with all the formal trappings of deductive proof and mathematical/logical formalisms. They also present several examples using other people's data in order to show how their TETRAD program works and how it improves upon what other people have found. There is much to digest here, and I expect that TETRAD will be the focus of attention among causal methodologists for many years to come.

Having been raised in the causal modeling tradition referred to at the beginning of this review, I have never believed that one can develop a casual model by looking at correlational data. *Discovering* has not changed my mind. I remain skeptical that the analysis of a set of correlational data, whether by TETRAD or by some other means, can inform basic questions of causation. In this regard the authors of *Discovering* promise much more than they can ever deliver. I see nothing wrong with using TETRAD to generate testable hypotheses – tested on a new sample or in a different population – but such use needs to be kept in perspective. Whether model revisions represent new "causal structures" or simply the capitalization on sampling errors in the data, if they are not examined on a new sample, they amount to nothing more than "theory trimming," in the sense of looking at one's data after the fact, and reparameterizing the model, in order to give the appearance of a better fit to the data than what one's model actually achieved. Of course, that is not TETRAD's problem. Some analysts will do that anyway, with or without TETRAD, but reference to TETRAD will seem to justify what they have done.

There is no question that the examination of nonexperimental data can lead to theoretical insights about the ordering of the social universe. In this sense the authors of *Discovering* offer an important perspective on the development of causal hypotheses in social science. What is not clear is whether their computer program is the solution. I disagree with their cynicism about human capacities for "intelligent search" and put greater stock in the type of "educated guesses" they disdain. And I doubt that very many major theoretical revolutions will occur through the use of TETRAD. In fact, it may generate as many mistakes of "scientific discovery" as has the human mind, unaided by "heuristic search." Especially so, given the possibility of sampling error and the likelihood that TETRAD will capitalize on chance. But if the grandiose claims of the authors are to be believed – that doing science with TETRAD is superior to doing science without it – one wonders how we have managed to make it this far.

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Jöreskog, K.G. and Sörbom, D. (1986): LISREL – Analysis of Linear Structural Relationships by the Method of Maximum Likelihood. User's Guide, Version VI. National Educational Resources, Chicago.

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Kiefer, J.C., Introduction to Statistical Inference. (Edited by G. Lorden). Springer-Verlag, New York, 1987. ISBN 0-387-96420-7, 3-540-96420-7. viii + 334 pp., DM 98.00.

According to the preface written by the editor Professor Gary Lorden, this book is based on a collection of lecture notes developed by the author for a first course in statistical inference taught at Cornell University. It relies on modest prerequisites of calculus, and probability theory at the level of, say, Woodroofe (1975) or Rohatgi (1984). This would place the intended audience at an advanced junior or senior level at many American universities. The material covered is much more than one can follow in a one semester course and less than what one needs for a year's course. If one begins with six to eight weeks of probability required by this text, it will make a comfortable one year course.

An attractive feature of the book is its simplicity of language and clarity of presentation. The style is often conversational. Most topics are well motivated. Each topic begins with a clear statement of the problem. Discussion is supplemented by a large number of well-chosen examples. Each chapter ends with a generous number of problems sometimes divided into sets corresponding to sections of the chapter.

There are nine chapters and three appendices as outlined below:

1. Introduction to Statistical Inference
2. Specification of a Statistical Problem
3. Classification of Statistical Problems
4. Some Criteria for Choosing a Procedure
   Criteria included here are: Bayes, minimax, randomization, admissibility, unbiasedness, maximum likelihood and substitution principle.
5. Linear Unbiased Estimation
   Topics include: linear unbiased estimation in simple settings, general linear models (least squares), and orthogonalization.
6. Sufficiency
   Meaning of sufficiency, recognizing a sufficient statistic, reconstruction of the sample, "no loss of information," and convex loss.
7. Point Estimation
   Completeness and unbiasedness, information inequality, invariance, computation of minimax procedures, maximum likelihood and asymptotic theory.
8. Hypothesis Testing
   Basic notions, simple vs. composite hypotheses, UMP and unbiased tests, likelihood ratio tests, invariance, and summary of "normal theory" tests.
9. Confidence Intervals

Appendix A. Notation, terminology, and background material.

Appendix B. Conditional probability and expectation, Bayes computations.

Appendix C. Inequalities and some minimization methods.

The book ends with a short list of 15 references most of which are fairly advanced for the intended audience and a relatively short author and subject index.

Chapter 1 sets the tone of the book. "It is unfortunate that the modern approach to statistical inference is generally ignored in elementary textbooks. Books and articles developed in the modern spirit are ordinarily written at a slightly more advanced mathematical level. Nevertheless, it is possible to discuss all of the important ideas of modern statistical inference at an accessible mathematical level, and we shall try to do this" (pp. 2 and 3). It is not quite clear to this reviewer, as to what "modern approach to statistical inference" means. If it means a decision theoretical approach that was considered modern and fashionable twenty years ago, then the author is quite successful. If it means exploratory data analysis, Bayesian methods, robust procedures, and nonparametrics, then one will have to reserve judgement. There is little or nothing here about data analytic techniques or nonparametric statistics. It should be noted that since Chapter 1 gives one example which talks only about guessing at the probability of heads for a given coin, a more appropriate title for the chapter would have

been "Introduction to Parametric Point Estimation."

Chapter 2 begins with a formulation of the statistics problem in a decision theoretic setting. The author introduces basic notions such as decision space, loss function, regret function, decision function, and so on. Discussion is supplemented by several well conceived examples. There are only three problems for the reader to try but each is long and has several parts. However, all are fairly theoretical relating to some well known distributions and none includes applications.

Chapter 3 classifies statistical problems according to the structure of the parameter space, or according to the structure of D, the decision space.

Chapter 4 covers nine sections in about 50 pages. Here the author introduces the usual criteria for choosing a statistical procedure. The discussion of some topics is detailed (for example the Bayes criterion takes fifteen pages with some nice examples) whereas other topics are discussed briefly, with few or no examples. There are, however, nine problems on Bayes and minimax procedures, nine on randomized procedures and admissibility, and eleven on unbiased estimators, mle, method of moments, and computation of minimax procedures. These problems are well selected and should keep the student occupied.

In Chapter 5 the author begins with a discussion of linear unbiased estimation in simple settings and then goes on to discuss the analysis of the general linear model. The problems include several numerical examples.

Chapter 6 is devoted to sufficiency, its meaning, sufficient partitions and minimal sufficiency. For the most part, the discussion is restricted to discrete models. Minimal sufficiency is defined but the usual method for finding a minimal sufficient statistic (partition) appears as a problem. Section 6.2 deals with Neyman factorization. Also included are small sections on reconstructing the sample, sufficiency as "no loss of information," and convex loss functions.

Up to this point one can argue that the author basically covers elements of decision theory at a somewhat lower and more accessible level than texts such as Ferguson (1967) or Berger (1980). The classical theory of inference is contained in the last three chapters which span about half the book.

Chapter 7 dealing with point estimation begins with completeness and unbiasedness. The Lehmann-Scheffé theorem is proved for convex loss functions, although Rao-Blackwellization appears later as Method 2 (p. 161) for obtaining a best unbiased estimator. There is a careful discussion (pp. 164–65) of when a sufficient statistic is complete. Examples are well selected. There is a curious remark on page 167 ". . . in settings where there is no complete sufficient statistic and $\phi(\theta)$ can be estimated without bias, ... There is no uniformly best unbiased estimator in such circumstances . . . ." Section 7.2 deals with the information inequality (referred to as the Cramér-Rao-Fréchet-Darmois inequality). There is a good discussion of why one needs the inequality. Invariance is well motivated in Section 7.3 while in Section 7.4 the author shows how to compute minimax procedures by using the information inequality and by invariance. Unfortunately the discussion is too skimpy and there are no worked out examples. There is a small subsection sketching the idea of the proof of the Hunt-Stein theorem.

The discussion on maximum likelihood estimation in Section 7.5 begins with an unusually long discussion of cases when the mle may not exist. The author devotes much attention to cases when the mle is made to exist by adjoining boundary points to the parameter set Ω.

In Section 7.6 limiting distributions of sample moments and sample quantiles are obtained, some asymptotic optimality properties (such as asymptotic efficiency) are discussed and B.A.N. estimates are introduced. There is a short but readable subsection on the use of inefficient procedures. The selection of problems at the end is as usual good and plentiful but theoretical.

The discussion of hypothesis testing in Chapter 8 begins under a decision theoretic setting. The Neyman-Pearson lemma is proved from a Bayesian perspective. The

discussion is supplemented by good examples. Example 8.2 illustrates the fact "that intuitive arguments about f_1 and f_0, rather than a precise look at their ratio, can lead one astray." UMP tests and unbiased tests are briefly discussed (Section 8.3) and there are small (too small to be meaningful) sections on likelihood ratio tests, finding sample size and invariant tests. Section 8.7 gives a detailed summary of the common normal theory tests (including analysis of variance). The chapter ends with only a handful of problems.

The discussion of confidence intervals in Chapter 9 is supplemented by some well-chosen examples and good diagrams. There is a very brief discussion of Bayes and fiducial intervals. There are an adequate number of problems.

There are three appendices. Appendix B reviews conditional probability and conditional expectation as required in computing Bayes procedures. Appendix C deals with convex functions and some moment inequalities. Several methods of minimization using Lagrange multipliers, or geometric arguments, or arguments using convexity and symmetry, or using Schwarz's inequality are illustrated.

The author succeeds in what he set out to do: to discuss important ideas of statistics (decision theory) at an accessible mathematical level. It is clear from reading the book that it is a collection of lecture notes as pointed out in the preface. One can differ with the author in the selection or complete omission of certain topics. However, there can be no disagreement that there is a lot in this book that the reader will benefit from. The book is filled with well-crafted examples and a large number of challenging problems. The book appears to be error free. It is curious, however, to see a large number of comments concerning unnamed authors of unnamed "standard texts." A sample: ". . . most standard texts discuss '(uniformly) best estimators' (with illustrations) without mentioning the fact that such estimators do not always exist . . ." (p. 159), "Most books discuss only the classical case of squared error, . . ." (p. 161), "A remarkable error in the treatment of this subject can be found in some books." (p. 176), ". . . there are cases in the literature in which statisticians wax mystical over the fact . . ." (p. 206), and so on. Apart from these somewhat distracting comments the book is very well written and, I feel certain, will be around for a long time. It will be a source of examples and challenging problems for students and teachers. Whether it can be used as a textbook will depend much on the instructor's interests and goals.

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Lewis, P.A.W. and Orav, E.J., Simulation Methodology for Statisticians, Operations Analysts, and Engineers, Volume I. Wadsworth & Brooks/Cole Advanced Books & Software, Pacific Grove, CA, 1989. ISBN 0–534–09450–3. xvi + 416 pp., $49.95.

While reading this entertaining text, I was struck by the realization that we do not at present offer a course at Georgia Institute of Technology for which this volume is appropriate although perhaps we should. Historically, simulation methodology has tended to evolve in isolation from statistics and similarly, curricula in statistics have rarely made adequate use of simulation methods in teaching. The present volume provides a

text that conceivably could be used to fill this void.

One handicap I had in reviewing this book was that I did not have access to the Enhanced Simulation and Statistics Package which is intended to be used with the text. The authors have also elected to produce two volumes (I: Incorporating Topics in Crude Simulation and Some Sophisticated Simulation Topics; II: More Sophisticated Simulation Topics.) The chapter headings are useful in conveying the topics covered in Volume I.

1. Definition of Simulation
2. Golden Rules and Principles of Simulation
3. Modeling: Illustrative Examples and Problems
4. Crude (or Straightforward) Simulation and Monte Carlo
5. Uniform Pseudo-Random Variable Generation
6. Descriptions and Quantifications of Univariate Samples: Numerical Summaries
7. Descriptions and Quantifications of Univariate Samples: Graphical Summaries
8. Comparisons in Multifactor Simulations: Graphical and Formal Methods
9. Assessing Variability in Univariate Samples: Sectioning, Jackknifing, and Bootstrapping
10. Bivariate Random Variables: Definitions, Generation, and Graphical Analysis
11. Variance Reduction

The following list of minor points are offered to assist potential readers:

1. In the passage of ships through a mined channel problem of Section 4.3, I would expect that the ships would not behave independently.
2. The exercises at the end of most chapters are frequently labelled as T or C to indicate "theoretical" or "computational." This inference seems to hold in the sample of problems I examined.
3. The GFSR generator that I have recommended to clients and received support from Ripley (1987) is not included.
4. Many sample moment expressions found in my dog-eared Cramér (1946) are now given in this volume.
5. The statistical simulation studies in which I participated never benefited from fast generators. In fact, simple, reliable algorithms have been adequate. Most of the CPU was expanded in processing the samples rather than in generating them.
6. Figure 6.2.5 is in error. An incorrect value of the Cauchy scale parameter is quite apparent here as the advertised 90% content in $(-1.96, 1.96)$ looks more like 65% here.
7. Luc Devroye from McGill University, Montreal, Canada has made numerous innovative contributions to simulation. Throughout the volume his name appears as DeVroye.
8. Personally, I do not find bivariate scatter plots superior to contours of the underlying model. Further printer plot graphics although portable are aesthetically unappealing. Figure 10.1.1 indicates a bimodal bivariate normal density due to resolution problems.
9. Example 6.0.1 offers surprising evidence of a case in which a moment estimate seems superior to an MLE. Further scrutiny of the example indicated boundary problems for the parameter of interest. From the physics standpoint, the interval of interest is $(-1/3, 1/3)$. The simulated examples use values of -0.4 and 0.8.

In summary, it is difficult indeed to criticize a book with no apparent competitors. The book is incredibly free of typos. A fair evaluation would require further consideration of Volume II and the associated computer package.

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Pearce, S.C., Clarke, G.M., Dyke, G.V., and Kempson, R.E., A Manual of Crop Experimentation. Charles Griffin and Company Limited, London, Oxford University Press, New York, 1988. ISBN 0-85264-289-X, 0-19-520631-2. xi + 358 pp., £32.50.

Dyke, G.V., Comparative Experiments with Field Crops. Second Edition. Charles Griffin and Company Limited, London, Oxford University Press, New York, 1988. ISBN 0-85264-282-2, 0-19-520633-9. xiv + 262 pp., £27.50.

The *Manual of Crop Experimentation* was developed as a three-month course taught by the Applied Statistics Research Unit of the University of Kent at Canterbury to scientists in less developed countries who are engaged in agricultural research. Because the intended audience of this book is a mixture of agronomists and biometricians, the material presented emphasizes the applied rather than the mathematical nature of statistics. Even the linear models for the different designs are not given, with the exception of the model for the randomized complete block design which was addressed in explaining additivity. In lieu of mathematical derivations, this book discusses the experiment from the planning stages to the writing of the report. The authors focus their discussion on such design considerations as replication, randomization, the use of local control, the choice of site, the size and shape of the plots, the application of the treatments, and the size of the experiment. All of the usual designs from the completely randomized to triple lattices, and confounding in a 4^k design are covered. Moreover, special topics consisting of systematic designs, fan trials for spacing treatments as well as rotation, intercropping, and long term experiments are discussed.

While the formulas for calculating the sums of squares for the basic designs are given, all of the calculations for these and more complex designs are carried out using the method of "sweeping" and the concepts of "strata." The sweeping method consists of eliminating the effect of the nuisance parameters (e.g., blocks) and then viewing the resulting data, consisting of the effects of treatments and error, as essentially responses in a "completely randomized design within a single stratum." Further sweeping by treatment-means results in the residuals which can be used to calculate the error mean square for testing and to check the assumptions. While the method of sweeping may be very familiar to British statisticians, it is not as well known, or at least not so often used in the United States. A reference in the text to earlier papers on the subject would definitely have been in order. Indeed, a reference is cited in the list of references in the back of the book but one needs to know exactly what one is looking for in order to find it. A big drawback of this book is that there are no references in the text to lead readers to further explanations on particular topics; the references are all found in the back. Nevertheless, it is very difficult for an uninitiated reader to determine exactly which ones are appropriate for the given topics.

The Kuiper-Corsten iteration procedure is illustrated with an example and is recommended for use on non-orthogonal designs which are not balanced. For balanced designs such as the simple lattice, step by step calculation procedures using the method of sweeping are given.

Another drawback to this book is that due to the great number of topics treated, the coverage is of necessity superficial. For example, the Z, t, χ^2, binomial, and Poisson distributions are introduced and confidence intervals and hypothesis testing for one, two, and several means are covered in a

span of only sixteen pages. The F-value is presented for the first time in the analysis of variance table for the randomized complete block design and is described as the variance ratio of treatment and "error" mean squares. However, no mention is made as to where it came from or how it is used. Moreover, since the book is in its first printing it has many mistakes.

In spite of the drawbacks pointed out here the book has much merit. It has many good and realistic problems albeit taken from the literature. Additionally it treats practical considerations which are not usually covered in design texts, such as field labels, precision in calculations, scoring of the plots and harvesting and recording as well as the design considerations and special topics previously mentioned.

I am somewhat puzzled by the intended audience for this book. On the one hand it appears that no prior statistical training is required judging from the level at which the book is written. On the other hand it appears that substantial statistical training is required to get something out of this book due to the superficial nature in which it is written. I believe that this book would be good supplemental reading for statistical students requiring a more mathematical analysis of designed experiments.

The book *Comparative Experiments with Field Crops* is divided into two major sections; one entitled "How to Do and Interpret Field Experiments" and the other "Statistics in Field Experiments." The first section contains virtually everything anybody would want to know about planning and implementing agronomic experiments. It contains explanations on such topics as the choice of design, what area one should harvest, calibration of machinery such as fertilizer distributors, marking out the plots in the field, labeling and weighing the produce, crop-sequence experiments, problems with using percentages, and so on. There are many diagrams throughout this section which depict things such as how to lay down the blocks, where to place the irrigation ditches, how to keep the tractor in the correct rows, where labels should be perforated, etc.

The second section deals with explanations of randomization, degrees of freedom, contrasts, and "error." A geometric interpretation of the analysis of variance and comparisons among treatment means is presented. The use of dummy variables in regression to obtain the analysis of variance for designed experiments is also explained. Other topics covered are transformations, analysis of covariance, residual plots, and the use of Fourier series for accounting for patterns of yield.

I enjoyed reading this book and am thankful to the author for sharing his experience and expertise acquired during his many years as head of the Field Experiments Section at Rothamsted.

Although both of these books were written primarily for agronomists, I believe that these books or similar books should be required reading for students working on statistical degrees, particularly those students who hope to be consulting statisticians. If a statistician is to be a good consultant he or she must be aware of some of the problems which are faced by scientists implementing surveys or experiments. Books of this type go a long way to help statisticians know what to look for and what questions to ask while consulting.

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Young, P., Recursive Estimation and Time-Series Analysis: An Introduction. Springer-Verlag, Berlin, 1984. ISBN 3–540–13677–0, 0–387–13677–0. xiii + 300 pp., DM 86.00.

Recursive estimation of parameters and structures in models for dynamic stochastic systems encompasses a variety of techniques which have been developed initially to treat estimation of time-varying system properties. Recursive estimation can be used as a part of adaptive algorithms, e.g., for detection, prediction, or control, but it also offers

natural possibilities to handle missing data, varying sampling intervals, etc. The computational demands in recursive estimation are usually low compared to those of batch processing. Therefore recursiveness in estimation sometimes is a way of treating large data sets while retaining the asymptotic properties of the corresponding off-line method without loosing too much efficiency. The subject appeared initially in the engineering literature during the 1960s and early 1970s, but is today a well established topic also in statistics.

The current book treats recursive parameter estimation in time-invariant single-input – single-output (SISO) systems and to some extent also time-varying systems are discussed. It reflects the author's own activity and position in the field and is enthusiastically written. The examples that are used take advantage of the control theoretical background of the author, including his considerable activity on hydrological and environmental problems.

The book is intended to provide an elementary introduction to recursive estimation, e.g., for undergraduate or master's students. In the first part, which contains four chapters (2–5), the author discusses recursive regression analysis. He first, at some length and starting on a very elementary level, considers the problem of recursive estimation of a single parameter. This leads in Chapter 3 to an initial study of the least squares algorithm and its connections to stochastic approximation techniques. The development in this chapter considers stochastic approximation as a tool in optimization, hence modern statistical aspects are not treated. He then, in Chapter 4, returns to the recursive least squares algorithm for the general linear regression model. In this chapter the practically important regression problems connected to multicollinearity and structural models with erroneous regressors are treated, and the instrumental variables method is introduced as a vehicle to solve the "errors-in-variables" problem.

The final chapter in this first part of the book discusses estimation of time-varying parameters. Different ad hoc techniques to adapt the algorithm to the time-variations, such as rectangular and exponential windows, or different Gauss-Markov models for the parameters are shown. In a latter part of the chapter fastly varying parameters are treated and it is argued in favour of Gauss-Markov modelling, where also detection algorithms could have been mentioned. The chapter also contains a very short discussion about recursive smoothing.

The second part of the book, which contains 6 chapters, is devoted to recursive time-series analysis. The main topic of this part of the book is the development and analysis of two versions of one possible technique, the Instrumental Variables – Approximate Maximum Likelihood procedure (IVAML).

After studying different difference equation forms for the description of SISO dynamic systems with external input signals in Chapter 6 where the main result concerns the need for alternatives to the least squares method, the author develops the standard IVAML in Chapter 7 and the refined version in Chapter 8. In the IV part of the algorithms, the transfer function relating the external input and the output signal is estimated, and in the AML part, the noise transfer function is computed. The refinements that are used to develop the second version of the IVAML algorithm are derived from a comparison with maximum likelihood technique for a special model structure. Both IVAML techniques demand a filtering operation of the input, output, and noise variables. Since the parameters in the filters are to be estimated, the two algorithms are given as iterative procedures. They can be made recursive using parameter filters and stability checks, but the algorithms that are presented and exemplified are in fact iterative and just partially recursive. In Chapter 9 alternatives to the IVAML method are discussed, the Prediction Error technique partly to illustrate the properties of IVAML. Extended Kalman Filters (EKF) and Maximum Likelihood estimation in state space models are also treated, only EKF being recursive.

Parameter estimation is the dominating subject of the book. It does not treat choice

of model structure, initialization, or model validation; neither frequency methods nor the use of the obtained models for control, supervision, detection, or prediction are mentioned. The material in the book is illustrated with practical applications of the IVAML method, but there is no comparable treatment of alternative techniques and there are no "textbook examples" or exercises, which as a whole make the book less suited for classroom use. A large appendix with basic mathematics, mathematical statistics, and system theory makes it possible to read the book with a minimum of prerequisites.

Taken as a whole, we believe that the main advantage of this book is its thorough exposition of the IVAML technique. More care could have been taken to the treatment of its statistical properties. Many of the references that are given in discussion of these properties are from econometric or control literature and there are very few references to modern statistical literature. This makes the book in this respect somewhat old-fashioned. Hence, the book may be less useful as an introduction for statisticans to the important field of recursive estimation.

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