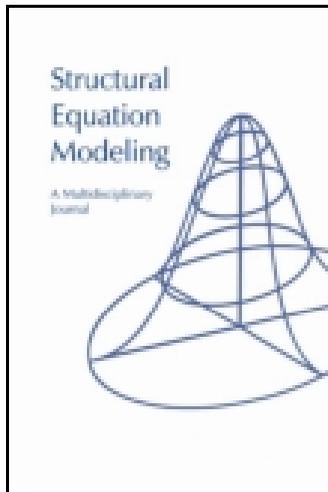


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## Structural Equation Modeling: A Multidisciplinary Journal

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### Analysis of Multivariate Social Science Data (2nd ed.)

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## BOOK REVIEW

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**Analysis of Multivariate Social Science Data** (2nd ed.). David J. Bartholomew, Fiona Steele, Iirini Moustaki, and Jane I. Galbraith. New York, NY: Chapman & Hall/CRC Press, 2008, 384 pages, \$71.95 (softcover).

Reviewed by André A. Rupp and Shauna J. Sweet  
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*Analysis of Multivariate Social Science Data* is written by four well-respected scholars in the social sciences and is designed “to give students and social researchers with limited mathematical and statistical knowledge a basic understanding of some of the main multivariate methods and the knowledge to carry them out” (p. ix). Using practical examples and minimizing the use of formal mathematics, the authors aim to provide practitioners with an accessible common-language introduction to what they consider the most important multivariate methods used in social scientific research.

We reviewed the second edition of this book; for an alternative review of this edition see Mair (2009), and for a review of the first edition see Austin (2003). In this second edition, the authors have maintained the use of practical examples that were cited by reviewers as a clear strength of the book. This has resulted in an emphasis on example-driven interpretation of statistical results that serve to explain, illustrate, and even to compare and contrast the different methods.

The first chapter is designed to orient the reader by providing a brief history of how the book was developed from course notes; it includes detailed explanations of the authors’ non-mathematical approach to instruction, provides a review of basic notation and terminology, and discusses the focal role of examples throughout the book. Each of the subsequent 11 chapters is devoted to exploring a particular analytic method following a progression that the authors describe as moving “from simpler to more complex” (p. x). The first four of these chapters are devoted to methods that the authors collect under the terms *descriptive methods*, *data reduction methods*, and *methods for data summarization*: cluster analysis (Chapter 2), multidimensional scaling (Chapter 3), correspondence analysis (Chapter 4), and principal components analysis (Chapter 5). Simple linear regression, multiple linear regression, logistic regression, and path analysis are all covered in Chapter 6 (new to this edition), which serves as a pivotal transitional chapter between the first and second main sections of the book. In these later chapters,

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the authors present methods that they collect under the terms *inferential methods*, *model-based methods*, and *method for data generalization*: exploratory factor analysis for continuous response variables (Chapter 7), exploratory factor analysis for dichotomous response variables (Chapter 8), exploratory factor analysis for polytomous response variables (Chapter 9), latent class analysis (Chapter 10), confirmatory factor analysis and structural equation models for continuous response variables (Chapter 11; new to this edition), and multilevel modeling (Chapter 12; new to this edition). The book has an accompanying Web site with supplementary materials at [www.cmm.bristol.ac.uk/team/amssd.shtml](http://www.cmm.bristol.ac.uk/team/amssd.shtml), which currently includes sample SPSS syntax for Chapters 1 through 7, software and input files for Chapters 8 through 11, LISREL syntax for Chapter 11, and MLwiN instructions for Chapter 12.

### STRATEGY FOR REVIEW

The authors recommend that “there are many cross linkages between different parts of the book and to gain the full benefit, the development should be followed from beginning to end” (p. x). In other words, they encourage a linear use of the book typical of textbooks for a multivariate data analysis course, rather than a nonlinear use typical of reference handbooks. During our reading we found that many of the facets of the book that we considered noteworthy were common across multiple chapters, however, so we decided to structure our review according to key themes, rather than on a chapter-by-chapter basis.

In line with the authors’ stated goals we asked whether or not the book provides students and applied researchers with the practical tools and level of conceptual understanding that is required to responsibly select appropriate analytic methods, to conduct those analyses as needed, and to provide a meaningful interpretation of the results. We kept in mind that the authors specified their targeted audience on the Web site as graduate and advanced undergraduate students, researchers, and practitioners of statistics and the social sciences.

Specifically, we first consider the content of the book and the authors’ selection of what they view as “some of the main multivariate methods” (p. ix) relevant to practicing social scientists. Although the authors need not be comprehensive in their treatment, we examine how well they represent and promote an understanding of the complexity of the modeling and decision-making space. We also turn our attention to whether or not the authors present the information they selected such that it is accessible to readers who will range widely in professional interest and also in level of statistical training. Lastly, given that “examples are a key feature of this book and they play a central role in . . . exposition” (p. 11), we ask whether the examples are designed such that they foster an understanding of the methods and their application, whether the authors provide sufficient guidance for the interpretation of results for sample analyses, whether the examples help to establish connections across methods, and whether the examples effectively “counter the idea, common among students, that there is one and only one ‘correct’ method for any given problem” (p. 12).

### CONTENT COVERAGE

There are currently several books on the market that are designed to provide a practical

introduction to multivariate statistical methods for researchers in the social and behavioral sciences (e.g., Hair, Black, Babin, & Anderson, 2009; Lattin, Carroll, & Green, 2003; Manly, 2005; Tabachnick & Fidell, 2006; Warner, 2008). Among these, *Analysis of Multivariate Social Science Data* is somewhat of an outlier in terms of the methods that the authors cover.

The book is characterized by a heavy latent-variable focus, which makes sense given the expertise of the distinguished scholars who wrote it. This results, however, in an omission of factorial and multivariate analysis of variance methods, as well as approaches for discriminant function analysis common to many other textbooks. Moreover, *Analysis of Multivariate Social Science Data* is one of the few books on the market that includes a detailed discussion of correspondence analysis. Given this unique angle, it would be helpful for readers to be guided more strongly toward an understanding of the kind of “snapshot” of the methodological space that is provided by the book.

Given this heavy latent-variable focus, it also seems legitimate to ask whether the didactic presentation in this book is superior to other specialized books that are targeted at the same readership such as Brown (2006) and Kline (2010) for factor-analytic and structural equation methods or de Ayala (2009) for item response theory methods. Overall, in contrast to the exclusively positive reviews cited earlier, we found that the results are mixed.

Our main criticism can be cast in terms of a lack of consistency and coherence in presentation across, and sometimes within, chapters in the book. Specifically, looking across all chapters, there are certain key areas for statistical reasoning that are inconsistently addressed:

1. The assumptions that methods rely on for proper application and inference.
2. The robustness of different computational methods to different optimization criteria, starting points, and related aspects that influence any given solution.
3. The robustness of different latent-variable estimation methods to violations of model assumptions, sample sizes for items and respondents, and related aspects that influence parameter estimates and inference.
4. The assessment of the degree of model-data fit at different levels, including absolute, relative, item, and person fit.
5. The use of standard errors, hypothesis tests, and confidence intervals for statistical inference.
6. The use of effect sizes for gauging practical significance.
7. The ability of methods to deal with data missing by design or at random.

For example, Chapter 6 contains an explicit section on assumptions for simple linear regression analysis, but summary tables for these assumptions, systematic descriptions of the effects of assumption violations on inference, or guidance for the use of graphical displays (see, e.g., Lomax, 2007) are lacking in this and other chapters. Similarly, the chapters on latent-variable models all contain some discussion of goodness of fit, but key differences among relative and absolute model fit, item fit, and person fit are rarely explicitly elaborated on. For instance, Chapters 7 and 8 contain only one sentence on relative fit assessment via information indexes (pp. 188, 222) and Chapters 8 and 9 contain no extended discussion of item and person fit indexes from an item response theory perspective. We also found that the authors rarely made a concerted effort to link the choice of candidate analytic methods, fit assessment, and parameter

interpretations to the research questions and research design that were used for data generation (e.g., Lomax, 2007; see Shadish, Cook, & Campbell, 2001).

## GENERAL PRESENTATION

As noted at the beginning, the authors organized the book into two sections comprised of computational and model-based methods, which is certainly defensible. Yet in the introductory chapter the authors also discuss this organization as one reflecting a distinction between data summarization and data generalization, which suggests the chapters are meant to distinguish between descriptive and inferential statistical methods at some level of definitional grain size. This alternate framing could confuse or possibly mislead a reader who might not understand that various descriptive statistics and displays play a key role for computational and model-based methods alike and that inferential facets of analysis (e.g., hypothesis tests and confidence intervals) coexist next to descriptive facets (e.g., point estimates for model parameters) for model-based methods. We found that the authors could make these key ideas of evidence-based reasoning clearer throughout all chapters when they discuss their examples and accompanying interpretations.

With regard to the technical complexity of their presentation, the authors note that “very little mathematical skill is needed to grasp the main ideas behind the methods or to use them intelligently . . . but for those who are ill at ease with any kind of mathematics . . . the effort to become, at least, familiar with the language will be amply repaid” (p. 4). To this end, most textbooks and handbooks that are currently available on the market devote the first one or two chapters to orienting the reader through the definition of key terms, review of mathematical notation, and formal introduction to core ideas such as statistical significance and hypothesis testing (e.g., Lattin et al., 2003; Manly, 2005). This is not done with the same level of care here. The first chapter provides a very spotty review of some terms, some formulas, and some key ideas without any clear rationale on why these particular ones were chosen and others were omitted. Instead, a list of references at the end of the first chapter is provided for “readers who wish to refresh their knowledge of elementary statistics” (p. 14), which puts great responsibility for self-learning on a relatively untrained reader who is just beginning to learn about multivariate methods.

We would further argue that simply minimizing the use of mathematics does not guarantee an effective understanding of the material covered in this book. In fact, the authors themselves warn “that ‘non-mathematical’ does not mean the same as ‘easy’ in this context. The fundamental ideas remain the same whether we express them mathematically or in words” (p. 8). Unfortunately, although this might be true abstractly, we found that they do little to establish a common language or notation and that the nature and amount of mathematics differs quite a bit across chapters. Most chapters contain, indeed, only few simple mathematical equations, but it is not always clear for what model components or statistics those equations are provided. Moreover, there are instances of algebraic equations that can be solved by “those who enjoy algebra” (p. 174) and “model specifications using matrices” (p. 307) at a level of complexity that seems out of place. Again, none of these components of the book is a poor choice per se, but we felt that more consistency across chapters would improve the didactic accessibility of the book.

The authors did use regression analysis as a framework for presenting various observed- and latent-variable models, which is clearly an informed choice. Surprisingly, however, the authors never explicitly frame their descriptions of models in terms of important model families like general linear models, generalized linear models, or generalized linear and latent mixed models (e.g., Skrondal & Rabe-Hesketh, 2004) even though they point to appropriate references. In our view, this could be done at least conceptually without an overly heavy notational burden and would help to create a more unifying framework for the model space.

A clear strength of this book is that it is grounded in the first author's extensive experience teaching multivariate methods to graduate students in the social sciences. There are still some areas, however, where students' understanding of the content could benefit from additional structure, including stronger transitions between sections, advance organizers, and coherent summary displays such as tables or flowcharts. For example, later chapters often refer back to previous chapters when discussing the context of an example without an exact page reference or a short summary of the context as a reminder. Many chapters also cover a lot of ground, but descriptions are sometimes incomplete due to space limitations. In a few cases, statements are also dated, especially when reasoning seems to rely on computational arguments. For example, in Chapter 2 on cluster analysis the authors state that nonhierarchical methods "are more difficult to carry out and are less commonly used" (p. 20) even though *K*-means cluster analysis is clearly an extremely popular nonhierarchical method nowadays (e.g., Steinley, 2006).

Despite these criticisms, however, we found that both the general writing and organization of the chapters on latent-variable methods are clearer, better structured, and didactically more effective than the writing of the chapters on the computational methods, which could be a direct result of the authors' expertise in this area. Thus, for the third edition, it might be advantageous to update all chapters and streamline the presentation of the chapters on computational methods and regression analyses with the presentation in the chapters on latent-variable models. Alternatively, we could also see omitting the first few methods chapters completely and making this explicitly into a book on latent-variable modeling for the social and behavioral sciences where more space is available to present the key components of each model in more detail.

### USE OF REAL-LIFE EXAMPLES

The authors highlight the use of worked examples for this book, which notably stem almost exclusively from research contexts in Europe and the United Kingdom that the authors "have worked with or with which [they] have been associated" (p. x). We found that the examples varied quite a bit in terms of their recency and appeal for a prototypical social science researcher. For example, the authors use features of carvings of Persian archers in bas relief for a cluster analysis (pp. 41–46), employment data in Europe from 1979 for a principal components analysis (pp. 129–134), and standardized assessment data from 1963 and 1965 (pp. 312–316) to estimate a structural equation model. It is clearly not absolutely necessary to have exclusively recent and more prototypical examples, but it would probably strengthen the appeal of the book and the accessibility of the methods presented.

Visually, the authors sometimes use figures alongside tables and text effectively to show different representations of the same analysis. At other times, however, the reader is made to

struggle through graphical representations of data that are less adequate and informative and, in some cases, even described explicitly by the authors as such. For example, working through a cluster analysis example in Chapter 2, the authors provide several graphical representations of the data and an agglomerative clustering process, including an icicle plot and multiple dendrograms. Unfortunately, they state several pages later that “the clustering in this example is too ill-defined to give a clear idea how such a dendrogram might help us to choose a set of clusters” (p. 26) and that “the numbers involved here are too small to demonstrate adequately the usefulness of the icicle plot, and we simply use this example to show how the figure is constructed” (p. 28).

Thus, the authors occasionally undermine the legitimacy of their own analyses because examples are sometimes presented with the caveat that they are incomplete, insufficient, or otherwise unsuccessful demonstrations of the methods they are meant to illustrate. For example, in Chapter 2 they state at one point that “we shall analyse the same set of data in Chapter 3 using multidimensional scaling which, in retrospect, will turn out to be more informative.” (p. 35). The naive reader might take this to conclude that a haphazard approach to data analysis is justifiable where the use of any given method can be defended based on the fact that it produces some interpretable results in a sample, rather than because it was carefully selected to match particular research questions or data collection designs. We would recommend making such linkages more explicit and expressing them more carefully in the next edition of the book.

Moreover, to be fair, the use of worked examples is quite common across applied multivariate textbooks. We generally support the use of examples that show the “messiness” of data in real-life applications in line with the authors’ intentions. Yet, we did not find their use of multiple examples effective throughout the book, largely because different examples typically illustrated isolated aspects of an application of a particular method resulting in an incoherent picture for the reader. Such instances include the example for section 6.13, which illustrates only the interpretation of basic parameters of a path analysis model; the first example of section 6.14, which focuses on inferences and variable selection for a multiple linear regression model that reads like a sample question for a homework assignment; the second example of section 6.13, which discusses potential violations of model assumptions and introduces analysis of covariance in passing; and the third example of section 6.13, which uses a logistic regression model with transformed predictors that introduces new nuances in parameter interpretation. We would recommend creating dedicated sections with sample problems and solutions for the end of each chapter and using fewer examples in a more complete fashion within the main text of each chapter.

There are a number of applied textbooks on methods for multivariate data analysis that successfully unify diverse approaches and incorporate examples that are current, appropriately complex, and powerfully illustrative (e.g., Agresti, 2007; Lattin et al., 2003); some textbooks even use a single data set consistently throughout the book (e.g., Hair et al., 2009). In addition, most textbooks and practical handbooks align themselves with one or more statistical packages (e.g., SAS, SPSS, R) and provide step-by-step program-specific instructions alongside theoretical discussions. *Analysis of Multivariate Social Science Data* is an exception to this; no particular software is mentioned in discussions of descriptive methods. This deficiency in the book is compensated for with the accompanying Web site, however, and we would encourage the authors to update the text to integrate input syntax and output file segments into their next edition to provide more guidance to the reader.

## CONCLUSION

The authors state at the outset that *Analysis of Multivariate Social Science Data* “aims to give students and social researchers with limited mathematical and statistical knowledge a basic understanding of some of the main multivariate methods and the knowledge to carry them out” (p. ix). Ultimately, we found that the authors could have done more to engender a sense of responsibility for the many choices analysts make when they apply multivariate statistical methods to data. Statements like “finally, note that the choice of the number of factors depends on statistical criteria or rules that might not be clearly defined or valid” (p. 289), in the absence of further elaboration, will almost certainly lead to confusion for readers.

The authors state in the introduction that “we have not thought it desirable to burden the reader with many of the practical issues on which good applied research depends” (p. 13). It seems to us, however, that imposing *some* burden would be advisable for the third edition of this book because one of the objectives of a good textbook should be to encourage thoughtful, efficacious, and responsible decision making for data analysis independent of the level of background knowledge of the reader. We are sure that the authors have this intention in mind and have laid the necessary foundations for doing so; yet, we found that several key opportunities for additional improvement remain.

In short, although not wholly unsuccessful as an advanced undergraduate or lower level graduate textbook, it is not entirely clear what aspects of the authors’ treatment would warrant its selection for a course over other textbooks that are available on the market. The emphasis on latent-variable models comes to mind as a selection criterion, but the incomplete and, at times, seemingly unsystematic treatment of computational methods coupled with the didactic shortcomings discussed in this review make this book less attractive to us than some other textbooks currently available. Thus, unfortunately, we do not feel that we can unconditionally recommend this edition of the book as either a textbook or a manual for best practices for social scientists as other reviewers have done.

Nevertheless, we clearly support many of the cited intentions of the authors, we greatly respect the body of scholarly work that provides the foundation of this edition of the book, and we certainly appreciate the dedication that has gone into the creation of this book. Given the current state of the supplementary Web site and the positive components of the current second edition of this book, we are certain that the book can be strengthened in a third edition. We hope that some of our comments prove helpful in this regard and are looking forward to reviewing a future edition.

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