and distribution centers. In many cases, the locations must be selected to minimize travel time. In other cases, such as deciding where to locate a garbage dump or nuclear power plant, the aim is to maximize distance from the public. LT models are heuristic and capitalize on distance theory and its associated algorithms. Examples are provided that illustrate how LT can solve a variety of problems under multiple constraints. Extensive references are provided as are helpful examples of how to solve simple location problems using EXCEL.

Data envelopment analysis involves the analysis of the ratio of organizational outputs to inputs. This chapter describes data envelopment analysis as a nonparametric procedure designed to assess the performance of units (e.g., companies or individual stores) that use multiple inputs to produce multiple outputs. Units can be evaluated with respect to the average unit, "peer" units, or other criteria. The analyses are complex, and being unfamiliar with this area, I found the numerous equations hard to follow. However, the author provides several graphs, tables, and examples to illustrate the utility of data envelopment analysis and contrasts the method with multiple regression. Readers interested in evaluating particular units within a larger system with respect to their relative efficiency would benefit from reading this chapter.

The heuristic search chapter describes several methods used to provide practical and understandable solutions to optimization problems. The chapter focuses on (a) constructive-based heuristics, (b) simulated annealing, (c) tabu search, and (d) genetic algorithms. The author provides excellent rationale for using heuristic models and does a good job in illustrating their utility. Although these procedures are not model based, they provide useful solutions by exploiting the advantages of today's computing capabilities. Much attention is given to the problem of avoiding local minima (suboptimal solutions), and the tabu search algorithm seems particularly applicable in this regard. The simulated annealing and tabu search descriptions were especially compelling, as their generality to other areas was evident. This chapter is recommended reading for those working on optimization problems in many areas, including scaling and test construction.

Although the topics covered in this book are extensive, I was disappointed that discussions of multidimensional scaling and cluster analysis were omitted. I realize it is not possible to include all modern methods in a single volume; however, these procedures are widely used in business research and would fit nicely with the other chapters.

In summary, *Modern Methods for Business Research* is an extremely comprehensive text that describes many of the important new developments in applied research. Although many of the topics are technical, each chapter stresses conceptual understanding and includes helpful examples. Nevertheless, this book is not for novice researchers. I recommend this book for those who wish to stay abreast of the most provocative and practical developments in research methods for business and the social sciences.

STRUCTURAL EQUATION MODELING, 7(3), 489–495

Principles and Practice of Structural Equation Modeling. Rex B. Kline. New York: The Guilford Press, 1998, 354 pages.

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Up until a few years ago, outside of Schumacker and Lomax (1996), there was a paucity of texts that were suitable for gingerly introducing the graduate student to structural equation modeling (SEM). Even though Hayduk (1987) and Bollen (1989) were both excellent in their comprehensive review of SEM, for the student who was being introduced to covariance modeling for their first time, and especially if SEM was being instructed as part of a semester length multivariate statistics course, their texts were a bit difficult to digest given the temporal and pedagogical constraints. However, recently there has been a flourish of introductory texts (e.g., Byrne, 1998; Kelloway, 1998; Maruyama, 1997) that may prove to be appropriate as introductory windows into SEM. One recent addition is *Principles and Practice of Structural Equation Modeling* authored by Rex Kline. Kline makes clear in his preface that "although this book is written for applied researchers and not statisticians and assumes only familiarity with very basic statistical concepts ... complex topics are not avoided" (p. ix). Hence, even though there may be passages in this text that the seasoned modeler could readily bypass, there is enough substantive material that will intrigue both novice and expert.

In his introductory chapter, Kline assures the reader that advanced quantitative skills will not be needed for this text, even though a background in elementary statistics (e.g., correlation) will be fruitful. An egalitarian approach is employed in the notation, hence, not favoring any one particular software (e.g., Greek subscripts for LISREL). Besides briefly delineating the outline of the text, the bulk of this chapter covers some very general principles (e.g., SEM can be applied to nonexperimental and experimental data, the SEM family also includes many standard statistical procedures, and so forth). Even though one of the principles, "SEM is a large-sample technique" (p. 12), has generally been the normative guideline, a text that has since been released—*Statistical Strategies for Small Sample Research* (Hoyle, 1999)—may have others give some pause to small sample issues and is a useful citation for Kline's subsequent edition of this text.

Chapter 2 ("Basic Statistical Concepts") reviews some of the fundamental statistical topics associated with the correlational or regression approach. For the sea-

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soned modeler, this chapter can readily be skipped even though there are some sections (e.g., Factors that Affect the Magnitudes of Correlations and The Problem of Omitted Variables) that will certainly engage the experienced reader. Areas reviewed include level of measurement, standardized and unstandardized variables, bivariate correlation, partial correlation, and regression as well as the attendant statistical assumptions. In the section titled Factors that Affect the Magnitudes of Correlations, Kline does a nice job of detailing the differences between linear and nonlinear effects (the latter encompassing both curvilinear and interactive relations) and the analytical implications for the modeler. Kline's discussion on the ramifications of omitted variables and the impact on model specification, even though presented in a regression context, serves as a nice precursor to subsequent chapters that cover model development. Kline also provides a necessary warning about the use of significance testing in a SEM context—many SEM studies have large enough sample sizes that many (if not all) of the parameter estimates may result in a reject-the-null decision. However, in the spirit of the lively discussions that have been reinvigorated by Cohen's (1994) article on significance testing, the researcher is cautioned not to rely solely on significance testing as being the barometer of model fit.

Chapter 3 (SEM Family Tree) illustrates the graphical methods used to generate model diagrams. As a precursor to a fuller exposition on each of the major techniques (i.e., path analysis, confirmatory factor analysis [CFA], hybrid models), the process of model diagramming is applied to each of the primary techniques with examples of the syntax from three separate software applications (i.e., AMOS, EQS, SIMPLIS language from LISREL). Kline describes the hybrid model as consisting of "a structural component (like a path model) and a measurement component (like a factor model)" (p. 61). Hence, what Kline describes as the hybrid model other researchers may call the structural model. Again, instead of using the Greek notation that is inextricably linked with LISREL, Kline uses a more generic nomenclature (e.g., E for measurement error instead of θ).

The following chapter, Data Preparation and Screening, serves as a rudimentary reminder for those who are relatively savvy about scrutinizing their data for outliers, nonnormality, and missing data. However, it is still a chapter worth perusing for even the most experienced of modelers. Kline discusses the various types of input data sets that can be employed in SEM, with the emphasis being on covariance matrices. The attendant implications of missing data, the various kinds of missing data (e.g., missing at random, nonignorable, missing completely at random), and the various strategies available to the user (e.g., listwise deletion, pairwise deletion, imputation) are discussed in sufficient detail. Given the necessary brevity devoted to this subject area, maximum likelihood (ML) approaches to missing data are not reviewed. Hence, Roth's (1994) article, which is cited in this chapter, is recommended reading for those interested in a cogent summary regarding the efficacy of various missing data strategies (e.g., mean substitution, regression imputation, ML, expectation maximization). Multicollinearity, normality, transformations, and outli

are other assumptive domains covered in this chapter. Especially relevant
univariate and multivariate normality is the investigation of kurtosis and skewne
It is necessary to keep in mind that in the context of kurtosis, DeCarlo's (1997) arti
(which I highly recommend) makes clear that positive kurtotic distributions
heavy tailed whereas negative kurtosis implies a light-tailed distribution. This i
point that is frequently misconstrued and merits mentioning.

Chapters 5 and 6 encompass both recursive and nonrecursive path models.
Chapter 5, the tenets of ascribing causality are initially reviewed as a precursor t
fuller exposition on the specification of path models. Model development a
measurement issues are briefly delineated, even though for the novice modeler it
imperative that they access the psychometric literature (e.g., Nunnally
Bernstein, 1994) to develop the requisite knowledge base in this area. Instructo
using this text will be pleased with Kline's treatment of identification. Ev
though Bollen (1989) provided a coverage of this subject matter that is exemplar
Kline provides a very intelligible review of identification, a subject area that c
be relatively complex. Sample size issues are discussed in a subsequent secti
with the oft-cited recommendation that there be at least a 10:1 ratio of participar
to parameters. Even though published after Kline's book went to press, this samp
size convention has come under some scrutiny, with some rather counterintuiti
findings by Marsh, Hau, Balla, and Grayson (1998). Estimation and interpretati
of a path model in a regression context and the decomposed effects, using a samp
data set, is discussed in detail. This segues into a nontechnical description of M
estimation and the attendant assumptions when employing ML. The various typ
of fit indexes (e.g., incremental fit indexes) are described, with a necessary elab
ration on the caveats associated with interpretation as well as what constitutes
good fit. With the plethora of fit indexes now available in most of the software a
plications, it is not the exception that in many modeling efforts there is bound to
at least one fit index (e.g., Goodness-of-Fit Index) that may be indicative of one
model fitting the data. Hence, in that context it was encouraging that Kline emph
sized that "model fit is a multifaceted concept" (p. 131) and sole reliance on on
one type of fit index is problematic. Testing path models, model trimming, and
nice discussion of equivalent models follows, with the chapter on recursive mode
finishing up with a brief review of alternative estimation procedures (e.g., genera
ized least squares, unweighted least squares, and so forth). Kline's comment th
unweighted least squares and generalized least squares may be advantageous ov
ML in that they require "less computation time and presumably less comput
memory" (p. 144) probably should not be a crucial determinant in the selection
estimation procedures given the relative acceleration in the quality and speed
present-day computers. Rather, statistical or theoretical considerations should
the driving force (a recent article by Olsson, Troye, & Howell [1999] further co
tributes to the ML vs. GLS literature).

At first blush, it seemed that an entire chapter in an introductory text devoted to nonrecursive models (chapter 6) was a bit excessive. However, this is one chapter that many SEM users will find most profitable, especially the extended discussion on rank and order conditions. Given the unique problems and issues encountered with identification for nonrecursive models, this may prove to be a rather complex chapter for the novice. Hence, in an introductory course, especially if there are severe time constraints (e.g., SEM as part of a multivariate course), this chapter could potentially be deferred. I also found the excerpt at the end of the chapter Multiple Group Path Analysis to be a bit out of place, with the feeling that it might better fit elsewhere in the text (e.g., the chapter on advanced techniques).

The following chapter is a lengthy exposition regarding Measurement Models and Confirmatory Factor Analysis. Kline starts off the chapter with a brief treatise about the conceptual nature of latent variables with an especially engaging explication about the dangers of reification, that is, "that the latent construct must correspond to a real thing" (p. 191) and other logical errors. A general discourse on reliability and validity follows, much of which will be familiar to those versed in the foundation of psychometrics (e.g., correction for attenuation, types of validity, and so forth). Specification of CFA models is discussed next, including a brief review of measurement error and alternative methods used toward modeling correlated errors. An extended discussion follows regarding requirements for the identification of CFA models, including an elaboration of the pros and cons for two methods of scaling: (a) fix the variance of a factor to equal a constant, and (b) fix the loading of one indicator per factor to equal 1.0. Kline comments on the potential arbitrariness of the latter option when each of the indicators has equal reliability. However, it is the exception that equal reliability ensues; hence, the oft-cited recommendation is that scaling be based on the most reliable indicator.

Other issues germane to scaling and identification are discussed with the observation being that "if a standard CFA model with a single factor has at least three indicators, then the model is identified. If a standard model with two or more factors has at least two indicators per factor, then the model is identified" (p. 205). Even though that description is mathematically veridical, there have been many discussions in SEMNET, part and parcel based on a chapter by Hayduk (1996), challenging the requirement for multiple indicators in the context of the one-step versus two-step modeling process. Estimation methods and the implications for nonnormality are given a nice treatment. A variety of CFA models are presented next, including single factor and multifactor models, equivalent models, multiple-group CFA, and so on. Kline provides the necessary statistics and data set for each of the CFA examples; hence, this could lead to an appropriate homework assignment if this text is used in a classroom environment. The chapter finishes with a brief but essential review of models with ordinal or categorical indicators. Within this section, readers who are intrigued by Kline's reference to item response theory as an alternative to CFA may also be interested in a recent article by

Reise and Widaman (1999) that explored "similarities and differences in person-fit assessment under item response theory (IRT) and covariance structure analysis (CSA) measurement models" (p. 3).

Chapter 8 brings together the measurement and structural models, with Kline coining the term *hybrid model* to describe this synthesis of model testing. Much of the beginning of this review is patterned after the CFA chapter, including model characteristics and issues related to model identification. For the purpose of identification and testing strategy, Kline also delineates the two-step rule (measurement then structural model), which has been an accepted practice in the testing of hybrid models. However, and as mentioned earlier, Hayduk's (1996) chapter on one-step vs. two-step modeling (which generated much discussion on SEMNET) provides an option that argues against the sole reliance on the two-step process. A detailed example of the two-step process is provided using a clinical example (i.e., familial risk for psychopathology and child adjustment). The results of alternative specifications (e.g., three-factor vs. four-factor CFA model) are also contrasted and discussed in sufficient detail. A brief description of a two-wave longitudinal model follows, which for some introductory texts might be included in a chapter of advanced topics.

As with any statistical tool, whether it be a simple 2×2 contingency analysis (χ^2) or a more advanced modeling endeavor (e.g., SEM, hierarchical linear modeling), an understanding of the fundamental assumptions and properties of the technique at hand is imperative. As the researcher pursues methods requiring higher levels of sophistication, such as SEM, then even more background knowledge is necessitated. Hence, Chapter 9 (How to Fool Yourself with SEM) will provide for the introductory student a much relied-on checklist of pitfalls, cautions, and do's and don'ts. This set of guidelines is demarcated by four major topics: specification (e.g., fail to have sufficient numbers of indicators of latent variables, add disturbance or measurement error correlations without substantive reason); data (e.g., fail to examine distributional characteristics, assume that all relations are linear without checking); analysis and respecification (e.g., respecify a model based entirely on statistical criteria, estimate a very complex model with a small sample); and interpretation (e.g., interpret good fit as meaning that the model is proved, fail to consider [nonequivalent] alternative models). As with any checklist, issue can be taken with some of the guidelines (e.g., recent results in the area of small sample research that may be at odds with normative practice). However, Kline has done a most serviceable job in providing a cautionary template for the budding modeler.

Chapter 10 provides an overview of more advanced techniques with the discussion starting off with the subject of nonlinear (curvilinear and interactive) effects. A small data set illustrating the modeling of linear and interactive effects in a regression context is presented, with an ensuing encapsulation of this method employing latent variables. For those desiring a more comprehensive introduction to interactive and nonlinear effects, recent texts by Schumacker and Marcoulides

(1998) and Jaccard and Wan (1996) will serve as apt references. Another topic that is covered in this chapter that has become of some interest to the general user of SEM is latent categorical variables. Parallels that latent analysis holds with item response theory is delineated; it is worth mentioning again that, within this vein, the interested reader should peruse Reise and Widaman (1999). Even though others may differ, categorical analysis within an SEM context becomes more intelligible (or at least less inscrutable) when a fundamental understanding of logistic, logit, and loglinear analysis is achieved. Analysis of mean structures is reviewed next, with analysis of a small data set provided initially via regression. The gist of this tutorial is to illuminate the differences when an intercept is included versus omitted from a model, as well as the effects of including a constant. Those who are facile with dummy or effects coding, and the process of extracting means from the regression equation, will find the treatment of mean structures in a regression context to be on familiar ground. Examples of mean structures for both path analysis and the measurement model are provided (for an interesting extension of mean structure analysis, even if the mean structures may not be of primary interest, see Yung and Bentler, 1999). Other areas briefly detailed in this chapter include analysis of incomplete data, latent growth models, power analysis, and bootstrapping, all topics that have become of burgeoning interest to the SEM community.

The final chapter compares and contrasts the following software applications: AMOS, EQS, and LISREL. Descriptions of the features associated with each of the software are detailed as well as examples of syntax. However, as Kline makes clear, there are bound to be future iterations of the reviewed software (since publication of the text) with evolving functionality; hence the user is encouraged to contact the manufacturer for information on any updates or upgrades. The only contention I have with this chapter (with the understanding that these three packages do not encompass all the existing SEM packages) is Klines' presentation of LISREL in SIMPLIS code without an accompanying example of LISREL syntax. Even though he provides a just rationale for this omission, based in part on the learning curve necessitated for the matrix algebra associated with LISREL syntax, a cursory glance at SEMNET finds discussion of matrices such as phi (ϕ) or gamma (Γ) still a frequent reference point, so at least a brief review of each of the matrices might have been fruitful.

As the usage of SEM experiences exponential growth and becomes a staple in many graduate programs (either as a stand-alone class or as a segment of a multivariate course), the need for introductory texts, each with their own flavor and emphasis, will be a desired commodity. Kline has done an excellent job in adding to this library. The text is sufficiently comprehensive that it could serve as the primary text for a semester course, and at the same time, if the presentation of SEM is part of a multivariate course, the judicious instructor could select excerpts that will provide a suitable foundation. Furthermore, even without the benefit of an academic environment, the book is written clearly enough that the interested reader can readily absorb the material on his or her own initiative.

REFERENCES

Bollen, K. (1989). *Structural equations with latent variables.* New York: Wiley.

Byrne, B. (1998). *Structural equation modeling with LISREL, PRELIS, and SIMPLIS.* Mahwah: NJ: Lawrence Erlbaum Associates, Inc.

Cohen J. (1994). The earth is round ($p < .05$). *American Psychologist, 49,* 997–1003.

DeCarlo, L.T. (1997). On the meaning and use of kurtosis. *Psychological Methods, 2,* 292–307.

Hayduk (1987). *Structural equation modeling with LISREL: Essentials and advances.* Baltimore, MD: Johns Hopkins University Press.

Hayduk (1996). *LISREL issues, debates, and strategies.* Baltimore, MD: Johns Hopkins University Press.

Hoyle, R. H. (Ed.). (1999). *Statistical strategies for small sample research.* Thousand Oaks, CA: Sage.

Jaccard, J., & Wan, C. K. (1996). *LISREL approaches to interaction effects in multiple regression.* Thousand Oaks, CA: Sage.

Kelloway, E. K. (1998). *Using LISREL for structural equation modeling.* Thousands Oaks, CA: Sage.

Marsh, H. W., Hau, K., Balla, J. R., & Grayson, D. (1998). Is more ever too much? The number of indicators per factor in confirmatory factor analysis. *Multivariate Behavioral Research, 33,* 181–220.

Maruyama, G. M. (1997). *Basics of structural equation modeling.* Thousands Oak, CA: Sage.

Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric theory* (3rd ed.). New York: McGraw-Hill.

Olsson, U. H., Troye, S. V., & Howell, R. D. (1999). Theoretic fit and empirical fit: The performance of maximum likelihood versus generalized least squares estimation in structural equation models. *Multivariate Behavioral Research, 34,* 31–58.

Reise, S. P., & Widaman, K. F. (1999). Assessing the fit of measurement models at the individual level: A comparison of item response theory and covariance structure approaches. *Psychological Methods, 4,* 3–21.

Roth, P. L. (1994). Missing data: A conceptual review for applied psychologists. *Personnel Psychology, 47,* 537– 559.

Schumacker, R. E., & Lomax, R. G. (1996). *A beginner's guide to structural equation modeling.* Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Schumacker, R. E., & Marcoulides, G. A. (Eds.). (1998). *Interaction and nonlinear effects in structural equation modeling.* Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Yung, Y. F., & Bentler, P. M. (1999). On added information for ML factor analysis with mean and covariance structures. *Journal of Educational and Behavioral Statistics, 24,* 1–20.