Introduction

It is an honor to present the fourth edition of this book. Like the previous editions, this one introduces structural equation modeling (SEM) in a clear, accessible way for readers without strong quantitative backgrounds. New examples of the application of SEM are included in this edition, and all the examples cover a wide range of disciplines, including education, psychometrics, human resources, and psychology, among others. Some examples were selected owing to technical problems in the analysis, but such examples give a context for discussing how to handle problems that can crop up in SEM. So not all applications of SEM described in this book are picture perfect, but neither are actual research problems.

The many changes in this edition are intended to enhance the pedagogical presentation and cover recent developments. The biggest changes are as follows.

1. This is one of the first introductory books to introduce Judea Pearl's structural causal model (SCM), an approach that offers unique perspectives on causal modeling. It is also part of new developments in causal mediation analysis.

2. Computer files for all detailed examples are now available for a total of six widely used SEM computer tools, including Amos, EQS, `lavaan` for R, LISREL, Mplus, and Stata. Computer tools for the SCM are also described.

3. Presentations on model specification, identification, and estimation are reorganized to separate coverage of observed variable (path) models from that of latent variable models. The specification and identification of path models are covered before these topics are dealt with for latent variable models. Later chapters that introduce estimation and hypothesis testing do not assume knowledge of latent variable models. This organization makes it easier for instructors who prefer to cover the specification, identification, and analysis of path models before doing so for latent variable models.

4. Two changes concern the technique of confirmatory factor analysis (CFA). The analysis of ordinal data in CFA is covered in more detail with two new examples, one of which concerns the topic of measurement invariance. The topic just mentioned is now covered in its own chapter in this edition.

BOOK WEBSITE

The address for this book's website is *www.guilford.com/kline*. From the site, you can freely access or download the following resources:

- Computer files—data, syntax, and output—for all detailed examples in this book.
- Links to related web pages, including sites for computer programs and calculating webpages that perform certain types of analyses.

The website promotes a learning-by-doing approach. The availability of both syntax and data files means that you can reproduce the analyses in this book using the corresponding software program. Even without access to a particular program, such as Mplus, you can still download and open on your own computer the Mplus output files for a particular example and view the results. This is because all computer files on the website are either plain text (ASCII) files that require nothing more than a basic text editor to view their contents or they are PDF (Portable Document Format) files that can be viewed with the freely available Adobe Reader. Even if you use a particular SEM computer tool, it is still worthwhile to review the files on the website generated by other programs. This is because it can be helpful to consider the same analysis from somewhat different perspectives. Some of the exercises for this book involve extensions of the analyses for these examples, so there are plenty of opportunities for practice with real data sets.

PEDAGOGICAL APPROACH

You may be reading this book while participating in a course or seminar on SEM. This context offers the potential advantage of the structure and support available in a classroom setting, but formal coursework is not the only way to learn about SEM. Another is self-study, a method through which many researchers learn about what is, for them, a new statistical technique. (This is how I first learned about SEM, not in classes.) I assume that most readers are relative newcomers to SEM or that they already have some knowledge but wish to hone their skills.

Consequently, I will speak to you (through my author's voice) as one researcher to another, not as a statistician to the quantitatively naïve. For example, the instructional language of statisticians is matrix algebra, which conveys a lot of information in a rela-

tively short amount of space, but you must already be familiar with linear algebra to decode the message. There are other, more advanced works about SEM that emphasize matrix representations (Bollen, 1989; Kaplan, 2009; Mulaik, 2009b), and these works can be consulted when you are ready. Instead, fundamental concepts about SEM are presented here using the language of researchers: words and figures, not matrix equations. I will not shelter you from some of the more technical aspects of SEM, but I aim to cover requisite concepts in an accessible way that supports continued learning.

PRINCIPLES OVER COMPUTER TOOLS

You may be relieved to know that you are not at a disadvantage at present if you have no experience using an SEM computer tool. This is because the presentation in this book is not based on the symbolism or syntax associated with a particular software package. In contrast, some other books are linked to specific SEM computer tools. They can be invaluable for users of a particular program, but perhaps less so for others. Instead, key principles of SEM that users of *any* computer tool must understand are emphasized here. In this way, this book is more like a guide to writing style than a handbook about how to use a particular word processor. Besides, becoming proficient with a particular software package is just a matter of practice. But without strong conceptual knowledge, the output one gets from a computer tool for statistical analyses—including SEM—may be meaningless or, even worse, misleading.

SYMBOLS AND NOTATION

As with other statistical techniques, there is no gold standard for notation in SEM, but the symbol set associated with the original syntax of LISREL is probably the most widely used in advanced works. For this reason, this edition introduces LISREL symbolism, but these presentations are optional; that is, I do not force readers to memorize LISREL symbols in order to get something out of this book. This is appropriate because the LISREL notational system can be confusing unless you have memorized the whole system. I use a few key symbols in the main text, but the rest of LISREL notation is described in chapter appendices.

LIFE'S A JOURNEY, NOT A DESTINATION

Learning to use a new set of statistical techniques is also a kind of journey, one through a strange land, at least at the beginning. Such journeys require a commitment of time and the willingness to tolerate the frustration of trial and error, but this is one journey that you do not have to make alone. Think of this book as a travel atlas or even someone to advise you about language and customs, what to see and pitfalls to avoid, and what

lies just over the horizon. I hope that the combination of a conceptually based approach, many examples, and the occasional bit of sage advice presented in this book will help to make the statistical journey a little easier, maybe even enjoyable. (Imagine that!)

PLAN OF THE BOOK

The topic of SEM is very broad, and not every aspect of it can be covered in a single volume. With this reality in mind, I will now describe the topics covered in this book. Part I introduces fundamental concepts and computer tools. Chapter 1 lays out the basic features of SEM. It also deals with myths about SEM and outlines its relation to other causal inference frameworks. Chapters 2 and 3 review basic statistical principles and techniques that form a groundwork for learning about SEM. These topics include regression analysis, statistical significance testing, and bootstrapping. How to prepare data for analysis in SEM and select good measures is covered in Chapter 4, and computer tools for SEM and the SCM are described in Chapter 5.

Part II consists of chapters about the specification and identification phases in SEM. Chapters 6 and 7 cover observed variable models, or path models. Chapter 8 deals with path analysis from the perspective of the SCM and causal graph theory. Chapters 9 and 10 are about, respectively, CFA models and structural regression (SR) models. The latter (SR models) have features of both path models and measurement models. Part III is devoted to the analysis. Chapters 11 and 12 deal with principles of estimation and hypothesis testing that apply to any type of structural equation model. The analysis of CFA models is considered in Chapter 13, and analyzing SR models is the subject of Chapter 14. Actual research problems are considered in these presentations.

Part IV is about advanced techniques and best practices. The analysis of means in SEM is introduced in Chapter 15, which also covers latent growth models. How to analyze a structural equation model with data from multiple samples is considered in Chapter 16, which also deals with the topic of measurement invariance in CFA. Estimation of the interactive effects of latent variables, conditional process analysis, causal mediation analysis, and the relation between multilevel modeling and SEM are all covered in Chapter 17. Chapter 18 offers best practice recommendations in SEM. This chapter also mentions common mistakes with the aim of helping you to avoid them.

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