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Multivariate Analysis with LISREL

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Multivariate data are widely used in disciplines as diverse as public health, psychometrics, economics, psychology, and marketing. Methods such as logistic regression, factor analysis, multidimensional scaling, canonical correlation, and structural equation modeling, and longitudinal data analysis are among some statistical tools widely used by researchers in these fields. For instance, many graduate and advanced students in the social and behavioral sciences are familiar with the theory and application of factor analysis (FA) and structural equation modeling (SEM). In addition, many researchers, practitioners, and students may also be familiar with **LISREL**, which is a statistical program used for latent variable modeling in the SEM framework.

There are several books, online resources, and manuals that present multivariate statistics, the theory, and the programming language. In fact, because the **LISREL** program was originally associated with SEM modeling, the literature in various forms is rich with learning resources. However, the later versions of **LISREL** can not only be used for SEM modeling, but also they can be utilized for more general statistical analysis, including multivariate analysis. This fact may be one motivation for the publication of *Multivariate Analysis with LISREL*, mainly to reiterate the point that researchers can use **LISREL** in a wider variety of applications than primarily for SEM.

This book presents topics in multivariate statistics in ten chapters. The structure of each chapter is organized around a brief introduction to theory, examples, and illustrated implementation in **LISREL**. The inclusion of numerous examples reflects the learning-by-example approach of the authors in writing the book.

One prominent feature of the book throughout is the presentation of numerous visuals to demonstrate the use of the software and illustrate different aspects of data and the analysis output. Despite the inclusion of a remarkable number of visuals, plots, tables, code, and output, the layout of the pages is absolutely uncluttered and comfortable to the discerning mind.

The step-by-step demonstration of the programming part implies that the authors had conceptualized the book as an independent learning resource or a textbook to be used both in the

class and in a lab. In addition to the ten chapters, the book has seven technical appendices on matrix algebra, mathematical statistics, and computational statistics. The appendices are mainly provided to contain refreshing materials or additional details for certain topics in the book.

In Chapter 1, *Getting Started*, the authors discuss data types, data management (importing, storing, missing data), plotting, and the syntax of **LISREL**. Examples with real data are used to illustrate the steps in data management and plotting. **LISREL** code and output are presented for each example with explanation of the results.

Statistical methods are introduced beginning with Chapter 2, *Regression Models*. Linear regression, logistic regression, probit regression, censored data regression, ANOVA models, and multivariate regression are presented in this chapter along with mathematical exposition, several examples, code, and program output. The authors also introduce PRELIS and SIMPLIS syntax. Towards the end of the chapter the authors introduce notation and diagrams used extensively in FA and SEM analyses. Therefore, readers interested to know more about the relationship between regression and SEM (and their shared notations and symbolism) will find this chapter very instructive. Chapter 3, *Generalized Linear Models* (GLM), presents the unified approach to linear and nonlinear models, in which Poisson-log, binomial logit/probit, log-linear, nominal logistic, and ordinal logistic models are discussed with worked out examples, code, output, and several supporting plots.

Analysis of nested data is presented in Chapter 4, *Multilevel Analysis*. The authors begin with introducing contexts in which multilevel analysis may produce more accurate estimates than fixed effects models. Model fit, repeated measures, growth curve analysis, multilevel GLM models, and multivariate multilevel data are other topics introduced in this chapter.

Chapters 5 to 8 of the book present the foundation for latent variable and SEM data analysis.

In Chapter 5, *Principal Components (PCA)*, the authors introduce data reduction methods in statistics (and a comparison with FA). This is a very short chapter, with contents mostly devoted to examples and program output. *Exploratory Factor Analysis (EFA)* is the topic of Chapter 6, where the authors introduce the EFA model, factor extraction methods, EFA for ordinal, binary, and multinomial variables, and several interesting examples with code and output. Chapter 7, *Confirmatory Factor Analysis (CFA)*, introduces measurement models for factor structure testing. This chapter, similar to the EFA chapter, uses extensive examples, code, and output to present a clear understanding of the CFA. Transition to the SEM model through use of path models is understandable in this chapter.

Structural Equation Models (SEM) with Latent Variables is presented in Chapter 8. The authors begin with demonstrating how to build a hypothetical model using both diagrams (paths) and code. The point that the authors use the term **LISREL** model is of historical interest, where SEM models used to be known as **LISREL** models. In this chapter, the authors use extensive explanations, examples, and code to present fundamental topics in SEM, such as model specification, scaling, measurement errors, multilevel factor analysis, multiple indicators and multiple causes (MIMIC) models, and latent variable rescaling. This chapter presents an original and very clear introduction to the SEM, with numerous examples and output interpretations to help the reader attain a firm understanding of SEM and its applications. I highly recommend this chapter to learners who are new to the SEM framework.

Chapter 9, *Analysis of Longitudinal Data*, considers modeling data that are collected over time. Panel data and repeated measures data modeling (SIMPLEX and latent growth curves)

are discussed with examples. In Chapter 10, *Multiple Groups*, measurement invariance of the factor structure between groups is discussed. Both CFA and MIMIC models are used to perform multiple group invariance test. Multiple group tests are used to test the equivalence of a measure across different groups and on different levels. This is a validity issue and is fundamental in psychometric analysis of an instrument and its items.

The book appendices run about 80 pages long, and they are so rich in technical information that they are aptly headed as Chapters 11 to 17. These appendices provide the reader without much statistical theory with enough knowledge to understand clearly the concepts throughout the book. These appendices may also prove very useful for readers who already have practical exposure to the methods but may need further understanding of the mathematical and computational components of multivariate statistics.

The primary audience for the book are researchers and graduate students in social sciences, public health, education, psychology, economics, and management. Because the book takes on a practical approach to multivariate statistics with numerous examples, graduate students will find an excellent source for hands-on practice. In addition, the rich appendices will definitely appeal to readers who intend to go beyond and learn about the mathematical and computational aspects of multivariate data structure.

One prominent feature of *Multivariate Analysis with LISREL* is its engaging and lively presentation approach. Rather than getting the reader immersed in theory and frustrated by the technicalities, the authors start with a brief context-setting introduction, a very clear presentation of the theory, and numerous examples with plentiful plots, graphics, code, and output to ensure the reader understands every chapter completely before moving to the next. The authors in this regard have definitely lived up to their approach of learning by examples. Readers who need data, example, clear explanation and interpretation of multivariate statistics will definitely find this book an excellent resource. The inclusion of numerous color plots and graphics and a very clear and personal expository language make this book a friendly companion to advanced statistics.

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