Contents

Introduction

Book Website 2 Pedagogical Approach 2 Principles over Computer Tools 3 Symbols and Notation 3 Life's a Journey, Not a Destination 3 Plan of the Book 4

PART I. CONCEPTS AND TOOLS

1 • Coming of Age

Preparing to Learn SEM 7 Definition of SEM 9 Importance of Theory 10 A Priori, but Not Exclusively Confirmatory 11 Probabilistic Causation 11 Observed Variables and Latent Variables 12 Data Analyzed in SEM 13 SEM Requires Large Samples 14 Less Emphasis on Significance Testing 17 SEM and Other Statistical Techniques 17 SEM and Other Causal Inference Frameworks 18 Myths about SEM 20 Widespread Enthusiasm, but with a Cautionary Tale 21 Family History 23 Summary 24 Learn More 24

1

7

2 • Regression Fundamentals

Bivariate Regression 25 Multiple Regression 30 Left-Out Variables Error 35 Suppression 36 Predictor Selection and Entry 37 Partial and Part Correlation 39 Observed versus Estimated Correlations 41 Logistic Regression and Probit Regression 44 Summary 47 Learn More 47 Exercises 48

3 • Significance Testing and Bootstrapping

Standard Errors 49
Critical Ratios 51
Power and Types of Null Hypotheses 52
Significance Testing Controversy 54
Confidence Intervals and Noncentral Test Distributions 57
Bootstrapping 60
Summary 62
Learn More 62
Exercises 63

4 • Data Preparation and Psychometrics Review

Forms of Input Data 64 Positive Definiteness 67 Extreme Collinearity 71 Outliers 72 Normality 74 Transformations 77 Relative Variances 81 Missing Data 82 Selecting Good Measures and Reporting about Them 88 . Score Reliability 90 Score Validity 93 Item Response Theory and Item Characteristic Curves 94 Summary 95 Learn More 96 Exercises 96

5 • Computer Tools

Ease of Use, Not Suspension of Judgment 97 Human–Computer Interaction 98 97

49

64

Tips for SEM Programming 100 SEM Computer Tools 101 Other Computer Resources for SEM 111 Computer Tools for the SCM 112 Summary 113 Learn More 113

PART II. SPECIFICATION AND IDENTIFICATION

6•	Specification of Observed-Variable (Path) Models	117
	Steps of SEM 117 Model Diagram Symbols 121 Causal Inference 122 Specification Concepts 126 Path Analysis Models 129 Recursive and Nonrecursive Models 135 Path Models for Longitudinal Data 138 Summary 141 Learn More 142 Exercises 142	
	APPENDIX 6.A. LISREL Notation for Path Models	143
7•	Identification of Observed-Variable (Path) Models	145
	General Requirements 145 Unique Estimates 148 Rule for Recursive Models 149 Identification of Nonrecursive Models 150 Models with Feedback Loops and All Possible Disturbance Correlations 150 Graphical Rules for Other Types of Nonrecursive Models 153 Respecification of Nonrecursive Models That Are Not Identified 155 A Healthy Perspective on Identification 157 Empirical Underidentification 157 Managing Identification Problems 158 Path Analysis Research Example 159 Summary 159 Learn More 160 Exercises 160	
	APPENDIX 7.A. Evaluation of the Rank Condition	161
8•	Graph Theory and the Structural Causal Model	164
	Introduction to Graph Theory 164 Elementary Directed Graphs and Conditional Independences 166	

	Implications for Regression Analysis 170 d-Separation 170 Basis Set 173 Causal Directed Graphs 174 Testable Implications 176 Graphical Identification Criteria 177 Instrumental Variables 180	
	Causal Mediation 181 Summary 184 Learn More 185 Exercises 185	
	APPENDIX 8.A. Locating Conditional Independences in Directed Cyclic Graphs	186
	APPENDIX 8.B. Counterfactual Definitions of Direct and Indirect Effects	187
	Specification and Identification of Confirmatory Factor Analysis Models	188
	Latent Variables in CFA 188 Factor Analysis 189 Characteristics of EFA Models 191 Characteristics of CFA Models 193 Other CFA Specification Issues 195 Identification of CFA Models 198 Rules for Standard CFA Models 201 Rules for Nonstandard CFA Models 202 Empirical Underidentification in CFA 206 CFA Research Example 206 Summary 207 Learn More 207 Exercises 209 APPENDIX 9.A. LISREL Notation for CFA Models	210
	AFFENDIX 9.A. LISIKEE NOIGHON TOP CITY MODELS	
10 •	Specification and Identification of Structural Regression Models	212
	Causal Inference with Latent Variables 212 Types of SR Models 213 Single Indicators 214 Identification of SR Models 217 Exploratory SEM 219 SR Model Research Examples 220 Summary 223 Learn More 225 Exercises 225	
	APPENDIX 10.A. LISREL Notation for SR Models	226

PART III. ANALYSIS

11 •	Estimation and Local Fit Testing	231
	Types of Estimators 231 Causal Effects in Path Analysis 232 Single-Equation Methods 233 Simultaneous Methods 235 Maximum Likelihood Estimation 235 Detailed Example 239 Fitting Models to Correlation Matrices 253 Alternative Estimators 255 A Healthy Perspective on Estimation 258 Summary 259 Learn More 259 Exercises 260	
	APPENDIX 11.A. Start Value Suggestions for Structural Models	261
12 •	Global Fit Testing State of Practice, State of Mind 262 A Healthy Perspective on Global Fit Statistics 263 Model Test Statistics 265 Approximate Fit Indexes 266 Recommended Approach to Fit Evaluation 268 Model Chi-Square 270 RMSEA 273 SRMR 277 Tips for Inspecting Residuals 278 Global Fit Statistics for the Detailed Example 278 Testing Hierarchical Models 280 Comparing Nonhierarchical Models 286 Power Analysis 290 Equivalent and Near-Equivalent Models 292 Summary 297 Learn More 298 Exercises 298	262
	APPENDIX 12.A. Model Chi-Squares Printed by LISREL	299
13 •	Analysis of Confirmatory Factor Analysis Models Fallacies about Factor or Indicator Labels 300 Estimation of CFA Models 301 Detailed Example 304 Respecification of CFA Models 309 Special Topics and Tests 312 Equivalent CFA Models 315 Special CFA Models 319	300

	Analyzing Likert-Scale Items as Indicators 323 Item Response Theory as an Alternative to CFA 332 Summary 333 Learn More 333 Exercises 334	
	APPENDIX 13.A. Start Value Suggestions for Measurement Models	335
	APPENDIX 13.B. Constraint Interaction in CFA Models	336
14•	Analysis of Structural Regression Models	338
	Two-Step Modeling 338 Four-Step Modeling 339 Interpretation of Parameter Estimates and Problems 340 Detailed Example 341 Equivalent SR Models 348 Single Indicators in a Nonrecursive Model 349 Analyzing Formative Measurement Models in SEM 352 Summary 361 Learn More 362 Exercises 362	
	APPENDIX 14.A. Constraint Interaction in SR Models	363
	APPENDIX 14.B. Effect Decomposition in Nonrecursive Models and the Equilibrium Assumption	364
	APPENDIX 14.C. Corrected Proportions of Explained Variance for Nonrecursive Models	365
PART	IV. ADVANCED TECHNIQUES AND BEST PRACTICES	
15 •	Mean Structures and Latent Growth Models	369
	Logic of Mean Structures 369 Identification of Mean Structures 373 Estimation of Mean Structures 374 Latent Growth Models 374 Detailed Example 375 Comparison with a Polynomial Growth Model 387 Extensions of Latent Growth Models 390 Summary 392 Learn More 392 Exercises 393	
16 •	Multiple-Samples Analysis and Measurement Invariance	394
	Rationale of Multiple-Samples SEM 394 Measurement Invariance 396 Testing Strategy and Related Issues 399 Example with Continuous Indicators 403	

	Example with Ordinal Indicators 411	
	Structural Invariance 420	
	Alternative Statistical Techniques 420	
	Summary 421	
	Learn More 421	
335	Exercises 422	
336	APPENDIX 16.A. Welch-James Test	423
550		
338	17 • Interaction Effects and Multilevel	424
	Structural Equation Modeling	
	Interactive Effects of Observed Variables 424	
	Interactive Effects in Path Analysis 431	
	Conditional Process Modeling 432	
	Causal Mediation Analysis 435 Interactive Effects of Latent Variables 437	
	Multilevel Modeling and SEM 444	
	Summary 450	
	Learn More 450	
	Exercises 451	
363	18 • Best Practices in Structural Equation Modeling	452
364	Resources 452	
	Specification 454	
365	Identification 457	
	Measures 458	
	Sample and Data 458 Estimation 461	
S	Respecification 463	
	Tabulation 464	
369	Interpretation 465	
	Avoid Confirmation Bias 466	
	Bottom Lines and Statistical Beauty 466	
	Summary 467	
	Learn More 467	
	Suggested Answers to Exercises	469
	References	489
	Author Index	510
	Subject Index	516
variance 394	About the Author	534
	The companion website www.guilford.com/kline-materials provides	
	downloadable data, syntax, and output for all the book's examples in	
	six widely used SEM computer tools and links to related web pages.	