

# Contents

Preface xiv

Acknowledgments xvii

## 1 Overview of Multivariate Methods 1

### What Is Multivariate Analysis? 3

#### Three Converging Trends 4

Topic 1: Rise of Big Data 4

Topic 2: Statistical Versus Data Mining Models 7

Topic 3: Causal Inference 9

Summary 9

#### Multivariate Analysis in Statistical Terms 9

#### Some Basic Concepts of Multivariate Analysis 10

The Variate 10

Measurement Scales 11

Measurement Error and Multivariate Measurement 13

#### Managing the Multivariate Model 14

Managing the Variate 14

Managing the Dependence Model 17

Statistical Significance Versus Statistical Power 18

Review 20

#### A Classification of Multivariate Techniques 21

Dependence Techniques 21

Interdependence Techniques 25

#### Types of Multivariate Techniques 25

Exploratory Factor Analysis: Principal Components  
and Common Factor Analysis 25

Cluster Analysis 26

Multiple Regression 26

Multivariate Analysis of Variance and Covariance 26

Multiple Discriminant Analysis 26

Logistic Regression 27

Structural Equation Modeling and Confirmatory Factor  
Analysis 27

Partial Least Squares Structural Equation Modeling 28

Canonical Correlation 28

Conjoint Analysis 28

Perceptual Mapping 29

Correspondence Analysis 29

#### Guidelines for Multivariate Analyses and Interpretation 29

Establish Practical Significance as Well as Statistical  
Significance 30

Recognize That Sample Size Affects All Results 30

Know Your Data 30

Strive for Model Parsimony 31

Look at Your Errors 31

Simplify Your Models By Separation 31

Validate Your Results 32

#### A Structured Approach to Multivariate Model Building 32

Stage 1: Define the Research Problem, Objectives,  
and Multivariate Technique to Be Used 33

Stage 2: Develop the Analysis Plan 33

Stage 3: Evaluate the Assumptions Underlying the  
Multivariate Technique 33

Stage 4: Estimate the Multivariate Model and Assess  
Overall Model Fit 34

Stage 5: Interpret the Variate(s) 34

Stage 6: Validate the Multivariate Model 34

A Decision Flowchart 34

#### Databases 34

Primary Database 35

Other Databases 37

#### Organization of the Remaining Chapters 37

Section I: Preparing for a Multivariate Analysis 37

Section II: Interdependence Techniques 38

Sections III and IV: Dependence Techniques 38

Section V: Moving Beyond the Basics 38

Online Resources: Additional Chapters 38

#### Summary 39

#### Questions 41

#### Suggested Readings and Online Resources 41

#### References 41

## SECTION I

### Preparing for Multivariate Analysis 43

## 2 Examining Your Data 45

### Introduction 49

### The Challenge of Big Data Research Efforts 49

|  |            |
|--|------------|
| Data Management  | 50         |
| Data Quality   | 50         |
| Summary  | 51         |
| <b>Preliminary Examination of the Data</b>   | <b>51</b>  |
| Univariate Profiling: Examining the Shape of the Distribution                      | 51         |
| Bivariate Profiling: Examining the Relationship Between Variables                  | 52         |
| Bivariate Profiling: Examining Group Differences                                   | 53         |
| Multivariate Profiles  | 54         |
| New Measures of Association  | 55         |
| Summary  | 55         |
| <b>Missing Data</b>  | <b>56</b>  |
| The Impact of Missing Data   | 56         |
| Recent Developments in Missing Data Analysis                                       | 57         |
| A Simple Example of a Missing Data Analysis  | 57         |
| A Four-Step Process for Identifying Missing Data and Applying Remedies             | 58         |
| An Illustration of Missing Data Diagnosis with the Four-Step Process               | 72         |
| <b>Outliers</b>  | <b>85</b>  |
| Two Different Contexts for Defining Outliers                                       | 85         |
| Impacts of Outliers  | 86         |
| Classifying Outliers   | 87         |
| Detecting and Handling Outliers  | 88         |
| An Illustrative Example of Analyzing Outliers                                      | 91         |
| <b>Testing the Assumptions of Multivariate Analysis</b>                            | <b>93</b>  |
| Assessing Individual Variables Versus the Variate                                  | 93         |
| Four Important Statistical Assumptions   | 94         |
| <b>Data Transformations</b>  | <b>100</b> |
| Transformations Related to Statistical Properties                                  | 101        |
| Transformations Related to Interpretation  | 101        |
| Transformations Related to Specific Relationship Types                             | 102        |
| Transformations Related to Simplification  | 103        |
| General Guidelines for Transformations   | 104        |
| <b>An Illustration of Testing the Assumptions Underlying Multivariate Analysis</b> | <b>105</b> |
| Normality  | 105        |
| Homoscedasticity   | 108        |
| Linearity  | 108        |
| Summary  | 112        |
| <b>Incorporating Nonmetric Data with Dummy Variables</b>                           | <b>112</b> |
| Concept of Dummy Variables   | 112        |
| Dummy Variable Coding  | 113        |
| Using Dummy Variables  | 113        |
| <b>Summary</b>   | <b>114</b> |
| <b>Questions</b>   | <b>115</b> |

|  |            |
|--|------------|
| <b>Suggested Readings and Online Resources</b> | <b>116</b> |
| <b>References</b>                              | <b>116</b> |

## SECTION II

### Interdependence Techniques 119

#### 3 Exploratory Factor Analysis 121

##### What Is Exploratory Factor Analysis? 124

##### A Hypothetical Example of Exploratory Factor Analysis 126

##### Factor Analysis Decision Process 127

##### Stage 1: Objectives of Factor Analysis 127

Specifying the Unit of Analysis 127

Achieving Data Summarization Versus Data Reduction 129

Variable Selection 131

Using Factor Analysis with Other Multivariate Techniques 131

##### Stage 2: Designing an Exploratory Factor Analysis 132

Variable Selection and Measurement Issues 132

Sample Size 132

Correlations among Variables or Respondents 133

##### Stage 3: Assumptions in Exploratory Factor Analysis 135

Conceptual Issues 135

Statistical Issues 135

Summary 136

##### Stage 4: Deriving Factors and Assessing Overall Fit 136

Selecting the Factor Extraction Method 138

Stopping Rules: Criteria for the Number of Factors to Extract 140

Alternatives to Principal Components and Common Factor Analysis 144

##### Stage 5: Interpreting the Factors 146

The Three Processes of Factor Interpretation 146

Factor Extraction 147

Rotation of Factors 147

Judging the Significance of Factor Loadings 151

Interpreting a Factor Matrix 153

##### Stage 6: Validation of Exploratory Factor Analysis 158

Use of Replication or a Confirmatory Perspective 158

Assessing Factor Structure Stability 159

Detecting Influential Observations 159

### **Stage 7: Data Reduction—Additional Uses of Exploratory Factor Analysis Results** 159

Selecting Surrogate Variables for Subsequent Analysis 160

Creating Summated Scales 160

Computing Factor Scores 163

Selecting among the Three Methods 164

#### **An Illustrative Example** 165

Stage 1: Objectives of Factor Analysis 165

Stage 2: Designing a Factor Analysis 165

Stage 3: Assumptions in Factor Analysis 165

Principal Component Factor Analysis: Stages 4–7 168

Common Factor Analysis: Stages 4 and 5 181

A Managerial Overview of the Results 183

**Summary** 184

**Questions** 187

**Suggested Readings and Online Resources** 187

**References** 187

## **4 Cluster Analysis** 189

### **What Is Cluster Analysis?** 192

Cluster Analysis as a Multivariate Technique 192

Conceptual Development with Cluster Analysis 192

Necessity of Conceptual Support in Cluster Analysis 193

### **How Does Cluster Analysis Work?** 193

A Simple Example 194

Objective Versus Subjective Considerations 199

### **Cluster Analysis Decision Process** 199

Stage 1: Objectives of Cluster Analysis 199

Stage 2: Research Design in Cluster Analysis 202

Stage 3: Assumptions in Cluster Analysis 211

Stage 4: Deriving Clusters and Assessing Overall Fit 212

Stage 5: Interpretation of the Clusters 227

Stage 6: Validation and Profiling of the Clusters 228

### **Implication of Big Data Analytics** 230

Challenges 230

### **An Illustrative Example** 230

Stage 1: Objectives of the Cluster Analysis 231

Stage 2: Research Design of the Cluster Analysis 232

Stage 3: Assumptions in Cluster Analysis 235

Stages 4–6: Employing Hierarchical and Nonhierarchical Methods 235

Part 1: Hierarchical Cluster Analysis (Stage 4) 235

Part 2: Nonhierarchical Cluster Analysis

(Stages 4–6) 245

Examining an Alternative Cluster Solution:

Stages 4–6 251

A Managerial Overview of the Clustering Process 252

**Summary** 253

**Questions** 254

**Suggested Readings and Online Resources** 255

**References** 255

## **SECTION III**

### **Dependence Techniques – Metric Outcomes** 257

## **5 Multiple Regression Analysis** 259

**What Is Multiple Regression Analysis?** 265

**Multiple Regression in the Era of Big Data** 265

**An Example of Simple and Multiple Regression** 266

Prediction Using a Single Independent Variable: Simple Regression 267

Prediction Using Several Independent Variables: Multiple Regression 269

Summary 271

**A Decision Process for Multiple Regression Analysis** 272

**Stage 1: Objectives of Multiple Regression** 273

Research Problems Appropriate for Multiple Regression 273

Specifying a Statistical Relationship 274

Selection of Dependent and Independent Variables 275

**Stage 2: Research Design of a Multiple Regression Analysis** 278

Sample Size 278

Creating Additional Variables 281

Overview 286

**Stage 3: Assumptions in Multiple Regression Analysis** 287

Assessing Individual Variables Versus the Variate 287

Methods of Diagnosis 288

Linearity of the Phenomenon 288

Constant Variance of the Error Term 290

Normality of the Error Term Distribution 291

Independence of the Error Terms 291

Summary 292

**Stage 4: Estimating the Regression Model and Assessing Overall Model Fit** 292

Managing the Variate 292

- Variable Specification 294
- Variable Selection 295
- Testing the Regression Variate for Meeting the Regression Assumptions 298
- Examining the Statistical Significance of Our Model 299
- Understanding Influential Observations 302
- Stage 5: Interpreting the Regression Variate** 308
  - Using the Regression Coefficients 308
  - Assessing Multicollinearity 311
  - Relative Importance of Independent Variables 317
  - Summary 320
- Stage 6: Validation of the Results** 321
  - Additional or Split Samples 321
  - Calculating the PRESS Statistic 321
  - Comparing Regression Models 322
  - Forecasting with the Model 322
- Extending Multiple Regression** 322
  - Multilevel Models 323
  - Panel Models 328
- Illustration of a Regression Analysis** 331
  - Stage 1: Objectives of Multiple Regression 331
  - Stage 2: Research Design of a Multiple Regression Analysis 331
  - Stage 3: Assumptions in Multiple Regression Analysis 332
  - Stage 4: Estimating the Regression Model and Assessing Overall Model Fit 332
  - Stage 5: Interpreting the Regression Variate 348
  - Stage 6: Validating the Results 353
- Evaluating Alternative Regression Models** 355
  - Confirmatory Regression Model 355
  - Use of Summated Scales as Remedies for Multicollinearity 357
  - Including a Nonmetric Independent Variable 361
  - A Managerial Overview of the Results 361
- Summary** 363
- Questions** 366
- Suggested Readings and Online Resources** 367
- References** 367
  
- 6 MANOVA: Extending ANOVA** 371
  - Re-Emergence of Experimentation** 376
  - Experimental Approaches Versus Other Multivariate Methods** 376
  - MANOVA: Extending Univariate Methods for Assessing Group Differences** 377
    - Multivariate Procedures for Assessing Group Differences 377
    - A Hypothetical Illustration of MANOVA** 381
      - Analysis Design 381
      - Differences from Discriminant Analysis 381
      - Forming the Variate and Assessing Differences 382
    - A Decision Process for MANOVA** 383
    - Stage 1: Objectives of MANOVA** 385
      - When Should We Use MANOVA? 385
      - Types of Multivariate Questions Suitable for MANOVA 385
      - Selecting the Dependent Measures 386
    - Stage 2: Issues in the Research Design of MANOVA** 387
      - Types of Research Approaches 387
      - Types of Variables in Experimental Research 389
      - Sample Size Requirements—Overall and by Group 391
      - Factorial Designs—Two or More Treatments 391
      - Using Covariates—ANCOVA and MANCOVA 394
      - Modeling Other Relationships Between Treatment and Outcome 396
      - MANOVA Counterparts of Other ANOVA Designs 397
      - A Special Case of MANOVA: Repeated Measures 397
    - Stage 3: Assumptions of ANOVA and MANOVA** 398
      - Independence 399
      - Equality of Variance—Covariance Matrices 399
      - Normality 400
      - Linearity and Multicollinearity among the Dependent Variables 401
      - Sensitivity to Outliers 401
    - Stage 4: Estimation of the MANOVA Model and Assessing Overall Fit** 401
      - Estimation with the General Linear Model 403
      - Measures for Significance Testing 403
      - Statistical Power of the Multivariate Tests 403
      - Estimating Additional Relationships: Mediation and Moderation 407
    - Stage 5: Interpretation of the MANOVA Results** 410
      - Evaluating Covariates 410
      - Assessing Effects on the Dependent Variate 411
      - Identifying Differences Between Individual Groups 415
      - Assessing Significance for Individual Outcome Variables 417
      - Interpreting Mediation and Moderation 419
    - Stage 6: Validation of the Results** 421
    - Advanced Issues: Causal Inference in Nonrandomized Situations** 421

|   |     |
|---|-----|
| Causality in the Social and Behavioral Sciences | 422 |
| The Potential Outcomes Approach                 | 423 |
| Counterfactuals in Non-experimental Research    |     |
| Designs   | 423 |
| Propensity Score Models                         | 424 |
| Overview  | 428 |
| <b>Summary</b>                                  | 430 |

|  |     |
|--|-----|
| <b>Illustration of a MANOVA Analysis</b> | 430 |
| Research Setting                         | 430 |

|   |     |
|---|-----|
| <b>Example 1: Difference Between Two Independent Groups</b>       | 432 |
| Stage 1: Objectives of the Analysis                               | 432 |
| Stage 2: Research Design of the MANOVA                            | 433 |
| Stage 3: Assumptions in MANOVA                                    | 433 |
| Stage 4: Estimation of the MANOVA Model and Assessing Overall Fit | 434 |
| Stage 5: Interpretation of the Results                            | 437 |
| Summary   | 438 |

|   |     |
|---|-----|
| <b>Example 2: Difference Between K Independent Groups</b>         | 438 |
| Stage 1: Objectives of the MANOVA                                 | 438 |
| Stage 2: Research Design of MANOVA                                | 439 |
| Stage 3: Assumptions IN MANOVA                                    | 439 |
| Stage 4: Estimation of the MANOVA Model and Assessing Overall Fit | 440 |
| Stage 5: Interpretation of the Results                            | 443 |
| Summary   | 444 |

|  |     |
|--|-----|
| <b>Example 3: A Factorial Design for MANOVA with Two Independent Variables</b> | 444 |
| Stage 1: Objectives of the MANOVA  | 445 |
| Stage 2: Research Design of the MANOVA   | 445 |
| Stage 3: Assumptions in MANOVA   | 447 |
| Stage 4: Estimation of the MANOVA Model and Assessing Overall Fit              | 448 |
| Stage 5: Interpretation of the Results   | 451 |
| Summary  | 452 |

|   |     |
|---|-----|
| <b>Example 4: Moderation and Mediation</b>                                | 452 |
| Moderation of Distribution System ( $X_5$ ) by Firm Size ( $X_3$ )        | 453 |
| Summary   | 456 |
| Mediation of Distribution System ( $X_5$ ) By Purchase Level ( $X_{22}$ ) | 457 |
| Summary   | 459 |

|   |     |
|---|-----|
| <b>A Managerial Overview of the Results</b> | 459 |
| <b>Summary</b>                              | 460 |

|                  |     |
|------------------|-----|
| <b>Questions</b> | 463 |
|------------------|-----|

|  |     |
|--|-----|
| <b>Suggested Readings and Online Resources</b> | 464 |
|--|-----|

|                   |     |
|-------------------|-----|
| <b>References</b> | 464 |
|-------------------|-----|

## SECTION IV

### Dependence Techniques – Non-metric Outcomes 469

#### 7 Multiple Discriminant Analysis 471

##### What Is Discriminant Analysis? 474

|                    |     |
|--------------------|-----|
| The Variate        | 474 |
| Testing Hypotheses | 475 |

##### Similarities to Other Multivariate Techniques 476

##### Hypothetical Example of Discriminant Analysis 476

|  |     |
|--|-----|
| A Two-Group Discriminant Analysis: Purchasers Versus Non-purchasers  | 476 |
| A Three-Group Example of Discriminant Analysis: Switching Intentions | 481 |

##### The Decision Process for Discriminant Analysis 484

##### Stage 1: Objectives of Discriminant Analysis 484

|                              |     |
|------------------------------|-----|
| Descriptive Profile Analysis | 485 |
| Classification Purposes      | 485 |

##### Stage 2: Research Design for Discriminant Analysis 485

|   |     |
|---|-----|
| Selecting Dependent and Independent Variables | 485 |
| Sample Size                                   | 487 |
| Division of the Sample                        | 488 |

##### Stage 3: Assumptions of Discriminant Analysis 488

|  |     |
|--|-----|
| Impacts on Estimation and Classification | 489 |
| Impacts on Interpretation                | 489 |

##### Stage 4: Estimation of the Discriminant Model and Assessing Overall Fit 490

|                                |     |
|--------------------------------|-----|
| Selecting an Estimation Method | 491 |
| Statistical Significance       | 492 |
| Assessing Overall Model Fit    | 493 |
| Casewise Diagnostics           | 501 |

##### Stage 5: Interpretation of the Results 503

|   |     |
|---|-----|
| Discriminant Weights                    | 503 |
| Discriminant Loadings                   | 503 |
| Partial $F$ Values                      | 504 |
| Interpretation of Two or More Functions | 504 |
| Which Interpretive Method to Use?       | 506 |

##### Stage 6: Validation of the Results 506

|                             |     |
|-----------------------------|-----|
| Validation Procedures       | 506 |
| Profiling Group Differences | 507 |

##### A Two-Group Illustrative Example 508

|   |     |
|---|-----|
| Stage 1: Objectives of Discriminant Analysis                            | 508 |
| Stage 2: Research Design for Discriminant Analysis                      | 508 |
| Stage 3: Assumptions of Discriminant Analysis                           | 509 |
| Stage 4: Estimation of the Discriminant Model and Assessing Overall Fit | 509 |

Stage 5: Interpretation of the Results 520

Stage 6: Validation of the Results 522

A Managerial Overview 523

**A Three-Group Illustrative Example 523**

Stage 1: Objectives of Discriminant Analysis 524

Stage 2: Research Design for Discriminant Analysis 524

Stage 3: Assumptions of Discriminant Analysis 524

Stage 4: Estimation of the Discriminant Model and Assessing Overall Fit 525

Stage 5: Interpretation of Three-Group Discriminant Analysis Results 537

Stage 6: Validation of the Discriminant Results 542

A Managerial Overview 543

**Summary 544**

**Questions 546**

**Suggested Readings and Online Resources 547**

**References 547**

## **8 Logistic Regression: Regression with a Binary Dependent Variable 548**

**What Is Logistic Regression? 551**

**The Decision Process for Logistic Regression 552**

**Stage 1: Objectives of Logistic Regression 552**

Explanation 552

Classification 553

**Stage 2: Research Design for Logistic Regression 553**

Representation of the Binary Dependent Variable 553

Sample Size 555

Use of Aggregated Data 556

**Stage 3: Assumptions of Logistic Regression 556**

**Stage 4: Estimation of the Logistic Regression Model and Assessing Overall Fit 557**

Estimating the Logistic Regression Model 558

Assessing the Goodness-of-Fit of the Estimated Model 563

Overview of Assessing Model Fit 571

Casewise Diagnostics 571

Summary 572

**Stage 5: Interpretation of the Results 572**

Testing for Significance of the Coefficients 573

Interpreting the Coefficients 574

Calculating Probabilities for a Specific Value of the Independent Variable 578

Overview of Interpreting Coefficients 579

**Stage 6: Validation of the Results 579**

**An Illustrative Example of Logistic Regression 580**

Stage 1: Objectives of Logistic Regression 580

Stage 2: Research Design for Logistic Regression 580

Stage 3: Assumptions of Logistic Regression 581

Stage 4: Estimation of the Logistic Regression Model and Assessing Overall Fit 581

Stage 5: Interpretation of Results 592

Stage 6: Validation of the Results 596

A Managerial Overview 596

**Summary 596**

**Questions 598**

**Suggested Readings and Online Resources 598**

**References 598**

## **SECTION V**

**Moving Beyond The Basics 601**

### **9 Structural Equation Modeling: An Introduction 603**

**What Is Structural Equation Modeling? 607**

Estimation of Multiple Interrelated Dependence Relationships 607

Incorporating Latent Variables Not Measured Directly 608

Defining a Model 610

**SEM and Other Multivariate Techniques 613**

Similarity to Dependence Techniques 613

Similarity to Interdependence Techniques 613

The Emergence of SEM 614

**The Role of Theory in Structural Equation Modeling 614**

Specifying Relationships 614

Establishing Causation 615

Developing a Modeling Strategy 618

**A Simple Example of SEM 619**

Theory 619

Setting Up the Structural Equation Model for Path Analysis 620

The Basics of SEM Estimation and Assessment 621

**Six Stages in Structural Equation Modeling 625**

**Stage 1: Defining Individual Constructs 627**

Operationalizing the Construct 627

Pretesting 627

**Stage 2: Developing and Specifying the Measurement Model** 627

SEM Notation 628  
 Creating the Measurement Model 629

**Stage 3: Designing a Study to Produce Empirical Results** 629

Issues in Research Design 629  
 Issues in Model Estimation 633

**Stage 4: Assessing Measurement Model Validity** 635

The Basics of Goodness-of-Fit 635  
 Absolute Fit Indices 636  
 Incremental Fit Indices 638  
 Parsimony Fit Indices 639  
 Problems Associated with Using Fit Indices 639  
 Unacceptable Model Specification to Achieve Fit 641  
 Guidelines for Establishing Acceptable and Unacceptable Fit 641

**Stage 5: Specifying the Structural Model** 643

**Stage 6: Assessing the Structural Model Validity** 644

Competitive Fit 645  
 Testing Structural Relationships 647

**Summary** 648

**Questions** 649

**Suggested Readings and Online Resources** 649

**Appendix 9A: Estimating Relationships Using Path Analysis** 650

**Appendix 9B: SEM Abbreviations** 653

**Appendix 9C: Detail on Selected GOF Indices** 654

**References** 656

**10 SEM: Confirmatory Factor Analysis** 658

**What Is Confirmatory Factor Analysis?** 660

CFA and Exploratory Factor Analysis 660  
 Measurement Theory and Psychometrics 661  
 A Simple Example of CFA and SEM 661  
 A Visual Diagram 661

**SEM Stages for Testing Measurement Theory Validation with CFA** 663

**Stage 1: Defining Individual Constructs** 663

**Stage 2: Developing the Overall Measurement Model** 663

Unidimensionality 664  
 Congeneric Measurement Model 665  
 Items per Construct 665  
 Reflective Versus Formative Measurement 668

**Stage 3: Designing a Study to Produce Empirical Results** 670

Measurement Scales in CFA 670  
 SEM and Sampling 670  
 Specifying the Model 670  
 Issues in Identification 671  
 Problems in Estimation 673

**Stage 4: Assessing Measurement Model Validity** 673

Assessing Fit 674  
 Path Estimates 674  
 Construct Validity 675  
 Model Diagnostics 677  
 Summary Example 681

**CFA Illustration** 681

**Stage 1: Defining Individual Constructs** 682

**Stage 2: Developing the Overall Measurement Model** 682

**Stage 3: Designing a Study to Produce Empirical Results** 684

**Stage 4: Assessing Measurement Model Validity** 685

HBAT CFA Summary 692  
 CFA Results Detect Problems 693

**Summary** 696

**Questions** 697

**Suggested Readings and Online Resources** 697

**References** 697

**11 Testing Structural Equation Models** 699

**What Is a Structural Model?** 700

**A Simple Example of a Structural Model** 701

**An Overview of Theory Testing with SEM** 702

**Stages in Testing Structural Theory** 703

One-Step Versus Two-Step Approaches 703

**Stage 5: Specifying the Structural Model** 703

Unit of Analysis 704  
 Model Specification Using a Path Diagram 704  
 Designing the Study 708

**Stage 6: Assessing the Structural Model Validity** 710

Understanding Structural Model Fit from CFA Fit 710  
 Examine the Model Diagnostics 712

**SEM Illustration** 713

Stage 5: Specifying the Structural Model 713  
 Stage 6: Assessing the Structural Model Validity 715

**Summary** 722

**Questions** 723

**Suggested Readings and Online Resources** 723

**Appendix 11A** 724**References** 725**12 Advanced SEM Topics** 726**Reflective Versus Formative Scales** 728

Reflective Versus Formative Measurement Theory 728

Operationalizing a Formative Measure 729

Differences Between Reflective and Formative Measures 730

Which to Use—Reflective or Formative? 732

**Higher-Order Factor Models** 732

Empirical Concerns 733

Theoretical Concerns 734

Using Second-Order Measurement Theories 735

When to Use Higher-Order Factor Analysis 736

**Multiple Groups Analysis** 736

Measurement Model Comparisons 737

Structural Model Comparisons 741

**Measurement Type Bias** 742

Model Specification 742

Model Interpretation 744

**Relationship Types: Mediation and Moderation** 744

Mediation 745

Moderation 748

**Developments in Advanced SEM Approaches** 752

Longitudinal Data 752

Latent Growth Models 752

Bayesian SEM 753

**Summary** 755**Questions** 756**Suggested Readings and Online Resources** 757**References** 757**13 Partial Least Squares Structural Equation Modeling (PLS-SEM)** 759**What is PLS-SEM?** 764

Structural Model 764

Measurement Model 764

Theory and Path Models in PLS-SEM 765

The Emergence of SEM 765

Role of PLS-SEM Versus CB-SEM 766

**Estimation of Path Models with PLS-SEM** 766

Measurement Model Estimation 766

Structural Model Estimation 767

Estimating the Path Model Using the PLS-SEM Algorithm 767

**PLS-SEM Decision Process** 768**Stage 1: Defining Research Objectives and Selecting Constructs** 768**Stage 2: Designing a Study to Produce Empirical Results** 769

Metric Versus Nonmetric Data and Multivariate Normality 769

Missing Data 770

Statistical Power 770

Model Complexity and Sample Size 770

**Stage 3: Specifying the Measurement and Structural Models** 771

Measurement Theory and Models 773

Structural Theory and Path Models 774

**Stage 4: Assessing Measurement Model Validity** 774

Assessing Reflective Measurement Models 775

Assessing Formative Measurement Models 776

Summary 779

**Stage 5: Assessing the Structural Model** 779

Collinearity among Predictor Constructs 779

Examining the Coefficient of Determination 780

Effect Size 780

Blindfolding 780

Size and Significance of Path Coefficients 780

Summary 781

**Stage 6: Advanced Analyses Using PLS-SEM** 782

Multi-Group Analysis of Observed Heterogeneity 782

Detecting Unobserved Heterogeneity 782

Confirmatory Tetrad Analysis 782

Mediation Effects 782

Moderation 783

Higher-Order Measurement Models 783

Summary 783

**PLS-SEM Illustration** 783

Theoretical PLS-SEM Path Model 784

**Stage 4: Assessing Measurement Model Reliability and Validity** 785

Path Coefficients 785

Construct Reliability 786

Construct Validity 787

HBAT CCA Summary 790

**Stage 5: Assessing the Structural Model** 790

HBAT PLS-SEM Summary 791

**Summary** 792**Questions** 793**Suggested Readings and Online Resources** 793**References** 793

Index 800