

Vithala R. Rao

Applied Conjoint Analysis

 Springer

Applied Conjoint Analysis

Vithala R. Rao

Applied Conjoint Analysis

 Springer

Vithala R. Rao
S. C. Johnson Graduate School of
Management
Cornell University
Ithaca, New York
USA

ISBN 978-3-540-87752-3 ISBN 978-3-540-87753-0 (eBook)
DOI 10.1007/978-3-540-87753-0
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2013949178

© Springer-Verlag Berlin Heidelberg 2014

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. Exempted from this legal reservation are brief excerpts in connection with reviews or scholarly analysis or material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work. Duplication of this publication or parts thereof is permitted only under the provisions of the Copyright Law of the Publisher's location, in its current version, and permission for use must always be obtained from Springer. Permissions for use may be obtained through RightsLink at the Copyright Clearance Center. Violations are liable to prosecution under the respective Copyright Law.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

To the memory of esteemed Professor Paul E. Green, founder of conjoint analysis methods, a revered scholar, a wise advisor, and a dear friend.

Preface

I started this project some 10 years back; Professor Paul Green assisted me in the early phase of this work.

During the last 5 years or so, there have been several interesting developments in the conjoint analysis methods and models, notably incentive-aligned methods. I attempted to incorporate these yet keeping the basic thrust of the applied nature of this work. New methods appear on an almost daily basis. It is rather difficult to keep the coverage current. But, I tried to be up to date as much as feasible.

My intent is to bring various conjoint analysis methods to a level understandable to students and practitioners without losing rigor. As I ventured on this book, I soon realized how vast this field had become. Selection of topics and illustrations has become a difficult task. Nevertheless, I hope that this book presents an array of applications in marketing in a reasonably comprehensive manner. The edited book by Anders Gustafsson, Andreas Herrmann, and Frank Huber, *Conjoint Measurement: Methods and Applications*, Fourth Edition, Springer, 2007, in particular will be a good complement to this work. I wish that I was able to devote space to various behavioral aspects of choice.

I am grateful to several people in helping me make sure that this work is of a high caliber. These include two anonymous reviewers of my early versions and several colleagues such as Olivier Toubia and Oded Netzer of Columbia. My thanks are due to Abba Krieger of the Wharton School whose encouragement provided the necessary impetus to complete this work. Seenu Srinivasan of Stanford gave me early access to his paper on adaptive self-explicated method. Young-Hoon Park of Cornell gave me early access to his paper on barter conjoint, which is covered in Chap. 9; he also was a sounding board for ideas on organizing materials in Chap. 3. Sundar Balakrishnan of the University of Washington, Bothell, kindly reviewed the material on genetic algorithms for product design. Steve Gaskin graciously reviewed the material on legal applications covered in Chap. 8. Wes Hutchinson of the Wharton School kindly shared his working paper on self-designed products. Carlyne Saunders, a doctoral student in marketing at Cornell University, carefully read this volume and made several suggestions to enhance clarity. Yu Yu of Georgia State University helped with the analysis reported in Chap. 4. Chang Hee

Park of Binghamton University assisted me with the WinBUGS analysis reported in Chap. 4.

I am grateful to Brian Orme of Sawtooth Software for giving me access to their versatile software, which now includes several newer methods, not all of which are discussed here.

I appreciate *Marketing Letters* for allowing me to reproduce a paper written based on the 2008 Choice Symposium as a supplement. This paper, published in this journal (Vol. 19, December 2008 issue), gives a contemporary view of where conjoint methods stood a short while back.

I thank Christian Rauscher, editor from Springer, for his patience with the completion of this volume. Finally, I thank Saroj Rao for her help and patience throughout this project.

December 2013
Ithaca, NY

Vithala R. Rao

Contents

| | | |
|----------|---|----|
| 1 | Problem Setting | 1 |
| 1.1 | Introduction | 1 |
| 1.1.1 | Marketing Decisions and Role of Consumer Choice | 1 |
| 1.1.2 | A Framework for Understanding Consumer Choice | 2 |
| 1.2 | Origins of Conjoint Analysis | 3 |
| 1.3 | Some Terminology | 5 |
| 1.4 | Principal Types of Conjoint Analysis | 5 |
| 1.5 | Focus of this Book | 7 |
| 1.6 | Industry Uses of Conjoint Analysis | 7 |
| 1.7 | An Illustration of Conjoint Method | 9 |
| 1.7.1 | Application of Choice-Based Conjoint Analysis | 16 |
| 1.7.2 | Implementation of a Conjoint Study | 16 |
| 1.7.3 | Another Illustration | 17 |
| 1.7.4 | Features of Conjoint Analysis | 19 |
| 1.8 | Taxonomy of Conjoint Methods | 23 |
| 1.9 | Overview of Subsequent Chapters | 27 |
| | Appendix: A Selection of Applications of Conjoint Analysis in Areas Other than Marketing | 30 |
| | References | 34 |
| 2 | Theory and Design of Conjoint Studies (Ratings Based Methods) | 37 |
| 2.1 | Introduction | 37 |
| 2.2 | Designing a Conjoint Study | 38 |
| 2.3 | Types of Attributes and Partworth Functions | 40 |
| 2.4 | Selection of Attributes and Levels | 43 |
| 2.5 | Stimulus Set Construction | 44 |
| 2.5.1 | General Considerations | 44 |
| 2.5.2 | Statistical Designs for Generating Full Profiles | 45 |
| 2.5.3 | Full Factorial Designs | 46 |
| 2.5.4 | Fractional Factorial Designs | 46 |
| 2.5.5 | Orthogonal Main Effects Plans | 47 |

| | | |
|----------|--|-----------|
| 2.5.6 | Incomplete Block Designs | 52 |
| 2.5.7 | Random Sampling | 55 |
| 2.5.8 | Generating “Acceptable” Designs | 56 |
| 2.6 | Data Collection Methods | 56 |
| 2.6.1 | Full Profile Approach | 57 |
| 2.6.2 | Trade-off Matrix Method | 57 |
| 2.6.3 | Paired Comparison Methods | 59 |
| 2.6.4 | Self-explication Methods | 60 |
| 2.6.5 | Adaptive Methods | 61 |
| 2.6.6 | Hybrid Methods | 63 |
| 2.7 | Stimulus Presentation | 64 |
| 2.8 | Reliability and Validity | 64 |
| 2.9 | Summary | 65 |
| | Appendix 1: Illustration of a Ratings-Based Conjoint Questionnaire | 68 |
| | Appendix 2: Measures of Efficiency of an Experimental Design | 73 |
| | Appendix 3: Several Orthogonal Plans | 74 |
| | References | 77 |
| 3 | Analysis and Utilization of Conjoint Data (Ratings Based Methods) | 79 |
| 3.1 | Introduction | 79 |
| 3.2 | Analysis Models for Ratings Data | 81 |
| 3.2.1 | Notation | 81 |
| 3.2.2 | Additive Utility Model | 82 |
| 3.2.3 | Utility Model with Interactions | 83 |
| 3.2.4 | Coding for Categorical Attributes | 84 |
| 3.2.5 | Model Selection | 86 |
| 3.3 | Level of Analysis | 87 |
| 3.3.1 | Individual Level Analysis (Approaches IA and IB) | 88 |
| 3.3.2 | Subgroup Level Analysis (Approaches IIA and IIB) | 89 |
| 3.3.3 | Pooled Analysis for the Sample as a Whole (Approaches IIIA and IIIB) | 89 |
| 3.3.4 | Some Comparisons | 93 |
| 3.4 | Methods for Simulation | 98 |
| 3.4.1 | Illustration | 100 |
| 3.5 | Estimating the Hybrid Conjoint Model | 103 |
| 3.5.1 | Notation | 103 |
| 3.5.2 | Models Comparison | 104 |
| 3.6 | Individualized Hybrid Conjoint Models | 106 |
| 3.6.1 | Notation | 106 |
| 3.7 | Model for Adaptive Conjoint Analysis | 109 |
| 3.7.1 | Polyhedral estimation | 111 |
| 3.8 | Methods for Ranking and Categorical Response Data | 112 |
| 3.9 | Summary | 113 |

Appendix 1: Computation of Trade-offs from Utility Functions in Attributes 113

Appendix 2: Specification of Utility Functions 115

Appendix 3: Hierarchical Bayesian Method for Ratings-Based Conjoint Analysis 117

Appendix 4: Linear Programming Approach to Ranked Response Data 121

Appendix 5: A Method for Analyzing Categorical Response Data: Categorical Conjoint Analysis 122

References 125

4 Choice Based Conjoint Studies: Design and Analysis 127

 4.1 Introduction 127

 4.2 The Choice Process 128

 4.3 Choice Experiments for Conjoint Analysis: An Illustration 130

 4.4 Design of Choice Sets and Data Collection for Choice-Based Conjoint Studies 131

 4.4.1 Two Types of Designs 131

 4.4.2 Factors to Be Considered in Choice Set Design 132

 4.4.3 Examples of Designs Used in Some Past Studies 133

 4.4.4 Criteria for Evaluating Designs 136

 4.4.5 A Taxonomy of Choice Set Designs 138

 4.5 Strategies for Designing Choice Sets 140

 4.5.1 Methods Based on Linear Models 140

 4.5.2 Methods Based on Nonlinear Models for with Assumed Beta Values 145

 4.5.3 Bayesian Methods Based on Nonlinear Model for a Prior Distribution for Betas 147

 4.5.4 Other Methods 147

 4.5.5 Which Method to Use for Developing Designs? 152

 4.6 Incentive-Aligned Methods 152

 4.7 Partial Profile Choice Experiments 153

 4.8 Analysis Methods for Choice-Based Conjoint Data 154

 4.9 Multinomial Logit Model for Choice-Based Conjoint Data 154

 4.9.1 Modeling Utility 154

 4.9.2 Interpretation of Coefficients 157

 4.9.3 Data Structure 158

 4.9.4 Model Fit and Test 159

 4.9.5 Some Examples of MNL Analyses 160

 4.10 Some Alternatives to MNL for Stated Choice Data 162

 4.11 Bayesian Methods for Choice-Based Conjoint Analysis 167

 4.12 Which Conjoint Approach (Ratings-Based or Choice-Based)? 170

 4.13 Software for Design and Analysis 171

 4.14 Summary 172

Appendix 1: Illustration of Designing Choice Sets 173

Appendix 2: Design Plans for Pre-specified Holistic Alternatives Using Fractional Factorial Method 174

Appendix 3: Illustration of Design Efficiency in Choice-Based Conjoint Designs 174

Appendix 4: Illustration of Managerial Efficiency 176

Appendix 5: Empirical Illustration of Availability Designs 178

Appendix 6: Weighted Least Squares Method 180

References 181

5 Methods for a Large Number of Attributes 185

5.1 Introduction 185

5.2 Alternative Methods for Massive Number of Attributes 185

5.3 Details of the Methods and Applications 187

5.3.1 Methods of Category A: Profile Methods 187

5.3.2 Methods of Category B: Attribute Simplification Methods 191

5.3.3 Methods of Category C: Self Explicated Methods 195

5.3.4 Category D: Methods Combining Several Approaches 202

5.3.5 Category E: Upgrading Methods 207

5.3.6 Category F: SVM Methods 215

5.4 A Comparison of Methods 217

5.5 Summary 221

References 221

6 Applications for Product and Service Design and Product Line Decisions 225

6.1 Introduction 225

6.2 General Problem of Product and Product Portfolio Design 226

6.3 An Unified Framework for Product Design 227

6.3.1 Role of Choice Simulators 228

6.4 Applications for New Product Design 229

6.4.1 Application 1: Design of a Truck 229

6.4.2 Application 2: Design of a SLR Camera 229

6.4.3 Application 3: Design of a Course at a University 230

6.4.4 Application 4: Design of Microfinance Products 232

6.4.5 Application 4: Design of Dental Benefit Plans 236

6.4.6 Application 5: Design of a Hotel 236

6.4.7 Application 6: Design of Electronic Toll Collection System 242

6.4.8 Optimal Design of a Pharmaceutical Product 246

6.5 Applications for Product Line Decisions 247

6.5.1 Application 1: Redesigning Product Lines at the Sunbeam Appliance Company 249

6.5.2 Application 2: Redesign of Product Lines for an Herbicide Company 252

6.6 Conclusions 255

Appendix 1: A Mathematical Formulation of the Product Design and Positioning Problem 256

Appendix 2: Details on the SIMOPT Model 259

Appendix 3: Description of Algorithms for Product Line Design 263

References 272

7 Applications for Product Positioning and Market Segmentation 275

7.1 Introduction 275

7.2 Methods of Forming Segments with Conjoint Results 276

7.3 Applications for Product Positioning 277

7.3.1 Application: Positioning of an Antidepressant Drug 277

7.4 Market Segmentation Applications 278

7.4.1 Application 1: Segments of Camera Buyers 278

7.4.2 Application 2: Segments of Food Processor Buyers 279

7.4.3 Application 3: Segments of Buyers of an Antifungal Medication 281

7.4.4 Application 4: Segments from a Choice-Based Conjoint Study 284

7.5 Comparison of Different Conjoint Segmentation Approaches 287

7.6 Conclusion 290

References 290

8 Applications for Pricing Decisions 291

8.1 Introduction 291

8.2 Conjoint Method for Determining Price Elasticities (Brand/Price Trade-off) 292

8.3 Conjoint Method for Competitor Reaction Elasticities 294

8.4 Method Based on Reservation Prices 297

8.5 Measurement of Price Effects 300

8.5.1 Using Ratings-Based Approach 300

8.5.2 Using Choice-Based Approach 302

8.6 More Applications 303

8.6.1 Application 1: Bidding for a Contract 303

8.6.2 Application 2: Pricing Digital Content Product Lines 306

8.6.3 Application 3: Multipart Pricing 309

8.7 Summary 313

Appendix 1: Technical Details for Estimating Self- and Cross-Price/Demand Relationships 313

Appendix 2: Estimation of Mean and Variance from Truncated Normal Distribution 315

References 315

9 Applications to a Miscellany of Marketing Problems 317

9.1 Introduction 317

9.2 Competitive Strategy Decisions 317

9.3 Distribution and Personal Selling Decisions 321

- 9.3.1 Store Location Decisions 321
- 9.3.2 Setting Sales Quotas 323
- 9.3.3 Choice of a Distribution Channel 325
- 9.3.4 Web Page Design 328
- 9.4 Legal Decisions 330
 - 9.4.1 Measuring Damage Due to Patent Infringement 330
 - 9.4.2 An Application to a Class Action Suit 331
- 9.5 Resource Allocation Decisions 335
 - 9.5.1 Allocation of Push Marketing Mix Budget for a Brand 336
 - 9.5.2 Market Value of an Attribute Improvement (MVAI) 337
- 9.6 Measurements for Marketing Strategies 339
 - 9.6.1 Measuring Brand Equity 339
 - 9.6.2 Customer Satisfaction 339
- 9.7 Summary 342
- References 343
- 10 Recent Developments and Future Outlook 345**
 - 10.1 Introduction 345
 - 10.2 Experimental Designs for Mixture and Mixture-Amount 346
 - 10.3 Conjoint Approaches 347
 - 10.3.1 Barter Conjoint Method 347
 - 10.3.2 Conjoint Poker 350
 - 10.3.3 Best-Worst Scaling 351
 - 10.3.4 Peer Influence Measurement 352
 - 10.3.5 Incorporating Non-compensatory Choice Processes 354
 - 10.3.6 Combining Preference and Choice Data 354
 - 10.4 Applications 354
 - 10.4.1 Self-designed Products 355
 - 10.4.2 Bundle Choice Models 356
 - 10.5 Future Outlook 358
 - 10.6 Summary 360
 - References 360
- 11 Beyond Conjoint Analysis: Advances in Preference Measurement 363**
 - 11.1 Introduction: Beyond Conjoint Analysis 363
 - 11.2 Problem 365
 - 11.2.1 Helping Companies 365
 - 11.2.2 Helping Consumers 366
 - 11.2.3 Helping Policy Makers and Health Care Professionals 366
 - 11.2.4 Helping Academic Researchers 366
 - 11.3 Design and Data Collection 367
 - 11.3.1 Optimal Experimental Design: Beyond A-Efficiency and D-Efficiency 367
 - 11.3.2 New Forms of Interactions 368

- 11.3.3 Dealing with a Large Number of Attributes and Products 369
- 11.3.4 Combining Multiple Sources of Data 370
- 11.4 Model Specification, Estimation, and Action 371
 - 11.4.1 Taking Social Interactions into Account 371
 - 11.4.2 Meta-attributes 371
 - 11.4.3 More Flexible Utility Functions 372
 - 11.4.4 Incorporating Behavioral Effects 373
 - 11.4.5 Modeling Learning, Dynamics and Preference Formation 374
 - 11.4.6 Recent Tools for Estimation 374
 - 11.4.7 From Model to Action 375
- 11.5 In Conclusion. . . “Every Generation Needs a New Revolution” . . . 376
- References 377
- Index 383**

Chapter 1

Problem Setting

1.1 Introduction

1.1.1 Marketing Decisions and Role of Consumer Choice

Several interdependent decisions are involved in the formulation of a marketing strategy for a brand (of a product or service). These include not only decisions about the product's characteristics but also its positioning, communication, distribution, and pricing to chosen sets of targeted customers. The decisions will need to be made in the wake of uncertain competitive reactions and a changing (and often unpredictable) environment. For a business to be successful, the decision process must include a clear understanding of how customers will choose among (and react to) various competing alternatives. It is well accepted in marketing that choice alternatives can be described as profiles on multiple attributes and that individuals consider various attributes while making a choice. While choosing, consumers typically make trade-offs among the attributes of a product or service. Conjoint analysis is a set of techniques ideally suited to studying customers' choice processes and determining tradeoffs.

Conjoint analysis is probably the most significant development in marketing research over the last 30 years or so. Since its introduction to marketing research in 1971 (Green and Rao 1971), it has been applied in several thousand applied marketing research projects. The method has been applied successfully for tackling several marketing decisions such as optimal design of new products, target market selection, pricing a new product, and competitive reactions. A significant advantage of the method has been its ability to answer various "what if" questions using market simulators; these simulators are based on the results of an analysis of conjoint data collected on hypothetical and real choice alternatives.

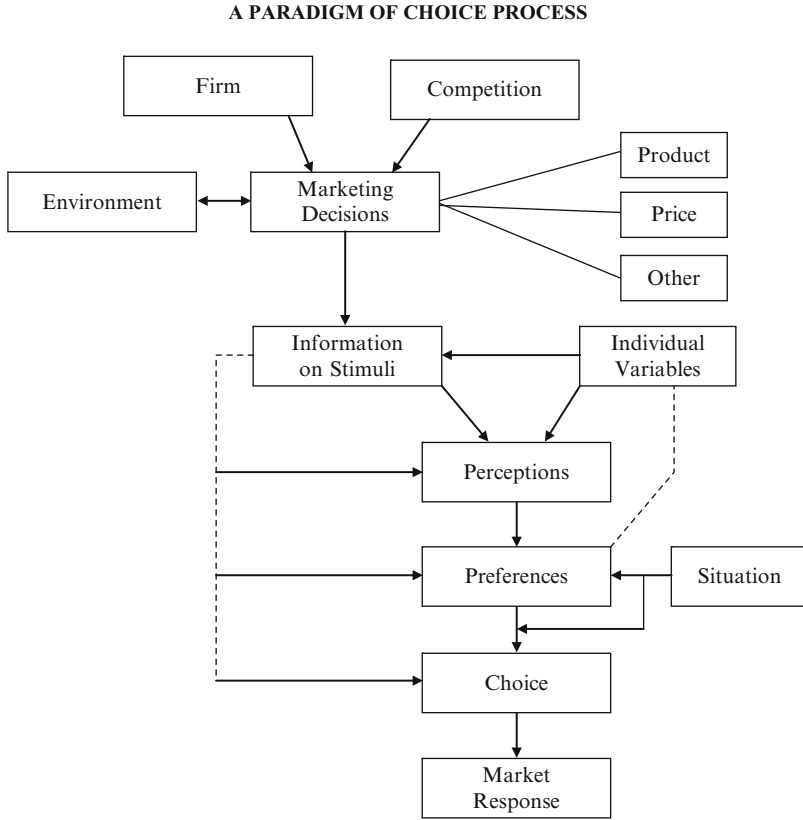


Fig. 1.1 A paradigm of choice process

1.1.2 A Framework for Understanding Consumer Choice

Established methods of marketing research are often used in developing an understanding of consumers' choice processes. A marketing research study involves the study of consumer perceptions, preferences, and choices in a set of choice situations. A streamlined view of how various consumer behavior constructs are related is shown in Fig. 1.1. Beginning at the top of the figure, a marketing manager makes decisions about her brand in light of the information gathered from the environment. According to this view, a consumer assimilates the information across all (considered) alternatives and forms perceptions about the choice set. These perceptions form the basis for preferences toward the alternatives; one should note that both the perceptions and preferences can be idiosyncratic to the individual. Stated differently, this paradigm incorporates individual heterogeneity in the way information on alternatives is assimilated by the individuals. The next stage in this process is the way preferences get translated into choices; it is an individual's preferences which form the basis for choices in the marketplace. An individual's

preferences will naturally be modified by characteristics of the choice situation (e.g. choices made for one's own consumption or for a gift, changes in one's income and so on). Finally, aggregation of the choices by all potential consumers will lead to a prediction of the overall market response (e.g., sales of an item).

1.2 Origins of Conjoint Analysis

While the foundations of conjoint analysis go back to at least the 1920s, it is generally agreed that the seminal paper by Luce and Tukey (1964) on the theory of conjoint measurement formed the basis for the applied field of conjoint analysis. The development of the field was aided considerably by the proliferation of algorithms for the computations involved.

Conjoint measurement is concerned with determining the joint effect of levels of two or more attributes of stimuli on the total evaluative judgments of a set of stimuli (see Rao 1977 for a review of conjoint measurement in marketing analysis). The objective is to decompose the total evaluation into component scores, imputable to each attribute level or combination of attribute levels. The theory is concerned with the conditions under which there exist measurement scales for both the evaluative score (dependent variable) and each attribute level (independent variables), and a pre-specified composition rule. All are based on formal axiomatic system formulated by Krantz et al. (1971), including the axioms of consistency, transitivity, and attribute independence. The evaluative score can be categorical, ordinal or interval-scaled. For example, consider an individual's evaluation of a pair of running sneakers described on two attributes of price and quality (e.g., \$70 per pair and medium quality); these responses can be categorical (e.g. suitable for serious young runners, for casual young runners, or for retirees), ordinal (e.g., very good, good, bad or very bad value for money), or interval-scaled (e.g., a rating on a 10 point scale on value for money). With such evaluation scores of price and quality on a number of profiles, an analyst can develop a utility function for the individual. Calling the functions for price and quality v_p , and v_q respectively (called partworth functions), the composite specification for the evaluation can be additive as $a*v_p + b*v_q$ or polynomial as $a*v_p + b*v_q + c*v_p*v_q$ or some other formulation. The axioms enable the analyst to choose the appropriate specification.

In the course of implementing conjoint measurement methods to applied business problems, such as those encountered in marketing, the emphasis on theoretical aspects of measurement has given way to the more pragmatic issues of design of studies and analysis of data. This is due to various intricacies in testing¹ whether the axioms are satisfied in the data collected. The testing procedures require extensive data and are highly complicated even for a small number of respondents. This process became frustrating for applied researchers.

¹ See Corstjens and Gautschi (1983) for detailed methods for testing these axioms.

The methodology that has evolved to handle these problems is popularly called “conjoint analysis” to reflect the stated distinction. Conjoint analysis refers to any decompositional method that estimates the structure of a consumer’s preferences² in terms of the levels of attributes of the alternatives. The methodology quite heavily uses statistical experimental design and parameter estimation methods.

Conjoint analysis is quite closely related to other developments in Information Integration Theory and its associated method of Functional Measurement (Anderson 1970). The functional measurement approach involves the use of analysis of variance (ANOVA) methods for problems of information integration. These methods have been applied in a variety of contexts dealing with understanding and modeling the process of judgment and groups including Social Judgment Theory and its related method of Policy Capturing.³ Early applications in psychology were concerned with the modeling of clinical judgments (Dawes and Corrigan 1974), which basically involved estimating a multiple regression model between the overall judgments of an object and its characteristics (for example, relating the characteristics of a job candidate to a job in a company).

Thus, the conjoint analysis approach is decompositional in nature as contrasted with the approaches of Fishbein (1967) and Rosenberg (1956) which are compositional or buildup methods. The compositional approaches were popular in marketing research in the 1970s and 1980s. In these methods,⁴ the overall attitude (or preference) towards an object is expressed as a weighted sum of the importance of attributes and the scores of the object on various attributes. This formulation is utilized in the self-explicated methods of conjoint analysis (described in Chaps. 2 and 5). Further, the self-explicated methods can be integrated in some of the models by which conjoint analysis is implemented in practice (e.g., the hybrid modeling approach); we will describe these in Chaps. 2 and 3.

The methods of conjoint analysis are quite distinct from those of multiattribute utility estimation developed by Keeney and Raiffa (1976). This approach derives the utility function deductively from a set of assumptions and the parameters of the function are obtained from tradeoff judgments and from preferences for alternative gambles. The theory is normative as opposed to that in conjoint analysis which is descriptive (or paramorphic). Further, the data collection procedures needed for estimating these multiattribute utility functions are quite complicated and tedious. Accordingly, these methods are not used much in marketing studies.

² This method is quite similar to preference analysis in multidimensional scaling which focuses on estimating the ideal points for or weights on perceptual dimensions. These functions will be described in Chap. 2.

³ A computer software called Policy-PC offered by the Executive Decision Services, Albany, NY allows for a menu of utility functions.

⁴ See Wilkie and Pessemier (1973) for a comprehensive review.