CONTENTS

PREFACE ix

INTRODUCTION 1 1.1 The Need 1 1.2 Why a Book? 1 1.3 Different Users 2

1.4 Sketch of the Chapters 21.5 Computer Programs 71.6 How to Proceed from Here 7

2	2.1 2.2 2.3 2.4 2.5 2.6 2.7	Introduction 9 Introduction 9 Two Dimensions—The Fourfold Table 11 Two Dimensions—The Rectangular Table 24 Models for Three-Dimensional Arrays 31 Models for Four or More Dimensions 42 Exercises 48 Appendix: The Geometry of a 2 × 2 Table 49
3	MAX TAB 3.1 3.2 3.3 3.4 3.5 3.6 3.7 3.8	IMUM LIKELIHOOD ESTIMATES FOR COMPLETE LES 57 Introduction 57 Sampling Distributions 62 Sufficient Statistics 64 Methods of Obtaining Maximum Likelihood Estimates 73 Iterative Proportional Fitting of Log-Linear Models 83 Classical Uses of Iterative Proportional Fitting 97 Rearranging Data for Model Fitting 102 Degrees of Freedom 114
4		MAL GOODNESS OF FIT: SUMMARY STATISTICS AND DEL SELECTION 123 Introduction 123 Summary Measures of Goodness of Fit 124 Standardized Rates 131 Internal Goodness of Fit 136 Choosing a Model 155 Appendix: Goodman's Partitioning Calculus 169
5	MAX TAB 5.1 5.2 5.3 5.4 5.5	IMUM LIKELIHOOD ESTIMATION FOR INCOMPLETE LES 177 Introduction 177 Incomplete Two-Way Tables 178 Incomplete Two-Way Tables for Subsets of Complete Arrays 206 Incomplete Multiway Tables 210 Representation of Two-Way Tables as Incomplete Multiway Arrays 225

vi Contents

6	ESTIN 6.1 6.2 6.3 6.4 6.5 6.6	MATING THE SIZE OF A CLOSED POPULATION 229 Introduction 229 The Two-Sample Capture-Recapture Problem 231 Conditional Maximum Likelihood Estimation of N 236 The Three-Sample Census 237 The General Multiple Recapture Problem 246 Discussion 254
7	7.1 7.2 7.3	Higher-Order Markov Models 267 Markov Models with a Single Sequence of Transitions 270
8	MAF 8.1 8.2 8.3	LYSIS OF SQUARE TABLES: SYMMETRY AND RGINAL HOMOGENEITY 281 Introduction 281 Two-Dimensional Tables 282 Three-Dimensional Tables 299 Summary 309
9		DEL SELECTION AND ASSESSING CLOSENESS OF FIT: CTICAL ASPECTS 311 Introduction 311 Simplicity in Model Building 312 Searching for Sampling Models 315 Fitting and Testing Using the Same Data 317 Too Good a Fit 324 Large Sample Sizes and Chi Square When the Null Model is False 329 Data Anomalies and Suppressing Parameters 332 Frequency of Frequencies Distribution 337
0	CRO 10.1 10.2 10.3 10.4 10.5 10.6	ER METHODS FOR ESTIMATION AND TESTING IN SS-CLASSIFICATIONS 343 Introduction 343 The Information-Theoretic Approach 344 Minimizing Chi Square, Modified Chi Square, and Logit Chi Square 348 The Logistic Model and How to Use It 357 Testing via Partitioning of Chi Square 361 Exact Theory for Tests Based on Conditional Distributions 364 Analyses Based on Transformed Proportions 366
	10.8	Necessary Developments 371

	11.2 11.3	Measures of Association for 2 \times 2 Tables 376 Measures of Association for $I \times J$ Tables 385			
	11.3	Agreement as a Special Case of Association 393			
12	PSEUDO-BAYES ESTIMATES OF CELL PROBABILITIES 401				
	12.1	Introduction 401			
	12.2	,			
	12.3	Asymptotic Results for Pseudo-Bayes Estimators 410			
	12.4	Small-Sample Results 416			
	12.5	Data-Dependent λ's 419			
	12.6	Another Example: Two Social Mobility Tables 426			
	12.7	Recent Results and Some Advice 429			
13	SAMPLING MODELS FOR DISCRETE DATA 435				
	13.1	Introduction 435			
	13.2	The Binomial Distribution 435			
	13.3	The Poisson Distribution 438			
	13.4	The Multinomial Distribution 441			
	13.5	The Hypergeometric Distribution 448			
	13.6	The Multivariate Hypergeometric Distribution 450			
	13.7	The Negative Binomial Distribution 452			
	13.8	The Negative Multinomial Distribution 454			
14	ASYMPTOTIC METHODS 457				
	14.1	Introduction 457			
	14.2	The O, o Notation 458			
	14.3	Convergence of Stochastic Sequences 463			
	14.4	The O_p , O_p Notation for Stochastic Sequences 475			
	14.5	Convergence of Moments 484			
	14.6	The δ Method for Calculating Asymptotic Distributions 486			
	14.7	General Framework for Multinomial Estimation and			
		Testing 502			
	14.8	Asymptotic Behavior of Multinomial Maximum Likelihood			
		Estimators 509			
	14.9	Asymptotic Distribution of Multinomial Goodness-of-Fit			
		Tests 513			
REF	ERENCE	ES 531			

11 MEASURES OF ASSOCIATION AND AGREEMENT 373

11.1 Introduction 373

INDEX TO DATA SETS 543

AUTHOR INDEX 547

SUBJECT INDEX 551