

---

## Contents

<b>1</b>	<b>Introduction</b> .....	1
1.1	Marginal Models for Categorical Data .....	1
1.2	Historical and Comparable Approaches .....	5
1.3	Coefficients for the Comparison of Marginal Distributions .....	9
1.3.1	Measuring Differences in Location .....	9
1.3.2	Measuring Differences in Dispersion .....	13
1.3.3	Measuring Association .....	16
1.3.4	Measuring Agreement .....	20
<b>2</b>	<b>Loglinear Marginal Models</b> .....	23
2.1	Ordinary Loglinear Models .....	23
2.1.1	Basic Concepts and Notation .....	23
2.1.2	Modeling Association Among Three Variables .....	30
2.2	Applications of Loglinear Marginal Models .....	34
2.2.1	Research Questions and Designs Requiring Marginal Models .....	34
2.2.2	Comparing One Variable Distributions .....	36
2.2.3	More Complex Designs and Research Questions .....	42
2.3	Maximum Likelihood Inference for Loglinear Marginal Models ...	51
2.3.1	Sampling Methods .....	51
2.3.2	Specifying Loglinear Marginal Models by Constraining the Cell Probabilities .....	52
2.3.3	Simultaneous Modeling of Joint and Marginal Distributions: Redundancy, Incompatibility and Other Issues	61
2.3.4	***Maximum Likelihood Estimates of Constrained Cell Probabilities .....	65
2.3.5	***A Numerical Algorithm for ML Estimation .....	67
2.3.6	***Efficient Computation of ML Estimates for Simultaneous Joint and Marginal Models .....	70
2.3.7	***Large Sample Distribution of ML estimates .....	71
2.3.8	Model Evaluation .....	73

<b>3</b>	<b>Nonlinear Marginal Models</b> .....	75
3.1	Comparing Item Characteristics for Different Measurement Levels .	75
3.1.1	Interval Level of Measurement .....	76
3.1.2	Ordinal Level of Measurement .....	79
3.1.3	Nominal Level of Measurement .....	82
3.2	Comparing Associations .....	83
3.3	Maximum Likelihood Estimation .....	86
3.3.1	Generalized exp-log Specification of Nonlinear Marginal Models .....	86
3.3.2	Compatibility and Redundancy of Restrictions .....	93
3.3.3	Homogeneous Specification of Coefficients .....	93
3.3.4	***Algorithm for Maximum Likelihood Estimation .....	94
3.3.5	***Asymptotic Distribution of ML Estimates .....	95
<b>4</b>	<b>Marginal Analysis of Longitudinal Data</b> .....	97
4.1	Trend Data .....	99
4.1.1	Comparing Net Changes in More Than One Characteristic ..	99
4.1.2	Simultaneous Tests for Restrictions on Association and Net Change: Modeling Joint and Marginal Tables .....	102
4.2	Panel Data: Investigating Net Changes in One Characteristic .....	104
4.2.1	Overall Net Changes; Cumulative Proportions; Growth Curves .....	104
4.2.2	Subgroup Comparisons of Net Changes .....	115
4.2.3	Changes in Associations .....	118
4.3	Gross Changes in One Characteristic .....	120
4.3.1	Comparing Turnover Tables for Different Periods .....	120
4.3.2	Comparing Summary Measures of Gross Change .....	126
4.3.3	Extensions; Net <i>Plus</i> Gross Changes; Multiway Turnover Tables; Subgroup Comparisons .....	129
4.4	Net and Gross Changes in Two Related Characteristics .....	130
4.4.1	Net Changes in Two Characteristics .....	131
4.4.2	Changes in Association Between Two Changing Characteristics .....	136
4.4.3	Gross Changes in Two Characteristics .....	140
4.4.4	Combining Hypotheses about Net and Gross Changes .....	147
4.5	Minimally Specified Models for Comparing Tables with Overlapping Marginals; Detection of Problematic Models .....	148
<b>5</b>	<b>Causal Analyses: Structural Equation Models and (Quasi-)Experimental Designs</b> .....	155
5.1	SEMs - Structural Equation Models .....	156
5.1.1	SEMs for Categorical Data .....	156
5.1.2	An Example: Women's Role .....	160
5.1.3	Marginal Modeling and Categorical SEM .....	165
5.2	Analysis of (Quasi-)Experimental Data .....	172

5.2.1	The One-group Pretest-Posttest Design .....	173
5.2.2	The Nonequivalent Control Group Design .....	175
5.2.3	A Truly Experimental Design .....	182
<b>6</b>	<b>Marginal Modeling with Latent Variables .....</b>	<b>191</b>
6.1	Latent Class Models .....	191
6.2	Latent Marginal Homogeneity .....	196
6.3	Loglinear and Nonloglinear Latent Class Models: Equal Reliabilities	198
6.3.1	Restrictions on Conditional Response Probabilities .....	199
6.3.2	Restrictions on Odds Ratios .....	201
6.3.3	Restrictions on Percentage Differences .....	204
6.3.4	Restrictions on Agreement .....	206
6.4	Marginal causal analyses .....	207
6.4.1	SEMs with latent marginal homogeneity .....	207
6.4.2	Latent Variable SEMs for Clustered Data .....	209
6.5	Estimation of Marginal Models with Latent Variables	
	Using the EM Algorithm .....	212
6.5.1	Basic EM Algorithm .....	213
6.5.2	***General EM for Marginal Models .....	215
6.5.3	***Marginal Restrictions in Combination with a Loglinear Model for the Complete Table .....	217
6.5.4	***Speeding up of the EM Algorithm for Separable Models	218
6.5.5	***Asymptotic Distribution of ML Estimates .....	219
<b>7</b>	<b>Conclusions, Extensions, and Applications .....</b>	<b>223</b>
7.1	Marginal Models for Continuous Variables .....	224
7.1.1	Changes in Means .....	224
7.1.2	Changes in Correlation and Regression Coefficients .....	226
7.2	Alternative Procedures and Models .....	228
7.2.1	Alternative Estimation Procedures: WLS and GEE .....	228
7.2.2	Modeling Dependent Observations: Marginal, Random Effects, and Fixed Effects Models .....	230
7.3	Specific Applications .....	236
7.3.1	Multiple Responses .....	237
7.3.2	Categorical Dyadic Data .....	238
7.3.3	Mokken Scale Analysis .....	241
7.4	Problems and Future Developments .....	242
7.5	Software, Generalized exp-log Routines, and Website .....	244
	<b>References .....</b>	<b>247</b>
	<b>Author Index .....</b>	<b>259</b>
	<b>Subject Index .....</b>	<b>263</b>