Contents

Preface Dedication				ix	
				xi	
Ι	Me	${f thodology}$		xiii	
1	Th	e omni-presence of latent variables		1	
	1.1	Introduction		1	
	1.2	'True' variable measured with error		2	
	1.3	Hypothetical constructs		4	
	1.4	Unobserved heterogeneity		9	
	1.5	Missing values and counterfactuals		14	
	1.6	Latent responses		16	
	1.7	Generating flexible distributions		17	
	1.8	Combining information		18	
	1.9	Summary	•	18	
2	Мо	deling different response processes		21	
	2.1	Introduction		21	
	2.2	Generalized linear models		22	
	2.3	Extensions of generalized linear models		27	
	2.4	Latent response formulation		33	
	2.5	Modeling durations or survival		39	
	2.6	Summary and further reading		46	
3	Cla	ssical latent variable models		49	
	3.1	Introduction		49	
	3.2	Multilevel regression models		49	
	3.3	Factor models and item response models		63	
	3.4	Latent class models		74	
	3.5	Structural equation models with latent variables		75	
9	3.6	Longitudinal models		80	
	3.7	Summary and further reading		93	
4	Ger	neral model framework		95	
	4.1	Introduction		95	

vi CONTENTS

	4.2	Response model	96
	4.3	Structural model for the latent variables	108
	4.4	Distribution of the disturbances	112
	4.5	Parameter restrictions and fundamental parameters	117
	4.6	Reduced form of the latent variables and linear predictor	120
	4.7	Moment structure of the latent variables	121
	4.8	Marginal moment structure of observed and latent responses	123
	4.9	Reduced form distribution and likelihood	127
	4.10	Reduced form parameters	130
	4.11	Summary and further reading	132
5	Ider	ntification and equivalence	135
	5.1	Introduction	135
	5.2	Identification	136
	5.3	Equivalence	152
	5.4	Summary and further reading	157
6	Esti	mation	159
	6.1	Introduction	159
	6.2	Maximum likelihood: Closed form marginal likelihood	160
	6.3	Maximum likelihood: Approximate marginal likelihood	161
	6.4	Maximizing the likelihood	174
	6.5	Nonparametric maximum likelihood estimation	182
	6.6	Restricted/Residual maximum likelihood (REML)	184
	6.7	Limited information methods	185
		Maximum quasi-likelihood	191
	6.9	Generalized Estimating Equations (GEE)	197
	6.10	Fixed effects methods	200
	6.11	Bayesian methods	204
	6.12	Summary	214
		Appendix: Some software and references	216
7	Ass	igning values to latent variables	221
	7.1	Introduction	221
	7.2	Posterior distributions	222
	7.3	Empirical Bayes (EB)	225
	7.4	Empirical Bayes modal (EBM)	235
	7.5	Maximum likelihood	237
	7.6	Relating the scoring methods in the 'linear case'	241
	7.7	Ad hoc scoring methods	241
	7.8	Some uses of latent scoring and classification	243
	7.9	Summary and further reading	247
		Appendix: Some software	2/10

8	Mod	del specification and inference	251
	8.1	Introduction	251
	8.2	Statistical modeling	251
	8.3	Inference (likelihood based)	257
	8.4	Model selection: Relative fit criteria	262
	8.5	Model adequacy: Global absolute fit criteria	267
	8.6	Model diagnostics: Local absolute fit criteria	272
	8.7	Summary and further reading	280
II	Ap	plications	283
9	Dicl	notomous responses	285
	9.1	Introduction	285
	9.2	Respiratory infection in children: A random intercept model	285
	9.3	Diagnosis of myocardial infarction: A latent class model	288
	9.4	Arithmetic reasoning: Item response models	292
	9.5	Nicotine gum and smoking cessation: A meta-analysis	299
	9.6	Wives' employment transitions: Markov models with unob-	
		served heterogeneity	307
	9.7	Counting snowshoe hares: Capture-recapture models with	
		heterogeneity	311
	9.8	Attitudes to abortion: A multilevel item response model	315
	9.9	Summary and further reading	318
10	Ord	inal responses	321
	10.1	Introduction	321
	10.2	Cluster randomized trial of sex education: Latent growth curve model	321
	10.3	Political efficacy: Factor dimensionality and item-bias	326
		Life satisfaction: Ordinal scaled probit factor models	338
		Summary and further reading	347
11	Cou	ints	349
		Introduction	349
		Prevention of faulty teeth in children: Modeling overdispersion	349
		Treatment of epilepsy: A random coefficient model	355
		Lip cancer in Scotland: Disease mapping	361
		Summary and further reading	370
12	Dur	ations and survival	373
	12.1	Introduction	373
	12.2	Modeling multiple events clustered duration data	373
		Onset of smoking: Discrete time frailty models	375
		Exercise and angina: Proportional hazards random effects and	
		factor models	382

viii CONTENTS

	12.5 Summary and further reading	390
13	Comparative responses	393
	13.1 Introduction	393
	13.2 Heterogeneity and 'Independence from Irrelevant Alternatives'	393
	13.3 Model structure	395
	13.4 British general elections: Multilevel models for discrete choice and rankings	397
	13.5 Post-materialism: A latent class model for rankings	404
	13.6 Consumer preferences for coffee makers: A conjoint choice	
	model	408
	13.7 Summary and further reading	415
14	Multiple processes and mixed responses	417
	14.1 Introduction	417
	14.2 Diet and heart disease: A covariate measurement error model	417
	14.3 Herpes and cervical cancer: A latent class covariate measure-	
	ment error model for a case-control study	422
	14.4 Job training and depression: A complier average causal effect	
	model	427
	14.5 Physician advice and drinking: An endogenous treatment	
	model	432
	14.6 Treatment of liver cirrhosis: A joint survival and marker model	438
	14.7 Summary and further reading	443
Re	eferences	445
In	dex	487
۸,	thor index	406