

Contents

Preface	ix
1. Introduction to multilevel analysis	1
1.1. Why do we need special multilevel analysis techniques?	5
1.2. Multilevel theories	7
1.3. Models described in this book	8
2. The basic two-level regression model: introduction	11
2.1 Example	11
2.2 An extended example	15
2.3 Inspecting residuals	22
2.3.1 Examples of residuals plots	22
2.3.2 Examining slope variation: OLS and shrinkage estimators	27
2.4 Three- and more-level regression models	30
2.4.1 Multiple-level models	30
2.4.2 Intraclass-correlations in three-level models	31
2.5A note about notation and software	33
2.5.1 Notation	33
2.5.2 Software	34
3. Estimation and hypothesis testing in multilevel regression	37
3.1 Which estimation method?	37
3.1.1 Maximum Likelihood	37
3.1.2 Generalized Least Squares	39
3.1.3 Generalized Estimating Equations	40
3.1.4 Bootstrapping	40
3.1.5 Bayesian methods	41
3.2 Significance testing and confidence intervals	42
3.2.1 Testing regression coefficients and variance components	42
3.2.2 Comparing nested models	43
3.2.3 Comparing non-nested models	45
3.3 Contrasts and constraints	46

4. Some Important Methodological and Statistical Issues	49
4.1 Analysis strategy	49
4.2 Centering and standardizing explanatory variables	54
4.3 Interpreting interactions	58
4.4 How much variance is explained?	63
5. Analyzing Longitudinal Data	73
5.1 Fixed and varying occasions	74
5.2 Example with fixed occasions	75
5.3 Example with varying occasions	86
5.4 Advantages of multilevel analysis for longitudinal data	93
5.5 Some statistical issues in longitudinal analysis	93
5.5.1 Investigating and analyzing patterns of change	93
5.5.2 Handling missing data and panel dropout	95
5.6 Complex covariance structures	96
5.7 Some software issues	102
6. The logistic model for dichotomous data and proportions	103
6.1 Generalized linear models	103
6.2 Multilevel generalized linear models	107
6.2.1 Estimating generalized multilevel models	108
6.3 Example: analyzing dichotomous data	110
6.4 Example: analyzing proportions	112
6.5 Analyzing event counts and other nonlinear models	122
7. Cross-classified multilevel models	123
7.1 Example of cross-classified data: pupils nested within (primary and secondary schools)	124
7.2 Example of cross-classified data: (sociometric ratings) in small groups	128
7.3 Statistical and computational issues	136
8. The multilevel approach to meta-analysis	139
8.1 Meta-analysis and multilevel modeling	139
8.2 The variance-known model	141
8.3 Example and comparison with classical meta-analysis	145
8.3.1 Classical meta-analysis	146
8.3.2 Multilevel meta-analysis	147
8.4 Correcting for artifacts	149
8.5 Statistical and software issues	153
Appendix	154

9. Multivariate multilevel regression models	157
9.1 The basic model	158
9.2 Example of multivariate multilevel analysis: multiple response variables	161
9.3 Example of multivariate multilevel analysis: measuring group characteristics	168
10. Sample sizes and power analysis in multilevel regression	173
10.1 Sample size and accuracy of estimates	173
10.1.1 Accuracy of fixed parameters and their standard errors	173
10.1.2 Accuracy of random parameters and their standard errors	174
10.1.3 Accuracy and sample size	174
10.1.4 Accuracy and sample size with proportions and dichotomous data	175
10.2 Estimating power in multilevel regression designs	177
10.2.1 Post hoc power analysis	179
10.2.2 A priori power analysis: general issues	180
10.2.3 A priori power analysis: the intercept variance and intraclass correlation	184
10.2.4 A priori power analysis: designing an intervention study	186
10.2.5 A general procedure for power analysis	194
11. Advanced methods for estimation and testing	197
11.1 The profile likelihood method	199
11.2 Robust standard errors	200
11.3 Bootstrapping estimates and standard errors	203
11.3.1 A simple example of bootstrapping	205
11.3.2 Bootstrapping multilevel regression models	207
11.3.3 An example of the bootstrap	208
11.4 Bayesian estimation methods	211
11.4.1 Simulating the posterior distribution	213
11.4.2 An example of Bayesian estimation using MlwiN: the estrone data	214
11.4.3 An example of Bayesian estimation using MlwiN: the popularity data	220
11.4.4 Some remarks on Bayesian estimation methods	223

12. Multilevel factor models	225
12.1 Decomposing multilevel variables	227
12.2 Muthén's pseudobalanced approach	228
12.2.1 An example of pseudobalanced multilevel factor analysis	232
12.2.2 Goodness of fit using the pseudobalanced approach	238
12.3 Direct estimation of the covariances at each level: the multivariate multilevel approach	242
12.4 Standardizing parameter estimates in multilevel structural equation modeling	248
13. Multilevel path models	251
13.1 Example of a multilevel path analysis	252
13.2 Statistical and software issues in multilevel factor and path models	259
14. Latent curve models	263
14.1 Example of latent curve modeling	266
14.2 A brief comparison of multilevel regression analysis and latent curve modeling of longitudinal data	273
Appendix: Data and stories	275
References	281
Author index	293
Subject index	299