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Book review: Rabe-Hesketh S, Skrondal A 2008: Multilevel and Longitudinal Modeling Using Stata, second edition. College Station, TX: Stata Press. 562pp. USD 59.00. ISBN 978-1-59718-040-5

Daniel Stahl

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Book reviews

Rabe-Hesketh S, Skrondal A 2008: *Multilevel and Longitudinal Modeling Using Stata*, second edition. College Station, TX: Stata Press. 562pp. USD 59.00. ISBN 978-1-59718-040-5.

The analysis of longitudinal and other clustered data, such as patients within hospitals, is a common feature in medical research. Sophia Rabe-Hesketh and Anders Skrondal's book provides a comprehensive and thorough introduction to the analysis of such data using the general purpose statistical package Stata. The focus of the book is on multilevel modelling (or generalised linear mixed modelling) approaches. Alternative methods, such as general estimation equations, are only discussed briefly.

The text is written for applied statisticians, graduate students and researchers with experience in statistical modelling (including the regression approach to ANOVA), who have come across repeated measurements or other kinds of clustered data.

The second edition of this book, with almost twice as many pages includes three new chapters and an update to Stata 10 commands, including the new Stata commands `xtmelogit` and `xtmepoisson`. The authors are the developers of the Stata add-on program `gllamm`. It is, therefore, hardly surprising that the authors describe in detail the use of `gllamm`, which expands Stata's own commands considerably, especially for the analysis of categorical or discrete data. `gllamm` is a powerful program to analyse latent variable models, of which generalised linear mixed models are a special case.¹

The book consists of 13 chapters. The first is a new review chapter and introduces the reader to linear regression and the general linear model. It explains in detail the use and interpretation of dummy coded categorical independent variables and interactions. An understanding of these concepts is a prerequisite for the following chapters. Chapter 2 introduces the concept of random effects or multilevel modelling by means of the variance component model, a simple random intercept model

without any covariates. Chapter 3 expands the random-intercept model by including covariates and in chapter 4 the model is extended further by including interactions between random factors and covariates (random intercept and slope or random-coefficient models). The new chapter 5 provides more details of the analysis of longitudinal data, including discussions of time varying covariates, autoregressive models and growth curves.

The following four chapters apply these concepts to models with non-normal responses: binary responses (Chapter 6, e.g. logit and probit models), ordinal responses (Chapter 7, e.g. ordered logit and ordered probit models), a new chapter on discrete survival times, including survival models with truncated and censored observations (Chapter 8) and count responses (Chapter 9, e.g. Poisson and negative binomial models). Finally, the last two chapters extend the random effects models to higher level models with nested (Chapter 10) and crossed (nonnested models: Chapter 11) random effects. An appendix containing an overview of the syntax of the `gllamm` commands completes the book.

The authors state in their preface that the 'emphasis is on explaining the models and their assumptions, applying the methods to real data, and interpreting results'. They succeed in their goal and provide a comprehensive and lucid account of multilevel modelling. Even complex models are clearly and sufficiently explained with surprisingly little mathematical content. Often neglected topics, such as the empirical Bayes' estimator, are covered in sufficient details. The book discusses many topics which are ignored in other standard textbooks, such as endogeneity, the difference between within and between subject effects in panel models or lagged response and autoregressive models.

The authors present Stata commands and output for all steps of an analyses, starting from initial examination of the data, fitting the model, visualising the results to model diagnostics. The book is, therefore, an excellent combination of

a thorough introduction to multilevel modelling and a tutorial on Stata commands for analysing such models. This is a major advantage to other textbooks that may show how to run the main analysis in software but leave the reader alone with assessing the model fit or visualising the results. The excellent integration of Stata analyses within the text, however, restricts the audience of this book to Stata users.

Examples in the text and exercises at the end of each chapter are stimulating and cover a wide range of real life applications from medical, behavioural and social science research. All data sets and Stata commands used in the text are available from an accompanying webpage or can be downloaded directly from within Stata. Answers to the exercises are only available to instructors adopting the book for a course.

There are only a few topics I missed: One is that problems with missing data are only briefly discussed. The authors explain that multilevel models are less restrictive in the assumption of missingness (missing at random) than complete case or GEE analysis (missing completely at random). However, they do not provide guidance to assess the type of randomness or provide recommendations how to analyse data if missingness is not at random. I also missed a paragraph on model selection, e.g. the use (and its potential problems) of information criteria. My only minor criticism of this book is the index. It is not very extensive, which makes it difficult for the reader to find minor topics, like power or explained variance.

In summary, the book is a very well-written and provides comprehensive guide to multilevel modelling, both from a practical and a theoretical point of view. The second edition of this book will continue to be an invaluable help for every Stata user involved in the analysis of clustered data and it will replace the tattered first edition in my bookshelf.

Reference

- 1 Skrondal A, Rabe-Hesketh S. *Generalized latent variable modeling: multilevel, longitudinal and structural equation models*. Chapman & Hall/CRC, Boca Raton, FL, 2004.

Reviewed by Daniel Stahl, Department of Biostatistics, Institute of Psychiatry, King's College London, UK.

Hauschke D, Steinijans V and Pigeot I 2007: *Bioequivalence studies in drug development methods and application*. Chichester: John Wiley & Sons Ltd. 311 p. ISBN 978-0-470-09475-4.

This book is written for clinical pharmacologists, biopharmaceutical scientists, reviewers from regulatory affairs and biometricians. It also provides a reference for scientists from academia conducting research in the area of biopharmaceutics and clinical pharmacokinetics. The book covers setting up, conduct, analysis and reporting of bioequivalence studies according to regulatory requirements. Example data sets and SAS® code have been used to illustrate methods and to help the reader rework the analysis. Screenshots are also available from nQuery Advisor® for power and sample size determination. The conclusions at the end of each chapter provide an excellent summary. The book provides a good reference text to bioequivalence but will probably be more useful to professionals and research workers with some background to pharmacokinetics rather than those who have no prior knowledge.

The book contains 10 chapters, each with a list of references. The introduction gives definitions of bioavailability, bioequivalence and therapeutic equivalence taken from current guidelines of the US and European regulatory bodies. It also explains when bioequivalence studies are performed, as well as the design and running of such studies. Chapter 2 examines ways to characterise the concentration–time profile in single and multiple dose bioequivalence studies, where the main interest is assessment of ‘rate and extent of absorption’. Chapter 3 covers the basic statistical methods necessary for bioequivalence trials, for example the relationship between AUC, dose and clearance, the fundamental properties of the normal and log-normal distributions and hypothesis testing with respect to bioequivalence designs, including a discussion on Type I and Type II errors (consumer and producer risk). The statistical methodology described here is introductory and will be accessible to the non-statistician. It covers the analysis of the standard two-period, two-sequence, crossover design and the consideration of period, carryover and formulation effects.

The focus of chapter 4 is to demonstrate the underlying methodology for the statistical assessment of average bioequivalence. The author introduces the multiplicative model, following on from the additive model introduced