

Longitudinal Research with Latent Variables

Kees van Montfort

Johan H.L. Oud

Albert Satorra

Editors

Longitudinal Research with Latent Variables

 Springer

Editors

Professor Dr. Kees van Montfort
Vrije Universiteit Amsterdam
Department of Econometrics and
Operations Research
De Boelelaan 1105
1081 HV Amsterdam
Netherlands
kvmontfort@feweb.vu.nl

Professor Dr. Albert Satorra
Universitat Pompeu Fabra
Department of Economics and Business
Ramon Trias Fargas 25-27
08005 Barcelona
Spain
albert.satorra@upf.edu

Professor Dr. Johan H.L. Oud
Radboud University Nijmegen
Behavioural Science Institute
Montessorilaan 3
6525 HR Nijmegen
Netherlands
j.oud@pwo.ru.nl

ISBN 978-3-642-11759-6 e-ISBN 978-3-642-11760-2
DOI 10.1007/978-3-642-11760-2
Springer Heidelberg Dordrecht London New York

Library of Congress Control Number: 2010926488

© Springer-Verlag Berlin Heidelberg 2010

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilm or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

The use of general descriptive names, registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

Cover design: WMXDesign GmbH, Heidelberg, Germany

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

Since Charles Spearman published his seminal paper on factor analysis in 1904 and Karl Jöreskog replaced the observed variables in an econometric structural equation model by latent factors in 1970, causal modelling by means of latent variables has become the standard in the social and behavioural sciences. Indeed, the central variables that social and behavioural theories deal with, can hardly ever be identified as observed variables. Statistical modelling has to take account of measurement errors and invalidities in the observed variables and so address the underlying latent variables.

Moreover, during the past decades it has been widely agreed on that serious causal modelling should be based on longitudinal data. It is especially in the field of longitudinal research and analysis, including panel research, that progress has been made in recent years. Many comprehensive panel data sets as, for example, on human development and voting behaviour have become available for analysis. The number of publications based on longitudinal data has increased immensely. Papers with causal claims based on cross-sectional data only experience rejection just for that reason.

The chapters in this book combine longitudinal research and latent variable research. They all explain how longitudinal studies with objectives formulated in terms of latent variables should be performed. The emphasis is on exposing how the methods are applied. Because currently longitudinal research with latent variables follows different approaches with different histories, different types of research questions, and different computer programs to perform the analysis, the book is divided into nine, rather self sufficient chapters. The chapters give an up to date overview of the current state of the approach. Each chapter is written by one or more experts in the approach. In addition to some background information about the specific approach (short history and main publications), the chapter describes the type of research questions the approach is able to answer and the kind of data to be collected, gives the statistical and mathematical explanation of the models used in the analysis of the data, discusses the input and output of the programs used in the analysis, and provides one or more examples with typical data sets enabling the reader to apply the programs themselves. Data sets and computer

code for the analysis with various software programs are a very important component of the book and partly made available at the book website <http://www.econ.upf.edu/~satorra/longitudinallatent/readme.html>.

The chapters present an up to date overview of the current state of the approach in such detail that readers get the means for application in their own research. The emphasis is not on new results. The main purpose is to give a state of the art explanation of longitudinal research methodology with latent variables and to show how this methodology is implemented in practice with current state of art software and real data sets. Each of the chapters is supposed to be rather complete for the specific approach and the chapters together are meant to cover the field exhaustively.

The book “Longitudinal Research with Latent Variables” addresses the great majority of researchers in the behavioural and related sciences, in academic as well as non-academic environments. This includes readers who are involved in research in psychology, sociology, education, economics, management, and medical sciences. It is meant as a reference work for all those actually doing longitudinal research. The book also addresses methodologists and statisticians, who are professionally dealing with longitudinal research, to provide standards for state of the art practices. It specially offers PhD students in the fields indicated the means to carry out longitudinal research with latent variables.

Kees van Montfort, Han Oud, and Albert Satorra

Contents

Preface	v
List of contributors	ix
1 Loglinear Latent Variable Models for Longitudinal Categorical Data <i>Jacques A. Hagnaars</i>	1
2 Random Effects Models for Longitudinal Data <i>Geert Verbeke, Geert Molenberghs, and Dimitris Rizopoulos</i>	37
3 Multivariate and Multilevel Longitudinal Analysis <i>Nicholas T. Longford</i>	97
4 Longitudinal Research Using Mixture Models <i>Jeroen K. Vermunt</i>	119
5 An Overview of the Autoregressive Latent Trajectory (ALT) Model <i>Kenneth A. Bollen and Catherine Zimmer</i>	153
6 State Space Methods for Latent Trajectory and Parameter Estimation by Maximum Likelihood <i>Jacques J.F. Commandeur, Siem Jan Koopman, and Kees van Montfort</i>	177
7 Continuous Time Modeling of Panel Data by means of SEM <i>Johan H.L. Oud and Marc J.M.H. Delsing</i>	201
8 Five Steps in Latent Curve and Latent Change Score Modeling with Longitudinal Data <i>John J. McArdle and Kevin J. Grimm</i>	245
9 Structural Interdependence and Unobserved Heterogeneity in Event History Analysis <i>Daniel J. Blake, Janet M. Box-Steffensmeier, and Byungwon Woo</i>	275

List of Contributors

Daniel J. Blake

Department of Political Science, 2140 Derby Hall, 154 N. Oval Mall, Ohio State University, Columbus, OH 43210-1373, USA

E-mail: blake.165@polisci.osu.edu

Kenneth A. Bollen

Odum Institute for Research in Social Science, CB 3355 Manning Hall, University of North Carolina, Chapel Hill, NC 27599-3355, USA

E-mail: bollen@unc.edu

Janet M. Box-Steffensmeier

Department of Political Science, 2140 Derby Hall, 154 N. Oval Mall, Ohio State University, Columbus, OH 43210-1373, USA

E-mail: steffensmeier.2@polisci.osu.edu

Jacques J. F. Commandeur

Department of Econometrics, VU University Amsterdam, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands

E-mail: jcommandeur@feweb.vu.nl

and

Dutch National Road and Safety Research Institute (SWOV), Duindoorn 32, 2262 AR Leidschendam, The Netherlands

E-mail: jacques.commandeur@swov.nl

Marc J. M. H. Delsing

Praktikon, Radboud University Nijmegen, Postbus 9104, 6500 HE Nijmegen, The Netherlands

E-mail: m.delsing@acsw.ru.nl

Kevin J. Grimm

Department of Psychology, University of California, Davis, One Shields Avenue,
Davis, CA 95616, USA
E-mail: kjgrimm@ucdavis.edu

Jacques A. Hagenaars

Department of Methodology and Statistics, Tilburg University, Warandelaan 2, 5037
AB Tilburg, The Netherlands
E-mail: jacques.a.hagenaars@uvt.nl

Siem Jan Koopman

Department of Econometrics, VU University Amsterdam, De Boelelaan 1105, 1082
HV Amsterdam, The Netherlands
E-mail: s.j.koopman@feweb.vu.nl

Nicholas T. Longford

SNTL, Barcelona, Spain
E-mail: NTL@sntl.co.uk
and

Department d'Economia i Empresa, Universitat Pompeu Fabra, Ramon Trias Farga
25-27, 08005 Barcelona, Spain
E-mail: nick.longford@upf.edu

John J. McArdle

Department of Psychology, University of Southern California, Los Angeles, CA
90089, USA
E-mail: jmcardle@usc.edu

Geert Molenberghs

Interuniversity Institute for Biostatistics and Bioinformatics (I-BioStat), Universiteit
Hasselt, Agoralaan, B-3590 Diepenbeek, Belgium
E-mail: geert.molenberghs@uhasselt.be
and

Interuniversity Institute for Biostatistics and Bioinformatics (I-BioStat), Katholieke
Universiteit Leuven, Kapucijnenvoer 35, B-3000 Leuven, Belgium
E-mail: geert.molenberghs@med.kuleuven.be

Johan H. L. Oud

Behavioural Science Insitute, Radboud University Nijmegen, Postbus 9104, 6525
HR Nijmegen, The Netherlands
E-mail: j.oud@pwo.ru.nl

Dimitris Rizopoulos

Department of Biostatistics, Erasmus University Medical Center, NL-3000 CA Rot-
terdam, The Netherlands
E-mail: d.rizopoulos@erasmusmc.nl

Albert Satorra

Department of Economics and Business, Universitat Pompeu Fabra, Ramon Trias Fargas 25-27, 08005 Barcelona, Spain
E-mail: albert.satorra@upf.edu

Kees van Montfort

Department of Econometrics and Operations Research, VU University Amsterdam, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands
E-mail: kvmontfort@feweb.vu.nl
and
Nyenrode Business Universiteit, Straatweg 25, 3621 BG Breukelen, The Netherlands
E-mail: k.van.montfort@nyenrode.nl

Geert Verbeke

Interuniversity Institute for Biostatistics and Bioinformatics (I-BioStat), Katholieke Universiteit Leuven, Kapucijnenvoer 35, B-3000 Leuven, Belgium
E-mail: geert.verbeke@med.kuleuven.be
and
Interuniversity Institute for Biostatistics and Bioinformatics (I-BioStat), Universiteit Hasselt, Agoralaan, B-3590 Diepenbeek, Belgium
E-mail: geert.verbeke@uhasselt.be

Jeroen K. Vermunt

Department of Methodology and Statistics, Tilburg University, Warandelaan 2, 5037 AB Tilburg, The Netherlands
E-mail: j.k.vermunt@uvt.nl

Byungwon Woo

Department of Political Science, 2140 Derby Hall, 154 N. Oval Mall, Ohio State University, Columbus, OH 43210-1373, USA
E-mail: woo.54@polisci.osu.edu

Catherine Zimmer

Odum Institute for Research in Social Science, CB 3355 Manning Hall, University of North Carolina, Chapel Hill, NC 27599-3355, USA
E-mail: cathy_zimmer@unc.edu