MULTILEVEL MODELLING NEWSLETTER

The Multilevel Models Project:

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Workshop on Three-level Modelling: The Multilevel Models Project Team has scheduled another 3 day Multilevel Modelling Workshop in July 1994 at the Institute of Education, University of London, using the ML3 package. The workshop will cover:

- basic variance component model
- complex level 1 variance model
- models for repeated measures
- logistic model for binary response
- random coefficients model
- residual diagnostic
- multivariate model
- models for randomly cross-classified data

The ESRC funded project which has until now supported these workshops ends in May 1994. It is therefore necessary to make a nominal charge for academics attending to cover expenses. There will be £50, covering costs for a copy of the basic ML3 program and a set of three documentation booklets. A charge of £500 will be made for non-academic who will receive a copy of the ML3-E program, worth £400, and a set of documentation.
For booking enquiries and information contact *Min Yang* at the project address.

The 13th Sociology World Congress will be organized in *Bielefeld, Germany* from 18-23 July 1994. A session, 'The Theory and Model in Multilevel Research', has been arranged in the Congress, focusing on the problems of integrating theory, analysis and developments in the statistical techniques in social research. For future information contact Dr. *J.J.Hox*, Department of Education, University of Amsterdam, Ijsbaanpad 9, 1076 CV Amsterdam, (Tel: 31 20 5703530, FAX: 31 20 5703500, internet mail: a716hox@hasara11).

The LAMDA (Longitudinal and Multilevel Data Analysis) seminars have been funded by ESRC for a further year, taking them up to the end of 1994. They will take on a rather different form in 1994, concentrating on applications of the ideas covered during the first two years to data from the National Child Development Study and British Household Panel Study. For more information contact co-ordinator Ian Plewis at Thomas Coram Research Unit, Institute of Education, 20 Bedford Way, London WC1 (email:tesp102@ioe.ac.uk).

Also In This Issue

ML3 Clinics in London 1994

Free for users of *ML3/ML3-E*

Tuesday January 11
Tuesday February 8
Tuesday March 8
Tuesday May 10
Tuesday June 7

11.00 am - 5.30 pm,
Multilevel Models Project
11 Woburn Square, Second floor
London WC1A 0SN
Call *Min Yang* for appointment
at 071 612 6682

ALCD analysis OF LARGE AND COMPLEX DATASETS

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

Multilevel Modelling in the Analysis of Large and Complex Datasets (ALCD)

The ALCD Programme is one of the largest resource programmes commissioned by Economic & Social Research Council in the U.K.. It has a half-time co-ordinator Professor *Fred Smith* and five out of fifteen teams funded under Phase 1 for a 2-3 year period are applying multilevel approaches in their substantive areas. In addition to support research teams, the ESRC is also providing opportunities through Visiting Fellowships and Research Student Grants for individual social scientists outside of these Teams to contribute to the Programme. Further information on any aspect of the ALCD Programme can be obtained from Paul Rouse on (0793) 413135 or email paul.rouse@a.prime.esrc.ac.uk. In the following pages we give details of these teams' work.

MERGE: a multi-level modelling study at University of Newcastle

Mike Coombes

The MERGE (Multi-level Explorations of Results in GCSE Exams) project involves three teams of researchers. In the School of Education's CEM Centre, *Carol FitzGibbon* and *Peter Tymms* will lead the substantive research into the influence of local and household level factors on Newcastle children's GCSE results. The project's main base is in the Geography Department, where the team will be using Geographic Information System (GIS) techniques to model data at the individual and 'environmental' levels.

Finally, researchers in Newcastle City Council are not only providing access to administrative records but also ensuring that the study considers issues of confidentiality and of the relevance of the integrated database - and its subsequent analysis - to policy makers and the community (including the schools and pupils themselves). The role of multilevel modelling in the MERGE project is integrate administrative and other data.

In its use of MLMs, the project is likely to face complex issues of cross-classification. Pupils' educational outcomes will be related to school factors and to a diversity of neighbourhood-level factors, each of which may operate over different types of area (eg housing estates, or community 'locales').

The MERGE project team will also be exploring some of the potential effects upon MLM analyses from the errors which are inherent in the data collected, or are generated by the procedures for data linkage.

Future information can be obtained from Mr. *Mike Coombes* at Centre for Urban and Regional Development Studies (CURDS), University of Newcastle, Newcastle upon Tyne, NE1 7RU, England. Tel: 091 222 8014, FAX: 091 232 9259. Email: Mike.Coombes@newcastle.ac.uk.

Development of Dataset Linkage Management Strategy and Intergenarational Analysis Using Longitudinal Data

The project is based at the Social Statistics Research Unit, City University in London, and comprises two components. One component of the programme will be devoted to the development of optimum strategies in large data management in terms of organisation, storage, updating, linkage, meta data and methods of search and access. The second component will utilise the intergenerational element of a cohort study together with a sample of cohort member's children. In collaboration with the team at the Institute of Education, the multilevel modelling strategy will be called and extended for intergenerational data analysis.

A software and documentation from data management project will be developed for dissemination purpose. Several complex cohort datasets will be used as examples for testing the strategies.

The project is directed by Professor *John Bynner*. More detailed information can be obtained by contacting him at SSRU, City University, Northampton Square, London EC1V 0HB (Tel: 071 477 8480. Fax: 071 477 8583).

Latent Variable Models in Social Science

Led by Professor *David Bartholomew* at London School of Economics and Political Science, the project aims to develop and disseminate new statistical methods for handling problems involving variables which cannot be directly observed, and to draw on some of the same methodology and the methods of hierarchical modelling to provide a structure within which the treatment of measurement error can be incorporated directly into the analysis of social surveys.

The work involves formulating probability models for the relationship between the latent variables and their indicators. The problems of estimation and scaling typically involving the maximization of functions of many variables will be tackled. The

sample design problems such as non-random sampling, missing data and different levels of measurement of the variables in social surveys which has close links with work on measurement error will be explored. Software tools to implement the methods will be developed.

The work will be pursued in collaboration with colleagues from the team at the Institute of Education, and from the team at the City University.

For future information contact Professor *David Bartholomew*, Methodology Institute, London School of Economics and Political Science (LSE), Houghtou Street, London WC2A 2AE. (Tel: 071 955 7639, FAX: 071 955 7416)

Multilevel Modelling at the University of Southampton

Chris Skinner

Three research projects are commencing at the University of Southampton on the methodology of multilevel modelling. The projects are broadly concerned with discrete-choice and discrete-time hierarchical event history and longitudinal data. Times between different events for the same individual or times for groups of individuals may be dependent, eg an individual's age at first birth and age at marriage or the lengths of repeated spells of unemployment are typically associated. Similarly, household members often share common unmeasured or unobserved factors and thus will typically have dependent event times, eg ages at leaving home for siblings. Multilevel models which reflect this type of hierarchical data structure will be developed and applied to event history and longitudinal data. These models will embrace time-dependent state variables and allow for unobserved heterogeneity. The three planned projects are as follows.

Multilevel Discrete Choice Models (***Ian Diamond***): Multilevel models for binary data will be extended to data where there are more than two outcomes. Discrete choice models (*Duncan and Hoffman*, 1988) will be used to study contraceptive use dynamics (contraceptive choice, discontinuation and method switching over time) initially using data from the Family Planning in Scotland 1982 Survey. As it is likely that the impact of local social norms and facilities will occur to all members of a particular social network. It is essential to use a multilevel multinomial or conditional logit model. Unobservable heterogeneity in individual factors such as motivation and use efficiency can be modelled using random effects models for discrete choice.

Multilevel Event History Models (***'Mac' McDonald, Nick Buck***): Discrete-time event history models including unobserved heterogeneity will be extended to the multilevel context. 'Mixed-geometric' models (beta-geometric and logistic-normal-geometric) allow for piecewise constant hazard models to be fitted with (possibly state-dependent) unobserved heterogeneity using software which can fit random-effects logit models. Data from the Panel Study of Income Dynamics and British Household Panel Study will be used to analyse the ages at leaving home for siblings (*Buck and Scott*, 1992) event times for different demographic events occurring to the same individual and repeated spells of labour market activity.

Multilevel Models for Longitudinal Data (***Neil Wrigley, Kelvyn Jones***): Longitudinal data models for categorical response data involving unobserved heterogeneity (*Wrigley*, 1991) will be extended to the context of repeated measurements nested within units at a higher level (*Jones*, 1992). This project aims at empirical analysis of two types of multilevel structure: (a) true panel designs with repeated measures (level 1) on individuals (level 2) nested in localities (level 3); (b) longitudinal designs where repeated measures are made at the higher-levels; thus individuals (level 1) at measurement occasions (level 2) in localities (level 3); in this design it is not individuals who are repeatedly measured but localities. Data from the National Health and Lifestyle Survey and the Cardiff Consumer Panel Survey and repeated health surveys undertaken by the Health Promotion Authority for Wales will be utilised.

The common features of multilevel hierarchical data and the time dimension as well as the use of random-effects logit models link these projects. Existing software such as EGRET, ML3 and SABRE as well as a Gibbs sampling approach (*Zeger & Karim*, 1991) will be used for fitting multilevel random-effects models. For further information contact Dr *J W McDonald*, Department of Social Statistics, University of Southampton, Southampton SO9 5NH.

References

(to be continued on p.7)

A MULTILEVEL MODELLING WORKSHOP

The growth of theory and practical experience in multilevel modelling has been rapid in last decade. Due to the availability of specialized software such as HLM, VARCL and ML3, the applications have been in education, psychology, sociology, geography, politics and biology among others. Many institutions have set up courses and workshops on multilevel models routinely for research students. But how much of the modelling theory has been understood, and have the models been used correctly by substantive users? A workshop organized by experienced researchers at Rand Corporation and Cal State University LA has raised some important issues for researchers both in methodological and practical areas. The following report by *Ita Kreft* is a thought-provoking account of this workshop and raising issues we should all be carefully with. Readers of the Newsletter are invited to respond and we hope to publish responses in future issues. (*Min Yang*)

Ita Kreft

The Department of Social Policy at Rand and the Department of Statistics at UCLA co-sponsored a Workshop on 'Multilevel Modeling in the Social Sciences' on October 1st and 2nd at Rand. Organizers were *Hilary Saner* (Rand) and *Ita Kreft* (Cal State University LA).

The objective of the workshop was to stimulate discussion concerning the usefulness of multilevel models (ML) especially the extension to various non linear models. Some critics doubt the advantages of these models over the traditional ones. Others are concerned over the properties of the model in specific situations such as small sample sizes and about the correctness of standard errors, and the power of the models. No clear answers seem to be available for these questions.

For that reason following specialists in the multilevel modeling field were invited to present critical evaluations. We invited a knowledgeable audience to ask challenging questions.

Moderator *Carl Morris* (Department of Mathematics, Harvard, on sabbatical at Stanford)

1. *Rod McDonald* (Department of Psychology, University of Illinois, Champaign): Some of the Models for the Bilevel Bivariate Relationship
2. *Nick Longford* (Educational Testing Service): Inference about Variation in Clustered Binary Data
3. *Jan de Leeuw* (UCLA Statistics Program) and *Ita Kreft*: Interpretation of Multilevel Models
4. *Bengt Muthen* (School of Education, UCLA): Issues in Latent Variable Modeling with Multilevel Data
5. *David Rogosa* (School of Education, Stanford) and *Hilary Saner*: Longitudinal Data Analysis Examples with Random Coefficient Models
6. *Bill Mason* (Department of Sociology, UCLA): Practical Problems in Multilevel Analysis
7. Discussion and Summary by *Carl Morris*:

(No attempt will be made to summarize the papers here, for copies of them please contact the authors. The papers will be revised and appear as a special issue of the Journal of Educational Statistics in Spring 1995. The issue will concentrate around the problems discussed below).

The first day started with the introduction of a paper by *David Draper*, The Inference and Hierarchical Modelling in the Social Sciences. This paper was sent to all participants inn advance.

Following is brief history of this workshop and some account of issues raised.

I. Why we wanted this workshop

Multilevel models have raised high expectations, but how much of their promises is real? Is this model truly a panacea for all problems arising in complex sampling schemes? Based on some expressions in the literature: some seem to think so:

> '...multilevel methods can potentially provide a bridge between quantitative and qualitative approaches.' (*Raudenbush & Willms*, 1991, p.5)

In reality multilevel models become more general (random variables are added, for instance in multilevel path models, e.g. *Leeuw & Kreft* (1993), latent variables are added, for instance in multilevel latent variable models in the software BIRAM. See *McDonald* (1994) based on *McDonald & Goldstein* (1989)). In general it is true that the more general a multilevel model is, the more observational units are needed, especially at the higher levels. In school effectiveness research that stays close to the reality of teaching (such as qualitative research or small scale experimentation) the number of second level variables (schools or classes) is traditionally small.

The observed trend towards more general models may widen the gap between qualitative and quantitative research, instead of providing a bridge, as stated in the above citation.

Raudenbush and Willms (1991) state:

> 'The benefit of using multilevel methods to study schools and classrooms is the increased credibility of statistical findings' (p.2)

Is the above statement true? We don't know yet. But the impression is that some people have fallen in love with multilevel models as the panacea for all troubles in educational research. The following warning, found in many text books, (see e.g. *McCullagh and Nelder* (1983)), is valid again in this situation. 'If you fall in love with your model, you may start to believe that the model is perfect. The truth is that all models are wrong and the eternal truth is outside our grasp'. An old but again disappointing message. In this workshop we considered whether we can say that one analysis model is better than or superior to another. Better for what and in what conditions?

Can we say, for instance, that the more complicated (read: general) the model is, the better reality is replicated, and the closer we come to understand that reality? Some speakers at the conference believe the opposite and proposed to go back to simple Least Squares models with a correction for the second level standard errors. In fact, even developers of complicated software for multilevel data expressed their doubts about applying complicated models to small data sets and have shown this with examples (e.g. *Muthen*, with multilevel factor analyses, *McDonald* with multilevel latent variable models). All this was tentative, and we know that this workshop is just a start in the direction of becoming more critical towards the application of multilevel models. More has to be done with Monte Carlo studies and bootstrapping. Two papers on the topic of bias in small samples based on Monte Carlo studies have been presented recently at conferences (see e.g. *Rodriguez & Goldman*, 1993, and *Van der Leeden & Busing*, 1993), which show some interesting but worrying results.

II Logic

One can distinguish two extreme types of statisticians/researchers: ones who think of solutions in technical terms and ones who think of solutions in practical terms. Most of the presenters in this workshop would think of themselves as a third type: the one that tries to make both ends meet.

Do these models WORK? And if something comes out of the multilevel software do the results make a difference compared to the solutions provided by traditional software that uses fixed coefficients and (single level) generalised linear models? In what ways are the outcomes of the first more reliable?

There are two possible ways of answering the above question: a technical one and a practical one. Can the two meet? This question was addressed at the workshop. The audience of applied researchers kept the more theoretically oriented presenters on track. The presenters, ready to supply us with technical solutions, took their task seriously and kept the workshop practical, understandable and useful. That brings us to the next question. Can researchers afford to use software the way they use their TV sets: it does not matter how, as long as the picture is clear? Again the solution can be one of two: trust the authority and have the multilevel machine fixed (more general packages, more complicated models?), or use your own common sense and find the answer in the data. Researchers should hold statisticians to their obligation to make clear to users what the software does and what it does not do. It is the data structure that researchers need to know to be able to judge for themselves. On the other hand researchers need information concerning the software presented to them as solutions for their problems. As the situation seems to be at the present moment some statisticians and/or technicians and/or software writers seem to be acting like magicians: it is all very mysterious and also very fashionable. Maybe all software that is as complicated as multilevel software are, should be forced to use stickers of the sort we find on cigarette packages: 'Using this software package may result in injury to your career and can be fatal to the development of scientific social theories.'

III. Statistics as magic?

Magic has certain traditions:

1. It is handed down by wizards: technicians and statisticians.

2. It is described in language that only the initiated can speak: ML estimation, Empirical Bayes, centering.

3. If you change one syllable of the spell it can go wrong: EM algorithm is superior. Restricted maximum likelihood (REML) is better than unrestricted Full ML. Centering the data around

the group mean is better than centering around the grand mean or raw scores. Some software is superior to others.

4. The application requires some special implements and ingredients, so that only certain software is acceptable for research sponsors.

5. The magic goal is $p < 0.05$. And if the package does not provide the familiar tests (Chi-square or t-test) it is useless.

My question here is: Is it reasonable or unreasonable to hail and praise these new developments or has the enthusiasm with which these models are received overcome the critical faculties of most researchers? I believe, if the last is true, that this is not entirely the researchers fault. Developers of software are also responsible for the proper use of the techniques they offer.

But: How to de-mystify?
There is a suggestion. Statisticians should declare that the results are based on ordinary (common sense) reasoning along with (simple?) mathematics, that anyone can/should be able to use and understand. Which means that the limits and failings of the methods should be stated as well, even if this causes some disappointment to developers and users alike.

IV. Conclusion.

None of the multilevel analysis models provide any direct test of their causal assumptions. The models are merely mathematical descriptions of investigators beliefs about the structure of the data. The decision that the world is structured as a BIRAM model (see *McDonald*, 1994), a random coefficient path model (see *De Leeuw and Kreft*, 1993), or as the by now familiar random coefficient model (see *Bryk* et al. 1988, *Longford* 1990, *Prosser* et al, 1991) cannot be decided by the techniques applied. It has to be decided by the researcher. This combination of objective technique and the subjective choice of an underlying model makes it likely that two independent researchers will choose different models for the same data, except may be in the simplest situation.

Is software developed because it is technically possible? Does that mean that statisticians are technicians, and solve technical problems, not, or hardly, understood by the user? Do such complex data analysis tools help develop theories or do we need theories to use these complex tools? Has the software developer a moral obligation to warn the user against making interpretations based on a single significance test within the model, or to warn against causal statements and unspecified or ill fitting models? So far not many have answered these questions.

V How to avoid misuse of ML-software and how to stimulate proper use?

The following is more relevant for some software than for others. Software that is easy to use and does not require much knowledge of the model underlying the software needs more warning signals than software that needs extensive knowledge of what is happening. For that reason some presenters (*McDonald and De Leeuw*) are promoting the use of ML3 (see *Prosser* et al. 1991) since that software cannot be used when the underlying theory is not well understood. Besides that, ML3 allows data manipulation, data checking and plotting of residuals. All presenters were convinced that nobody should use any of the multilevel software without carefully checking the data before and after.

In any case there is a need for:

1. Warning messages. VARCL (*Longford*, 1990) and ML3 include warning messages that inform the user that certain variances or covariances are set to zero. The message that aliasing is happening at second level variances means that the number of parameters is too large or that covariances are close to zero, or matrices are not identified,. These warnings could be made more explicit and some help could be built into the package to allow more data checking.

2. Warnings should be issued about predictable areas of confusion and advice about how to proceed in such cases.

3. Explanations should be provided when some choices are offered, and advice on making them. For example: In HLM (see *Bryk* et al. 1988) the question appears: 'Do you want to center?' indicating centering variables to be around the group mean. No explanation is available in the manual why a user should choose this option, nor is a warning issued that a different model is fitted compared to a model that uses the raw scores instead (for a discussion of this problem see *Kreft, Aiken & de Leeuw*, 1993).

We hope this workshop will be followed by others and that the discussion regarding multilevel models will find a follow up in this Newsletter.

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Many thanks to the people who provided articles for this issue.

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Please send us any multilevel modelling publications for inclusion in this section in future issues.