Module 8: Multilevel Modelling in Practice: Research Questions, Data Preparation and Analysis

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Pre-requisites

Modules 1-5

Contents

8.1 Introduction and Features of the Module

This module is an examination of the stages in undertaking empirical research involving analysis by multilevel modelling. Some important issues arising at each step in the whole process are addressed, starting with the formulation of research questions in need of answers. Important subsequent steps are associated with the management of a suitable raw data set. When those data have a multilevel structure, appropriate strategies for building multilevel models are examined which seek to answer the initial specific research questions. The process of the research will then involve using that modelling framework to elaborate on and further refine these questions.

All the discussion is contextualised by a focus on a particular research area: ethnic differences in educational achievement and progress. Some basic initial questions in that area are approached. These are stimulated by reviewing the literature and some exploratory initial data analysis. Replication, amplification and also extension of existing knowledge in some newer contexts are then sought.

The dataset used for analysis in the module is then introduced. It is a two-level dataset which is available to the author from previous research. It organises information on a cohort of pupils in an English region completing Key Stage 3 (KS3) in 2003 and on secondary schools which they attend.[1]

After a discussion of some essential aspects of data preparation there is then a move to analysis by multilevel modelling. It is aimed to show how, by using various aspects of the modelling procedures introduced in previous modules, research can be progressed in a strategic way both in addressing initial research questions and then refining them. Through careful analysis, the data may suggest interesting and meaningful modifications to these initial questions.

In summary, the discussion centres on what a practical researcher might do in planning and executing a piece of investigative research in which multilevel modelling has a critical role.

Particular features of the module are:

- Framing the initial research questions;
- How does a multilevel structure affect the management of a dataset?
- Checking the data set and getting familiar with its features;
- Building in essential features to exploit its multilevel nature;
- Data management and transformation to make it amenable to answering the questions of interest, including:
    - Recoding;

[1]In England children attending a state school from ages 11 to 14 (Years 7 to 9) follow Key Stage 3 of the National Curriculum. National tests are taken in a variety of areas at the end of this Key Stage to monitor children's achievements. Similarly Key Stage 2 (KS2) covers primary school stages of learning Years 3 to 6 and is assessed by end of KS2 tests just before transition to secondary schooling.

- Creating new variables and in particular level 2 variables as aggregates of individual level variables;
- Merging data from several sources, e.g. school level or neighbourhood variables;
- Identifying and knowing about missing values;
- Initial exploratory analyses and possible feedback to the research questions;
- Tentative initial modelling strategies and reshaping research questions;
- Working towards a series of models to address the research questions in a strategic way.

In summary the aims of the module are to describe:

The process of doing empirical research with multilevel models warts and all —from a rough data set to a polished end result.

8.2 Framing the Initial Research Questions

8.2.1 The initial context: results on Key Stage 3 for the West Midlands

The focus of this module is ethnic group differences in KS3 achievements at secondary school and progress up to KS3. Much of the previous work in this field has been on the primary stage of education or terminal stages of compulsory secondary education at age 16 (end of Key Stage 4). Mathematics achievement is studied as an exemplar although other outcomes could have been examined.

To contextualise the issues we begin by carrying out some basic descriptive analysis to explore the distribution of children by ethnic group, and to summarise the distribution of KS3 achievement by ethnic group. This might help to sharpen insights and highlight specific foci for our research. Table 8.1 presents this summary of KS3 mathematics test results for 32232 children attending local education authority schools in 2003 in the West Midlands region. The raw scores have been normalised[2] across KS3 for England as a whole, so they have a mean of zero (corresponding to the national mean) and a standard deviation of one. Ethnic group is classified into 19 groups which is the finest categorisation available in this dataset. The rows of Table 8.1 are ordered by the code number of group in the official dataset, but the criterion effectively gives a broad grouping: White groups, then those with Mixed ethnicity, followed by Asian (except Chinese), Black, and finally other smaller groups including Chinese. The numbers and percentage distribution across the groups are given together with the mean and standard deviations of KS3 scores for pupils within each group. The final column gives in addition the standard error of the mean, which is a measure of how precisely the mean is estimated.[3] When the mean of a group is divided by the standard error this gives a Z statistic which may be referred to a normal distribution to test whether that group differs significantly from the national mean of zero.

Some key features of Table 8.1 may be noted:

- Chinese pupils do well. Even though their number is small, when the precision of the estimate of the mean is considered, they are still quite significantly above the national average score of zero.

- Students from the three black groups do not perform well and are all significantly below average.

- Amongst the main South Asian groups Indians do much better than average (and hence better than the large majority White group), whereas Pakistani and Bangladeshi achievements are much lower. The mean score of the Any Other Asian group is similar to that of Indians.

- Most Mixed Ethnicity groups have lower than average scores except for Mixed

[2] **See Section 8.5 for a discussion of normalisation.**
[3] **See Module 2, C2.5.2.**

White and Asian but this group is not significantly above the average.

Table 8.1 Normalised KS3 Mathematics (ks3matn) results for students in West Midlands local education authorities

Ethnic Group	Number	%	Mean Ks3matn	SD	St Err of the Mean
White British	22744	70.6	0.04	0.98	0.006
Irish	236	0.7	0.09	1.025	0.067
Irish Traveller	4	<0.05	0.39	1.215	0.608
Roma	4	<0.05	-0.36	1.314	0.657
Other White	393	1.2	0.04	1.060	0.053
Mixed White and Black Caribbean	572	1.8	-0.31	0.917	0.038
Mixed White and Black African	57	0.2	-0.84	0.888	0.118
Mixed White and Asian	197	0.6	0.11	1.046	0.075
Any other mixed background	342	1.1	-0.21	1.014	0.055
Indian	2260	7.0	0.17	0.985	0.021
Pakistani	2007	6.2	-0.36	1.032	0.023
Bangladeshi	444	1.4	-0.28	0.954	0.045
Any Other Asian	196	0.6	0.26	1.144	0.082
Black Caribbean	973	3.0	-0.45	0.928	0.030
Black African	82	0.3	-0.21	0.964	0.106
Any other Black background	144	0.5	-0.25	0.941	0.078
Chinese	103	0.3	1.26	1.015	0.101
Any other background	154	0.5	0.02	1.181	0.095
Unclassified /Missing	1320	4.1	-0.03	0.989	0.027
ALLWEST MIDLANDS	32232	100.0	0.00	0.996	0.006

Specific questions are now motivated, and we focus on framing plausible explanations and hypotheses about the ethnic group differences observed. However, before this point is reached, any empirical research will also usually be guided by a search of existing research literature. This may point to lines of enquiry that may be fruitful, or also prevent research going along unpromising tangential lines that initially may have seemed promising.

8.2.2 Background literature

There are considerable contributions in the research literature related to the topic we have chosen.[4] Examination of this contributes to the initial questions to be

[4] Examples, full details of which are given in the References section at the end of the Module, include Amin et al. (1997), Archer and Francis (2007), Bradley & Taylor (2004), Cassen & Kingdon (2007),