



Five-level model for simulated data

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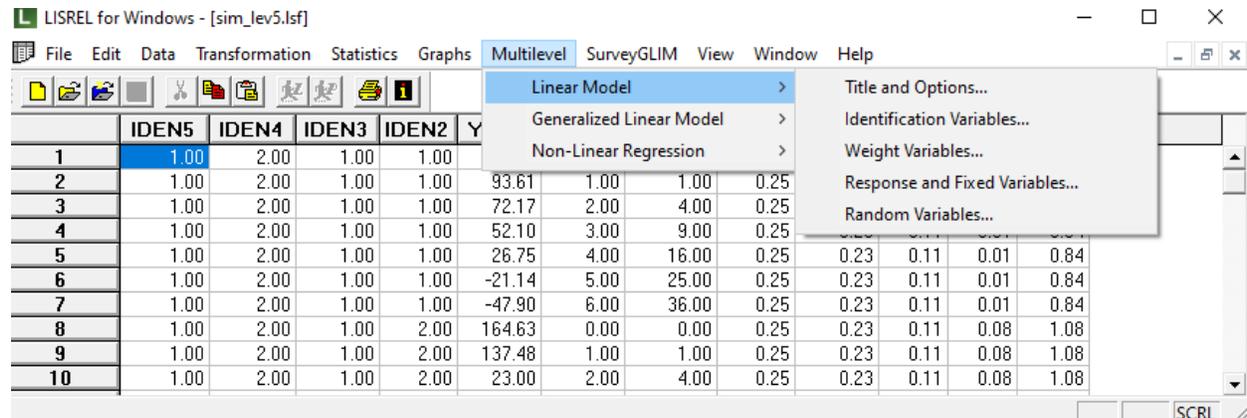
1. Introduction

In this example we illustrate the use of the GUI for setting up a 5-level multilevel model with weights at each level. The data set used is here **sim_lev5.lsf** from the **Multilevel examples\Linear examples** folder. The first ten lines of this simulated data set are shown below.

	IDEN5	IDEN4	IDEN3	IDEN2	YVAR	X1	X2	WT5	WT4	WT3	WT2	WT1
1	1.00	2.00	1.00	1.00	164.27	0.00	0.00	0.25	0.23	0.11	0.01	0.84
2	1.00	2.00	1.00	1.00	93.61	1.00	1.00	0.25	0.23	0.11	0.01	0.84
3	1.00	2.00	1.00	1.00	72.17	2.00	4.00	0.25	0.23	0.11	0.01	0.84
4	1.00	2.00	1.00	1.00	52.10	3.00	9.00	0.25	0.23	0.11	0.01	0.84
5	1.00	2.00	1.00	1.00	26.75	4.00	16.00	0.25	0.23	0.11	0.01	0.84
6	1.00	2.00	1.00	1.00	-21.14	5.00	25.00	0.25	0.23	0.11	0.01	0.84
7	1.00	2.00	1.00	1.00	-47.90	6.00	36.00	0.25	0.23	0.11	0.01	0.84
8	1.00	2.00	1.00	2.00	164.63	0.00	0.00	0.25	0.23	0.11	0.08	1.08
9	1.00	2.00	1.00	2.00	137.48	1.00	1.00	0.25	0.23	0.11	0.08	1.08
10	1.00	2.00	1.00	2.00	23.00	2.00	4.00	0.25	0.23	0.11	0.08	1.08

The variables IDEN5, IDEN4, IDEN3 and IDEN2 represent the IDs identifying units at the levels of the hierarchy. WT5 to WT1 denote the weights at each level, while the outcome and predictors are denoted by YVAR and X1 and X2 respectively.

The **Multilevel** menu provides you access to three options: **Linear Model**, **Generalized Linear Model** and **Non-Linear Regression**. In this example, the **Linear Model** option is used. This option provides you access to a sequence of five dialog boxes that can be used to create a basic syntax file interactively. It is located on the LSF (LISREL System File) window of LISREL which is used to display, manipulate and process raw data. In other words, this menu is only available when a LISREL data file (*.Isf) is opened. To illustrate this, the LSF window for the file **simlev_5.Isf** is shown below with the **Multilevel**, **Linear Model** menu expanded.



Presently, the **Multilevel**, **Linear Model** menu has five dialog boxes that can be used to perform basic multilevel analyses. Advanced options that enable the user to specify more complex models must be typed in once a syntax file has been generated.

The typical first step for using the **Multilevel**, **Linear Model** menu would be to click on the **Title and Options** option to activate that dialog box. However, you can click on other options to go directly to the **Identification Variables**, **Weight Variables**, **Response and Fixed Variables** or **Random Variables** dialog box.

2. The Title and Options dialog box

The **Title and Options** dialog box is used to provide a title for the analysis and keywords concerning the iterative procedure. The image below shows the default settings for this dialog box, except for the title we entered into the **Title** field.

Title and Options [X]

Title (Maximum 70 characters):
Level-5 model with design weights

Maximum Number of Iterations: 10

Convergence Criterion: 0.001

Missing Data Value: -999999 Nfree: 0

Missing Dep Value: -999999 Deviance:

Use OLS for starting values Calculate effect sizes

Additional Output

Asymptotic Covariances Residuals

Empirical Bayes Estimates No Data Summary

Between and Within Covariance Matrices

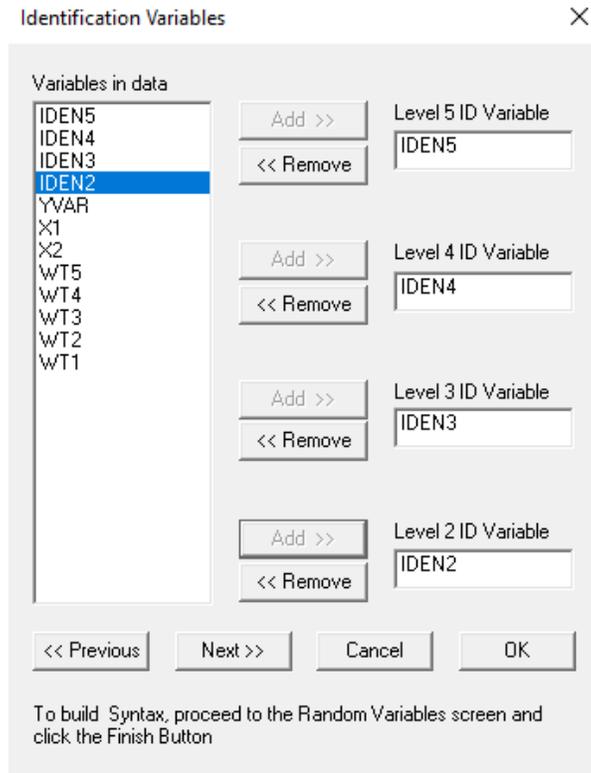
Next >> Cancel OK

To build Syntax, proceed to the Random Variables screen and click the Finish Button

The **Next** button takes you to the **Identification of Variables** dialog box.

3. The Identification Variables dialog box

The **Identification of Variables** dialog box is used to select the variables in the LISREL data file (*.Isf) that identify the various levels of the hierarchy. The image below shows the completed dialog box, obtained by clicking on IDEN5 to IDEN2 and adding them to the ID variable fields using the **Add** buttons.



The **Next** button provides access to the **Weight Variables** dialog box.

4. The Weight Variables dialog box

The **Weight Variables** dialog box is used to select the weight variables in the data file for each level of the model. This corresponds to the WEIGHTn statements in the syntax file. Again, completing the dialog box is done by selecting a weight variable and clicking the **Add** button next to the appropriate weight field to enter the variable into that box. Using weights is optional. In the current example, weighting variables are available at all levels, so all five weight variable fields are used.

Weight Variables

Variables in data

- IDEN5
- IDEN4
- IDEN3
- IDEN2
- YVAR
- X1
- X2
- WT5
- WT4
- WT3
- WT2
- WT1

Add >> << Remove

Level 5 Weight: WT5

Level 4 Weight: WT4

Level 3 Weight: WT3

Level 2 Weight: WT2

Level 1 Weight: WT1

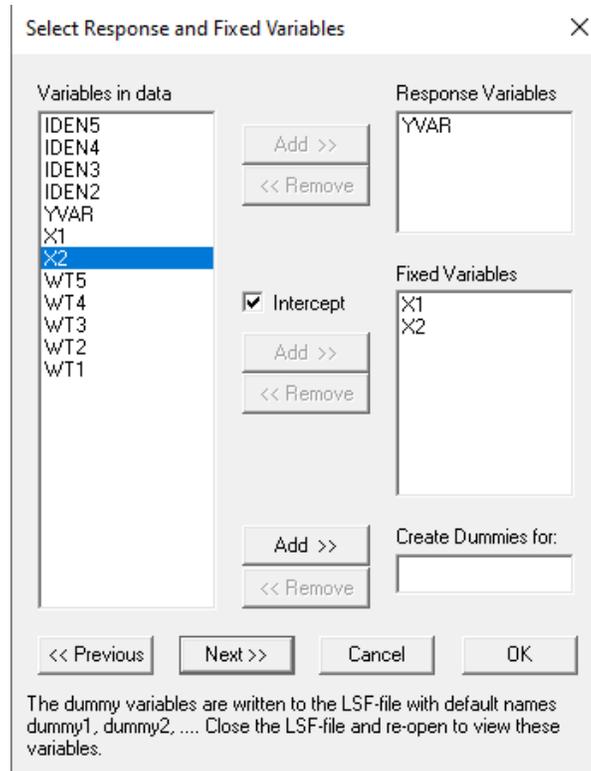
<< Previous Next >> Cancel OK

To build Syntax, proceed to the Random Variables screen and click the Finish Button

The **Next** button provides access to the **Select Response and Fixed Variables** dialog box.

5. The Response and Fixed Variables dialog box

The **Select Response and Fixed Variables** dialog box is used to select the outcome and fixed variables to be included in the model. The image below shows the completed dialog box. Variables are selected in the same way as previously described. The **Create Dummies for:** field is used when the user requests the program to create dummy variables for the categories of a categorical variable. In the present example, we have only continuous data and this field is not used. Note that this box is also used to indicate whether an intercept term should be included in the model. As we would like to include an intercept, we left this field at its default value (*i.e.*, checked).



The **Next** button take you to the **Random Variables** dialog box.

6. The Random Variables dialog box

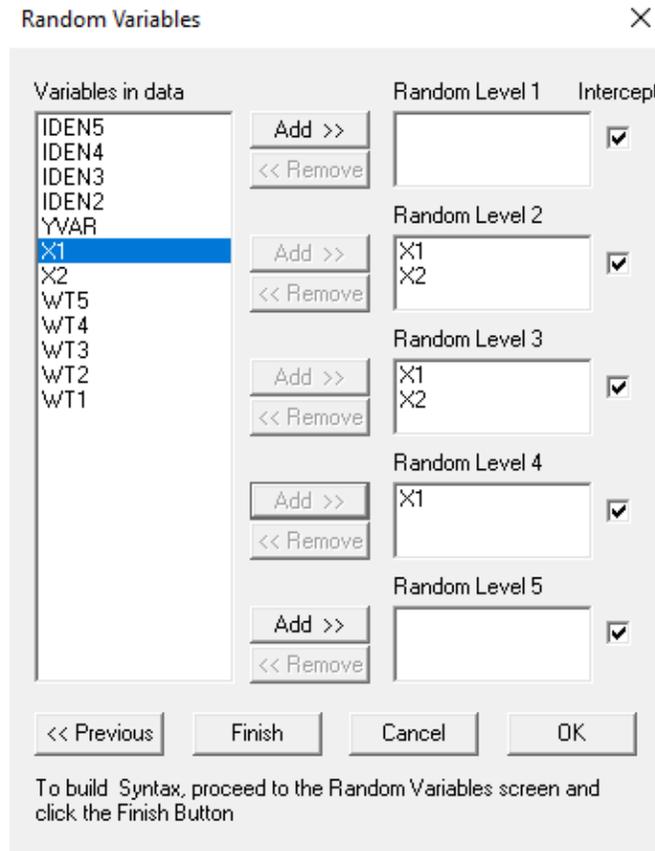
The **Random Variables** dialog box is used to select the variables for which coefficients are assumed to be random. In our example, we would like to allow the intercept to vary randomly at level-1, while also allowing the slopes of the two predictors X1 and X2 to vary randomly at levels 2 and 3. This selection is shown below. Again, the program assumes the inclusion of a random intercept at all levels, so the **Intercept** check boxes are checked. Should the model to be fitted require the removal of a random intercept term at any level, the corresponding **Intercept** box should simply be unchecked.

The screenshot shows the 'Random Variables' dialog box with the following configuration:

Variables in data	Random Level 1	Intercept
IDEN5 IDEN4 IDEN3 IDEN2 YVAR X1 X2 WT5 WT4 WT3 WT2 WT1		<input checked="" type="checkbox"/>
	X1 X2	<input checked="" type="checkbox"/>
	X1 X2	<input checked="" type="checkbox"/>
		<input checked="" type="checkbox"/>
		<input checked="" type="checkbox"/>

At the bottom of the dialog box, there are buttons for '<< Previous', 'Finish', 'Cancel', and 'OK'. Below the buttons, a note reads: 'To build Syntax, proceed to the Random Variables screen and click the Finish Button'.

At level 4 we would like to allow the predictor X1 to vary randomly along with the intercept, but at level-5 we only allow for a random intercept. The completed dialog box is shown below.



Click the **Finish** button to generate the syntax corresponding to the selections made on the dialog boxes. The syntax file **sim_lev5.prl** is shown below.

```

LISREL for Windows - [sim_lev5.PRL]
File Edit Options Window Help
OPTIONS OLS=YES CONVERGE=0.001000 MAXITER=10 OUTPUT=STANDARD ;
TITLE=Level-5 model with design weights;
SY='|sim_lev5.lsf';
ID5=IDEN5;
ID4=IDEN4;
ID3=IDEN3;
ID2=IDEN2;
WEIGHT5=WT5;
WEIGHT4=WT4;
WEIGHT3=WT3;
WEIGHT2=WT2;
WEIGHT1=WT1;
RESPONSE=YVAR;
FIXED=intcept X1 X2;
RANDOM1=intcept;
RANDOM2=intcept X1 X2;
RANDOM3=intcept X1 X2;
RANDOM4=intcept X1;
RANDOM5=intcept;
Ready

```

7. Discussion of results

Once the analysis is performed by clicking the “P” button on the main menu bar, the following output is obtained. For the fixed effects, we find that X2 does not make a significant contribution to the explanation of the variation in the outcome variable (P -value is 0.698).

```

o-----o
| FIXED PART OF MODEL |
o-----o

-----
COEFFICIENTS          BETA-HAT          STD.ERR.          Z-VALUE          PR > |Z|
-----
intcept                150.59155         1.12440          133.93073        0.00000
X1                     3.44557          1.20644          2.85597          0.00429
X2                     0.52756          1.35998          0.38792          0.69808

o-----o
| -2 LOG-LIKELIHOOD |
o-----o
DEVIANCE= -2*LOG(LIKELIHOOD) =      169641.310523784
NUMBER OF FREE PARAMETERS =                20

CHI-SQUARE SCALE FACTOR =          0.45936

```

The deviance and number of free parameters reported in the output may be used to compare this model with a subsequent model, provided that they are nested models. This is done by calculating the difference in deviances and the number of free parameters and evaluating the difference in deviance as a χ^2_{LR} with the difference in the number of free parameters as the degrees of freedom. Simulation studies indicated that the χ^2_{LR} -statistic based on the log-likelihood in general yields too high a rejection rate. Let

$$d = \text{tr}(\mathbf{I}_n(\hat{\gamma}) \text{Cov}(\hat{\gamma})),$$

where $\mathbf{I}_n(\gamma)$ denotes the information matrix.

A correction to the χ^2 -statistic for testing model fit is given by

$$\chi^2_{\text{robust}} = c \times \chi^2_{LR},$$

where

$$c = \frac{q}{d},$$

and where q denotes the number of parameters to be estimated. If, for example, the difference in the differences between this model and a previous (hypothetical) model was found to be 2.335, The χ^2 value to be evaluated would be obtained by multiplying 2.335 with the scale factor obtained when design weights are included (0.45936 in this case).

Inspection of the results for the random effects show that some of the 17 variance and covariance components estimated are statistically significant, while others are not. For example, there is no evidence supporting significant variation in the intercept at level-5. While the same may be said of the estimated variance of the intercept at level-4, we note that both the covariance between the intercept and X1 and the variance of X1 is reported as being statistically significant. At level-3, only the variance of X2 is significant; it may be worthwhile reducing the number of variance-covariance components, reestimating the smaller model and using the deviance statistic to compare the impact of the removal of terms on the overall model fit.

```

o-----o
| RANDOM PART OF MODEL |
o-----o

```

LEVEL 5		TAU-HAT	STD.ERR.	Z-VALUE	PR > Z
intcept	/intcept	1.8404	8.9189	0.2063	0.8365
LEVEL 4		TAU-HAT	STD.ERR.	Z-VALUE	PR > Z
intcept	/intcept	41.7777	25.0507	1.6677	0.0954
X1	/intcept	15.5653	6.2207	2.5022	0.0123
X1	/X1	29.8312	9.8524	3.0278	0.0025
LEVEL 3		TAU-HAT	STD.ERR.	Z-VALUE	PR > Z
intcept	/intcept	48.0254	31.1532	1.5416	0.1232
X1	/intcept	-28.6242	15.2790	-1.8734	0.0610
X1	/X1	35.6045	18.9092	1.8829	0.0597
X2	/intcept	-10.4329	14.6327	-0.7130	0.4759
X2	/X1	-1.1824	12.8753	-0.0918	0.9268
X2	/X2	91.3833	22.6123	4.0413	0.0001
LEVEL 2		TAU-HAT	STD.ERR.	Z-VALUE	PR > Z
intcept	/intcept	978.1149	42.7905	22.8582	0.0000
X1	/intcept	216.3812	29.3600	7.3699	0.0000
X1	/X1	818.2757	39.6978	20.6126	0.0000
X2	/intcept	162.8187	25.5273	6.3782	0.0000
X2	/X1	126.2366	16.7759	7.5249	0.0000
X2	/X2	923.4380	24.9728	36.9778	0.0000
LEVEL 1		TAU-HAT	STD.ERR.	Z-VALUE	PR > Z
intcept	/intcept	401.7934	6.0835	66.0466	0.0000