



Ordinal model for the Teacher data

1. Introduction to HGLM models	1
2. Description of the model	2
3. Description of the data.....	3
4. Creating the command file.....	5
5. Interpreting the output	8

1. Introduction to HGLM models

Model specification for nonlinear analysis are specified via the **Basic Settings** dialog box as shown below. Six options are currently available. For the Binomial model and Poisson (variable exposure) the TRIAL or exposure variable is selected to the right of these two options; for the multinomial and ordinal models the number of categories should also be specified to the right of these two options.

If desired, and over-dispersion option is available for binomial and Poisson models. This option is not available with Laplace estimation. To specify over-dispersion, set the σ^2 to **computed** on the **Estimation Settings** dialog box accessed via **Other Settings** on the main menu bar.

The nonlinear analysis is doubly iterative so the maximum number of macro iterations can be specified as well as the maximum number of micro iterations. Similarly, convergence criteria can be set for macro and micro iterations.

This is the sixth in a set of six examples illustrating HGLM models.

2. Description of the model

Let $\text{Prob}(R_{ij} = m) = \phi_{ij}$, that is, the probability that person i in group j lands in category m is ϕ_{ij} , for categories $m = 1, \dots, M$, there being M possible categories. Again a person falls into category m and there are M possible categories, so $m = 1, \dots, M$. But now the categories are ordered. Given the ordered nature of the data, we derive the M dummy variables $Y_{mij}, \dots, Y_{(M-1)ij}$ for case i in unit j as

$$Y_{mij} = 1 \quad \text{if} \quad R_{ij} \leq m, \quad 0 \quad \text{otherwise.}$$

For example, with $M = 3$, we have

$$\begin{aligned} Y_{1ij} &= 1 \quad \text{if} \quad R_{ij} = 1 \\ Y_{2ij} &= 1 \quad \text{if} \quad R_{ij} \leq 2 \end{aligned}$$

The probabilities $\text{Prob}(Y_{mij} = 1)$ are thus cumulative probabilities. For example, with $M = 3$,

$$\begin{aligned} \text{Prob}(Y_{1ij} = 1) &= \text{Prob}(R_{ij} = 1) = \phi_{1ij} \\ \text{Prob}(Y_{2ij} = 1) &= \text{Prob}(R_{ij} = 1) + \text{Prob}(R_{ij} = 2) = \phi_{2ij} \\ \text{Prob}(Y_{3ij} = 1) &= \text{Prob}(R_{ij} = 1) + \text{Prob}(R_{ij} = 2) + \text{Prob}(R_{ij} = 3) = 1 \end{aligned}$$

Since $Y_{3ij} = 1 - Y_{2ij}$, Y_{3ij} is redundant. We actually need only $M - 1$ dummy variables.

Associated with the cumulative probabilities are the cumulative logits,

$$\eta_{mij} = \log \left(\frac{\text{Prob}(R_{ij} \leq m)}{\text{Prob}(R_{ij} > m)} \right) = \log \left(\frac{\phi_{mij}}{1 - \phi_{mij}} \right).$$

The level-1 structural model assumes “proportional odds”,

$$\eta_{mij} = \beta_{0j} + \sum_{q=1}^Q \beta_{qj} X_{qij} + \sum_{m=2}^M \delta_m.$$

Under the proportional odds assumption, the relative odds that $R_{ij} \leq m$, associated with a unit increase in the predictor, does not depend on m .

Here δ_m is a “threshold” that separates categories $m - 1$ and m . For example, when $M = 4$,

$$\eta_{1ij} = \beta_{0j} + \sum_{q=1}^Q \beta_{qj} X_{qij}$$

$$\eta_{2ij} = \beta_{0j} + \sum_{q=1}^Q \beta_{qj} X_{qij} + \delta_2$$

$$\eta_{3ij} = \beta_{0j} + \sum_{q=1}^Q \beta_{qj} X_{qij} + \delta_2 + \delta_3$$

The multinomial and ordinal analyses currently produce unit-specific results only. They do not provide population-average results.

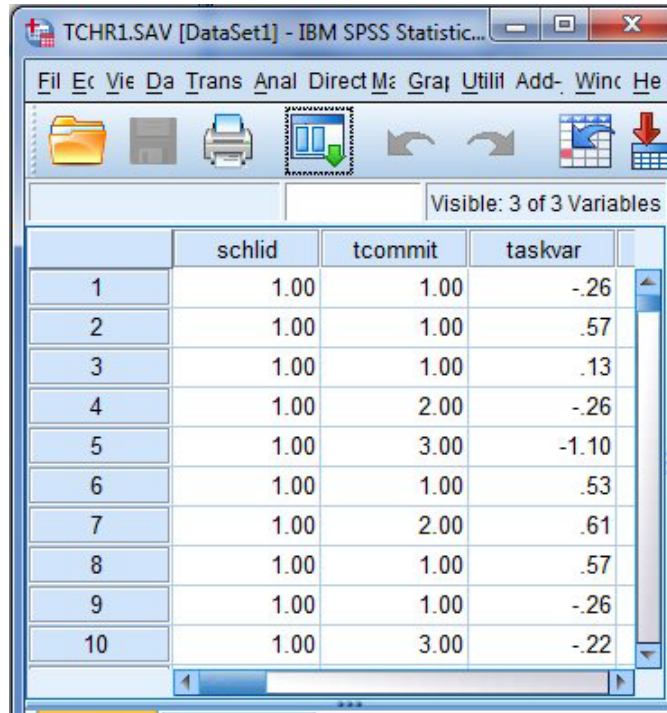
3. Description of the data

Data are from a 1990 survey of teachers in 16 high schools in California and Michigan. In the MDM file, not included with the software, there are a total of 650 teachers. The level-1 SPSS input file is TCHR1.SAV, and the level-2 file is TCHR2.SAV.

An outcome with three response categories tapping teachers' commitment to their career choice is derived from teachers' responses to the hypothetical question of whether they would become a teacher if they could go back to college and start over again. The possible responses are:

- yes, I would choose teaching again
- not sure
- no, I would not choose teaching again.

At the teacher level, it is hypothesized that teachers' perception of task variety is positively associated with greater odds of a teacher choosing the first category relative to the third category, and with greater odds of a teacher choosing the second category relative to the third category. The perception is measured by a task variety scale that assessed the extent to which teachers followed the same teaching routines each day, performed the same tasks each day, had something new happening in their job each day, and liked the variety present in their work (Rowan, Raudenbush & Cheong, 1993). The first 10 lines of the level-1 and level-2 data files are shown below.



The screenshot shows the IBM SPSS Statistics interface with a data table. The window title is 'TCHR1.SAV [DataSet1] - IBM SPSS Statistic...'. The menu bar includes 'Fil', 'Ec', 'Vie', 'Da', 'Trans', 'Anal', 'Direct', 'Me', 'Gra', 'Utilit', 'Add-', 'Winc', and 'He'. The toolbar contains icons for file operations and data manipulation. The data table has 10 rows and 3 columns: 'schlid', 'tcommit', and 'taskvar'. The values for 'schlid' are all 1.00. The values for 'tcommit' range from 1.00 to 3.00. The values for 'taskvar' range from -1.10 to .61. The status bar indicates 'Visible: 3 of 3 Variables'.

	schlid	tcommit	taskvar
1	1.00	1.00	-.26
2	1.00	1.00	.57
3	1.00	1.00	.13
4	1.00	2.00	-.26
5	1.00	3.00	-1.10
6	1.00	1.00	.53
7	1.00	2.00	.61
8	1.00	1.00	.57
9	1.00	1.00	-.26
10	1.00	3.00	-.22

	schlid	tcontrol
1	1.00	-.02
2	2.00	.18
3	3.00	.03
4	4.00	.68
5	5.00	.22
6	6.00	-.20
7	7.00	.07
8	8.00	.06
9	9.00	.52
10	10.00	.04

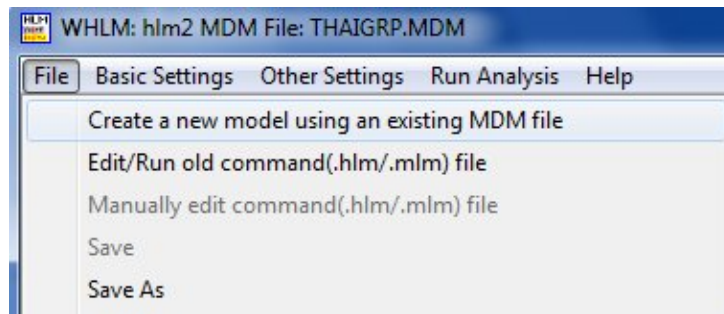
At the school level, it is postulated that the extent of teacher control has the same relationship to the two log odds as perception of task variety does. The teacher control scale is constructed by aggregating nine-item scale scores of teachers within a school. This scale indicates teacher control over school policy issues such as student behavior codes, content of in-service programs, student grouping, school curriculum, and text selection; and control over classroom issues such as teaching content and techniques, and amount of homework assigned (Rowan, Raudenbush & Kang, 1991).

As a previous analysis showed that there is little between-teacher variability in their log-odds of choosing the second category relative to the third category, the level-1 coefficient associated with it is fixed. Furthermore, the effects associated with perception of task variety are constrained to be the same across teachers for the sake of parsimony.

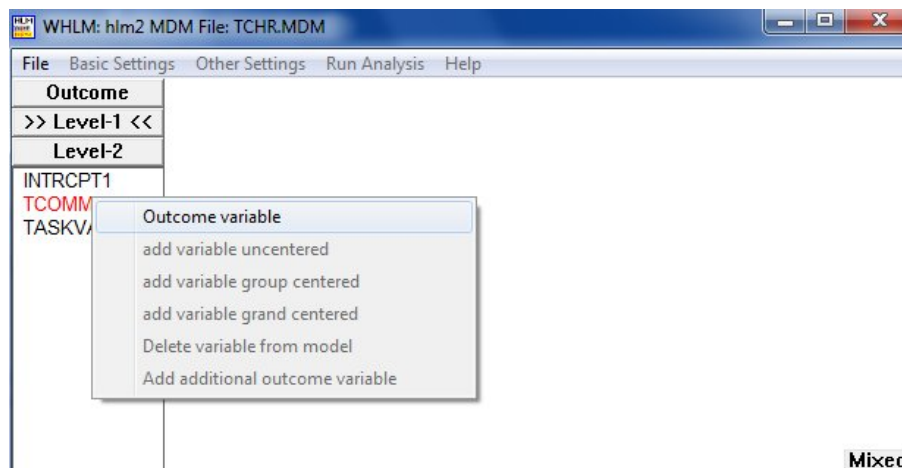
4. Creating the command file

The MDM file for a HGLM model is constructed in exactly the same way as for a linear model. The procedure is described in detail for the MDM and MDM data in other examples. Using the MDM file **TCHR.MDM**, we set up the model as shown below.

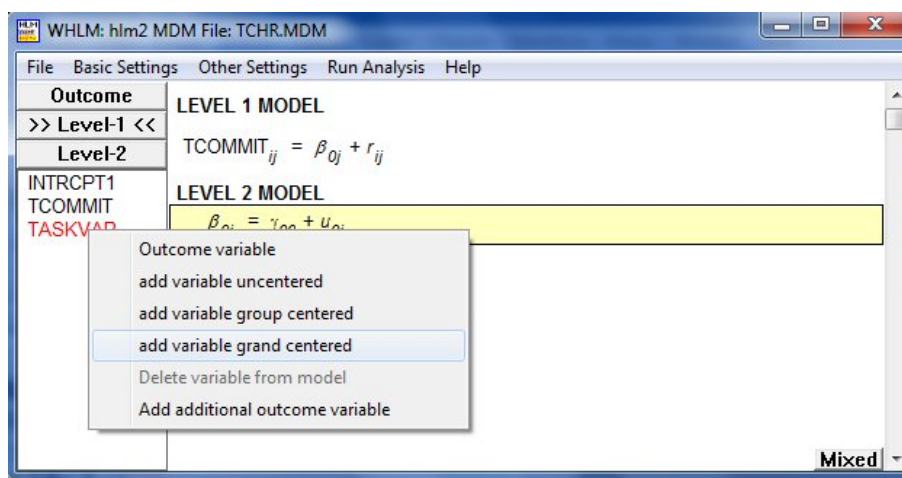
Start by selecting the **Create a new model using an existing MDM file** option from the **File** menu and open the MDM file **TCHR.MDM**.



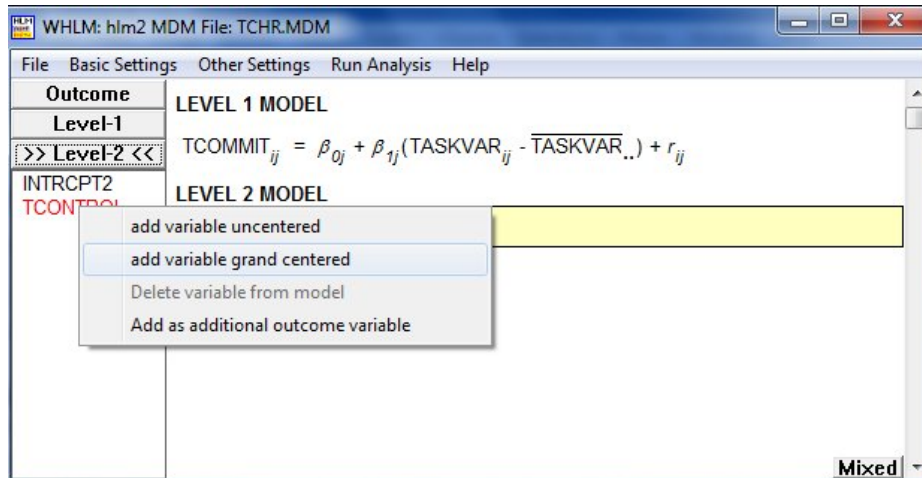
Select the outcome variable TCOMMIT by clicking on the variable name at left and selecting **Outcome variable** from the pop-up menu.



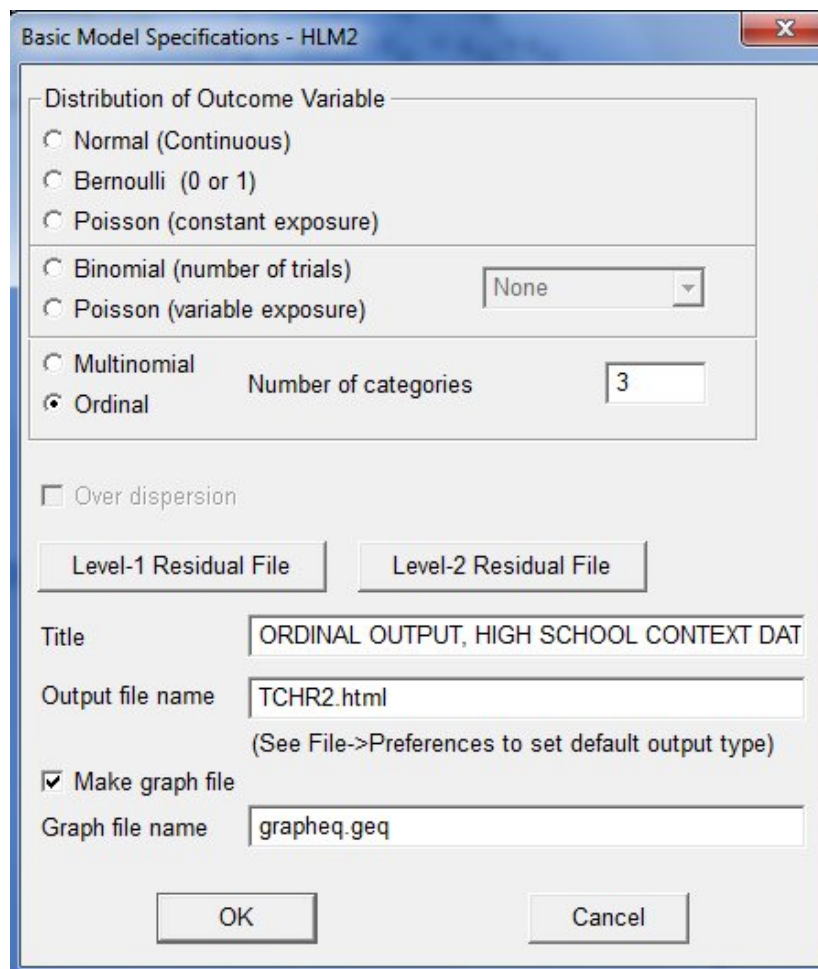
Next, add the variable TASKVAR to the model by selecting the **add variable grand centered** option from the pop-up menu.



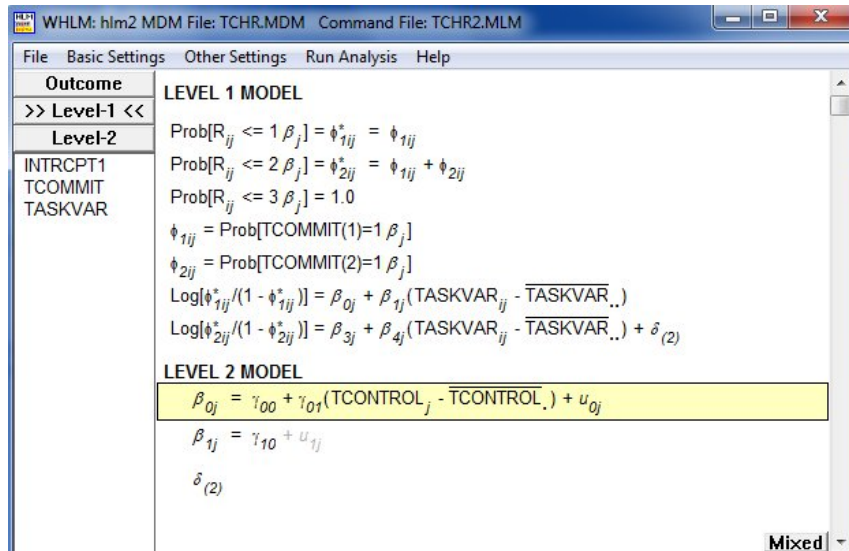
As a final step, include the level-2 predictor TCONTROL as **grand-mean centered** predictor on the level-2 intercept equation.



After specifying the basic model, click the **Outcome** button at the top of the variable list box to the left of the main HLM window to open the **Basic Model Specifications – HLM2** dialog box.



Select **Ordinal** to tell HLM that the level-1 sampling model is ordinal. Enter the value “3” in the **Number of categories** field. Click **OK** to return to the main window. The model specification is now that of an ordinal model with three categories.



Click **OK** to return to the main window and remember to save the command file prior to running the analysis.

5. Interpreting the output

The output obtained for this model follows.

Problem Title: Ordinal Output, HIGH SCHOOL CONTEXT DATA

The data source for this run = TCHR.MDM
 The command file for this run = TCHR2.HLM
 Output file name = TCHR2.HTML
 The maximum number of level-1 units = 650
 The maximum number of level-2 units = 16
 The maximum number of micro iterations = 14
 Number of categories = 3
 Method of estimation: restricted PQL

Distribution at Level-1: Ordinal

The outcome variable is TCOMMIT

Summary of the model specified

Level-1 Model

$$Prob[R_{ij} \leq 1 | \beta_j] = \phi_{ij}^* = \phi_{1ij}$$

$$\begin{aligned}
\text{Prob}[R_{ij} \leq 2|\beta_j] &= \phi_{2ij}^* = \phi_{1ij} + \phi_{2ij} \\
\text{Prob}[R_{ij} \leq 3|\beta_j] &= 1.0 \\
\phi_{1ij} &= \text{Prob}[\text{TCOMMIT}(1) = 1|\beta_j] \\
\phi_{2ij} &= \text{Prob}[\text{TCOMMIT}(2) = 1|\beta_j] \\
\log[\phi_{1ij} / (1 - \phi_{1ij})] &= \beta_{0j} + \beta_{1j} * (\text{TASKVAR}_{ij}) \\
\log[\phi_{2ij} / (1 - \phi_{2ij})] &= \beta_{0j} + \beta_{1j} * (\text{TASKVAR}_{ij}) + \delta_2
\end{aligned}$$

Thus, the level-1 structural models are

$$\begin{aligned}
\eta'_{ij(1)} &= \left[\frac{\phi'_{ij(1)}}{1 - \phi'_{ij(1)}} \right] = \beta_{0j} + \beta_{1j} (\text{TASKVAR})_{ij} \\
\eta'_{ij(2)} &= \left[\frac{\phi'_{ij(2)}}{1 - \phi'_{ij(2)}} \right] = \beta_{0j} + \beta_{1j} (\text{TASKVAR})_{ij} + \delta_{(2)}.
\end{aligned}$$

Level-2 Model

$$\begin{aligned}
\beta_{0j} &= \gamma_{00} + \gamma_{01} * (\text{TCONTROL}_j) + u_{0j} \\
\beta_{1j} &= \gamma_{10} \\
\delta_2 &
\end{aligned}$$

TASKVAR has been centered around the grand mean.
TCONTROL has been centered around the grand mean.

The level-2 structural model is

$$\begin{aligned}
\beta_{0j} &= \gamma_{00} + \gamma_{01} (\text{TCONTROL})_{ij} + u_{0j} \\
\beta_{1j} &= \gamma_{10}
\end{aligned}$$

Final Results for Ordinal Iteration 9173

The extremely large number of iterations reflects the fact that the final estimate of the between-school variance, τ_{00} , is near zero, after adjusting for TCONTROL.

τ
INTRCPT1, β_0 0.00010

Random level-1 coefficient	Reliability estimate
INTRCPT1, β_0	0.001

The value of the log-likelihood function at iteration 2 = -1.249070E+003

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard error	t-ratio	Approx. d.f.	p-value
For INTRCPT1 slope, β_0					
INTRCPT2, γ_{00}	0.333918	0.089735	3.721	14	0.002
TCONTROL, γ_{01}	1.541051	0.365624	4.215	14	<0.001
For TASKVAR slope, β_1					
INTRCPT2, γ_{10}	0.348801	0.087280	3.996	633	<0.001
For THOLD2, δ_2	1.054888	0.080868	13.045	633	<0.001

Fixed Effect	Coefficient	Odds Ratio	Confidence Interval
For INTRCPT1 slope, β_0			
INTRCPT2, γ_{00}	0.333918	1.396429	(1.152,1.693)
TCONTROL, γ_{01}	1.541051	4.669496	(2.131,10.230)
For TASKVAR slope, β_1			
INTRCPT2, γ_{10}	0.348801	1.417367	(1.194,1.682)
For THOLD2, δ_2	1.054888	2.871653	(2.450,3.366)

γ_{00} , the unit-specific intercept, is the expected log-odds of an affirmative response relative to an undecided or negative response for a teacher with mean perception of task variety and working in a school with average teacher control and a random effect of zero. It is adjusted for the between-school heterogeneity in the likelihood of an affirmative response relative to a negative response, which is independent of the effect of task variety and teacher control. This conditional expected log-odds is 0.333918. The expected log-odds for a teacher to give an affirmative or undecided response relative to a negative response is $0.333918 + 1.054888 = 1.388806$. γ_{01} and γ_{10} give the estimates of the change in the respective cumulative logits, holding all other variables constant. For instance, all else being equal, a standard deviation increase in TCONTROL (.32) will increase the odds of an affirmative response to an undecided or negative response as well as the odds of an affirmative or undecided response to a negative response by a factor of 1.637 ($\exp\{1.541051 * .32\} = 1.637$).

Below is a table for the results for the fixed effects with robust standard errors.

Final estimation of fixed effects (with robust standard errors)

Fixed Effect	Coefficient	Standard error	t-ratio	Approx. d.f.	p-value
For INTRCPT1 slope, β_0					
INTRCPT2, γ_{00}	0.333918	0.092707	3.602	14	0.003
TCONTROL, γ_{01}	1.541051	0.340944	4.520	14	<0.001
For TASKVAR slope, β_1					
INTRCPT2, γ_{10}	0.348801	0.092285	3.780	633	<0.001
For THOLD2, δ_2	1.054888	0.080353	13.128	633	<0.001

Fixed Effect	Coefficient	Odds Ratio	Confidence Interval
For INTRCPT1 slope, β_0			
INTRCPT2, γ_{00}	0.333918	1.396429	(1.145,1.704)
TCONTROL, γ_{01}	1.541051	4.669496	(2.247,9.702)
For TASKVAR slope, β_1			
INTRCPT2, γ_{10}	0.348801	1.417367	(1.182,1.699)
For THOLD2,			
δ_2	1.054888	2.871653	(2.452,3.363)

The robust standard errors are appropriate for datasets having a moderate to large number of level 2 units. These data do not meet this criterion.

Final estimation of variance components

Random Effect	Standard Deviation	Variance Component	d.f.	χ^2	p-value
INTRCPT1, u_0	0.01016	0.00010	14	14.57034	0.408

Note that the residual variance of $\beta_{00(1)}$ is not statistically different from zero. In fact, it is very close to zero, which accounts for the large number of iterations required to achieve convergence. The model may be re-run with the coefficient set to be non-random. When this is done, very little difference is observed in the final estimates of the fixed effects., as shown below.

Final estimation of fixed effects (with robust standard errors)

Fixed Effect	Coefficient	Standard error	t-ratio	Approx. d.f.	p-value
For INTRCPT1 slope, β_0)					
INTRCPT2, γ_{00}	0.333954	0.092685	3.603	646	<0.001
TCONTROL, γ_{01}	1.541018	0.340923	4.520	646	<0.001
For TASKVAR slope, β_1					
INTRCPT2, γ_{10}	0.348809	0.092281	3.780	646	<0.001
For THOLD2,					
δ_2	1.054874	0.080351	13.128	646	<0.001