Example 40g — Crossed models (multilevel)

Description Remarks and examples Reference Also see

Description

To illustrate crossed models, we use

```
. use https://www.stata-press.com/data/r19/gsem_fifeschool
(School data from Fife, Scotland)
. describe
Contains data from https://www.stata-press.com/data/r19/gsem_fifeschool.dta
 Observations:         3,435                  School data from Fife, Scotland
    Variables:             5                  25 Mar 2024 16:17
                                              (_dta has notes)
------------------------------------------------------------------------------
Variable      Storage   Display    Value
    name         type    format    label      Variable label
------------------------------------------------------------------------------
pid             int     %9.0g                 Primary school ID
sid             byte    %9.0g                 Secondary school ID
attain          byte    %9.0g                 Attainment score at age 16
vrq             int     %9.0g                 Verbal-reasoning score from final
                                                year of primary school
sex             byte    %9.0g                 1: female; 0: male
------------------------------------------------------------------------------
Sorted by: pid  sid
. notes
_dta:
  1.  Paterson, L. 1991. "Socio-economic status and education attainment:  A
      multidimensional and multilevel study" in _Evaluation and Research in
      Education_ 5: 97-121.
  2.  Each observation is a different student. Each student attended a primary
      school (pid) and a secondary school (sid).
  3.  pid and sid are crossed, not nested.  All combinations are possible.
```

Rabe-Hesketh and Skrondal (2022, 493–512) give an introduction to crossed-effects models and provide other examples of crossed-effects models by using the school data from Fife, Scotland.

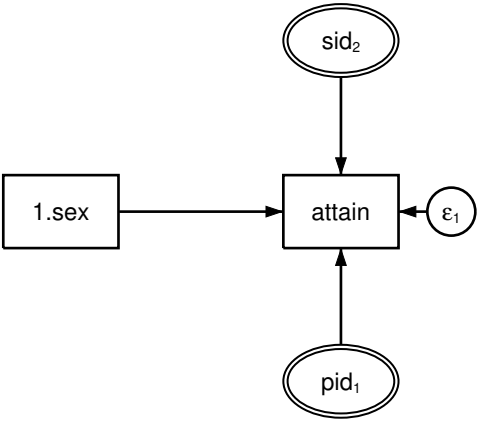
See *Structural models 1: Linear regression* and *Multilevel mixed-effects models* in [SEM] **Intro 5** for background.

Remarks and examples

Remarks are presented under the following headings:

The crossed model

In these data, 3,435 students attended 148 different primary schools and 19 different secondary schools. The model we wish to fit is



We include latent (random) effects for primary and secondary school because we think that school identities may have an effect.

The command syntax to fit this model is

```
. gsem (attain <- i.sex M1[pid] M2[sid])
note: crossed random-effects model specified; option intmethod(laplace)
      implied.
Fitting fixed-effects model:
Iteration 0:  Log likelihood = -8701.1372
Iteration 1:  Log likelihood = -8701.1372
Refining starting values:
Grid node 0:  Log likelihood = -8587.4875
Fitting full model:
Iteration 0:  Log likelihood = -8587.4875
Iteration 1:  Log likelihood = -8573.5619
Iteration 2:  Log likelihood = -8563.0123
Iteration 3:  Log likelihood = -8561.7426
Iteration 4:  Log likelihood = -8561.7354
Iteration 5:  Log likelihood = -8561.7354
Generalized structural equation model                  Number of obs = 3,435
Response: attain
Family:   Gaussian
Link:     Identity
Log likelihood = -8561.7354
 ( 1)  [attain]M2[sid] = 1
 ( 2)  [attain]M1[pid] = 1
```

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
attain						
1.sex	.4986152	.0982634	5.07	0.000	.3060224	.6912079
M1[pid]	1	(constrained)				
M2[sid]	1	(constrained)				
_cons	5.257372	.1813785	28.99	0.000	4.901876	5.612867
var(M1[pid])	1.104316	.2022595			.7712452	1.581226
var(M2[sid])	.3457089	.160868			.1388746	.8605941
var(e.attain)	8.053437	.1990023			7.672694	8.453074

Notes:

1. These data are not nested, but the diagram above would look the same even if they were. The fact that primary and secondary schools are crossed and not nested is, however, specified when we enter the model into the SEM Builder and is implicit in the command syntax.
2. We typed `attain <- i.sex M1[pid] M2[sid]`. We would have typed `attain <- i.sex M1[pid] M2[sid<pid]` had secondary school been nested within primary school.
3. `gsem` produced the following note when it began estimation: "crossed random effects detected; option intmethod(laplace) assumed". `gsem` provides four integration methods. The default is `mvaghermite`, which stands for mean–variance adaptive Gauss–Hermite quadrature. The others are `mcaghermite` (mode-curvature adaptive Gauss–Hermite quadrature); `ghermite` (nonadaptive Gauss–Hermite quadrature); and `laplace` (Laplacian approximation).

In general, the adaptive methods `mvaghermite` and `mcaghermite` are considered superior in terms of accuracy to the nonadaptive method `ghermite`, which is considered superior to the approximation method `laplace`. They also take longer.

Fitting crossed models can be difficult. You may specify `intmethod()` with one of the superior methods, but be aware, convergence may not be achieved in finite time.

Fitting the model with the Builder

Use the diagram in *The crossed model* above for reference.

1. Open the dataset.

   In the Command window, type

   ```
   . use https://www.stata-press.com/data/r19/gsem_fifeschool
   ```

2. Open a new Builder diagram.

   Select menu item **Statistics > SEM (structural equation modeling) > Model building and estimation**.

3. Put the Builder in `gsem` mode by clicking on the GSEM button.

4. Create the endogenous variable.

   a. Select the Add observed variable tool, □, and then click in the diagram about one-third of the way in from the right and halfway down from the top. After adding it, you can click inside the rectangle and move the variable if you wish.

   b. In the Contextual Toolbar, select `attain` with the *Variable* control.

5. Create the observed exogenous variable.

   a. Select the Add observed variable tool, □, and then click in the diagram about one-third of the way in from the left and halfway down from the top.

   b. In the Contextual Toolbar, type `1.sex` in the *Variable* control (typing `1.sex` rather than using the ··· button to create `i.sex` prevents the rectangle corresponding to the base category for this binary variable from being created);

6. Create the `pid`-level latent variable.

   a. Select the Add multilevel latent variable tool, ◎, and click below the rectangle for `attain`.

   b. In the Contextual Toolbar, click on the ··· button.

   c. Select the nesting level and nesting variable by selecting `2` from the *Nesting depth* control and selecting `pid` > *Observations* in the next control.

   d. Specify `M1` as the *Base name*.

   e. Click on **OK**.

7. Create the `sid`-level latent variable.

   a. Select the Add multilevel latent variable tool, ◎, and click above the rectangle for `attain`.

   b. In the Contextual Toolbar, click on the ··· button.

   c. Select the nesting level and nesting variable by selecting `2` from the *Nesting depth* control and selecting `sid` > *Observations* in the next control.

d. Specify `M2` as the *Base name*.

e. Click on **OK**.

8. Create the paths from the exogenous variables to `attain`.

   a. Select the Add path tool, ⟶.

   b. Click in the right side of the `1.sex` rectangle (it will highlight when you hover over it), and drag a path to the left side of the `attain` rectangle (it will highlight when you can release to connect the path).

   c. Continuing with the ⟶ tool, draw paths from bottom of the $\texttt{sid}_2$ double oval to the top of the `attain` rectangle and from the top of the $\texttt{pid}_1$ double oval to the bottom of the `attain` rectangle.

9. Clean up the location of the paths.

   If you do not like where the paths have been connected to the rectangles or oval, use the Select tool, , to click on the path, and then simply click on where it connects to a rectangle or oval and drag the endpoint.

10. Estimate.

    Click on the **Estimate** button, , in the Standard Toolbar, and then click on **OK** in the resulting *GSEM estimation options* dialog box.

You can open a completed diagram in the Builder by typing

```
. webgetsem gsem_cross
```

Reference

Rabe-Hesketh, S., and A. Skrondal. 2022. *Multilevel and Longitudinal Modeling Using Stata*. 4th ed. College Station, TX: Stata Press.

Also see

[SEM] **Example 38g** — Random-intercept and random-slope models (multilevel)

[SEM] **Intro 5** — Tour of models

[SEM] **gsem** — Generalized structural equation model estimation command