Example 32g — Full structural equation model (generalized response)

Description Remarks and examples Also see

Description

To demonstrate a structural model with a measurement component, we use the same data used in [SEM] **Example 31g**:

```
. use https://www.stata-press.com/data/r18/gsem_cfa
(Fictional math abilities data)
. summarize
```

Variable	Obs	Mean	Std. dev.	Min	Max
school	500	10.5	5.772056	1	20
id	500	50681.71	29081.41	71	100000
q1	500	.506	.5004647	0	1
q2	500	.394	.4891242	0	1
q3	500	.534	.4993423	0	1
q4	500	.424	.4946852	0	1
q5	500	.49	.5004006	0	1
q6	500	.434	.4961212	0	1
q7	500	.52	.5001002	0	1
q8	500	.494	.5004647	0	1
att1	500	2.946	1.607561	1	5
att2	500	2.948	1.561465	1	5
att3	500	2.84	1.640666	1	5
att4	500	2.91	1.566783	1	5
att5	500	3.086	1.581013	1	5
test1	500	75.548	5.948653	55	93
test2	500	80.556	4.976786	65	94
test3	500	75.572	6.677874	50	94
test4	500	74.078	8.845587	43	96

```
. notes
_dta:
  1.  Fictional data on math ability and attitudes of 500 students from 20
      schools.
  2.  Variables q1-q8 are incorrect/correct (0/1) on individual math questions.
  3.  Variables att1-att5 are items from a Likert scale measuring each
      student's attitude toward math.
  4.  Variables test1-test4 are test scores from tests of four different
      aspects of mathematical abilities.  Range of scores: 0-100.
```

These data record results from a fictional instrument measuring mathematical ability. Variables `q1` through `q8` are the items from the instrument.

In this example, we will also be using variables `att1` through `att5`. These are five Likert-scale questions measuring each student's attitude toward math.

See *Structural models 9: Unobserved inputs, outputs, or both* in [SEM] **Intro 5** for background.

Remarks and examples

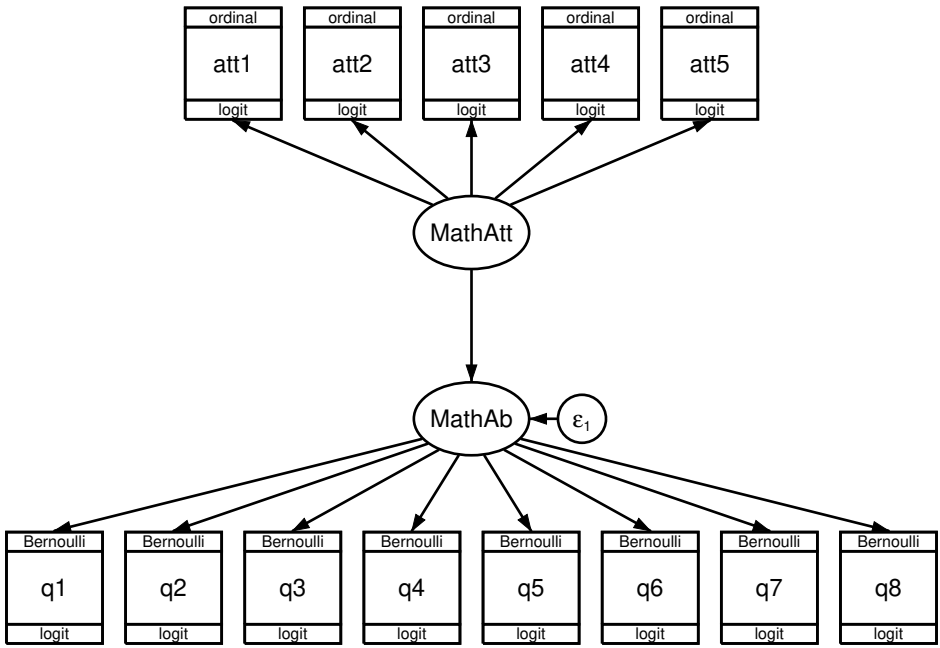
stata.com

Remarks are presented under the following headings:

Structural model with measurement component
Fitting the model with the Builder

Structural model with measurement component

We wish to fit the following model:



This is the same model we fit in [SEM] **Example 31g**, except that rather than a correlation (curved path) between `MathAtt` and `MathAb`, this time we assume a direct effect and so allow a straight path.

If you compare the two path diagrams, in addition to the new substitution of the direct path for the curved path signifying correlation, there is now an error variable on `MathAb`. In the previous diagram, `MathAb` was exogenous. In this diagram, it is endogenous and thus requires an error term. In the Builder, the error term is added automatically.

To fit this model in the command language, we type

```
. gsem (MathAb -> q1-q8, logit)
>      (MathAtt -> att1-att5, ologit)
>      (MathAtt -> MathAb)

Fitting fixed-effects model:

Iteration 0:  Log likelihood = -6629.7253
Iteration 1:  Log likelihood = -6628.7848
Iteration 2:  Log likelihood = -6628.7848

Refining starting values:

Grid node 0:  Log likelihood = -6429.1636
```

```
Fitting full model:

Iteration 0:  Log likelihood = -6429.1636
Iteration 1:  Log likelihood = -6396.7471
Iteration 2:  Log likelihood = -6394.6197
Iteration 3:  Log likelihood = -6394.3949
Iteration 4:  Log likelihood = -6394.3923
Iteration 5:  Log likelihood = -6394.3923

Generalized structural equation model                     Number of obs = 500

Response: q1
Family:   Bernoulli
Link:     Logit

Response: q2
Family:   Bernoulli
Link:     Logit

Response: q3
Family:   Bernoulli
Link:     Logit

Response: q4
Family:   Bernoulli
Link:     Logit

Response: q5
Family:   Bernoulli
Link:     Logit

Response: q6
Family:   Bernoulli
Link:     Logit

Response: q7
Family:   Bernoulli
Link:     Logit

Response: q8
Family:   Bernoulli
Link:     Logit

Response: att1
Family:   Ordinal
Link:     Logit

Response: att2
Family:   Ordinal
Link:     Logit

Response: att3
Family:   Ordinal
Link:     Logit

Response: att4
Family:   Ordinal
Link:     Logit

Response: att5
Family:   Ordinal
Link:     Logit

Log likelihood = -6394.3923

 ( 1)  [q1]MathAb = 1
 ( 2)  [att1]MathAtt = 1
```

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
q1						
MathAb	1	(constrained)				
_cons	.044612	.1272967	0.35	0.726	-.204885	.294109
q2						
MathAb	.3446066	.1050261	3.28	0.001	.1387593	.550454
_cons	-.4572215	.0979965	-4.67	0.000	-.6492911	-.2651519
q3						
MathAb	.5445222	.1386992	3.93	0.000	.2726767	.8163677
_cons	.1591406	.1033116	1.54	0.123	-.0433465	.3616276
q4						
MathAb	.2858862	.0948549	3.01	0.003	.099974	.4717984
_cons	-.3196648	.0947684	-3.37	0.001	-.5054075	-.1339222
q5						
MathAb	.8174769	.1867022	4.38	0.000	.4515473	1.183406
_cons	-.04543	.116575	-0.39	0.697	-.2739129	.1830528
q6						
MathAb	.6030423	.1471949	4.10	0.000	.3145457	.8915389
_cons	-.3099919	.1070853	-2.89	0.004	-.5198754	-.1001085
q7						
MathAb	.7208369	.171309	4.21	0.000	.3850774	1.056597
_cons	.1047264	.1116494	0.94	0.348	-.1141024	.3235553
q8						
MathAb	.5814736	.1426725	4.08	0.000	.3018406	.8611067
_cons	-.0250443	.1045135	-0.24	0.811	-.2298869	.1797984
att1						
MathAtt	1	(constrained)				
att2						
MathAtt	.3788715	.0971234	3.90	0.000	.1885131	.5692299
att3						
MathAtt	-1.592717	.3614956	-4.41	0.000	-2.301236	-.8841989
att4						
MathAtt	-.8100108	.1530675	-5.29	0.000	-1.110017	-.510004
att5						
MathAtt	.5225425	.1170166	4.47	0.000	.2931942	.7518907
MathAb						
MathAtt	.581103	.14776	3.93	0.000	.2914987	.8707072
/att1						
cut1	-1.10254	.131228			-1.359742	-.8453377
cut2	-.2495339	.1160385			-.4769652	-.0221025
cut3	.2983261	.1164415			.070105	.5265472
cut4	1.333052	.1391919			1.060241	1.605864

/att2				
cut1	-1.055791	.1062977	-1.264131	-.8474513
cut2	-.1941211	.0941435	-.378639	-.0096032
cut3	.3598488	.0952038	.1732528	.5464448
cut4	1.132624	.1082204	.9205156	1.344732
/att3				
cut1	-1.053519	.1734001	-1.393377	-.7136612
cut2	-.0491074	.1442846	-.3319	.2336853
cut3	.5570672	.1538702	.2554871	.8586472
cut4	1.666859	.2135557	1.248297	2.08542
/att4				
cut1	-1.07378	.1214071	-1.311734	-.8358264
cut2	-.2112462	.1076501	-.4222365	-.0002559
cut3	.406347	.1094847	.191761	.620933
cut4	1.398185	.1313327	1.140778	1.655593
/att5				
cut1	-1.244051	.1148443	-1.469142	-1.018961
cut2	-.336135	.0986678	-.5295203	-.1427498
cut3	.2137776	.0978943	.0219084	.4056468
cut4	.9286849	.107172	.7186316	1.138738
var(e.MathAb)	1.787117	.5974753	.9280606	3.441357
var(MathAtt)	1.520854	.4077885	.8991947	2.572298

Notes:

1. In the model fit in [SEM] **Example 31g**, we estimated a correlation between `MathAtt` and `MathAb` of 0.4725.
2. Theoretically speaking, the model fit above and the model in [SEM] **Example 31g** are equivalent. Both posit a linear relationship between the latent variables and merely choose to parameterize the relationship differently. In [SEM] **Example 31g**, it was parameterized as a covariance. In this example, it is parameterized as causal. People often use structural equation modeling to confirm a proposed hypothesis. It is important that the causal model you specify be based on theory or that you have some other justification. You need something other than empirical results to rule out competing but equivalent models such as the covariance model. Distinguishing causality from correlation is always problematic.
3. Practically speaking, note that the log-likelihood values for this model and the model in [SEM] **Example 31g** are equal at −6394.3923. Also note that the estimated variances of math attitude, `var(MathAtt)`, are also equal at 1.520854.

Fitting the model with the Builder

Use the diagram in *Structural model with measurement component* above for reference.

1. Open the dataset.

   In the Command window, type

   ```
   . use https://www.stata-press.com/data/r18/gsem_cfa
   ```

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 measurement component for `MathAb`.

   Select the Add Measurement Component tool, , and then click in the diagram about one-third of the way up from the bottom and slightly left of the center.

   In the resulting dialog box,

   a. change the *Latent variable name* to `MathAb`;

   b. select `q1`, `q2`, `q3`, `q4`, `q5`, `q6`, `q7`, and `q8` by using the *Measurement variables* control;

   c. check *Make measurements generalized*;

   d. select `Bernoulli, Logit` in the *Family/Link* control;

   e. select `Down` in the *Measurement direction* control;

   f. click on **OK**.

   If you wish, move the component by clicking on any variable and dragging it.
5. Create the measurement component for `MathAtt`.

   Select the Add Measurement Component tool, , and then click in the diagram about one-third of the way down from the top and slightly left of the center.

   In the resulting dialog box,

   a. change the *Latent variable name* to `MathAtt`;

   b. select `att1`, `att2`, `att3`, `att4`, and `att5` by using the *Measurement variables* control;

   c. check *Make measurements generalized*;

   d. select `Ordinal, Logit` in the *Family/Link* control;

   e. select `Up` in the *Measurement direction* control;

   f. click on **OK**.

   If you wish, move the component by clicking on any variable and dragging it.
6. Create path from `MathAtt` to `MathAb`.

   a. Select the Add Path tool, .

   b. Click in the bottom of the `MathAtt` oval (it will highlight when you hover over it), and drag a path to the top of the `MathAb` oval (it will highlight when you can release to connect the path).
7. Clean up the direction of the error.

   The error on `MathAb` has likely been created below the oval instead of to the right of the oval. If so, choose the Select tool, , and then click in the `MathAb` oval. Click on one of the **Error rotation** buttons, , in the Contextual Toolbar until the error is where you want it.
8. 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_sem
```

Also see

[SEM] **Example 9** — Structural model with measurement component

[SEM] **Example 31g** — Two-factor measurement model (generalized response)

[SEM] **Intro 5** — Tour of models

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

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