# Title

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

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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.

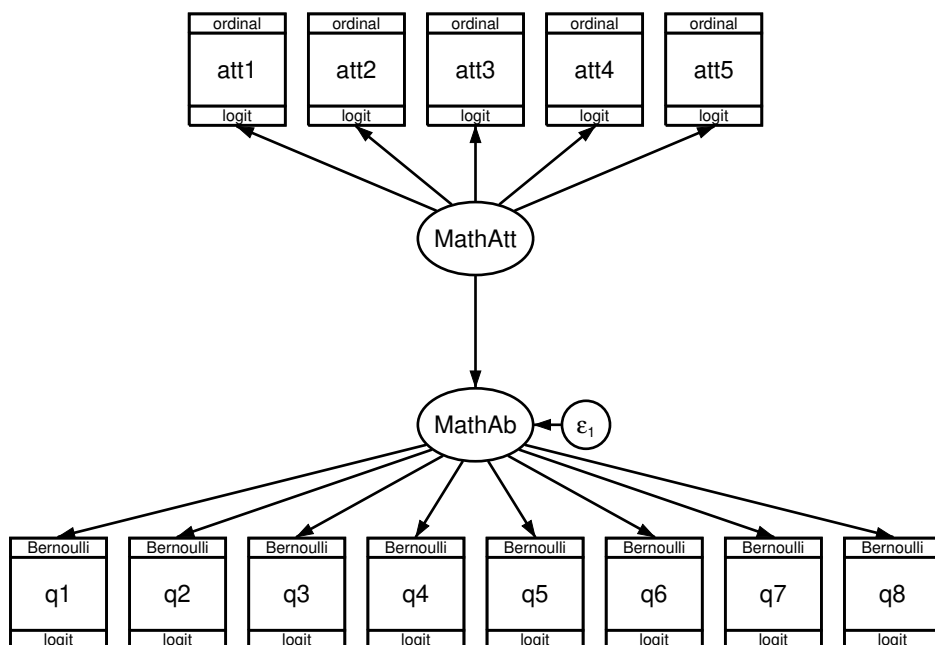See *Structural models 9: Unobserved inputs, outputs, or both* in [SEM] **Intro 5** for background.

# Remarks and examples

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 $\overset{\text{G}}{\text{SEM}}$ button.

4.  Create the measurement component for `MathAb`.

    Select the Add Measurement Component tool, $\overset{\text{wwww}}{\triangledown}$, 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, $\overset{\text{wwww}}{\triangledown}$, 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, $\rightarrow$.

    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, $\blacktriangle$, and then click in the `MathAb` oval. Click on one of the **Error rotation** buttons, $\curvearrowleft\curvearrowright$, in the Contextual Toolbar until the error is where you want it.

8.  Estimate.

    Click on the **Estimate** button, $\boxed{\blacktriangleright}$, 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