Title

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example 9 — Structural model with measurement component

Description Remarks and examples References Also see

Description

To demonstrate a structural model with a measurement component, we use data from Wheaton et al. (1977):

```
. use http://www.stata-press.com/data/r13/sem_sm2
(Structural model with measurement component)
. ssd describe
  Summary statistics data from
  http://www.stata-press.com/data/r13/sem_sm2.dta
    obs:             932                  Structural model with measurem..
   vars:              13                  25 May 2013 11:45
                                          (_dta has notes)
```

variable name	variable label
educ66	Education, 1966
occstat66	Occupational status, 1966
anomia66	Anomia, 1966
pwless66	Powerlessness, 1966
socdist66	Latin American social distance, 1966
occstat67	Occupational status, 1967
anomia67	Anomia, 1967
pwless67	Powerlessness, 1967
socdist67	Latin American social distance, 1967
occstat71	Occupational status, 1971
anomia71	Anomia, 1971
pwless71	Powerlessness, 1971
socdist71	Latin American social distance, 1971

```
. notes
_dta:
  1.  Summary statistics data from Wheaton, B., Muthen B., Alwin, D., &
      Summers, G., 1977, "Assessing reliability and stability in panel models",
      in D. R. Heise (Ed.), _Sociological Methodology 1977_ (pp. 84-136), San
      Francisco: Jossey-Bass, Inc.
  2.  Four indicators each measured in 1966, 1967, and 1981, plus another
      indicator (educ66) measured only in 1966.
  3.  Intended use: Create structural model relating Alienation in 1971,
      Alienation in 1967, and SES in 1966.
```

See *Structural models 8: Unobserved inputs, outputs, or both* in [SEM] **intro 5** for background.

Remarks and examples

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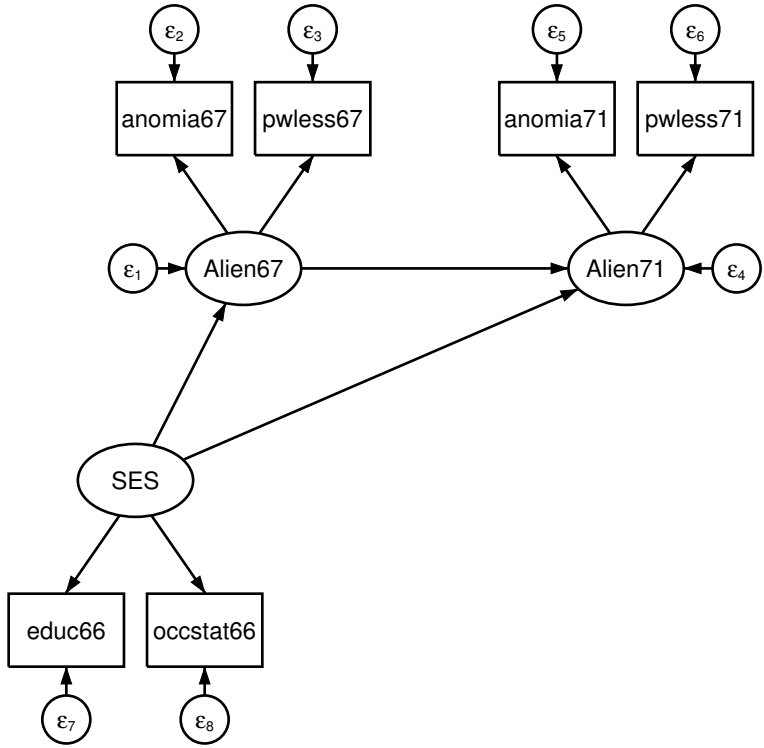
Remarks are presented under the following headings:

Fitting the model

Simplified versions of the model fit by the authors of the referenced paper appear in many SEM software manuals. A simplified model is




```
. sem                                   ///
>     (anomia67 pwless67 <- Alien67)    /// measurement piece
>     (anomia71 pwless71 <- Alien71)    /// measurement piece
>     (Alien67 <- SES)                  /// structural  piece
>     (Alien71 <- Alien67 SES)          /// structural  piece
>     (    SES -> educ66 occstat66)     //  measurement piece
Endogenous variables
Measurement:  anomia67 pwless67 anomia71 pwless71 educ66 occstat66
Latent:       Alien67 Alien71
Exogenous variables
Latent:       SES
Fitting target model:
Iteration 0:   log likelihood = -15249.988
Iteration 1:   log likelihood = -15246.584
Iteration 2:   log likelihood = -15246.469
Iteration 3:   log likelihood = -15246.469
```

```
Structural equation model                       Number of obs      =       932
Estimation method  = ml
Log likelihood     = -15246.469
 ( 1)  [anomia67]Alien67 = 1
 ( 2)  [anomia71]Alien71 = 1
 ( 3)  [educ66]SES = 1
```

	OIM Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
Alien67 <-						
SES	-.6140404	.0562407	-10.92	0.000	-.7242701	-.5038107
Alien71 <-						
Alien67	.7046342	.0533512	13.21	0.000	.6000678	.8092007
SES	-.1744153	.0542489	-3.22	0.001	-.2807413	-.0680894
Measurement						
anom~67 <-						
Alien67	1	(constrained)				
_cons	13.61	.1126205	120.85	0.000	13.38927	13.83073
pwle~67 <-						
Alien67	.8884887	.0431565	20.59	0.000	.8039034	.9730739
_cons	14.67	.1001798	146.44	0.000	14.47365	14.86635
anom~71 <-						
Alien71	1	(constrained)				
_cons	14.13	.1158943	121.92	0.000	13.90285	14.35715
pwle~71 <-						
Alien71	.8486022	.0415205	20.44	0.000	.7672235	.9299808
_cons	14.9	.1034537	144.03	0.000	14.69723	15.10277
educ66 <-						
SES	1	(constrained)				
_cons	10.9	.1014894	107.40	0.000	10.70108	11.09892
occs~66 <-						
SES	5.331259	.4307503	12.38	0.000	4.487004	6.175514
_cons	37.49	.6947112	53.96	0.000	36.12839	38.85161
var(e.ano~67)	4.009921	.3582978			3.365724	4.777416
var(e.pwl~67)	3.187468	.283374			2.677762	3.794197
var(e.ano~71)	3.695593	.3911512			3.003245	4.54755
var(e.pwl~71)	3.621531	.3037908			3.072483	4.268693
var(e.educ66)	2.943819	.5002527			2.109908	4.107319
var(e.occ~66)	260.63	18.24572			227.2139	298.9605
var(e.Ali~67)	5.301416	.483144			4.434225	6.338201
var(e.Ali~71)	3.737286	.3881546			3.048951	4.581019
var(SES)	6.65587	.6409484			5.511067	8.038482

```
LR test of model vs. saturated: chi2(6)   =     71.62, Prob > chi2 = 0.0000
```

Notes:

1. Measurement component: In both 1967 and 1971, anomia and powerlessness are used to measure endogenous latent variables representing alienation for the same two years. Education and occupational status are used to measure the exogenous latent variable SES.

2. Structural component: `SES->Alien67` and `SES->Alien71`, and `Alien67->Alien71`.
3. The model versus saturated χ^2 test indicates that the model is a poor fit.

Fitting the model with the Builder

Use the diagram above for reference.

1. Open the dataset.

   In the Command window, type

   ```
   . use http://www.stata-press.com/data/r13/sem_sm2
   ```

2. Open a new Builder diagram.

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

3. Create the measurement component for alienation in 1967.

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

   In the resulting dialog box,

   a. change the *Latent variable name* to `Alien67`;

   b. select `anomia67` and `pwless67` by using the *Measurement variables* control;

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

   d. click on **OK**.

   If you wish, move the component by clicking on any variable and dragging it.

4. Create the measurement component for alienation in 1971.

   Repeat the process from item 3, but place the measurement component about halfway down from the top and two-thirds of the way in from the left. Label the latent variable `Alien71`, and select measurement variables `anomia71` and `pwless71`. Again drag to reposition if desired.

5. Create the measurement component for socioeconomic status.

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

   In the resulting dialog box,

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

   b. select `educ66` and `occstat66` by using the *Measurement variables* control;

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

   d. click on **OK**.

6. Create a path from `Alien67` to `Alien71`.

   a. Select the Add Path tool, .

   b. Click in the right half of the `Alien67` oval (it will highlight when you hover over it), and drag a path to the left half of the `Alien71` oval (it will highlight when you can release to connect the path).

7. Create a path from `SES` to `Alien67`.

   Continuing with the → tool, click in the upper portion of the `SES` oval, and drag a path to the lower-left quadrant of the `Alien67` oval.

8. Create a path from `SES` to `Alien71`.

   Continuing with the → tool, click in the upper-right quadrant of the `SES` oval, and drag a path to the lower-left quadrant of the `Alien71` oval.

9. Clean up the direction of the errors.

   The error on `Alien67` may have been created under the path from `Alien67` to `Alien71`. If so, choose the Select tool,  , and then click in the `Alien67` oval. Click on one of the **Error Rotation** buttons,  , in the Contextual Toolbar until the error is where you want it.

10. Estimate.

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

Tips: We took some care above to click in specific quadrants of the ovals when creating paths. This is because, by default, the Builder places the ends of paths on the boundary of the ovals and rectangles closest to where we click. When you create paths, it is often convenient to change the automation settings (**Settings > Automation...**) so that *Connection attachment points* is *Attach based on position of variables* rather than *Attach nearest to drop point*. With the *Connection attachment points* setting, the paths connect nicely regardless of where we click or drop in the variables' ovals and rectangles.

Note that when you create covariances with the Covariances tool, , *Attach nearest to drop point* is sometimes preferred.

You can open a completed diagram in the Builder by typing

```
. webgetsem sem_sm2
```

Evaluating omitted paths with estat mindices

That the model is a poor fit leads us to look at the modification indices:

```
. estat mindices
Modification indices
```

		MI	df	P>MI	EPC	Standard EPC
Measurement						
anomia67 <-						
	anomia71	51.977	1	0.00	.3906425	.4019984
	pwless71	32.517	1	0.00	-.2969297	-.2727609
	educ66	5.627	1	0.02	.0935048	.0842631
pwless67 <-						
	anomia71	41.618	1	0.00	-.3106995	-.3594367
	pwless71	23.622	1	0.00	.2249714	.2323233
	educ66	6.441	1	0.01	-.0889042	-.0900664
anomia71 <-						
	anomia67	58.768	1	0.00	.429437	.4173061
	pwless67	38.142	1	0.00	-.3873066	-.3347904
pwless71 <-						
	anomia67	46.188	1	0.00	-.3308484	-.3601641
	pwless67	27.760	1	0.00	.2871709	.2780833
educ66 <-						
	anomia67	4.415	1	0.04	.1055965	.1171781
	pwless67	6.816	1	0.01	-.1469371	-.1450411
cov(e.anomia67,e.anomia71)		63.786	1	0.00	1.951578	.5069627
cov(e.anomia67,e.pwless71)		49.892	1	0.00	-1.506704	-.3953794
cov(e.anomia67,e.educ66)		6.063	1	0.01	.5527612	.1608845
cov(e.pwless67,e.anomia71)		49.876	1	0.00	-1.534199	-.4470094
cov(e.pwless67,e.pwless71)		37.357	1	0.00	1.159123	.341162
cov(e.pwless67,e.educ66)		7.752	1	0.01	-.5557802	-.1814365

EPC = expected parameter change

Notes:

1. There are lots of statistically significant paths we could add to the model.
2. Some of those statistically significant paths also make theoretical sense.
3. Two in particular that make theoretical sense are the covariances between `e.anomia67` and `e.anomia71` and between `e.pwless67` and `e.pwless71`.

Refitting the model

Let's refit the model and include those two previously excluded covariances:

```
. sem                                                  ///
>     (anomia67 pwless67 <- Alien67)                   /// measurement piece
>     (anomia71 pwless71 <- Alien71)                   /// measurement piece
>     (Alien67 <- SES)                                 /// structural  piece
>     (Alien71 <- Alien67 SES)                         /// structural  piece
>     (    SES -> educ66 occstat66)                    /// measurement piece
>                     , cov(e.anomia67*e.anomia71) ///
>                       cov(e.pwless67*e.pwless71)
Endogenous variables
Measurement:  anomia67 pwless67 anomia71 pwless71 educ66 occstat66
Latent:       Alien67 Alien71
Exogenous variables
Latent:       SES
Fitting target model:
Iteration 0:   log likelihood = -15249.988
Iteration 1:   log likelihood =  -15217.95
Iteration 2:   log likelihood = -15213.126
Iteration 3:   log likelihood = -15213.046
Iteration 4:   log likelihood = -15213.046
```

```
Structural equation model                       Number of obs      =       932
Estimation method  = ml
Log likelihood     = -15213.046

 ( 1)  [anomia67]Alien67 = 1
 ( 2)  [anomia71]Alien71 = 1
 ( 3)  [educ66]SES = 1
```

	OIM Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
Alien67 <-						
SES	-.5752228	.057961	-9.92	0.000	-.6888244	-.4616213
Alien71 <-						
Alien67	.606954	.0512305	11.85	0.000	.5065439	.707364
SES	-.2270301	.0530773	-4.28	0.000	-.3310596	-.1230006
Measurement						
anom~67 <-						
Alien67	1	(constrained)				
_cons	13.61	.1126143	120.85	0.000	13.38928	13.83072
pwle~67 <-						
Alien67	.9785952	.0619825	15.79	0.000	.8571117	1.100079
_cons	14.67	.1001814	146.43	0.000	14.47365	14.86635
anom~71 <-						
Alien71	1	(constrained)				
_cons	14.13	.1159036	121.91	0.000	13.90283	14.35717
pwle~71 <-						
Alien71	.9217508	.0597225	15.43	0.000	.8046968	1.038805
_cons	14.9	.1034517	144.03	0.000	14.69724	15.10276
educ66 <-						
SES	1	(constrained)				
_cons	10.9	.1014894	107.40	0.000	10.70108	11.09892
occs~66 <-						
SES	5.22132	.425595	12.27	0.000	4.387169	6.055471
_cons	37.49	.6947112	53.96	0.000	36.12839	38.85161
var(e.ano~67)	4.728874	.456299			3.914024	5.713365
var(e.pwl~67)	2.563413	.4060733			1.879225	3.4967
var(e.ano~71)	4.396081	.5171156			3.490904	5.535966
var(e.pwl~71)	3.072085	.4360333			2.326049	4.057398
var(e.educ66)	2.803674	.5115854			1.960691	4.009091
var(e.occ~66)	264.5311	18.22483			231.1177	302.7751
var(e.Ali~67)	4.842059	.4622537			4.015771	5.838364
var(e.Ali~71)	4.084249	.4038995			3.364613	4.957802
var(SES)	6.796014	.6524866			5.630283	8.203105
cov(e.ano~67, e.anomia71)	1.622024	.3154267	5.14	0.000	1.003799	2.240249
cov(e.pwl~67, e.pwless71)	.3399961	.2627541	1.29	0.196	-.1749925	.8549847

```
LR test of model vs. saturated: chi2(4)   =      4.78, Prob > chi2 = 0.3111
```

Notes:

1. We find the covariance between `e.anomia67` and `e.anomia71` to be significant ($Z = 5.14$).
2. We find the covariance between `e.pwless67` and `e.pwless71` to be insignificant at the 5% level ($Z = 1.29$).
3. The model versus saturated χ^2 test indicates that the model is a good fit.

References

Acock, A. C. 2013. *Discovering Structural Equation Modeling Using Stata*. Rev. ed. College Station, TX: Stata Press.

Wheaton, B., B. Muthén, D. F. Alwin, and G. F. Summers. 1977. Assessing reliability and stability in panel models. In *Sociological Methodology 1977*, ed. D. R. Heise, 84–136. San Francisco: Jossey-Bass.

Also see

[SEM] **example 32g** — Full structural equation model (generalized response)

[SEM] **estat mindices** — Modification indices

[SEM] **test** — Wald test of linear hypotheses