Title

example 15 — Higher-order CFA

Description Remarks and examples Reference Also see

Description

sem can be used to estimate higher-order confirmatory factor analysis models.

```
. use http://www.stata-press.com/data/r13/sem_hcfa1
(Higher-order CFA)

. ssd describe

  Summary statistics data from
  http://www.stata-press.com/data/r13/sem_hcfa1.dta
    obs:              251                 Higher-order CFA
   vars:               16                 25 May 2013 11:26
                                          (_dta has notes)
  ------------------------------------------------------------------------
  variable name                 variable label
  ------------------------------------------------------------------------
  phyab1                        Physical ability 1
  phyab2                        Physical ability 2
  phyab3                        Physical ability 3
  phyab4                        Physical ability 4
  appear1                       Appearance 1
  appear2                       Appearance 2
  appear3                       Appearance 3
  appear4                       Appearance 4
  peerrel1                      Relationship w/ peers 1
  peerrel2                      Relationship w/ peers 2
  peerrel3                      Relationship w/ peers 3
  peerrel4                      Relationship w/ peers 4
  parrel1                       Relationship w/ parent 1
  parrel2                       Relationship w/ parent 2
  parrel3                       Relationship w/ parent 3
  parrel4                       Relationship w/ parent 4
  ------------------------------------------------------------------------

. notes

_dta:
  1.  Summary statistics data from Marsh, H. W. and Hocevar, D., 1985,
      "Application of confirmatory factor analysis to the study of
      self-concept: First- and higher order factor models and their invariance
      across groups", _Psychological Bulletin_, 97: 562-582.
  2.  Summary statistics based on 251 students from Sydney, Australia in Grade
      5.
  3.  Data collected using the Self-Description Questionnaire and includes
      sixteen subscales designed to measure nonacademic traits: four intended
      to measure physical ability, four intended to measure physical
      appearance, four intended to measure relations with peers, and four
      intended to measure relations with parents.
```

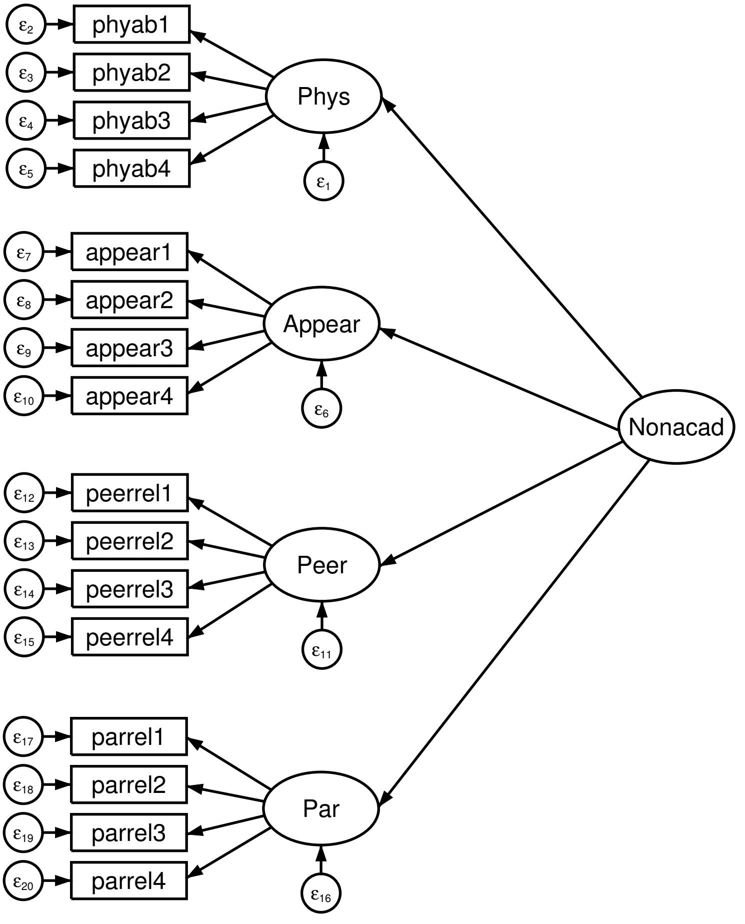
See *Higher-order CFA models* in [SEM] **intro 5** for background.

Remarks and examples

Remarks are presented under the following headings:

Fitting the model

We fit the following model:



```
. sem (Phys -> phyab1 phyab2 phyab3 phyab4)
>     (Appear -> appear1 appear2 appear3 appear4)
>     (Peer -> peerrel1 peerrel2 peerrel3 peerrel4)
>     (Par -> parrel1 parrel2 parrel3 parrel4)
>     (Nonacad -> Phys Appear Peer Par)
Endogenous variables

Measurement:  phyab1 phyab2 phyab3 phyab4 appear1 appear2 appear3 appear4
              peerrel1 peerrel2 peerrel3 peerrel4 parrel1 parrel2 parrel3
              parrel4
Latent:       Phys Appear Peer Par

Exogenous variables

Latent:       Nonacad

Fitting target model:

Iteration 0:   log likelihood = -7686.6699  (not concave)
Iteration 1:   log likelihood = -7643.7387  (not concave)
Iteration 2:   log likelihood = -7616.2966  (not concave)
Iteration 3:   log likelihood = -7597.6133
Iteration 4:   log likelihood = -7588.9515
Iteration 5:   log likelihood = -7585.3162
Iteration 6:   log likelihood = -7584.8125
Iteration 7:   log likelihood = -7584.7885
Iteration 8:   log likelihood = -7584.7881

Structural equation model                       Number of obs      =       251
Estimation method  = ml
Log likelihood     = -7584.7881

 ( 1)  [phyab1]Phys = 1
 ( 2)  [appear1]Appear = 1
 ( 3)  [peerrel1]Peer = 1
 ( 4)  [parrel1]Par = 1
 ( 5)  [Phys]Nonacad = 1

------------------------------------------------------------------------------
             |                 OIM
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
Structural   |
  Phys <-    |
     Nonacad |          1  (constrained)
-------------+----------------------------------------------------------------
  Appear <-  |
     Nonacad |   2.202491   .3975476     5.54   0.000     1.423312     2.98167
  -----------+----------------------------------------------------------------
  Peer <-    |
     Nonacad |   1.448035   .2921383     4.96   0.000     .8754549    2.020616
  -----------+----------------------------------------------------------------
  Par <-     |
     Nonacad |    .569956   .1382741     4.12   0.000     .2989437    .8409683
-------------+----------------------------------------------------------------
Measurement  |
  phyab1 <-  |
        Phys |          1  (constrained)
       _cons |        8.2   .1159065    70.75   0.000     7.972827    8.427173
  -----------+----------------------------------------------------------------
  phyab2 <-  |
        Phys |   .9332477   .1285726     7.26   0.000       .68125    1.185245
       _cons |       8.23    .122207    67.34   0.000     7.990479    8.469521
```

phyab3 <-						
Phys	1.529936	.1573845	9.72	0.000	1.221468	1.838404
_cons	8.17	.1303953	62.66	0.000	7.91443	8.42557
phyab4 <-						
Phys	1.325641	.1338053	9.91	0.000	1.063387	1.587894
_cons	8.56	.1146471	74.66	0.000	8.335296	8.784704
appear1 <-						
Appear	1	(constrained)				
_cons	7.41	.1474041	50.27	0.000	7.121093	7.698907
appear2 <-						
Appear	1.0719	.0821893	13.04	0.000	.9108121	1.232988
_cons	7	.1644123	42.58	0.000	6.677758	7.322242
appear3 <-						
Appear	1.035198	.0893075	11.59	0.000	.8601581	1.210237
_cons	7.17	.1562231	45.90	0.000	6.863808	7.476192
appear4 <-						
Appear	.9424492	.0860848	10.95	0.000	.7737262	1.111172
_cons	7.4	.1474041	50.20	0.000	7.111093	7.688907
peerr~1 <-						
Peer	1	(constrained)				
_cons	8.81	.1077186	81.79	0.000	8.598875	9.021125
peerr~2 <-						
Peer	1.214379	.1556051	7.80	0.000	.9093989	1.51936
_cons	7.94	.1215769	65.31	0.000	7.701714	8.178286
peerr~3 <-						
Peer	1.667829	.190761	8.74	0.000	1.293944	2.041714
_cons	7.52	.1373248	54.76	0.000	7.250848	7.789152
peerr~4 <-						
Peer	1.363627	.159982	8.52	0.000	1.050068	1.677186
_cons	8.29	.1222066	67.84	0.000	8.050479	8.529521
parrel1 <-						
Par	1	(constrained)				
_cons	9.35	.0825215	113.30	0.000	9.188261	9.511739
parrel2 <-						
Par	1.159754	.184581	6.28	0.000	.7979822	1.521527
_cons	9.13	.0988998	92.32	0.000	8.93616	9.32384
parrel3 <-						
Par	2.035143	.2623826	7.76	0.000	1.520882	2.549403
_cons	8.67	.1114983	77.76	0.000	8.451467	8.888533
parrel4 <-						
Par	1.651802	.2116151	7.81	0.000	1.237044	2.06656
_cons	9	.0926003	97.19	0.000	8.818507	9.181493
var(e.phyab1)	2.07466	.2075636			1.705244	2.524103
var(e.phyab2)	2.618638	.252693			2.167386	3.163841
var(e.phyab3)	1.231013	.2062531			.8864333	1.70954
var(e.phyab4)	1.019261	.1600644			.7492262	1.386621
var(e.appe~1)	1.986955	.2711164			1.520699	2.596169

var(e.appe~2)	2.801673	.3526427	2.189162	3.585561
var(e.appe~3)	2.41072	.300262	1.888545	3.077276
var(e.appe~4)	2.374508	.2872554	1.873267	3.009868
var(e.peer~1)	1.866632	.18965	1.529595	2.277933
var(e.peer~2)	2.167766	.2288099	1.762654	2.665984
var(e.peer~3)	1.824346	.2516762	1.392131	2.390749
var(e.peer~4)	1.803918	.212599	1.431856	2.272659
var(e.parr~1)	1.214141	.1195921	1.000982	1.472692
var(e.parr~2)	1.789125	.1748043	1.477322	2.166738
var(e.parr~3)	1.069717	.1767086	.7738511	1.478702
var(e.parr~4)	.8013735	.121231	.5957527	1.077963
var(e.Phys)	.911538	.1933432	.6014913	1.381403
var(e.Appear)	1.59518	.3704939	1.011838	2.514828
var(e.Peer)	.2368108	.1193956	.0881539	.6361528
var(e.Par)	.3697854	.0915049	.2276755	.600597
var(Nonacad)	.3858166	.1237638	.2057449	.7234903

```
LR test of model vs. saturated: chi2(100) =    219.48, Prob > chi2 = 0.0000
```

Notes:

1. The idea behind this model is that physical ability, appearance, and relationships with peers and parents may be determined by a latent variable containing nonacademic traits. This model was suggested by Bollen (1989, 315).

2. `sem` automatically provided normalization constraints for the first-order factors `Phys`, `Appear`, `Peer`, and `Par`. Their path coefficients were set to 1.

3. `sem` automatically provided a normalization constraint for the second-order factor `Nonacad`. Its path coefficient was set to 1.

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_hcfa1
   ```

2. Open a new Builder diagram.

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

3. Enlarge the size of the canvas to accommodate the length of the diagram.

   Click on the **Adjust Canvas Size** button, , in the Standard Toolbar, change the second size to 7 (inches), and then click on **OK**.

4. Change the size of the observed variables' rectangles.

   a. In the SEM Builder menu, select **Settings > Variables > All Observed...**.

   b. In the resulting dialog box, change the second size to .25 and click on **OK**.

5. Create the measurement component for physical ability.

   Select the Add Measurement Component tool, . Then using the darker one-inch grid lines in the background as a guide, click in the diagram about two inches in from the left and one inch down from the top.

In the resulting dialog box,

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

b. select `phyab1`, `phyab2`, `phyab3`, and `phyab4` by using the *Measurement variables* control;

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

d. click on **OK**.

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

6. Create the remaining first-order measurement components.

   a. Repeat the process from item 5, but place the measurement component on the grid line two inches in from the left and about two and one-half inches down from the top. Label the latent variable `Appear`, and select measurement variables `appear1`, `appear2`, `appear3`, and `appear4`.

   b. Repeat the process from item 5, but place the measurement component on the grid line two inches in from the left and about four inches down from the top. Label the latent variable `Peer`, and select measurement variables `peerrel1`, `peerrel2`, `peerrel3`, and `peerrel4`.

   c. Repeat the process from item 5, but place the measurement component on the grid line two inches in from the left and about five and one-half inches down from the top. Label the latent variable `Par`, and select measurement variables `parrel1`, `parrel2`, `parrel3`, and `parrel4`.

7. Create the second-order latent variable.

   a. Select the Add Latent Variable tool, ⬭, and then click in the diagram about two inches in from the right and vertically centered between the `Appear` and `Peer` latent variables.

   b. In the Contextual Toolbar, type `Nonacad` in the *Name* control and press *Enter*.

8. Create paths from `Nonacad` to each of the first-order latent variables.

   a. Select the Add Path tool, →.

   b. Click in the upper-left quadrant of the `Nonacad` oval (it will highlight when you hover over it), and drag a path to the lower-left quadrant of the `Phys` oval (it will highlight when you can release to connect the path).

   c. Continuing with the → tool, create the following paths by clicking first on the left side of the `Nonacad` variable and dragging to the right side of the first-order latent variable.

```
Nonacad -> Appear
Nonacad -> Peer
Nonacad -> Par
```

9. Clean up the direction of the errors.

   We want the errors for each of the latent variables to be below the latent variable. The errors for `Phys`, `Appear`, and `Peer` are likely to have been created in other directions.

   a. Choose the Select tool, ↖.

   b. Click in the `Phys` oval.

   c. Click on one of the **Error Rotation** buttons, ↺ ↻, in the Contextual Toolbar until the error is below the latent variable.

   Repeat this for all errors on latent variables that are not below the latent variable.

10. Clean up the paths.

    If you do not like where a path has been connected to its variable, use the Select tool, , to click on the path, and then simply click on where it connects to an oval and drag the endpoint.

11. Estimate.

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

Tip: See the tips of [SEM] **example 9** to make creating paths somewhat easier than described above.

You can open a completed diagram in the Builder by typing

```
. webgetsem sem_hcfa1
```

Reference

Bollen, K. A. 1989. *Structural Equations with Latent Variables*. New York: Wiley.

Also see

[SEM] **sem** — Structural equation model estimation command