

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/r14/sem_hcfa1
(Higher-order CFA)
. ssd describe
Summary statistics data from
http://www.stata-press.com/data/r14/sem_hcfa1.dta
  obs:                251                Higher-order CFA
  vars:                16                25 May 2014 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

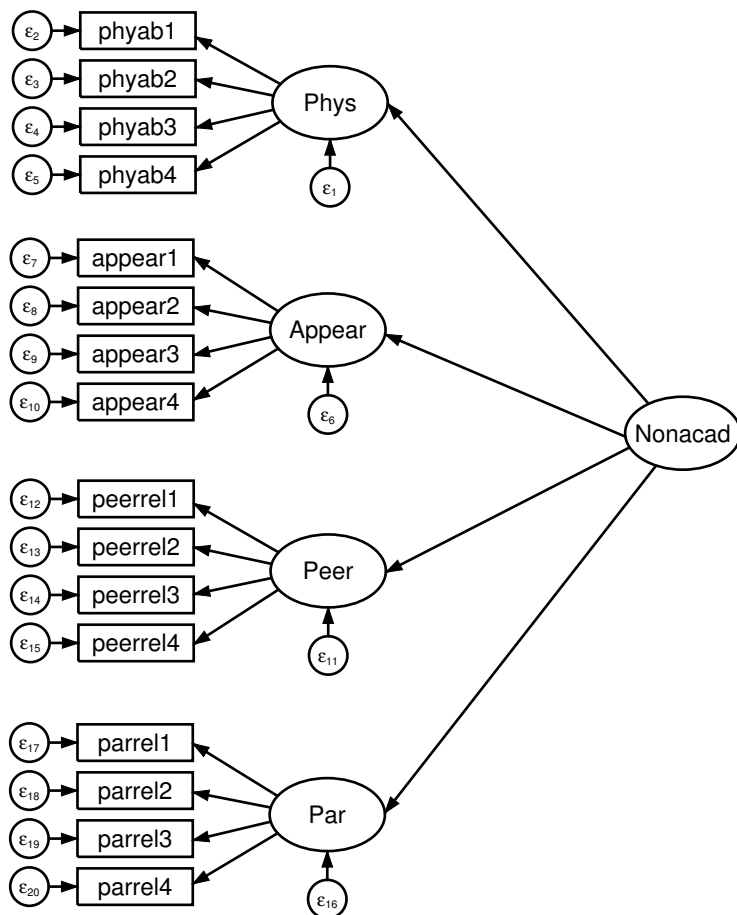
Remarks are presented under the following headings:

Fitting the model

Fitting the model with the Builder

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

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phyab3 <- Phys _cons	1.529936 8.17	.1573845 .1303953	9.72 62.66	0.000 0.000	1.221468 7.91443	1.838404 8.42557
phyab4 <- Phys _cons	1.325641 8.56	.1338053 .1146471	9.91 74.66	0.000 0.000	1.063387 8.335296	1.587894 8.784704
appear1 <- Appear _cons	1 7.41	(constrained) .1474041	50.27	0.000	7.121093	7.698907
appear2 <- Appear _cons	1.0719 7	.0821893 .1644123	13.04 42.58	0.000 0.000	.9108121 6.677758	1.232988 7.322242
appear3 <- Appear _cons	1.035198 7.17	.0893075 .1562231	11.59 45.90	0.000 0.000	.8601581 6.863808	1.210237 7.476192
appear4 <- Appear _cons	.9424492 7.4	.0860848 .1474041	10.95 50.20	0.000 0.000	.7737262 7.111093	1.111172 7.688907
peerr~1 <- Peer _cons	1 8.81	(constrained) .1077186	81.79	0.000	8.598875	9.021125
peerr~2 <- Peer _cons	1.214379 7.94	.1556051 .1215769	7.80 65.31	0.000 0.000	.9093989 7.701714	1.51936 8.178286
peerr~3 <- Peer _cons	1.667829 7.52	.190761 .1373248	8.74 54.76	0.000 0.000	1.293944 7.250848	2.041714 7.789152
peerr~4 <- Peer _cons	1.363627 8.29	.159982 .1222066	8.52 67.84	0.000 0.000	1.050068 8.050479	1.677186 8.529521
parrel1 <- Par _cons	1 9.35	(constrained) .0825215	113.30	0.000	9.188261	9.511739
parrel2 <- Par _cons	1.159754 9.13	.184581 .0988998	6.28 92.32	0.000 0.000	.7979822 8.93616	1.521527 9.32384
parrel3 <- Par _cons	2.035143 8.67	.2623826 .1114983	7.76 77.76	0.000 0.000	1.520882 8.451467	2.549403 8.888533
parrel4 <- Par _cons	1.651802 9	.2116151 .0926003	7.81 97.19	0.000 0.000	1.237044 8.818507	2.06656 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: $\chi^2(100) = 219.48$, Prob > $\chi^2 = 0.0000$

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/r14/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