**Example 5** — Modification indices

Description    Remarks and examples    Reference    Also see

# Description

Here we demonstrate the use of `estat mindices`; see [SEM] **Intro 7** and [SEM] **estat mindices**.

This example picks up where [SEM] **Example 3** left off:

```
. use https://www.stata-press.com/data/r19/sem_2fmm
. sem (Affective -> a1 a2 a3 a4 a5) (Cognitive -> c1 c2 c3 c4 c5)
```

# Remarks and examples

When we fit this model in [SEM] **Example 4**, we allowed the latent variables to be correlated. We typed

```
. sem (Affective -> a1 a2 a3 a4 a5) (Cognitive -> c1 c2 c3 c4 c5)
```

and by default in the command language, latent exogenous variables are assumed to be correlated unless we specify otherwise. Had we used the Builder, the latent exogenous variables would have been assumed to be uncorrelated unless we had drawn the curved path between them.

The original authors who collected these data analyzed them assuming no covariance, which we could obtain by typing

```
. sem (Affective -> a1 a2 a3 a4 a5) (Cognitive -> c1 c2 c3 c4 c5), ///
                                              cov(Affective*Cognitive@0)
```

It was Kline (2005, 70–74, 184) who allowed the covariance. Possibly he did that after looking at the modification indices.

The modification indices report statistics on all omitted paths and covariances. Let's begin with the model without the covariance:

```
. sem (Affective -> a1 a2 a3 a4 a5) (Cognitive -> c1 c2 c3 c4 c5),
>                                   cov(Affective*Cognitive@0)
  (output omitted)
. estat mindices
Modification indices
```

| | MI | df | P>MI | EPC | Standard EPC |
|---|---|---|---|---|---|
| Measurement | | | | | |
| a5 | | | | | |
| Cognitive | 8.059 | 1 | 0.00 | .1604476 | .075774 |
| c5 | | | | | |
| Affective | 5.885 | 1 | 0.02 | .0580897 | .087733 |
| cov(e.a1,e.a4) | 5.767 | 1 | 0.02 | 84.81133 | .1972802 |
| cov(e.a1,e.a5) | 7.597 | 1 | 0.01 | -81.82092 | -.2938627 |
| cov(e.a2,e.a4) | 14.300 | 1 | 0.00 | 129.761 | .3110565 |
| cov(e.a2,e.c4) | 4.071 | 1 | 0.04 | -45.44807 | -.1641344 |
| cov(e.a3,e.a4) | 21.183 | 1 | 0.00 | -116.8181 | -.4267012 |
| cov(e.a3,e.a5) | 25.232 | 1 | 0.00 | 118.4674 | .6681337 |
| cov(e.a5,e.c4) | 4.209 | 1 | 0.04 | 39.07999 | .184049 |
| cov(e.c1,e.c3) | 11.326 | 1 | 0.00 | 66.3965 | .3098331 |
| cov(e.c1,e.c5) | 8.984 | 1 | 0.00 | -47.31483 | -.2931597 |
| cov(e.c3,e.c4) | 12.668 | 1 | 0.00 | -80.98353 | -.333871 |
| cov(e.c4,e.c5) | 4.483 | 1 | 0.03 | 38.6556 | .2116015 |
| cov(Affective,Cognitive) | 128.482 | 1 | 0.00 | 704.4469 | .8094959 |

```
EPC is expected parameter change.
```

Notes:

1. Four columns of results are reported.
   a. `MI` stands for modification index and is an approximation to the change in the model's goodness-of-fit $\chi^2$ if the path were added.
   b. `df` stands for degrees of freedom and is the number that would be added to $d$ of the $\chi^2(d)$.
   c. `P>MI` is the value of the significance of $\chi^2$(`df`).
   d. `EPC` stands for expected parameter change and is an approximation to the value of the parameter if it were not constrained to 0. It is reported in unstandardized (column 3) and standardized (column 4) units.
2. There are lots of significant omitted paths and covariances in the above output.
3. Paths and covariances are listed only if the modification index is significant at the 0.05 level, corresponding to $\chi^2(1)$ value 3.8414588. You may specify the `minchi2()` option to use different $\chi^2(1)$ values. Specify `minchi2(0)` if you wish to see all tests.
4. The omitted covariance between `Affective` and `Cognitive` has the largest change in $\chi^2$ observed. Perhaps this is why Kline (2005, 70–74, 184) allowed a covariance between the two latent variables. The standardized `EPC` reports the relaxed-constraint correlation value, which is the value reported for the unconstrained correlation path in [SEM] **Example 3**.

Another way of dealing with this significant result would be to add a direct path between the variables, but that perhaps would have invalidated the theory being proposed. The original authors instead proposed a second-order model postulating that `Affective` and `Cognitive` are themselves measurements of another latent variable that might be called `Arousal`.

## Reference

Kline, R. B. 2005. *Principles and Practice of Structural Equation Modeling*. 2nd ed. New York: Guilford Press.

## Also see

[SEM] **Example 3** — Two-factor measurement model

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