Title

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intro 9 — Standard errors, the full story

Description

In [SEM] **intro 8**, we told you part of the story of the calculation of the VCE, the part we wanted to emphasize. In this section, we tell you the full story.

We at Stata try to draw a clear distinction between method and technique. The method is the process used to obtain the parameter estimates. The technique is the process used to obtain the variance–covariance matrix of the parameter estimates, which is to say, the standard errors.

The literature does not always draw such clear distinctions.

`sem` and `gsem` provide the following methods and techniques:

Methods	
ML	maximum likelihood
QML	quasimaximum likelihood
MLMV	maximum likelihood with missing values
ADF	asymptotic distribution free
Techniques	
OIM	observed information matrix
EIM	expected information matrix
OPG	outer product of the gradients
sbentler	Satorra–Bentler estimator
robust	Huber/White/sandwich estimator
clustered	generalized Huber/White/sandwich estimator
bootstrap	nonparametric bootstrap
jackknife	delete-one jackknife

They are allowed in the following combinations:

Command/ Method	Allowed techniques	Comment
`sem`		
ML	OIM	default
	EIM	
	OPG	
	sbentler	
	robust	a.k.a. QML
	clustered	
	bootstrap	
	jackknife	
MLMV	OIM	default
	EIM	
	OPG	
	robust	a.k.a. QML
	clustered	
	bootstrap	
	jackknife	
ADF	OIM	default; robust-like
	EIM	
	bootstrap	
	jackknife	
`gsem`		
ML	OIM	default
	OPG	
	robust	a.k.a. QML
	clustered	
	bootstrap	
	jackknife	

Options

The corresponding options for sem and gsem to obtain each allowed method-and-technique combination are

method()	vce()	Comment
sem		
method(ml)	vce(oim)	default
	vce(eim)	
	vce(opg)	
	vce(sbentler)	
	vce(robust)	a.k.a. QML
	vce(cluster *clustvar*)	
	vce(bootstrap)	
	vce(jackknife)	
method(mlmv)	vce(oim)	default
	vce(eim)	
	vce(opg)	
	vce(robust)	a.k.a. QML
	vce(cluster *clustvar*)	
	vce(bootstrap)	
	vce(jackknife)	
method(adf)	vce(oim)	default; vce(robust)-like
	vce(eim)	
	vce(bootstrap)	
	vce(jackknife)	
gsem		
method(ml)	vce(oim)	default
	vce(opg)	
	vce(robust)	a.k.a. QML
	vce(cluster *clustvar*)	
	bootstrap	no option; use bootstrap: prefix
	jackknife	no option; use jackknife: prefix

method(*emethod*) specifies the estimation method sem (gsem) is to use. If method() is not specified, then method(ml) is assumed.

vce(*vcetype*) specifies the technique to be used to obtain the VCE. When vce() is not specified, then vce(oim) is assumed.

In the case of gsem, vce(bootstrap) and vce(jackknife) are not allowed, although you can obtain the bootstrap or jackknife results by prefixing the gsem command with the bootstrap: or jackknife: prefix.

```
. bootstrap: gsem ...
. jackknife: gsem ...
```

See [R] **bootstrap** and [R] **jackknife**. If you are fitting a multilevel model, be sure to use bootstrap's and jackknife's cluster() and idcluster() options to obtain a correct resampling. If you have a crossed model, you cannot resample in both dimensions; there is no solution to that problem,

and therefore you cannot use the `bootstrap:` or `jackknife:` prefix. In addition, these prefixes are not allowed with models that have categorical latent variables because the categories of the latent variables (the latent classes) could change meaning from one sample to another, making it impossible to compute proper standard errors.

Remarks and examples

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In [SEM] **intro 4**, we gave reasons for why you might want to choose one method/technique over another. In that section, we did not draw the clear distinction between method and technique that we draw here.

The technique everyone is familiar with is OIM, although they might not know it by that name. OIM is the inverse of the negative matrix of second derivatives. Note that it is also the default for both `sem` and `gsem`.

The most common alternative techniques chosen are robust and cluster—options `vce(robust)` and `vce(cluster` *clustvar*`)`. That is because they relax assumptions; see [SEM] **intro 8**.

Aside: Robust and cluster are not allowed with `method(adf)`. Nonetheless, the default OIM technique is more robust when combined with `method(adf)` than OIM usually is. OIM can be used even when errors are heteroskedastic. That is, the assumptions justifying the OIM calculation when combined with `method(adf)` are they same as those justifying `vce(robust)`—the errors are merely assumed to be independent.

Technique sbentler provides another version of standard errors that are robust to nonnormality when one fits a model with `sem`. These standard errors are a function of fourth-order moments and correspond to the Satorra–Bentler (1994) scaled chi-squared test, which is an adjustment of the model-versus-saturated goodness-of-fit statistic for nonnormal data.

Technique EIM—available with `sem` but not `gsem`—has similar properties to OIM. It is used in performing score tests. The `sem` command secretly calculates the EIM when necessary so that you can use postestimation score-test commands even if you estimate using a technique other than EIM. EIM is available to you because the `sem` command needs EIM for its own hidden purposes.

Technique OPG is not used so much anymore, although historically it was popular because it took less computer time to calculate than OIM.

For a discussion of bootstrap and jackknife variance estimation, see [R] **bootstrap** and [R] **jackknife**.

Reference

Satorra, A., and P. M. Bentler. 1994. Corrections to test statistics and standard errors in covariance structure analysis. In *Latent Variables Analysis: Applications for Developmental Research*, ed. A. von Eye and C. C. Clogg, 399–419. Thousand Oaks, CA: Sage.

Also see

[SEM] **intro 8** — Robust and clustered standard errors

[SEM] **intro 10** — Fitting models with survey data

[SEM] **sem option method()** — Specifying method and calculation of VCE

[SEM] **gsem estimation options** — Options affecting estimation