Tests in RSiena, in particular Score-type tests

Tom A.B. Snijders

University of Oxford
University of Groningen

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Overview

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1. Tests

Parameters can be tested in the regular way, i.e., by the t-ratio

$$t_k = \frac{\hat{\beta}_k}{s.e.(\hat{\beta}_k)} ,$$

which can be referred to the standard normal null distribution.

If parameters are estimated by Maximum Likelihood,
statisticians call this a Wald test[1]. Since usually in RSiena , parameters are estimated by the Method of Moments,
we call this a Wald-type test.

[1] Abraham Wald, 1902-1950

Multiparameter tests

The Wald principle can also be used for multi-parameter tests
to test that several parameters together are 0
(or equal to a different hypothesized value).

This test is given by the function **`multipar.RSiena`**;
more generally, to test linear combinations, by **`Wald.RSiena`**.

The special case of testing equality of parameters is **`testSame.RSiena`**.

Multiparameter tests are of practical importance because often
there are high correlations between parameter estimates,
and also because network concepts sometimes are represented
by several effects taken together.

2. Score-type tests

The *score-type test* is a test that operates without estimating the parameter.

This can be useful because estimation in RSiena is time-consuming,
and because estimation of an effect may lead to instability of the estimation.

The score-type test for an effect is calculated by specifying

`fix=TRUE, test=TRUE`

in the model specification by **`setEffect`** or **`includeEffects`**.
The parameter value tested is given by `initialValue` in **`setEffect`**.

Note that tests of estimated parameters all control for one another
(like in multiple regression or logistic regression models),
but score-type tests are only controlled for the estimated parameters;
estimated parameters are not controlled for the `fix=TRUE` parameters
(when `initialValue=0`, the default).

Score-type tests can be done for single or multiple parameters.

Uses of score-type tests:

- ⇒ in an exploration phase of modeling;
- ⇒ to check that parameters which are thought not to be important, and expected to be non-significant, indeed are not significant;
- ⇒ to test parameters for which estimation leads to divergence; see the next pages.

The score-type test was developed by Michael Schweinberger (*Brit. J. Stat. Math. Psy., 2012)*.

Function **score.Test**

For an answer object `ans` produced by **siena07** for which
some of the effects were given with `fix=TRUE, test=TRUE`, function

`score.Test(ans)`

shows the score-type test for all tested parameters simultaneously.

If `test` is an index number of an effect with `fix=TRUE, test=TRUE`,

`score.Test(ans, test)`

will give the score-type test for this effect;
and similarly if `test` indicates a vector of fixed/tested effects.

Also

`summary(ans)`

gives the score-type tests; together with one-step estimates.
The latter are "quick and easy" estimates that are not totally reliable,
but may be used as approximations.

3. Quasi-complete separation: the Donner-Hauck phenomenon

In logistic regression, researchers sometimes encounter
complete separation or quasi-complete separation:
this happens when a predictor succeeds perfectly, or almost perfectly,
in distinguishing between outcomes 0 and 1.
Formally, the parameter estimate would be infinite, just like the standard error.

For quasi-complete separation,
the parameter estimate will be very large, and
the standard error of about the same size as the parameter estimate;
the ratio between parameter and standard error will **not** be very large,
suggesting non-significance to the naive researcher.

This is the Donner-Hauck phenomenon.

Hauck Jr., W.W., and Donner, A. (1977). Wald's test as applied to hypotheses in logit analysis.
Journal of the American Statistical Association, 72:851–853

The same is possible in the Stochastic Actor-Oriented Model, and (like in logistic regression) it shows up in divergence of the estimation, to very large positive or negative parameter values.

For example, it will happen exactly when the model includes a `sameX` or `simX` effect for a categorical variable V for which all changes are either creation of a same-V tie, or deletion of a different-V tie.

But estimation can also diverge if there is too little information, so divergence is (of course) not a telltale sign of a strong parameter value.

A score-type test can give the solution.

If the score-type test is significant

If the score-type test of the hypothesis "$\beta_k = 0$" is significant, this is convincing evidence that the parameter cannot be ignored.

You can still try to estimate the parameter, perhaps with further control effects; but this might be unsuccessful.

Else, you may fix (`fix=TRUE`) the parameter
at a large non-zero value (`initialValue` in **`setEffect`**),
(perhaps suggested by the one-step estimate in the **`summary`** — see above)
using the score-type test (`test=TRUE`).
Presumably it will be non-significant, and you can continue modeling.

For this fixed parameter, the test result of the score test for "$\beta_k = 0$" (`initialValue=0` in **`setEffect`**) can be reported.
You then will have two models, with different fixed values for this parameter.

(But perhaps in a better model, it still may be possible to estimate the parameter...)

If the score-type test is non-significant

If the score-type test of the hypothesis "$\beta_k = 0$" is non-significant, then presumably divergence of the estimation is a sign that the data contains too little information about this parameter.

You can just report the non-significant score-type test.

(But perhaps in a better model, it still may be possible to estimate the parameter...)