

semmcci: Monte Carlo Confidence Intervals

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Installation

You can install the CRAN release of `semmcci` with:

```
install.packages("semmcci")
```

You can install the development version of `semmcci` from [GitHub](#) with:

```
install.packages("remotes")  
remotes::install_github("jeksterslab/semmcci")
```

Documentation

See [GitHub Pages](#) for package documentation.

Description

In the Monte Carlo method, a sampling distribution of parameter estimates is generated from the multivariate normal distribution using the parameter estimates and the sampling variance-covariance matrix. Confidence intervals for defined parameters are generated by obtaining percentiles corresponding to $100(1 - \alpha)\%$ from the generated sampling distribution, where α is the significance level.

Monte Carlo confidence intervals for free and defined parameters in models fitted in the structural equation modeling package `lavaan` can be generated using the `semmcci` package. The package has two main functions, namely, `MC()` and `MCStd()`. The output of `lavaan` is passed as the first argument to the `MC()` function to generate Monte Carlo confidence intervals. Monte Carlo confidence intervals for the standardized estimates can also be generated by passing the output of the `MC()` function to the `MCStd()` function.

Example

A common application of the Monte Carlo method is to generate confidence intervals for the indirect effect. In the simple mediation model, variable `X` has an effect on variable `Y`, through a mediating variable `M`. This mediating or indirect effect is a product of path coefficients from the fitted model.

```
library(semmcci)
library(lavaan)
```

Data

```
n <- 1000
X <- rnorm(n = n)
M <- 0.50 * X + rnorm(n = n)
Y <- 0.25 * X + 0.50 * M + rnorm(n = n)
data <- data.frame(X, M, Y)
```

Model Specification

The indirect effect is defined by the product of the slopes of paths `X` to `M` labeled as `a` and `M` to `Y` labeled as `b`. In this example, we are interested in the confidence intervals of `indirect` defined as the product of `a` and `b` using the `:=` operator in the `lavaan` model syntax.

```

model <- "
  Y ~ cp * X + b * M
  M ~ a * X
  indirect := a * b
  direct := cp
  total := cp + (a * b)
"

```

Model Fitting

We can now fit the model using the `sem()` function from `lavaan`.

```

fit <- sem(data = data, model = model)

#> Error in sem(data = data, model = model): could not find function "sem"

```

Monte Carlo Confidence Intervals

The `fit` `lavaan` object can then be passed to the `MC()` function to generate Monte Carlo confidence intervals.

```

MC(fit, R = 20000L, alpha = c(0.001, 0.01, 0.05))

#> Error in methods::is(object, "lavaan"): object 'fit' not found

```

Standardized Monte Carlo Confidence Intervals

Standardized Monte Carlo Confidence intervals can be generated by passing the result of the `MC()` function to `MCStd()`.

Note: We recommend setting `fixed.x = FALSE` when generating standardized estimates and confidence intervals to model the variances and covariances of the predictors if they are assumed to be random.

```
fit <- sem(data = data, model = model, fixed.x = FALSE)

#> Error in sem(data = data, model = model, fixed.x = FALSE): could not find function
"sem"

unstd <- MC(fit, R = 20000L, alpha = c(0.001, 0.01, 0.05))

#> Error in methods::is(object, "lavaan"): object 'fit' not found

MCStd(unstd)

#> Error in methods::is(object, "semccci"): object 'unstd' not found
```

References

- MacKinnon, D. P., Lockwood, C. M., & Williams, J. (2004). Confidence limits for the indirect effect: Distribution of the product and resampling methods. *Multivariate Behavioral Research*, 39(1), 99–128. https://doi.org/10.1207/s15327906mbr3901_4
- Preacher, K. J., & Selig, J. P. (2012). Advantages of Monte Carlo confidence intervals for indirect effects. *Communication Methods and Measures*, 6(2), 77–98. <https://doi.org/10.1080/19312458.2012.679848>
- R Core Team. (2022). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. Vienna, Austria. <https://www.R-project.org/>
- Tofighi, D., & Kelley, K. (2019). Indirect effects in sequential mediation models: Evaluating methods for hypothesis testing and confidence interval formation. *Multivariate Behavioral Research*, 55(2), 188–210. <https://doi.org/10.1080/00273171.2019.1618545>

Tofighi, D., & MacKinnon, D. P. (2015). Monte Carlo confidence intervals for complex functions of indirect effects. *Structural Equation Modeling: A Multidisciplinary Journal*, 23(2), 194–205.
<https://doi.org/10.1080/10705511.2015.1057284>