Package 'bmem'

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Type Package

Title Mediation Analysis with Missing Data Using Bootstrap

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Description

Four methods for mediation analysis with missing data: Listwise deletion, Pairwise deletion, Multiple imputation, and Two Stage Maximum Likelihood algorithm. For MI and TS-ML, auxiliary variables can be included. Bootstrap confidence intervals for mediation effects are obtained. The robust method is also implemented for TS-ML. Since version 1.4, bmem adds the capability to conduct power analysis for mediation models. Details about the methods used can be found in these articles. Zhang and Wang (2003) <doi:10.1007/s11336-012-9301-5>. Zhang (2014) <doi:10.3758/s13428-013-0424-0>.

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`bmem-package` *Mediation analysis with missing data using bootstrap*

Description

Four methods for mediation analysis with missing data: Listwise deletion, Pairwise deletion, Multiple imputation, and Two Stage Maximum Likelihood algorithm. For MI and TS-ML, auxiliary variables can be included. Bootstrap confidence intervals for mediation effects are obtained. The robust method is also implemented for TS-ML. Since version 1.4, bmem adds the capability to conduct power analysis for mediation models. Details about the methods used can be found in these articles. Zhang and Wang (2003) <doi:10.1007/s11336-012-9301-5>. Zhang (2014) <doi:10.3758/s13428-013-0424-0>.

Details

Package:	bmem
Type:	Package
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Author(s)

Zhiyong Zhang and Lijuan Wang

Maintainer: Zhiyong Zhang <zhiyongzhang@nd.edu>

`bmem` *Mediation analysis based on bootstrap*

Description

Mediation analysis based on bootstrap

Usage

```
bmem(x, ram, indirect, v, method='tsml', ci='bc', cl=.95,
     boot=1000, m=10, varphi=.1, st='i', robust=FALSE,
     max_it=500, moment=FALSE, ...)
```

Arguments

`x`	A data set
`ram`	RAM path for the mediaiton model
`indirect`	A vector of indirect effec
`v`	Indices of variables used in the mediation model. If omitted, all variables are used.

method	list: listwise deletion, pair: pairwise deletion, mi: multiple imputation, em: EM algorithm.
ci	norm: normal approximation CI, perc: percentile CI, bc: bias-corrected CI, bca: BCa
cl	Confidence level. Can be a vector.
boot	Number of bootstraps
m	Number of imputations
varphi	Percent of data to be downweighted
st	Starting values
robust	Robust method
moment	Select mean structure or covariance analysis. moment=FALSE, covariance analysis. moment=TRUE, mean and covariance analysis.
max_it	Maximum number of iterations in EM
...	Other options for sem function can be used.

Details

The indirect effect can be specified using equations such as a*b, a*b+c, and a*b*c+d*e+f. A vector of indirect effects can be used indirect=c('a*b', 'a*b+c').

Value

The on-screen output includes the parameter estimates, bootstrap standard errors, and CIs.

Author(s)

Zhiyong Zhang and Lijuan Wang

References

Zhang, Z., & Wang, L. (2013). Methods for mediation analysis with missing data. Psychometrika, 78(1), 154-184.

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bmem.bs *Bootstrap but using the Bollen-Stine method*

Description

The same as bmem but using the Bollen-Stine method

Usage

```
bmem.bs(x, ram, indirect, v, ci='bc', cl=.95,
        boot=1000, max_it=500, ...)
```

Arguments

x	A data set
ram	RAM path for the mediaiton model
indirect	A vector of indirect effec
v	Indices of variables used in the mediation model. If omitted, all variables are used.
ci	norm: normal approximation CI, perc: percentile CI, bc: bias-corrected CI, bca: BCa
cl	Confidence level. Can be a vector.
boot	Number of bootstraps
max_it	Maximum number of iterations in EM
...	Other options for sem function can be used.

Value

The on-screen output includes the parameter estimates, bootstrap standard errors, and CIs.

Author(s)

Zhiyong Zhang and Lijuan Wang

References

Zhang, Z. & Wang, L. (2011) Four methods for mediation analysis with missing data.

Zhang, Z. (2011) Robust mediation analysis with missing data and auxiliary variables.

See Also

bmem, bmem.sobel, bmem.plot

---

bmem.ci.bc *Bias-corrected confidence intervals*

Description

Bias-corrected confidence intervals

Usage

```
bmem.ci.bc(par.boot, par0, cl=.95)
```

Arguments

par.boot	A bootstrap object.
par0	Original estimate
cl	Confidence level. Default 0.95.

Value

BC confidence intervals. The output includes - estimates, bootstrap standard errors, and confidence intervals.

Author(s)

Zhiyong Zhang and Lijuan Wang

See Also

bmem.ci.norm, bmem.ci.p, bmem.ci.bca

---

bmem.ci.bc1 *Bias-corrected confidence intervals (for a single variable)*

Description

Bias-corrected confidence intervals (for a single variable)

Usage

```
bmem.ci.bc1(x, b, cl = 0.95)
```

Arguments

x	A vector from a bootstrap output.
b	Parameter estimate from the original sample
cl	Confidence level. Default 0.95.

Author(s)

Zhiyong Zhang and Lijuan Wang

See Also

bmem.ci.norm, bmem.ci.p, bmem.ci.bca

bmem.ci.bca *Bias-corrected and accelerated confidence intervals*

Description

Bias-corrected and accelerated confidence intervals

Usage

```
bmem.ci.bca(par.boot, par0, jack, cl = 0.95)
```

Arguments

par.boot	A bootstrap object.
par0	Original estimate
jack	A Jackknife object.
cl	Confidence level. Default 0.95.

Value

BCa confidence intervals. The output includes - estimates, bootstrap standard errors, and confidence intervals.

Author(s)

Zhiyong Zhang and Lijuan Wang

See Also

bmem.ci.norm, bmem.ci.p, bmem.ci.bc, bmem.list.jack, bmem.pair.jack, bmem.mi.jack, bmem.em.jack,

bmem.ci.bca1 *BCa for a single variable*

Description

BCa for a single variable

Usage

```
bmem.ci.bca1(x, b, jack, cl = 0.95)
```

Arguments

x	A vector from a bootstrap output.
b	Parameter estimate from the original sample
jack	A vector from a Jackknife analysis
cl	Confidence level. Default 0.95.

---

bmem.ci.norm *Confidence interval based on normal approximation*

Description

Confidence interval based on normal approximation

Usage

```
bmem.ci.norm(par.boot, par0, cl = 0.95)
```

Arguments

par.boot	A bootstrap object.
par0	Original estimate
cl	Confidence level. Default 0.95.

Value

Normal confidence intervals. The output includes - estimates, bootstrap standard errors, and confidence intervals.

Author(s)

Zhiyong Zhang and Lijuan Wang

See Also

bmem.ci.bca, bmem.ci.p, bmem.ci.bc

bmem.ci.p *Percentile confidence interval*

Description

Percentile confidence interval

Usage

```
bmem.ci.p(par.boot, par0, cl = 0.95)
```

Arguments

par.boot	A bootstrap object.
par0	Original estimate
cl	Confidence level. Default 0.95.

Value

Percentile confidence intervals. The output includes - estimates, bootstrap standard errors, and confidence intervals.

Author(s)

Zhiyong Zhang and Lijuan Wang

See Also

bmem.ci.bca, bmem.ci.norm, bmem.ci.bc

bmem.cov *Calculate the covariance matrix based on a given ram model*

Description

Can be used to simulated data for an SEM model.

Usage

```
bmem.cov(ram,obs.variables,moment=FALSE, debug=FALSE)
```

Arguments

ram	An ram model
obs.variables	Names of the observed variables
moment	Whether to use the mean structure
debug	debug mode

bmem.em *Estimate a mediation model based on EM covariance matrix*

Description

Estimate a mediation model based on EM covariance matrix

Usage

```
bmem.em(x, ram, indirect, v, robust = FALSE,
        varphi = 0.1, st= "i", moment = FALSE,
        max_it = 500, ...)
```

Arguments

x	A data set
ram	RAM path for the mediaiton model
indirect	A vector of indirect effec
v	Indices of variables used in the mediation model. If omitted, all variables are used.
robust	Roubst method
varphi	Percent of data to be downweighted
st	Starting values
moment	Select mean structure or covariance analysis. moment=FALSE, covariance analysis. moment=TRUE, mean and covariance analysis.
max_it	Maximum number of iterations in EM
...	Other options for sem function can be used.

bmem.em.boot *Bootstrap for EM*

Description

Bootstrap for EM

Usage

```
bmem.em.boot(x, ram, indirect, v, robust = FALSE,
             varphi = 0.1, st= "i", boot = 1000,
             moment = FALSE, max_it = 500, ...)
```

Arguments

x	A data set
ram	RAM path for the mediaiton model
indirect	A vector of indirect effec
v	Indices of variables used in the mediation model. If omitted, all variables are used.
robust	Roubst method
varphi	Percent of data to be downweighted
st	Starting values
boot	Number of bootstraps. Default is 1000.
moment	Select mean structure or covariance analysis. moment=FALSE, covariance analysis. moment=TRUE, mean and covariance analysis.
max_it	Maximum number of iterations in EM
...	Other options for sem function can be used.

Details

The indirect effect can be specified using equations such as a*b, a*b+c, and a*b*c+d*e+f. A vector of indirect effects can be used indirect=c('a*b', 'a*b+c').

Value

par.boot	Parameter estimates from bootstrap samples
par0	Parameter estimates from the orignal samples

Author(s)

Zhiyong Zhang and Lijuan Wang

---

bmem.em.cov *Covariance matrix from EM*

Description

Covariance matrix from EM

Usage

```
bmem.em.cov(xmis, moment = FALSE, max_it = 500)
```

Arguments

xmis	An object from output of bmem.pattern.
moment	Whether estimating mean
max_it	Maximum number of iterations

`bmem.em.jack` *Jackknife estimate using EM*

Description

Jackknife estimate using EM

Usage

```
bmem.em.jack(x, ram, indirect, v, robust = FALSE,
             varphi = 0.1, st= "i", moment = FALSE,
             max_it = 500, ...)
```

Arguments

`x`	A data set
`ram`	RAM path for the mediaiton model
`indirect`	A vector of indirect effec
`v`	Indices of variables used in the mediation model. If omitted, all variables are used.
`robust`	Roubst method
`varphi`	Percent of data to be downweighted
`st`	Starting values
`moment`	Select mean structure or covariance analysis. moment=FALSE, covariance analysis. moment=TRUE, mean and covariance analysis.
`max_it`	Maximum number of iterations in EM
`...`	Other options for `sem` function can be used.

`bmem.em.rcov` *Estimation of robust covariance matrix*

Description

Estimation of robust covariance matrix

Usage

```
bmem.em.rcov(xmis, varphi=.1, moment=FALSE, max_it=1000, st='i')
```

Arguments

xmis	Missing data pattern
varphi	Percent of data to be downweighted
moment	Moment analysis if TRUE
max_it	Maximum number of iteration
st	Starting values

Value

An interval function to calculate the robust covaraince matrix

Author(s)

Zhiyong Zhang and Lijuan Wang

---

bmem.list *Estimate a mediaiton model based on listwise deletion*

Description

Estimate a mediaiton model based on listwise deletion

Usage

```
bmem.list(x, ram, indirect, moment = FALSE, ...)
```

Arguments

x	A data set
ram	RAM path for the mediaiton model
indirect	A vector of indirect effec
moment	Select mean structure or covariance analysis. moment=FALSE, covariance analysis. moment=TRUE, mean and covariance analysis.
...	Other options for sem function can be used.

bmem.list.boot *Bootstrap for listwise deletion method*

Description

Bootstrap for listwise deletion method

Usage

```
bmem.list.boot(x, ram, indirect, boot = 1000, moment = FALSE, ...)
```

Arguments

x	A data set
ram	RAM path for the mediaiton model
indirect	A vector of indirect effec
boot	Number of bootstraps. Default is 1000.
moment	Select mean structure or covariance analysis. moment=FALSE, covariance analysis. moment=TRUE, mean and covariance analysis.
...	Other options for sem function can be used.

bmem.list.cov *Covariance matrix for listwise deletion*

Description

Covariance matrix for listwise deletion

Usage

```
bmem.list.cov(x, moment = FALSE)
```

Arguments

x	A data set
moment	Estimate mean or not

bmem.list.jack *Jackknife for listwise deletion*

Description

Jackknife for listwise deletion

Usage

```
bmem.list.jack(x, ram, indirect, moment = FALSE, ...)
```

Arguments

x	A data set
ram	RAM path for the mediaiton model
indirect	A vector of indirect effec
moment	Select mean structure or covariance analysis. moment=FALSE, covariance analysis. moment=TRUE, mean and covariance analysis.
...	Other options for sem function can be used.

bmem.mi *Estimate a mediation model based on multiple imputation*

Description

Estimate a mediation model based on multiple imputation

Usage

```
bmem.mi(x, ram, indirect, v, m = 10, moment = FALSE, ...)
```

Arguments

x	A data set
ram	RAM path for the mediaiton model
indirect	A vector of indirect effec
v	Indices of variables used in the mediation model. If omitted, all variables are used.
m	Number of imputations.
moment	Select mean structure or covariance analysis. moment=FALSE, covariance analysis. moment=TRUE, mean and covariance analysis.
...	Other options for sem function can be used.

bmem.mi.boot *Bootstrap for multiple imputation*

Description

Bootstrap for multiple imputation

Usage

```
bmem.mi.boot(x, ram, indirect, v, m = 10, boot = 1000,
             moment = FALSE, ...)
```

Arguments

x	A data set
ram	RAM path for the mediaiton model
indirect	A vector of indirect effec
v	Indices of variables used in the mediation model. If omitted, all variables are used.
m	Number of imputations
boot	Number of bootstraps. Default is 1000.
moment	Select mean structure or covariance analysis. moment=FALSE, covariance analysis. moment=TRUE, mean and covariance analysis.
...	Other options for sem function can be used.

bmem.mi.cov *Covariance estimation for multiple imputation*

Description

Covariance estimation for multiple imputation

Usage

```
bmem.mi.cov(x, m = 10, moment = FALSE)
```

Arguments

x	A data set
m	Number of imputations
moment	Estimate mean or not

bmem.mi.jack *Jackknife for multiple imputation*

Description

Jackknife for multiple imputation

Usage

```
bmem.mi.jack(x, ram, indirect, v, m = 10, moment = FALSE, ...)
```

Arguments

x	A data set
ram	RAM path for the mediaiton model
indirect	A vector of indirect effec
v	Indices of variables used in the mediation model. If omitted, all variables are used.
m	Number of imputations.
moment	Select mean structure or covariance analysis. moment=FALSE, covariance analysis. moment=TRUE, mean and covariance analysis.
...	Other options for sem function can be used.

bmem.moments *Calculate the moments of a data set*

Description

Calculate the moments of a data set using either listwise deletion or pairwise deletion

Usage

```
bmem.moments(x, type=0)
```

Arguments

x	A data set
type	How to deal with missing data. 0: listwise deletion; 1: pairwise deletion

bmem.pair *Estimate a mediaiton model based on pairwise deletion*

Description

Estimate a mediaiton model based on pairwise deletion

Usage

```
bmem.pair(x, ram, indirect, moment = FALSE, ...)
```

Arguments

x	A data set
ram	RAM path for the mediaiton model
indirect	A vector of indirect effec
moment	Select mean structure or covariance analysis. moment=FALSE, covariance analysis. moment=TRUE, mean and covariance analysis.
...	Other options for sem function can be used.

bmem.pair.boot *Bootstrap for pairwise deletion*

Description

Bootstrap for pairwise deletion

Usage

```
bmem.pair.boot(x, ram, indirect, boot = 1000, moment = FALSE, ...)
```

Arguments

x	A data set
ram	RAM path for the mediaiton model
indirect	A vector of indirect effec
boot	Number of bootstraps. Default is 1000.
moment	Select mean structure or covariance analysis. moment=FALSE, covariance analysis. moment=TRUE, mean and covariance analysis.
...	Other options for sem function can be used.

bmem.pair.cov *Covariance matrix estimation based on pairwise deletion*

Description

Covariance matrix estimation based on pairwise deletion

Usage

```
bmem.pair.cov(x, moment = FALSE)
```

Arguments

x	A data set
moment	Estimate mean or not

bmem.pair.jack *Jackknife for pairwise deletion*

Description

Jackknife for pairwise deletion

Usage

```
bmem.pair.jack(x, ram, indirect, moment = FALSE, ...)
```

Arguments

x	A data set
ram	RAM path for the mediaiton model
indirect	A vector of indirect effec
moment	Select mean structure or covariance analysis. moment=FALSE, covariance analysis. moment=TRUE, mean and covariance analysis.
...	Other options for sem function can be used.

bmem.pattern *Obtain missing data pattern information*

Description

Obtain missing data pattern information

Usage

```
bmem.pattern(x)
```

Arguments

x	A data set

bmem.plot *Plot of the bootstrap distribution. This function is replaced by plot.*

Description

Plot of the bootstrap distribution

Usage

```
bmem.plot(x, par,...)
```

Arguments

x	A bmem object
par	Name of parameter to be plotted.
...	Options used for the generic plot function.

Value

A plot

Author(s)

Zhiyong Zhang and Lijuan Wang

References

Zhang, Z. & Wang, L. (2011) Four methods for mediation analysis with missing data.

Zhang, Z. (2011) Robust mediation analysis with missing data and auxiliary variables.

See Also

bmem, bmem.sobel, bmem.plot

bmem.raw2cov *Convert a raw moment matrix to covariance matrix*

Description

Convert a raw moment matrix to covariance matrix

Usage

```
bmem.raw2cov(x)
```

Arguments

x	A moment matrix

Value

A covariance matrix

Author(s)

Zhiyong Zhang and Lijuan Wang

References

Zhang, Z. & Wang, L. (2011) Four methods for mediation analysis with missing data.

Zhang, Z. (2011) Robust mediation analysis with missing data and auxiliary variables.

See Also

bmem, bmem.sobel, bmem.plot

bmem.sem *Estimate a mediaiton model using SEM technique*

Description

Estimate a mediaiton model using SEM technique

Usage

```
bmem.sem(x, ram, N, indirect, moment=FALSE, ...)
```

Arguments

x	A covariance matrix
ram	A path diagram from specify.model
N	Sample size
indirect	A vector of indirect effects
moment	Whether mean strucuture is used. The default is FALSE
...	Options that can be supplied to function sem.

See Also

bmem.list.cov, bmem.pair.cov, bmem.mi.cov, bmem.em.cov

---

bmem.sobel *Mediation analysis using sobel test (for complete data only)*

Description

Mediation analysis using sobel test (for complete data only)

Usage

```
bmem.sobel(x, ram, indirect, moment=FALSE, ...)
```

Arguments

x	A data set
ram	RAM path for the mediaiton model
indirect	A vector of indirect effec
moment	Covariance or moment analysis
...	Other options for sem function can be used.

Value

The on-screen output includes the parameter estimates and sobel standard errors.

Author(s)

Zhiyong Zhang and Lijuan Wang

References

Zhang, Z. & Wang, L. (2011) Four methods for mediation analysis with missing data.

Zhang, Z. (2011) Robust mediation analysis with missing data and auxiliary variables.

See Also

bmem, bmem.sobel, bmem.plot

bmem.sobel.ind *Mediation analysis using sobel test for one indirect effect*

Description

Internal function

Usage

```
bmem.sobel.ind(sem.object, ind)
```

Arguments

sem.object	A sem object
ind	Indirect effect

Value

Internal output

Author(s)

Zhiyong Zhang and Lijuan Wang

References

Zhang, Z. & Wang, L. (2011) Four methods for mediation analysis with missing data.

Zhang, Z. (2011) Robust mediation analysis with missing data and auxiliary variables.

See Also

bmem, bmem.sobel, bmem.plot

bmem.ssq *Sum square of a matrix*

Description

Sum square of a matrix

Usage

```
bmem.ssq(x)
```

Arguments

x	A matrix

bmem.v *Select data according to a vector of indices*

Description

Select data according to a vector of indices

Usage

```
bmem.v(x, v, moment = FALSE)
```

Arguments

x	A matrix
v	A vector of indices
moment	Covariane analysis or mean and covariance analysis

plot.bmem *Plot of the bootstrap distribution*

Description

Plot of the bootstrap distribution

Usage

```
## S3 method for class 'bmem'
plot(x, par, ...)
```

Arguments

x	A bmem object
par	Name of parameter to be plotted.
...	Options used for the generic plot function.

Value

Generate the bootstrap histogram for a chosen parameter.

Author(s)

Zhiyong Zhang and Lijuan Wang

References

Zhang, Z. & Wang, L. (2011) Four methods for mediation analysis with missing data.

Zhang, Z. (2011) Robust mediation analysis with missing data and auxiliary variables.

See Also

bmem, bmem.sobel, bmem.plot

---

popPar *Get the population parameter values*

Description

Get the population parameter values including both direct and indirect effects in a model

Usage

```
popPar(object)
```

Arguments

object	A lavaan object

---

power.basic *Conducting power analysis based on Sobel test*

Description

Different from power.boot, this function conduct power analysis based on the Sobel test.

Usage

```
power.basic(model, indirect = NULL, nobs, nrep = 1000, alpha = 0.95,
skewness = NULL, kurtosis = NULL, ovnames = NULL, se = "default",
estimator = "default", parallel = "no", ncore = 1,  ...)
```

Arguments

model	A model specified using lavaan notation and above. See model.syntax for basic model specification. For the power analysis, the population parameter values should be provided in the following way. For example, the coefficient between math and HE is .39. Then it is specified as start(.39). If the parameter will be referred in the mediation effect, a label should be given as a modifier as b*HE+start(.39)*HE. model<-' math ~ c*ME+start(0)*ME + b*HE+start(.39)*HE HE ~ a*ME+start(.39)*ME '
indirect	The indirect or other composite effects are specified in the following way indirect<-' ab: = a*b abc := a*b + c '
nobs	Number of observations for power analysis. If it is a vector, multiple group analysis will be conducted.
nrep	Number of replications for Monte Carlo simulation. At least 1,000 is recommended.
alpha	The alpha level is used to obtain the confidence interval for model parameters.
skewness	A vector to give the skewness for the observed variables.
kurtosis	A vector to give the kurtosis for the observed variables.
ovnames	A vector to give the variable names for the observed variables. This is only needed when the skewness and kurtosis are provided. The skewness, kurtosis and variable names should be in the same order.
se	How to calculate the standard error, for example, robust standard error can be specified using se="robust".
estimator	Estimation methods to be used here.
parallel	Parallel methods, snow or multicore, can be used here.
ncore	Number of cores to be used in parallel. By defautl, the maximum number of cores are used.
...	Other named arguments for lavaan can be passed here.

Value

power	power for all parameters and required ones in the model
coverage	coverage probability
pop.value	Population parameter values
results	A list to give all intermediate results
data	The last data set generated for checking purpose

Examples

```
ex1model<-'
math ~ c*ME+start(0)*ME + b*HE+start(0.39)*HE
HE ~ a*ME+start(0.39)*ME
'
```

```
indirect<-'ab:=a*b'

N<-50

## change nrep to at least 1000 in real analysis

system.time(non.normal<-power.basic(ex1model, indirect, N,
 nrep=30, skewness=c(-.3, -.7, 1.3),
 kurtosis=c(1.5, 0, 5), ovnames=c('ME', 'HE', 'math')))

summary(non.normal)
```

---

power.boot *Conducting power analysis based on bootstrap*

Description

Different from power.basic, this function conduct power analysis based on the bootstrap method.

Usage

```
power.boot(model, indirect = NULL, nobs, nrep = 1000, nboot = 1000,
alpha = 0.95, skewness = NULL, kurtosis = NULL, ovnames = NULL,
ci='default', boot.type='default',
se = "default", estimator = "default", parallel = "no",
ncore = 1,  ...)
```

Arguments

model	A model specified using lavaan notation and above. See model.syntax for basic model specification. For the power analysis, the population parameter values should be provided in the following way. For example, the coefficient between math and HE is .39. Then it is specified as start(.39). If the parameter will be referred in the mediation effect, a label should be given as a modifier as b*HE+start(.39)*HE. model<-' math ~ c*ME+start(0)*ME + b*HE+start(.39)*HE HE ~ a*ME+start(.39)*ME '
indirect	The indirect or other composite effects are specified in the following way indirect<-' ab: = a*b abc := a*b + c '
nobs	Number of observations for power analysis. If it is a vector, multiple group analysis will be conducted.
nrep	Number of replications for Monte Carlo simulation. At least 1,000 is recommended.
nboot	Number of bootstraps to conduct.

alpha	The alpha level is used to obtain the confidence interval for model parameters.
skewness	A vector to give the skewness for the observed variables.
kurtosis	A vector to give the kurtosis for the observed variables.
ovnames	A vector to give the variable names for the observed variables. This is only needed when the skewness and kurtosis are provided. The skewness, kurtosis and variable names should be in the same order.
se	How to calculate the standard error, for example, robust standard error can be specified using se="robust".
estimator	Estimation methods to be used here.
parallel	Parallel methods, snow or multicore, can be used here.
ncore	Number of cores to be used in parallel. By defautl, the maximum number of cores are used.
ci	Type of bootstrap confidence intervals. By default, the percentile one is used. To get the bias-corrected one, use ci='BC'
boot.type	Type of bootstrap method. By default, the nonparametric one is used. Changing it to "BS" to use the Bollen-Stine method.
...	Other named arguments for lavaan can be passed here.

Value

power	power for all parameters and required ones in the model
coverage	coverage probability
pop.value	Population parameter values
results	A list to give all intermediate results
data	The last data set generated for checking purpose

Examples

```
ex1model<-'
math ~ c*ME+start(0)*ME + b*HE+start(0.39)*HE
HE ~ a*ME+start(0.39)*ME
'

indirect<-'ab:=a*b'

N<-50

## change nrep and nboot to at least 1000 in real analysis
system.time(boot.non.normal<-power.boot(ex1model, indirect, N,
 nrep=100, nboot=100, skewness=c(-.3, -.7, 1.3),
 kurtosis=c(1.5, 0, 5), ovnames=c('ME', 'HE', 'math'),  ci='percent', boot.type='simple'))
summary(boot.non.normal)
```

power.curve *Generate a power curve*

Description

Generate a power curve either based on Sobel test or bootstrap

Usage

```
power.curve(model, indirect=NULL, nobs=100, type='basic', nrep=1000,
nboot=1000, alpha=.95, skewness=NULL, kurtosis=NULL, ovnames=NULL,
ci='default', boot.type='default',
se="default", estimator="default", parallel="no",
ncore=1, interactive=TRUE, ...)
```

Arguments

model	A model specified using lavaan notation and above. See model.syntax for basic model specification. For the power analysis, the population parameter values should be provided in the following way. For example, the coefficient between math and HE is .39. Then it is specified as start(.39). If the parameter will be referred in the mediation effect, a label should be given as a modifier as b*HE+start(.39)*HE. model<-' math ~ c*ME+start(0)*ME + b*HE+start(.39)*HE HE ~ a*ME+start(.39)*ME '
indirect	The indirect or other composite effects are specified in the following way indirect<-' ab: = a*b abc := a*b + c '
nobs	Number of observations for power analysis. It is typically should be a vector for single group analysis. For multiple group analysis, it should be a matrix.
type	Type of power analysis
nrep	Number of replications for Monte Carlo simulation. At least 1,000 is recommended.
nboot	Number of bootstraps to conduct.
alpha	The alpha level is used to obtain the confidence interval for model parameters.
skewness	A vector to give the skewness for the observed variables.
kurtosis	A vector to give the kurtosis for the observed variables.
ovnames	A vector to give the variable names for the observed variables. This is only needed when the skewness and kurtosis are provided. The skewness, kurtosis and variable names should be in the same order.
se	How to calculate the standard error, for example, robust standard error can be specified using se="robust".
estimator	Estimation methods to be used here.
parallel	Parallel methods, snow or multicore, can be used here.

ncore	Number of cores to be used in parallel. By default, the maximum number of cores are used.
ci	Type of bootstrap confidence intervals. By default, the percentile one is used. To get the bias-corrected one, use ci='BC'
boot.type	Type of bootstrap method. By default, the nonparametric one is used. Changing it to "BS" to use the Bollen-Stine method.
interactive	Whether to get the figure interactively.
...	Other named arguments for lavaan can be passed here.

Value

power	power for all parameters and required ones in the model
coverage	coverage probability
pop.value	Population parameter values
results	A list to give all intermediate results
data	The last data set generated for checking purpose

Examples

```
ex2model<-'
 ept ~ start(.4)*hvltt + b*hvltt + start(0)*age + start(0)*edu + start(2)*R
 hvltt ~ start(-.35)*age + a*age + c*edu + start(.5)*edu
 R ~ start(-.06)*age + start(.2)*edu
 R =~ 1*ws + start(.8)*ls + start(.5)*lt
 age ~~ start(30)*age
 edu ~~ start(8)*edu
 age ~~ start(-2.8)*edu
 hvltt ~~ start(23)*hvltt
 R ~~ start(14)*R
 ws ~~ start(3)*ws
 ls ~~ start(3)*ls
 lt ~~ start(3)*lt
 ept ~~ start(3)*ept
'

indirect<-'ind1 := a*b + c*b'

nobs <- seq(100, 200, by=100)

## change nrep and nboot to at least 1000 in real analysis
power.curve(model=ex2model, indirect=indirect, nobs=nobs,
type='boot', nrep=30, nboot=30, ci='percent',
boot.type='simple', interactive=FALSE)
```

summary.bmem *Calculate bootstrap confidence intervals*

Description

Calculate bootstrap confidence intervals

Usage

```
## S3 method for class 'bmem'
summary(object, ci='bc', cl=.95, ...)
```

Arguments

object	An output object from the function bmem
ci	norm: normal approximation CI, perc: percentile CI, bc: bias-corrected CI, bca: BCa
cl	Confidence level. Can be a vector.
...	other options can be used for the generic summary function.

Details

The other type of confidence intervals can be constructed from the output of the function bmem. Note if the BCa is required, the ci='BCa' should have been specified in the function bmem.

Value

The on-screen output includes the parameter estimates, bootstrap standard errors, and CIs.

summary.power *Organize the results into a table*

Description

This function is adpated from the lavaan summary function to put the results in a table.

Usage

```
## S3 method for class 'power'
summary(object,...)
```

Arguments

object	Output from the function either power.basic or power.boot.
...	Other options

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