Package 'Bayesrel'

September 13, 2021

Type Package

Title Bayesian Reliability Estimation

Version 0.7.1

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Description Functionality for reliability estimates. For unidimensional tests:
Coefficient alpha, 'Guttman's' lambda-2/-4/-6, the Greatest lower
bound and coefficient omega in a Bayesian and a frequentist version.
For multidimensional tests: omega-total and omega-hierarchical.
The results include confidence and credible intervals, the
probability of a coefficient being larger than a cutoff,
and a check for the factor models, necessary for the omega coefficients.
The method for the Bayesian unidimensional estimates, except for omega,
is sampling from the posterior inverse 'Wishart' for the
covariance matrix based measures (see 'Murphy', 2007,
<https://groups.seas.harvard.edu/courses/cs281/papers/murphy-2007.pdf>.
The Bayesian omegas (unidimensional, hierarchical, and total) are obtained by
'Gibbs' Sampling from the conditional posterior distributions of
(1) the single factor model and (2) the higher order factor model
('Lee', 2007, <doi:10.1002/9780470024737>).

URL https://github.com/juliuspf/Bayesrel

BugReports https://github.com/juliuspf/Bayesrel/issues

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Encoding UTF-8

LazyData true

Imports LaplacesDemon, MASS, lavaan, coda, methods, stats, graphics,
Rdpack, Rcpp (>= 1.0.4.6)

LinkingTo Rcpp, RcppArmadillo

RdMacros Rdpack

RoxygenNote 7.1.1

Depends R (>= 2.10)

Suggests testthat (>= 2.1.0), knitr, rmarkdown

NeedsCompilation yes

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R topics documented:

`asrm` *5-Item questionnaire data from Nicolai (2018)*

Description

A dataset consisting of 78 participants who filled out the 5-item Altman Self-Rating Mania Scale, rating from 1 to 5 on a Likert scale

Usage

```
asrm
```

Format

The format is a 5-column datamatrix containing 78 observations

Source

article

References

Nicolai, J., & Moshagen, M. (2018). Pathological buying symptoms are associated with distortions in judging elapsed time. Journal of Behavioral Addictions, 7(3), 752-759.

`asrm_mis` *5-Item questionnaire data from Nicolai (2018) with 10 % missings*

Description

A dataset consisting of 78 participants who filled out the 5-item Altman Self-Rating Mania Scale, rating from 1 to 5 on a Likert scale, 10 % missings were inserted at random

Usage

```
asrm_mis
```

Format

The format is a 5-column data matrix containing 78 observations, missing are NA

Source

article

References

Nicolai, J., & Moshagen, M. (2018). Pathological buying symptoms are associated with distortions in judging elapsed time. Journal of Behavioral Addictions, 7(3), 752-759.

`bomegas` *Estimate reliability estimates for multidimensional scales in the Bayesian framework*

Description

When supplying a data set that is multidimensional the function estimates the reliability of the set by means of omega-total and the general factor saturation of the set by means of omega-hierarchical In the process a higher-order factor model is estimated in the Bayesian framework, and posterior distributions of omega-t and omega-h are obtained from the posterior distributions of the factor model parameters The output contains the posterior distributions of omega-t and omega-h, their mean and credible intervals.

Usage

```
bomegas(
  data,
  n.factors,
  model = "balanced",
  n.iter = 2000,
  n.burnin = 200,
  n.chains = 3,
  thin = 1,
  interval = 0.95,
  missing = "pairwise",
  callback = function() { }
)
```

Arguments

data	A matrix or data.frame containing multivariate observations, rows = observations, columns = variables/items
n.factors	A number specifying the number of group factors that the items load on
model	A string that by default ("balanced") distributes the items evenly among the number of group factors. This only works if the items are a multiple of the number of group factors and the items are already grouped in the data set, meaning, e.g., items 1-5 load on one factor, 6-10 on another, and so on. A model file can be specified in lavaan syntax style (f1=~.+.+.) to relate the items to the group factors. The items can either be named as the columns in the data set or x1, ..., xn, where 1,...,n correspond to the column numbers
n.iter	A number for the iterations of the Gibbs Sampler
n.burnin	A number for the burnin in the Gibbs Sampler
n.chains	A number for the chains to run for the MCMC sampling
thin	A number for the thinning of the MCMC samples
interval	A number specifying the credible interval, the interval is the highest posterior desntiy interval (HPD)
missing	A string denoting the missing data handling, can be "pairwise" or "listwise. With pairwise the missing data will be "imputed" during the MCMC sampling as further unknown parameters
callback	An empty function for implementing a progressbar call from a higher program (e.g., JASP)

References

Lee S (2007). *Structural equation modeling: A Bayesian approach*. John Wiley & Sons.

Examples

```
# note that the iterations are set very low for smoother running examples, you should use
# at least the defaults
```

```
res <- bomegas(upps, n.factors = 5, model = "balanced", n.iter = 200, n.burnin = 50,
n.chains = 2, missing = "listwise")

# or with specified model syntax relating the group factors to the items:
model <- "f1 =~ U17_r + U22_r + U29_r + U34_r
f2 =~ U4 + U14 + U19 + U27
f3 =~ U6 + U16 + U28 + U48
f4 =~ U23_r + U31_r + U36_r + U46_r
f5 =~ U10_r + U20_r + U35_r + U52_r"
res <- bomegas(upps, n.factors = 5, model = model, n.iter = 200, n.burnin = 50,
n.chains = 2, missing = "listwise")
```

`cavalini` *8-Item Questionnaire Data from Cavalini (1992)*

Description

A dataset consisting of eight item questionnaire data. It's Likert scaled from 0-3. It is data measuring how annoyed people were by malodors

Usage

```
cavalini
```

Format

The format is a 8-column datamatrix containing 828 observations

Source

Doctoral Dissertation

References

Cavalini, P. M. (1992). It's an ill wind that brings no good: Studies on odour annoyance and the dispersion of odorant concentrations from industries. Rijksuniversiteit Groningen.

omegasCFA *Estimate reliability estimates for multidimensional scales in the frequentist framework*

Description

When supplying a data set that is multidimensional the function estimates the reliability of the set by means of omega-total and the general factor saturation of the set by means of omega-hierarchical The procedure entails fitting a hierarchical factor model using a CFA. Both the higher-order (second-order) and the bi-factor model can be used in the CFA. The CFA is fit using lavaan 'Yves Rosseel', <https://CRAN.R-project.org/package=lavaan>. Coefficients omega-t and omega-h can be computed from the factor model parameters.

Usage

```
omegasCFA(
  data,
  n.factors,
  model = "balanced",
  model.type = "higher-order",
  interval = 0.95,
  missing = "pairwise",
  fit.measures = FALSE
)
```

Arguments

data	A matrix or data.frame containing multivariate observations, rows = observations, columns = variables/items
n.factors	A number specifying the number of group factors that the items load on
model	A string that by default ("balanced") distributes the items evenly among the number of group factors. This only works if the items are a multiple of the number of group factors and the items are already grouped in the data set, meaning, e.g., items 1-5 load on one factor, 6-10 on another, and so on. A model file can be specified in lavaan syntax style (f1=~.+.+.) to relate the items to the group factors. The items can either be named as the columns in the data set or x1, ..., xn, where 1,...,n correspond to the column numbers
model.type	A string denoting if the model that should be fit is the higher-order or bi-factor model. This comes down to the researcher's theory about the measurement and the model fit
interval	A number specifying the confidence interval, which is Wald-type
missing	A string denoting the missing data handling, can be "pairwise" or "listwise. pairwise uses FIML in lavaan.
fit.measures	A logical denoting if fit.measures from the CFA should be computed

Examples

```
res <- omegasCFA(upps, n.factors = 5, model = "balanced", model.type = "bi-factor",
missing = "listwise")

# or with specified model syntax relating the group factors to the items:
model <- "f1 =~ x1+x2+x3+x4
f2 =~ x5+x6+x7+x8
f3 =~ x9+x10+x11+x12
f4 =~ x13+x14+x15+x16
f5 =~ x17+x18+x19+x20 "
res <- omegasCFA(upps, n.factors = 5, model = model, model.type = "higher-order",
missing = "listwise")
```

---

omega_fit *graphical posterior predictive check for the 1-factor omega model, based on covariance matrix eigenvalues*

Description

gives posterior predictive check for the 1-factor model: comparison between model implied covariance matrix and sample covariance matrix also displays frequentist fit indices

Usage

```
omega_fit(x)
```

Arguments

x	A strel output object (list)

Examples

```
omega_fit(strel(asrm, "omega", n.chains = 2, n.iter = 100))
```

---

p_omegas *prior and posterior probability of omega-t and omega-h being bigger than thresholds*

Description

takes mcmc posterior samples of omega-t and omega-h and calculates the prior and posterior probability of the estimate being bigger or smaller than an arbitrary value

Usage

```
p_omegas(x, cutoff.t = 0.8, cutoff.h = 0.6)
```

Arguments

x	A strel output object (list)
cutoff.t	A number indicating the threshold for omega-t
cutoff.h	A number indicating the threshold for omega-h

Examples

```
p_omegas(bomegas(upps, n.factors = 5, n.chains = 2, n.iter = 100, n.burnin = 50,
missing = "listwise"))
```

---

p_strel *prior and posterior probability of estimate being bigger than threshold*

Description

takes a mcmc posterior sample of any of the single test reliability estimates and calculates the prior and posterior probability of the estimate being bigger or smaller than an arbitrary value (priors are stored in the package)

Usage

```
p_strel(x, estimate, low.bound)
```

Arguments

x	A strel output object (list)
estimate	A character string indicating what estimate to plot from the strel output object
low.bound	A number for the threshold to be tested against

Examples

```
p_strel(strel(asrm, "lambda2", n.chains = 2, n.iter = 100, freq = FALSE), "lambda2", .80)
```

`seco_fit` *graphical posterior predictive check for the higher-order factor model,*

Description

gives posterior predictive check for the higher-factor model: comparison between posterior sample of model implied covariance matrices and sample covariance matrix. Gray bars should enclose the black dots for good fit.

Usage

```
seco_fit(x, data)
```

Arguments

`x`	A bomegas output object (list)
`data`	A matrix or data.frame containing the data set that produced x

Examples

```
seco_fit(bomegas(upps, n.factors = 5, n.chains = 2, n.iter = 100,
n.burnin = 50, missing = "listwise"), upps)
```

`strel` *Estimate single test reliability coefficients for unidimensional scales*

Description

Reported are Bayesian credible intervals (highest posterior density) and frequentist confidence intervals (non parametric or parametric bootstrap). The estimates supported are Cronbach alpha, Guttman's lambda2/4/6, the glb, and Mcdonald's omega. Beware of lambda4 with many indicators, the computational effort is considerable. The glb method uses adjusted code from the 'Rcsdp' package by 'Hector Corrada Bravo', <https://CRAN.R-project.org/package=Rcsdp>. This process applies a slightly adjusted solving algorithm from the 'CSDP' library by 'Brian Borchers' <https://github.com/coin-or/Csdp/wiki>, <doi:10.1080/10556789908805765>, but is wrapped in 'RcppArmadillo'. Guttman's Lambda-4 method is from 'Benton' (2015) <doi:10.1007/978-3-319-07503-7_19>. The principal factor analysis (pfa) for a version of frequentist omega can be found in 'Rencher' (2007) and is described in 'Schlegel' (2017) <https://www.r-bloggers.com/2017/03/iterated-principal-factor-method-of-factor-analysis-with-r/>. The analytic confidence interval of alpha is from 'Bonett' and 'Wright' (2015) <doi:10.1002/job.1960>.

Usage

```
strel(
  data = NULL,
  estimates = c("alpha", "lambda2", "glb", "omega"),
  interval = 0.95,
  n.iter = 1000,
  n.burnin = 50,
  thin = 1,
  n.chains = 3,
  n.boot = 1000,
  cov.mat = NULL,
  n.obs = NULL,
  freq = TRUE,
  Bayes = TRUE,
  para.boot = FALSE,
  item.dropped = FALSE,
  missing = "pairwise",
  omega.freq.method = "cfa",
  omega.int.analytic = TRUE,
  alpha.int.analytic = TRUE,
  callback = function() { }
)
```

Arguments

data	The dataset to be analyzed, observations are rows, items are columns
estimates	A character vector containing the estimands, we recommend using lambda4 with only a few items due to the computation time
interval	A number specifying the uncertainty interval
n.iter	A number for the iterations of the Gibbs Sampler
n.burnin	A number for the burnin in the Gibbs Sampler
thin	A number for the thinning of the MCMC samples
n.chains	A number for the chains to run for the MCMC sampling
n.boot	A number for the bootstrap samples
cov.mat	A covariance matrix can be supplied instead of a dataset, but number of observations needs to be specified
n.obs	A number for the sample observations when a covariance matrix is supplied and the factor model is calculated
freq	A logical for calculating the frequentist estimates
Bayes	A logical for calculating the Bayesian estimates
para.boot	A logical for calculating the parametric bootstrap, the default is the non-parametric
item.dropped	A logical for calculating the if-item-dropped statistics

`missing` A string specifying the way to handle missing data, 'listwise' is self-explanatory, 'pairwise' in the Bayesian paradigm means sampling the missing values as additional parameters from the joint conditional distribution, in the frequentist paradigm this means using the 'pairwise' covariance matrix and the full information ML method for omega

`omega.freq.method` A character string for the method of frequentist omega, either "cfa" (confirmatory factor analysis), or "pfa" (principal factor analysis), with "pfa" the interval is always bootstrapped

`omega.int.analytic` A logical for calculating the omega confidence interval analytically, only works with cfa as the omega.freq.method

`alpha.int.analytic` A logical for calculating the alpha confidence interval analytically

`callback` empty function call for external use

References

Bonett DG, Wright TA (2015). "Cronbach's alpha reliability: Interval estimation, hypothesis testing, and sample size planning." *Journal of Organizational Behavior*, **36**(1), 3–15. doi: 10.1002/job.1960.

Murphy KP (2007). "Conjugate Bayesian analysis of the Gaussian distribution." University of British Columbia.

Lee S (2007). *Structural equation modeling: A Bayesian approach*. John Wiley & Sons.

Pfadt JM, van den Bergh D, Sijtsma K, Moshagen M, Wagenmakers E (2021). "Bayesian estimation of single-test reliability coefficients." *Multivariate Behavioral Research*, 1–30. doi: 10.1080/00273171.2021.1891855.

Rencher AC (2002). *Methods of multivariate analysis*. John Wiley & Sons, Inc. doi: 10.1002/0471271357.

Examples

```
# note that these are very few iterations just for the example execution,
# you should use the defaults at least
summary(strel(asrm, estimates = "lambda2", n.chains = 2, n.iter = 200, n.boot = 200))
summary(strel(asrm, estimates = "lambda2", item.dropped = TRUE, n.chains = 2,
n.iter = 100, n.boot = 200))
```

Description

A dataset consisting of 455 participants who filled out the 20-item short form of the UPPS-P, and impulsivity scale, rating from 0 to 4 on a Likert scale. The scale has five subscales measured by four items each: negative urgency (columns 1-4), perserverance (columns 5-8), premeditation (columns 9-12), sensation seeking (columns 13-16), positive urgency (columns 17-20). The data contain 13 missing values.

Usage

```
upps
```

Format

The format is a 20-column datamatrix containing 455 observations

Source

article

References

Lozano, Ó. M., Díaz-Batanero, C., Rojas, A. J., Pilatti, A., & Fernández-Calderón, F. (2018). Concordance between the original and short version of the Impulsive Behaviour Scale UPPS-P using an IRT model. PLOS ONE,13(3), 1–15. https://doi.org/10.1371/journal.pone.0194390

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