Package 'Rnest'

May 7, 2026

Type Package

Title Next Eigenvalue Sufficiency Test

Version 1.3

Description Determine the number of dimensions to retain in exploratory factor analysis. The main function, nest(), returns the solution and the plot(nest()) returns a plot.

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Encoding UTF-8

LazyData true

RoxygenNote 7.3.2

Imports crayon (>= 1.4.0), ggplot2 (>= 3.3.0), scales (>= 1.0.0), EFA.MRFA (>= 1.1.2), MASS (>= 7.3-58.1), lavaan (>= 0.6), mvtnorm (>= 1.1), cli (>= 3.6.4)

NeedsCompilation no

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Depends R (>= 3.5.0)

Repository CRAN

Date/Publication 2025-12-04 13:40:07 UTC

Contents

`achim` *A list of seven correlation matrices.*

Description

A list of seven correlation matrices.

Usage

```
achim
```

Format

A list of correlation matrices.

Source

https://github.com/quantmeth

References

Achim, A. (personal communication).

achim24 *A correlation matrix composed of six factors.*

Description

A correlation matrix composed of 18 items based on six factors. Four have more than three variables, three variables have crossloadings (items 6, 7 and 13), two are doublets factors (items 13-14, 15-16), and there is two unique variables (17 and 18). Loadings range between .40 and .80.

Usage

```
achim24
```

Format

A 18 by 18 correlation matrix.

Source

https://github.com/quantmeth

References

Achim, A. (2024, April 4). *Signal cancellation factor analysis*. PsyArXiv, 1–13. doi:10.31234/osf.io/h7qwg

BartlettSphericity *Bartlett Sphericity Test*

Description

`BartlettSphericity` tests if variables are orthogonal.

Usage

```
BartlettSphericity(R, n)
```

Arguments

`R`	the correlation matrix.
`n`	the sample size.

Value

The χ^2 test of the correlation matrix `R` with sample size `n`.

Author(s)

André Achim (Matlab)

P.-O. Caron (R)

References

Bartlett, M. S. (1937). Properties of sufficiency and statistical tests. *Proceedings of the Royal Statistical Society, Series A*, *160*, 268–282

Examples

```
BartlettSphericity(ex_4factors_corr, 42)
```

`briggs_maccallum2003` *A list of three correlation matrices.*

Description

A list of three correlation matrices.

Usage

```
briggs_maccallum2003
```

Format

A a list of three correlation matrices.

Source

https://github.com/quantmeth

References

Briggs, N. E., & MacCallum, R. C. (2003). Recovery of weak common factors by Maximum likelihood and ordinary least squares estimation. *Multivariate Nehavioral Research*, *38*(1), 25–56. doi:10.1207/S15327906MBR3801_2

`caron2016` *A list of six correlation matrices composed of nine variables with three factors and different levels of correlations between factors.*

Description

A list of six correlation matrices composed of nine variables with three factors and different levels of correlations between factors.

Usage

```
caron2016
```

Format

A list of six 9 x 9 correlation matrices.

Source

https://github.com/quantmeth

References

Caron, P.-O. (2016). A Monte Carlo examination of the broken-stick distribution to identify components to retain in principal component analysis. *Journal of Statistical Computation and Simulation*, *86*(12), 2405-2410. doi:10.1080/00949655.2015.1112390

`caron2019` *A list of 15 correlation matrices composed of nine variables with three factors and different levels of correlations between factors.*

Description

A list of 15 correlation matrices composed of nine variables with three factors and different levels of correlations between factors.

Usage

```
caron2019
```

Format

A list of 15 9 x 9 correlation matrices.

Source

https://github.com/quantmeth

References

Caron, P.-O. (2019). Minimum average partial correlation and parallel analysis : The influence of oblique structures. *Communications in Statistics - Simulation and Computation*, *48*(7), 2110-2117. doi:10.1080/03610918.2018.1433843

`cormat` *A list containing 120 correlation matrices.*

Description

A list containing 120 24×24 correlation matrices (R) built to represent different factor structures. Details are found in the 'cormat.l' data.

Usage

```
cormat
```

Format

A a list of 120 correlation matrices.

Source

https://github.com/quantmeth

References

Caron, P.-O. (2025). A comparison of the Next Eigenvalue Sufficiency Test to other stopping rules for the number of factors in factor analysis. *Educational and Psychological Measurement*. doi:10.1177/00131644241308528

`cormat.l` *A list containing 120 lists of correlation matrices and their underlying characteristics.*

Description

A list containing 120 lists of 24×24 correlation matrices (R) built to represent different factor structures. Different levels of loadings (delta, .4, .5, .6, .7, .8), correlation between factors (corrfact, .0, .1, .2 .3), and. number of factors (nfactors, 1:8) are used. The list contained matrice (R), and their underlying characteristics (delta, corrfact, and nfactors).

Usage

```
cormat.l
```

Format

A list containing 120 matrices.

Source

https://github.com/quantmeth

References

See Caron, P.-O. (2025). A comparison of the Next Eigenvalue Sufficiency Test to other stopping rules for the number of factors in factor analysis. *Educational and Psychological Measurement*. doi:10.1177/00131644241308528

`covFIML` *Full Information Maximum Likelihood (FIML) correlation or covariance matrix*

Description

Full Information Maximum Likelihood (FIML) correlation or covariance matrix

Usage

```
covFIML(data, tol = 1e-6, maxiter = 1000, pvalue = FALSE)

corFIML(data, tol = 1e-6, maxiter = 1000, pvalue = FALSE)
```

Arguments

`data`	a data frame of rdata matrix.
`tol`	tolerance.
`maxiter`	maximum number of iterations.
`pvalue`	an argument to indicate if p-values are required.

Value

A list containing the means, th correlation or covariance matrix, and optionnaly the degree of freedom and the p-values.

Note

A not so efficient function. See `?cor_nest` instead.

Examples

```
covFIML(airquality)
```

`cov_nest` *Compute covariance or correlation matrix with treatments for clusters and missing values*

Description

Compute covariance or correlation matrix with treatments for clusters and missing values

Usage

```
cor_nest(.data, ..., cluster = NULL, missing = "fiml", ordered = NULL, pvalue = FALSE)

cov_nest(.data, ..., cluster = NULL, missing = "fiml", ordered = NULL, pvalue = FALSE)
```

Arguments

`.data`	a data frame, a numeric matrix.
`...`	further arguments.
`cluster`	a variable name defining the clusters in a two-level dataset in the data frame.
`missing`	treatment to deal with missing values. Options are `"listwise"` or `"pairwise"`. Default if `"fiml"`.
`ordered`	a character vector identifying which variables have an ordered (ordinal) scale. If `TRUE`, all observed endogenous variables are treated as ordered (ordinal). If `NULL`, all observed endogenous variables are considered to be numeric.
`pvalue`	an argument to indicate if p-values are required.

Details

A quick adaptation of the lavaan package (Rosseel, 2012) to estimate a covariance or correlation matrix with missing values, hierachical strcutures and ordinal scales.

Value

A list of class "covnest"

References

Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, *48*(2), 1–36. https://www.jstatsoft.org/v48/i02/

Examples

```
cov_nest(airquality)
```

EKC *Empirical Kaiser Criterion (EKC)*

Description

Empirical Kaiser Criterion (EKC)

Usage

```
EKC(.data = NULL, n = NULL, nv = NULL, lowest.eig = 1, ...)
```

Arguments

`.data`	a data frame, a numeric matrix, covariance matrix or correlation matrix from which to determine the number of factors.
`n`	the number of cases (subjects, participants, or units) if a covariance matrix is supplied in `.data`.
`nv`	the number of variables if the critical values are required.
`lowest.eig`	minimal eigenvalues to retain. Default is Kaiser's suggestion of 1.
`...`	further argument for `cor_nest()`.

Value

The number of factors to retain or the crititical eigenvalues.

Note

As Rnest version >= 1.2, a correction to EKC was done which was reported by Marcel van Assen (personnal communication, june 2025), which was found in Rnest and other packages as well. There was a confusion in the sample and critical eigenvalues in equation 2 (Braeken & van Assen, 2017, p. 454).

References

Braeken, J., & van Assen, M. A. L. M. (2017). An empirical Kaiser criterion. *Psychological Methods*, *22*(3), 450–466. doi:10.1037/met0000074

Examples

```
EKC(ex_4factors_corr, n = 42)
```

`ex_2factors` *A correlation matrix composed of 2 factors.*

Description

A correlation matrix composed of 10 items based on 2 factors with 5 variables each and loadings equals to .80.

Usage

```
ex_2factors
```

Format

A 10 by 10 correlation matrix.

Source

https://github.com/quantmeth

References

Caron, P.-O. (2025). *Rnest: An R package for the Next Eigenvalue Sufficiency Test*. https://github.com/quantmeth/Rnest

---

`ex_3factors_doub_unique`
A correlation matrix composed of two factors, a doublet factor and a unique variable.

Description

A correlation matrix composed of 10 items based on two main factors among which there is two cross-loadings. There is also a doublet factors and an unique variable.

Usage

```
ex_3factors_doub_unique
```

Format

A 10 by 10 correlation matrix.

Source

https://github.com/quantmeth

References

Achim, A. (personal communication).

`ex_4factors_corr` *A correlation matrix composed of 4 correlated factors.*

Description

A correlation matrix composed of 12 items based on 4 factors with 3 variables each. Loadings equals to .9, .9, and .3. Factors 1 and 2, and factors 3 and 4 are correlated at .7.

Usage

```
ex_4factors_corr
```

Format

A 12 by 12 correlation matrix.

Source

https://github.com/quantmeth

References

Achim, A (personal communication).

`ex_mqr` *A correlation matrix from chapter 19 Explorer of Méthodes quantitatives avec R (MQR).*

Description

A population correlation matrix composed of 6 items from a two factor stucture. Factor 1 is based on items 1 to 3 and 6, and Factor 2 is based on items 4 to 6.

Usage

```
ex_mqr
```

Format

A 6 by 6 correlation matrix.

Source

https://github.com/quantmeth

References

Caron, P.-O. (2024). *Méthodes quantitatives avec R*. https://mqr.teluq.ca

---

`fareg` *Regularized Factor Analysis*

Description

This function applies the regularized factoring method to extract an unrotated factor structure matrix.

Usage

```
fareg(R, numFactors = 1, facMethod = "rls")
```

Arguments

`R`	(Matrix) A correlation matrix to be analyzed.
`numFactors`	(Integer) The number of factors to extract. Default: numFactors = 1.
`facMethod`	(Character) "rls" for regularized least squares estimation or "rml" for regularized maximum likelihood estimation. Default: facMethod = "rls".

Value

The main output is the matrix of unrotated factor loadings.

- **loadings**: (Matrix) A matrix of unrotated factor loadings.
- **h2**: (Vector) A vector of estimated communality values.
- **L**: (Numeric) Value of the estimated penality parameter.
- **Heywood** (Logical) TRUE if a Heywood case is detected (this should never happen).

Note

This function is from the `fungible` package of Niels Waller which has been archived december 19th 2025 (CRAN team, personal communication). The relevant function are `fareg` and `rmsd`. The documentation is from the original function.

Author(s)

Niels G. Waller (nwaller@umn.edu)

References

Jung, S. & Takane, Y. (2008). Regularized common factor analysis. New trends in psychometrics, 141-149. Waller, N. G. (2024). `fungible`: Psychometric Functions from the Waller Lab. University of Minnesota, Minneapolis, Minnesota. R package 2.4.4, <https://CRAN.R-project.org/package=fungible>.

Examples

```
 # Conduct a regularized factor analysis
regOut <- fareg(R = ex_2factors,
                numFactors = 2,
                facMethod = "rls")
regOut$L
regOut$Heywood
```

---

genr8 *Simplify the the generation from a multivariate normal distributions.*

Description

Speed up the use of `MASS::mvrnorm`.

Usage

```
genr8(n = 1, R = diag(10), mean = rep(0, ncol(R)), ...)
```

Arguments

`n`	the number of samples required.
`R`	a positive-definite symmetric matrix specifying the covariance matrix of the variables.
`mean`	an optinal vector giving the means of the variables. Default is 0.
`...`	arguments for `MASS::mvrnorm()`, such as `tol`, `empirical`, and `EISPACK`.

Value

A data frame of size `n` by `ncol(R)`.

Examples

```
set.seed(19)
R <- caron2016$mat1
mydata <- genr8(n = nrow(R)+1, R = R, empirical = TRUE)
round(mydata, 2)
round(cov(mydata), 2)
```

Ledermann *Ledermann bound.*

Description

Returns the maximum number of latent factors in a factor analysis model.

Usage

```
Ledermann(p)
```

Arguments

p	The number of variables.

Value

The Ledermann bound.

Author(s)

André Achim (Matlab)

P.-O. Caron (R)

References

Ledermann, W. (1937). On the rank of reduced correlation matrices in multiple factor analysis. *Psychometrika*, 2, 85–93.

Examples

```
Ledermann(ncol(ex_4factors_corr))
```

loadings *Print Loadings in NEST*

Description

Print Loadings in NEST

Usage

```
loadings(x, nfactors = x$nfactors, method = x$method, ...)
```

Arguments

x	an object of class "nest".
nfactors	the number of factors to retains.
method	a method used to compute loadings and uniquenesses.
...	further arguments to methods in "nest" or the stats::loadings function.

Value

A $p \times k$ matrix containing loadings where p is the number of variables and k is the number of factors (nfactors).

Note

See stats::loadings for the original documentation.

Examples

```
results <- nest(ex_2factors, n = 100)
loadings(results)
```

MAP *Minimum average partial correlation (MAP)*

Description

Minimum average partial correlation (MAP)

Usage

```
MAP(.data, ...)
```

Arguments

.data	a data frame, a numeric matrix, covariance matrix or correlation matrix from which to determine the number of factors.
...	further argument for cor_nest().

Value

The number of factors to retain.

References

Velicer, W. F. (1976). Determining the number of components from the matrix of partial correlations. *Psychometrika*, *41*(3), 321-327. doi:10.1007/BF02293557

Examples

```
D <- genr8(n = 42, R = ex_4factors_corr)
MAP(D)
```

---

meek_bouchard *A correlation matrix from Meek-Bouchard.*

Description

A sample correlation matrix composed of 44 items.

Usage

```
meek_bouchard
```

Format

A 44 by 44 correlation matrix.

Source

https://github.com/quantmeth

References

Meek-Bouchard, C. (personal communication).

---

nest *Next Eigenvalue Sufficiency Test (NEST)*

Description

`nest` is used to identify the number of factors to retain in exploratory factor analysis.

Usage

```
nest(
  .data,
  ...,
  n = NULL,
  nreps = 1000,
  alpha = 0.05,
  max.fact = NULL,
  method = "ml",
  missing = "fiml",
  cluster = NULL,
  ordered = NULL
)
```

Arguments

`.data`	a data frame, a numeric matrix, covariance matrix or correlation matrix from which to determine the number of factors.
`...`	arguments for `method` that can be supplied. See details.
`n`	the number of cases (subjects, participants, or units) if a covariance matrix is supplied in `.data`.
`nreps`	the number of replications to derive the empirical probability distribution of each eigenvalue. Default is 1000.
`alpha`	a vector of type I error rates or `(1-alpha)*100%` confidence intervals. Default is .05.
`max.fact`	an optional maximum number of factor to extract. Default is `NULL`, so the maximum number possible.
`method`	a method used to compute loadings and uniquenesses. Four methods are implemented in `Rnest` : maximum likelihood `method = "ml"` (default), minimum rank factor analysis `method = "mrfa"`, and principal axis factoring `method = "paf"`. See details for custom methods. The regularized common factor analysis `method = "rcfa"` is depreceated from version 1.3.
`missing`	how should missing data be removed. `"fiml"` uses full information maximum likelihood to compute the correlation matrix. Other options are `"ml"`, `"pairwise"`, `"listwise"`. Default is `"fiml"`.
`cluster`	a (single) variable name in the data frame defining the clusters in a two-level dataset.
`ordered`	a character vector to treat the variables as ordered (ordinal) variables. If TRUE, all observed endogenous variables are treated as ordered (ordinal).

Details

The Next Eigenvalues Sufficiency Test (NEST) is an extension of parallel analysis by adding a sequential hypothesis testing procedure for every $k = 0, ..., \texttt{max.fact}$ factor until the hypothesis is not rejected.

At $k = 0$, NEST and parallel analysis are identical. Both use an identity matrix as the correlation matrix. Once the first hypothesis is rejected, NEST uses a correlation matrix based on the loadings and uniquenesses of the k^{th} factorial structure. NEST then resamples `nreps` times the k^{th} eigenvalue of this new correlation matrix. NEST stops when the k^{th} eigenvalues is below the $1 - \alpha$*100

There is four `method` already implemented in `nest` to estimate loadings and uniquenesses: maximum likelihood (`"ml"`; default), principal axis factoring (`"paf"`), regularized common factor analysis `method = "rcfa"`, and minimum rank factor analysis (`"mrfa"`). These functions use as arguments: `covmat`, `n`, `factors`, and `...` (supplementary arguments passed by `nest`). They return `loadings` and `uniquenesses`. Any other user-defined functions can be used as long as it is programmed likewise.

The `method = "paf"` is the same as Achim's (2017) NESTip.

Value

`nest()` returns an object of class `nest`. The functions `summary` and `plot` are used to obtain and show a summary of the results.

An object of class `nest` is a list containing the following components:

- `nfactors` - The number of factors to retains (one by `alpha`).
- `cor` - The supplied correlation matrix.
- `n` - The number of cases (subjects, participants, or units).
- `values` - The eigenvalues of the supplied correlation matrix.
- `alpha` - The type I error rate.
- `method` - The method used to compute loadings and uniquenesses.
- `nreps` - The number of replications used.
- `prob` - Probabilities of each factor.
- `Eig` - A list of simulated eigenvalues.

Generic function

`plot.nest` Scree plot of the eigenvalues and the simulated confidence intervals for `alpha`.

`loadings` Extract loadings. It does not overwrite `stat::loadings`.

`summary.nest` Summary statistics for the number of factors.

Author(s)

P.-O. Caron

References

Achim, A. (2017). Testing the number of required dimensions in exploratory factor analysis. *The Quantitative Methods for Psychology*, *13*(1), 64-74. doi:10.20982/tqmp.13.1.p064

Examples

```
nest(ex_2factors, n = 100)
nest(mtcars)
```

pa *Parallel analysis*

Description

Parallel analysis

Usage

```
pa(
  .data = NULL,
  n = NULL,
  nv = NULL,
  nreps = 1000,
  alpha = 0.05,
  ...,
  crit = NULL
)
```

Arguments

.data	a data.frame.
n	the number of subjects.
nv	the number of variables.
nreps	the number of replications.
alpha	type I error rate.
...	other arguments.
crit	critical values to compare the eigenvalues to.

Value

nfactors (if data is supplied) and sampled eigenvalues

References

Horn, J. L. (1965). A rationale and test for the number of factors in factor analysis. *Psychometrika*, *30*(2), 179–185. doi:10.1007/BF02289447

Examples

```
# To get the number of factors to retain
# from a correlation matrix
pa(ex_2factors, n = 42)

# from a data set
jd <- genr8(n = 404, R = ex_4factors_corr)
```

```
pa(jd)

# from a nest output
pa(nest(ex_2factors, n = 42))

# To get the 95th critical eigenvalues
pa(n = 10, nv = 2, nreps = 100)
```

`plot.nest` *Plot results of Next Eigenvalues Sufficiency Test (NEST)*

Description

Scree plot of the eigenvalues and the `(1-alpha)*100%` confidence intervals derived from the re-sampled eigenvalues supplied to `nest`.

Usage

```
## S3 method for class 'nest'
plot(x, pa = FALSE, ...)
```

Arguments

`x`	an object of class "nest".
`pa`	show results of Parallel Analysis.
`...`	further arguments for other methods, ignored for "nest".

Value

A ggplot output.

Note

This function is more interesting with many `alpha` values.

Examples

```
results <- nest(ex_2factors, n = 100, alpha = c(.01, .05, .01))
plot(results)
# Return the data used to produce the plot
df <- plot(results)$data
```

print.nest *Print results of NEST*

Description

Print the number of factors to retain according to confidence levels.

Usage

```
## S3 method for class 'nest'
print(x, ...)
```

Arguments

x	an object of class "nest".
...	further arguments for other methods, ignored for "nest".

Value

No return value, called for side effects.

Examples

```
results <- nest(ex_2factors, n = 100)
print(results)
```

remove_unique *Remove unique variables*

Description

Remove unique variables

Usage

```
remove_unique(.data, ..., alpha = 0.05)
```

Arguments

.data	a data frame, a numeric matrix, covariance matrix or correlation matrix from which to determine the number of factors.
...	further arguments for `unique_variable()` and `cor_nest()`.
alpha	type I error rate.

Value

A list containing the unique variables and a data frame containing their probabilities and the `.data` with the unique variable removed.

Examples

```
remove_unique(ex_3factors_doub_unique, n = 420)
```

`shem` *Split-Half Eigenvector Matching (SHEM)*

Description

`shem` estimates the number of principal components via Split-Half Eigenvector Matching (SHEM).

Usage

```
shem(.data, nIts = 30)
```

Arguments

`.data`	a data frame, a numeric matrix, covariance matrix or correlation matrix from which to determine the number of factors.
`nIts`	number of iterations.

Value

`shem` returns a list containing the number of components, `nfactors`, whether the additional step in case of zero true latent components was carried, `zeroComponents`, the `eigenvalues` and the `eigenvectors` of the solution.

References

Galdwin, T. E. (2023) Estimating the number of principal components via Split-Half Eigenvector Matching (SHEM). *MethodsX*, *11*, 102286. doi:10.1016/j.mex.2023.102286

Examples

```
jd <- genr8(n = 404, R = ex_4factors_corr)
shem(jd)
```

summary.nest *Summary results of NEST*

Description

summary method for class "nest".

Usage

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

Arguments

object	an object of class "nest".
...	further arguments for other methods, ignored for "nest".

Value

No returned value, called for side effects.

Examples

```
results <- nest(ex_2factors, n = 100)
summary(results)
```

tabachnick_fidell2019 *A covariance matrix composed of 11 variables.*

Description

A sample covariance matrix composed of 11 items based on two factors according to Tabachnick and Fidell (2019, see, 576-578). The first five variables are related to "Verbak IQ", the next five are related to "Performance IQ". The last variable CODING is unique. Loadings range between .39 and .76.

Usage

```
tabachnick_fidell2019
```

Format

A 11 by 11 covariance matrix.

Source

https://github.com/quantmeth

References

Tabachnick, B. G., & Fidell, L. S. (2019). *Using multivariate statistics*. Allyn and Bacon. p. 576-577.

`TEST1` *A problematic correlation matrix from Paquin.*

Description

A sample correlation matrix composed of 72 items with poorly defined factorial structure. NEST does not converge to a solution and reach very large number of factors. The associated sample size is 348. To investigate.

Usage

```
TEST1
```

Format

A correlation matrix in a data.frame.

Source

https://github.com/quantmeth

References

Paquin, S. (personal communication).

`unique_variable` *Probability of unique variables*

Description

Probability of unique variables

Usage

```
unique_variable(.data, n = NULL, ...)
```

Arguments

`.data`	a data frame, a numeric matrix, covariance matrix or correlation matrix from which to determine the number of factors.
`n`	the number of cases (subjects, participants, or units) if a covariance matrix is supplied in `.data`.
`...`	further arguments for `cov_nest()`.

Value

A data frame containing the F-values and probabilities of the variable to be an unique variable.

Author(s)

P.-O. Caron (R) André Achim (Matlab)

Examples

```
exData <- genr8(n = 420, R = ex_3factors_doub_unique)
unique_variable(exData)
```

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