Package ‘tsdistributions’

March 17, 2024

Type Package

Title Location Scale Standardized Distributions

Version 1.0.0

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Depends R (>= 3.5.0), methods, tsmethods

LinkingTo TMB, RcppEigen

Imports TMB (>= 1.7.20), GeneralizedHyperbolic, SkewHyperbolic, stats, utils, data.table, zoo, Rsolnp, sandwich, future.apply, future, progressr

Description Location-Scale based distributions parameterized in terms of mean, standard deviation, skew and shape parameters and estimation using automatic differentiation. Distributions include the Normal, Student and GED as well as their skewed variants ('Fernandez and Steel'), the 'Johnson SU', and the Generalized Hyperbolic.

License GPL-2

Encoding UTF-8

RoxygenNote 7.3.1

VignetteBuilder knitr

URL https://www.nopredict.com/packages/tsdistributions,
https://github.com/tsmodels/tsdistributions

Suggests knitr, rmarkdown, testthat (>= 3.0.0)

Config/testthat/edition 3

NeedsCompilation yes

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Repository CRAN

Date/Publication 2024-03-17 09:10:05 UTC

R topics documented:

`AIC.tsdistribution.estimate`

Akaike's An Information Criterion

Description

Extract the AIC from an estimated model.

Usage

```
## S3 method for class 'tsdistribution.estimate'
AIC(object, ..., k = 2)
```

Arguments

`object` an object of class “tsdistribution.estimate”.

`...` not currently used.

`k` the penalty per parameter to be used; the default k = 2 is the classical AIC.

Value

The AIC value (scalar).

`authorized_domain` *Distribution Authorized Domain*

Description

Calculated the region of Skewness-Kurtosis for which a density exists.

Usage

```
authorized_domain(distribution, max_kurt = 30, n = 25, lambda = 1)
```

Arguments

`distribution` a valid distribution with skew and shape parameters.

`max_kurt` the maximum kurtosis for which to determine the bounds for the skewness-kurtosis domain.

`n` the number of points between the lower and upper bounds of the skew and shape parameters for which to evaluate the skewness and excess kurtosis. This determines the kurtosis interval (3 - max_kurt) for which to calculate (solver based) the maximum skewness.

`lambda` additional shape parameter for the Generalized Hyperbolic distribution.

Value

A list with the lower half of the skewness and kurtosis values.

BIC.tsdistribution.estimate

Bayesian Information Criterion

Description

Extract the BIC from an estimated model.

Usage

```
## S3 method for class 'tsdistribution.estimate'
BIC(object, ...)
```

Arguments

`object`	an object of class “tsdistribution.estimate”.
`...`	not currently used.

Value

The BIC value (scalar).

bread.tsdistribution.estimate

Bread Method

Description

Bread Method

Usage

```
## S3 method for class 'tsdistribution.estimate'
bread(x, ...)
```

Arguments

`x`	an object of class “tsdistribution.estimate”.
`...`	not currently used.

Value

The analytic hessian of the model.

Author(s)

Alexios Galanos

`coef.tsdistribution.estimate` *Extract Model Coefficients*

Description

Extract Model Coefficients

Usage

```
## S3 method for class 'tsdistribution.estimate'
coef(object, ...)
```

Arguments

`object`	an object of class tsdistribution.estimate.
`...`	other arguments.

Value

A vector of the estimated model coefficients.

`ddist` *Distributions pqdr wrapper*

Description

Density, distribution, quantile function and random number generation for all the distributions in the package.

Usage

```
ddist(
  distribution = "norm",
  x,
  mu = 0,
  sigma = 1,
  skew = 1,
  shape = 5,
  lambda = -0.5,
  log = FALSE
)

pdist(
  distribution = "norm",
  q,
  mu = 0,
  sigma = 1,
  skew = 1,
  shape = 5,
  lambda = -0.5,
  lower_tail = TRUE,
  log = FALSE
)

qdist(
  distribution = "norm",
  p,
  mu = 0,
  sigma = 1,
  skew = 1,
  shape = 5,
  lambda = -0.5,
  lower_tail = TRUE,
  log = FALSE
)

rdist(
  distribution = "norm",
  n,
  mu = 0,
  sigma = 1,
  skew = 1,
  shape = 5,
  lambda = -0.5
)
```

Arguments

distribution	a valid distribution.
x, q	vector of quantiles.
mu	mean.
sigma	standard deviation.
skew	skew parameter.
shape	shape parameter.
lambda	additional shape parameter for the Generalized Hyperbolic distribution.
log	(logical) if TRUE, probabilities p are given as log(p).
lower_tail	if TRUE (default), probabilities are $P[X \leq x]$ otherwise, $P[X > x]$.
p	vector of probabilities.
n	number of observations.

Value

d gives the density, p gives the distribution function, q gives the quantile function and r generates random deviates. Output depends on x or q length, or n for the random number generator

dged *Generalized Error Distribution*

Description

Density, distribution, quantile function and random number generation for the generalized error distribution parameterized in terms of mean, standard deviation and shape parameters.

Usage

```
dged(x, mu = 0, sigma = 1, shape = 2, log = FALSE)

pged(q, mu = 0, sigma = 1, shape = 2, lower_tail = TRUE, log = FALSE)

qged(p, mu = 0, sigma = 1, shape = 2, lower_tail = TRUE, log = FALSE)

rged(n, mu = 0, sigma = 1, shape = 2)
```

Arguments

`x, q`	vector of quantiles.
`mu`	mean.
`sigma`	standard deviation.
`shape`	shape parameter.
`log`	(logical) if TRUE, probabilities p are given as log(p).
`lower_tail`	if TRUE (default), probabilities are $P[X \leq x]$ otherwise, $P[X > x]$.
`p`	vector of probabilities.
`n`	Number of observations.

Value

d gives the density, p gives the distribution function, q gives the quantile function and r generates random deviates. Output depends on x or q length, or n for the random number generator dgh *Generalized Hyperbolic Distribution*

Description

Density, distribution, quantile function and random number generation for the generalized hyperbolic distribution parameterized in terms of mean, standard deviation, skew and two shape parameters (shape and lambda)

Usage

```
dgh(x, mu = 0, sigma = 1, skew = 0, shape = 1, lambda = 1, log = FALSE)

pgh(
  q,
  mu = 0,
  sigma = 1,
  skew = 0,
  shape = 1,
  lambda = 1,
  lower_tail = TRUE,
  log = FALSE
)

qgh(
  p,
  mu = 0,
  sigma = 1,
  skew = 0,
  shape = 1,
  lambda = 1,
  lower_tail = TRUE,
  log = FALSE
)

rgh(n, mu = 0, sigma = 1, skew = 0, shape = 1, lambda = 1)
```

Arguments

x, q	vector of quantiles.
mu	mean.
sigma	standard deviation.
skew	skew parameter.
shape	shape parameter.
lambda	additional shape parameter determining subfamilies of this distributions.

`log`	(logical) if TRUE, probabilities p are given as log(p).
`lower_tail`	if TRUE (default), probabilities are $P[X \leq x]$ otherwise, $P[X > x]$.
`p`	vector of probabilities.
`n`	number of observations.

Value

d gives the density, p gives the distribution function, q gives the quantile function and r generates random deviates. Output depends on x or q length, or n for the random number generator

`dghst` *Generalized Hyperbolic Skewed Student Distribution*

Description

Density, distribution, quantile function and random number generation for the generalized hyperbolic skew student distribution parameterized in terms of mean, standard deviation, skew and shape parameters.

Usage

```
dghst(x, mu = 0, sigma = 1, skew = 1, shape = 8, log = FALSE)

rghst(n, mu = 0, sigma = 1, skew = 1, shape = 8)

pghst(
  q,
  mu = 0,
  sigma = 1,
  skew = 1,
  shape = 8,
  lower_tail = TRUE,
  log = FALSE
)

qghst(
  p,
  mu = 0,
  sigma = 1,
  skew = 1,
  shape = 8,
  lower_tail = TRUE,
  log = FALSE
)
```

Arguments

`x, q`	vector of quantiles.
`mu`	mean.
`sigma`	standard deviation.
`skew`	skew parameter.
`shape`	shape parameter.
`log`	(logical) if TRUE, probabilities p are given as log(p).
`n`	Number of observations.
`lower_tail`	if TRUE (default), probabilities are $P[X \leq x]$ otherwise, $P[X > x]$.
`p`	vector of probabilities.

Value

d gives the density, p gives the distribution function, q gives the quantile function and r generates random deviates. Output depends on x or q length, or n for the random number generator

`distribution_bounds` *Distribution Bounds*

Description

Distribution Bounds

Usage

```
distribution_bounds(distribution = "norm")
```

Arguments

`distribution`	A valid distribution

Details

Returns the upper a lower bounds for the parameters of a distribution.

Value

A data.table of the parameters and their default bounds.

`distribution_modelspec`

Specification of distribution model

Description

Specification of distribution model

Usage

```
distribution_modelspec(y, distribution = "norm", ...)
```

Arguments

`y`	a numeric vector
`distribution`	the type of distribution. Valid choices are norm (Normal), snorm (Skew Normal), std (Student), sstd (Skew Student), ged (Generalized Error), sged (Skew Generalized Error), nig (Normal Inverse Gaussian), gh (Generalized Hyperbolic), ghst (Generalized Hyperbolic Skew Student) and jsu (Johnson's SU).
`...`	not currently used

Details

All distributions are parameterized in terms of their mean ('mu'), standard deviation 'sigma', skew 'skew' and shape 'shape' parameters. Additionally, for the Generalized Hyperbolic distribution, there is an extra shape parameter "lambda" arising from the GIG mixing distribution. Parameters can be fixed post initialization by setting setting specific values to the 'value' column in the parmatrix table and setting the 'estimate' variable to 0 (instead of 1).

Value

An object of class "tsdistribution.spec"

Examples

```
spec <- distribution_modelspec(rnorm(1000), distribution = "gh")
# fix lambda and shape
spec$parmatrix[parameter == 'lambda', value := 30]
spec$parmatrix[parameter == 'lambda', estimate := 0]
```

djsu *Johnson's SU Distribution*

Description

Density, distribution, quantile function and random number generation for Johnson's SU distribution parameterized in terms of mean, standard deviation, skew and shape parameters.

Usage

```
djsu(x, mu = 0, sigma = 1, skew = 1, shape = 0.5, log = FALSE)

pjsu(
  q,
  mu = 0,
  sigma = 1,
  skew = 1,
  shape = 0.5,
  lower_tail = TRUE,
  log = FALSE
)

qjsu(
  p,
  mu = 0,
  sigma = 1,
  skew = 1,
  shape = 0.5,
  lower_tail = TRUE,
  log = FALSE
)

rjsu(n, mu = 0, sigma = 1, skew = 1, shape = 0.5)
```

Arguments

`x, q`	vector of quantiles.
`mu`	mean.
`sigma`	standard deviation.
`skew`	skew parameter.
`shape`	shape parameter.
`log`	(logical) if TRUE, probabilities p are given as log(p).
`lower_tail`	if TRUE (default), probabilities are $P[X \leq x]$ otherwise, $P[X > x]$.
`p`	vector of probabilities.
`n`	number of observations.

Value

d gives the density, p gives the distribution function, q gives the quantile function and r generates random deviates. Output depends on x or q length, or n for the random number generator

`dnig` *Normal Inverse Gaussian Distribution*

Description

Density, distribution, quantile function and random number generation for the normal inverse gaussian distribution generalized parameterized in terms of mean, standard deviation, skew and shape parameters.

Usage

```
dnig(x, mu = 0, sigma = 1, skew = 0, shape = 1, log = FALSE)

pnig(q, mu = 0, sigma = 1, skew = 0, shape = 1, lower_tail = TRUE, log = FALSE)

qnig(p, mu = 0, sigma = 1, skew = 0, shape = 1, lower_tail = TRUE, log = FALSE)

rnig(n, mu = 0, sigma = 1, skew = 0, shape = 1)
```

Arguments

`x, q`	vector of quantiles.
`mu`	mean.
`sigma`	standard deviation.
`skew`	skew parameter.
`shape`	shape parameter.
`log`	(logical) if TRUE, probabilities p are given as log(p).
`lower_tail`	if TRUE (default), probabilities are $P[X \leq x]$ otherwise, $P[X > x]$.
`p`	vector of probabilities.
`n`	number of observations.

Value

d gives the density, p gives the distribution function, q gives the quantile function and r generates random deviates. Output depends on x or q length, or n for the random number generator

dsged *Skewed Generalized Error Distribution of Fernandez and Steel*

Description

Density, distribution, quantile function and random number generation for the skewed generalized error distribution parameterized in terms of mean, standard deviation, skew and shape parameters.

Usage

```
dsged(x, mu = 0, sigma = 1, skew = 1.5, shape = 2, log = FALSE)

psged(
  q,
  mu = 0,
  sigma = 1,
  skew = 1.5,
  shape = 2,
  lower_tail = TRUE,
  log = FALSE
)

qsged(
  p,
  mu = 0,
  sigma = 1,
  skew = 1.5,
  shape = 2,
  lower_tail = TRUE,
  log = FALSE
)

rsged(n, mu = 0, sigma = 1, skew = 1.5, shape = 2)
```

Arguments

`x, q`	vector of quantiles.
`mu`	mean.
`sigma`	standard deviation.
`skew`	skew parameter.
`shape`	shape parameter.
`log`	(logical) if TRUE, probabilities p are given as log(p).
`lower_tail`	if TRUE (default), probabilities are $P[X \le x]$ otherwise, $P[X > x]$.
`p`	vector of probabilities.
`n`	number of observations.

Value

d gives the density, p gives the distribution function, q gives the quantile function and r generates random deviates. Output depends on x or q length, or n for the random number generator

---

dskewness *Distribution skewness and kurtosis*

Description

Calculates the skewness and excess kurtosis of the distribution given a set of parameters.

Usage

```
dskewness(distribution = "norm", skew = 1, shape = 5, lambda = -0.5)

dkurtosis(distribution = "norm", skew = 1, shape = 5, lambda = -0.5)
```

Arguments

`distribution`	a valid distribution.
`skew`	skew parameter.
`shape`	shape parameter.
`lambda`	additional shape parameter for the Generalized Hyperbolic distribution.

Value

A numeric value.

---

dsnorm *Skewed Normal Distribution of Fernandez and Steel*

Description

Density, distribution, quantile function and random number generation for the skewed normal distribution parameterized in terms of mean, standard deviation and skew parameters.

Usage

```
dsnorm(x, mu = 0, sigma = 1, skew = 1.5, log = FALSE)

psnorm(q, mu = 0, sigma = 1, skew = 1.5, lower_tail = TRUE, log = FALSE)

qsnorm(p, mu = 0, sigma = 1, skew = 1.5, lower_tail = TRUE, log = FALSE)

rsnorm(n, mu = 0, sigma = 1, skew = 1.5)
```

Arguments

`x, q`	vector of quantiles.
`mu`	mean.
`sigma`	standard deviation.
`skew`	skew parameter.
`log`	(logical) if TRUE, probabilities p are given as log(p).
`lower_tail`	if TRUE (default), probabilities are $P[X \leq x]$ otherwise, $P[X > x]$.
`p`	vector of probabilities.
`n`	Number of observations.

Value

d gives the density, p gives the distribution function, q gives the quantile function and r generates random deviates. Output depends on x or q length, or n for the random number generator

dsstd *Skewed Student Distribution of Fernandez and Steel*

Description

Density, distribution, quantile function and random number generation for the skewed student distribution parameterized in terms of mean, standard deviation, skew and shape parameters.

Usage

```
dsstd(x, mu = 0, sigma = 1, skew = 1.5, shape = 5, log = FALSE)

psstd(
  q,
  mu = 0,
  sigma = 1,
  skew = 1.5,
  shape = 5,
  lower_tail = TRUE,
  log = FALSE
)

qsstd(
  p,
  mu = 0,
  sigma = 1,
  skew = 1.5,
  shape = 5,
  lower_tail = TRUE,
  log = FALSE
)

rsstd(n, mu = 0, sigma = 1, skew = 1.5, shape = 5)
```

Arguments

x, q	vector of quantiles.
mu	mean.
sigma	standard deviation.
skew	skew parameter.
shape	shape parameter.
log	(logical) if TRUE, probabilities p are given as log(p).
lower_tail	if TRUE (default), probabilities are $P[X \leq x]$ otherwise, $P[X > x]$.
p	vector of probabilities.
n	number of observations.

Value

d gives the density, p gives the distribution function, q gives the quantile function and r generates random deviates. Output depends on x or q length, or n for the random number generator

dstd *Student Distribution*

Description

Density, distribution, quantile function and random number generation for the student distribution parameterized in terms of mean, standard deviation and shape parameters.

Usage

```
dstd(x, mu = 0, sigma = 1, shape = 5, log = FALSE)

pstd(q, mu = 0, sigma = 1, shape = 5, lower_tail = TRUE, log = FALSE)

qstd(p, mu = 0, sigma = 1, shape = 5, lower_tail = TRUE, log = FALSE)

rstd(n, mu = 0, sigma = 1, shape = 5)
```

Arguments

`x, q`	vector of quantiles.
`mu`	mean.
`sigma`	standard deviation.
`shape`	shape parameter.
`log`	(logical) if TRUE, probabilities p are given as log(p).
`lower_tail`	if TRUE (default), probabilities are $P[X \leq x]$ otherwise, $P[X > x]$.
`p`	vector of probabilities.
`n`	number of observations.

Value

d gives the density, p gives the distribution function, q gives the quantile function and r generates random deviates. Output depends on x or q length, or n for the random number generator

`estfun.tsdistribution.estimate` *Score Method*

Description

Score Method

Usage

```
## S3 method for class 'tsdistribution.estimate'
estfun(x, ...)
```

Arguments

`x`	an object of class “tsdistribution.estimate”.
`...`	not currently used.

Details

The function returns the scores of likelihood at the optimal solution.

Value

The score matrix

Author(s)

Alexios Galanos

estimate.tsdistribution.spec

Estimates the parameters of a distribution using autodiff.

Description

Estimates the parameters of a distribution using autodiff.

Usage

```
## S3 method for class 'tsdistribution.spec'
estimate(
  object,
  solver = "nlminb",
  control = list(trace = 0, eval.max = 300, iter.max = 500),
  use_hessian = TRUE,
  ...
)
```

Arguments

`object`	an object of class “tsdistribution.spec”.
`solver`	only “nlminb” currently supported.
`control`	solver control parameters.
`use_hessian`	whether to use the hessian in the calculation.
`...`	additional parameters passed to the estimation function

Details

The estimation makes use of the TMB package for minimizing the negative of the log-likelihood using automatic differentiation.

Value

An object of class “tsdistribution.estimate” with slots for the estimated coefficients, gradients, scores etc.

`logLik.tsdistribution.estimate` *Extract Log-Likelihood*

Description

Extract Log-Likelihood

Usage

```
## S3 method for class 'tsdistribution.estimate'
logLik(object, ...)
```

Arguments

`object`	an object of class tsdistribution.estimate.
`...`	other arguments.

Value

An object of class logLik. This is a number with at least one attribute, “df” (degrees of freedom), giving the number of (estimated) parameters in the model.

`nigtransform` *Parameter Transformation*

Description

Transforms parameters from standardized representation to distribution specific representation for the nig and gh distributions.

Usage

```
nigtransform(mu = 0, sigma = 1, skew = 0, shape = 3)

ghyptransform(mu = 0, sigma = 1, skew = 0, shape = 3, lambda = -0.5)
```

Arguments

`mu`	mean.
`sigma`	standard deviation.
`skew`	skew parameter.
`shape`	shape parameter.
`lambda`	additional shape parameter for the Generalized Hyperbolic distribution.

Value

The (alpha, beta, delta, mu) representation.

---

print.summary.tsdistribution

Model Estimation Summary Print method

Description

Print method for class “summary.tsdistribution”

Usage

```
## S3 method for class 'summary.tsdistribution'
print(
  x,
  digits = max(3L, getOption("digits") - 3L),
  signif.stars = getOption("show.signif.stars"),
  table.caption = paste0(toupper(x$distribution), " Model Summary\n"),
  ...
)
```

Arguments

`x`	an object of class “summary.tsdistribution”.
`digits`	integer, used for number formatting. Optionally, to avoid scientific notation, set ‘options(scipen=999)’.
`signif.stars`	logical. If TRUE, ‘significance stars’ are printed for each coefficient.
`table.caption`	an optional string for the table caption.
`...`	not currently used.

Value

Console output of the object summary.

print.summary.tsdistribution.profile

Profile Summary Print method

Description

Print method for class “summary.tsdistribution.profile”

Usage

```
## S3 method for class 'summary.tsdistribution.profile'
print(x, digits = max(3L, getOption("digits") - 3L), ...)
```

Arguments

x	an object of class “summary.tsdistribution.profile”.
digits	integer, used for number formatting. Optionally, to avoid scientific notation, set ‘options(scipen=999)’.
...	not currently used.

Value

Invisibly returns the original summary object and prints out to the console.

summary.tsdistribution.estimate

Summary of estimated distribution

Description

Summary of estimated distribution

Usage

```
## S3 method for class 'tsdistribution.estimate'
summary(object, digits = 4, vcov_type = "H", ...)
```

Arguments

object	an object of class tsdistribution.estimate.
digits	the number of significant digits to use when printing,.
vcov_type	the type of standard errors based on the vcov estimate (see vcov).
...	additional parameters passed to the summary method.

Value

A list of summary statistics of the fitted model given in object.

summary.tsdistribution.profile

Distribution Profile Summary

Description

Summary method for class “tsdistribution.profile”

Usage

```
## S3 method for class 'tsdistribution.profile'
summary(object, digits = 4, measure = "RMSE", ...)
```

Arguments

`object`	an object of class “tsdistribution.profile”.
`digits`	integer, used for number formatting. Optionally, to avoid scientific notation, set ‘options(scipen=999)’.
`measure`	either one of the 3 included measure in the summary slot of the returned object “RMSE”, “MAE” or “MAPE”, else any other user calculated measure which has been generated in the summary table post processing.
`...`	not currently used.

Value

A list with summary information of class “summary.tsdistribution.profile”, including a table with each actual parameter against the measure chosen across each size in the profile.

tsmoments.tsdistribution.estimate

Extract the moments of an estimated distribution

Description

Extract the moments of an estimated distribution

Usage

```
## S3 method for class 'tsdistribution.estimate'
tsmoments(object, ...)
```

Arguments

`object`	an object of class tsdistribution.estimate.
`...`	other arguments.

Value

A vector of the first four moments of the distribution based on the estimated parameters. The kurtosis represents the value in excess of 3.

tsprofile.tsdistribution.spec

Model Parameter Profiling

Description

Profiles the model parameters under the specified distribution.

Usage

```
## S3 method for class 'tsdistribution.spec'
tsprofile(
  object,
  nsim = 100,
  sizes = c(800, 1000, 1500, 2000, 3000),
  seed = NULL,
  trace = FALSE,
  ...
)
```

Arguments

`object`	an object of class "tsdistribution.spec" with pre-set parameters.
`nsim`	the number of paths to generate.
`sizes`	a vector of data sizes for which to simulate and estimate.
`seed`	an object specifying if and how the random number generator should be initialized. See the simulate documentation for more details.
`trace`	whether to show the progress bar. The user is expected to have set up appropriate handlers for this using the "progressr" package.
`...`	not currently used.

Details

The function profiles the parameters of a model by simulating and then estimating multiple paths from the assumed distribution. This makes it possible to obtain a better understanding of the convergence properties (RMSE) of each parameter under different data sizes.

Value

An object of class "tsdistribution.profile".

Note

The function can use parallel functionality as long as the user has set up a plan using the future package.

vcov.tsdistribution.estimate

The Covariance Matrix of the Estimated Parameters

Description

The Covariance Matrix of the Estimated Parameters

Usage

```
## S3 method for class 'tsdistribution.estimate'
vcov(object, adjust = FALSE, type = c("H", "OP", "QMLE", "NW"), ...)
```

Arguments

object	an object of class tsdistribution.estimate
adjust	logical. Should a finite sample adjustment be made? This amounts to multiplication with n/(n-k) where n is the number of observations and k the number of estimated parameters.
type	valid choices are “H” for using the analytic hessian for the ‘bread’, “OP” for the outer product of gradients, “QMLE” for the Quasi-ML sandwich estimator (Huber-White), and “NW” for the Newey-West adjusted sandwich estimator (a HAC estimator).
...	additional parameters passed to the Newey-West bandwidth function to determine the optimal lags.

Value

The variance-covariance matrix of the estimated parameters.

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