

# Package ‘libstable4u’

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**Version** 1.0.5

**Title** Stable Distribution Functions...For You

**Description** Tools for fast and accurate evaluation of skew stable distributions (CDF, PDF and quantile functions), random number generation, and parameter estimation. This is 'libstableR' as per Royuela del Val, Simmross-Wattenberg, and Alberola López (2017) <[doi:10.18637/jss.v078.i01](https://doi.org/10.18637/jss.v078.i01)> under a new maintainer.

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**License** GPL-3

**Imports** Rcpp (>= 0.12.9)

**LinkingTo** Rcpp, RcppGSL

**SystemRequirements** GNU GSL

**Encoding** UTF-8

**NeedsCompilation** yes

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**Repository** CRAN

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libstable4u-package    *libstable4u: Fast and accurate evaluation, random number generation and parameter estimation of skew stable distributions.*

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## Description

libstable4u provides functions to work with skew stable distributions in a fast and accurate way [1]. It performs:

## Details

- Fast and accurate evaluation of the probability density function (PDF) and cumulative density function (CDF).
- Fast and accurate evaluation of the quantile function (inverse CDF).
- Random numbers generation [2].
- Skew stable parameter estimation with:
  - McCulloch’s method of quantiles [3].
  - Koutrouvellis’ method based on the characteristic function [4].
  - Maximum likelihood estimation.
  - Modified maximum likelihood estimation as described in [1]. \*The evaluation of the PDF and CDF is based on the formulas provided by John P Nolan in [5].

## Author(s)

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## References

- [1] Royuela-del-Val J, Simmross-Wattenberg F, Alberola López C (2017). libstable: Fast, Parallel and High-Precision Computation of alpha-stable Distributions in R, C/C++ and MATLAB. Journal of Statistical Software, 78(1), 1-25. doi:10.18637/jss.v078.i01
- [2] Chambers JM, Mallows CL, Stuck BW (1976). A Method for Simulating Stable Random Variables. Journal of the American Statistical Association, 71(354), 340-344. doi:10.1080/01621459.1976.10480344
- [3] McCulloch JH (1986). Simple Consistent Estimators of Stable Distribution Parameters. Communications in Statistics - Simulation and Computation, 15(4), 1109-1136. doi:10.1080/03610918608812563
- [4] Koutrouvelis IA (1981). An Iterative Procedure for the Estimation of the Parameters of Stable Laws. Communications in Statistics - Simulation and Computation, 10(1), 17-28. doi:10.1080/03610918108812189
- [5] Nolan JP (1997). Numerical Calculation of Stable Densities and Distribution Functions. Stochastic Models, 13(4), 759-774. doi:10.1080/15326349708807450

**Examples**

```

# Set alpha, beta, sigma and mu stable parameters in a vector
pars <- c(1.5, 0.9, 1, 0)

# Generate an abscissas axis and probabilities vector
x <- seq(-5, 10, 0.05)
p <- seq(0.01, 0.99, 0.01)

# Calculate pdf, cdf and quantiles
pdf <- stable_pdf(x, pars)
cdf <- stable_cdf(x, pars)
xq <- stable_q(p, pars)

# Generate random values
set.seed(1)
rnd <- stable_rnd(100, pars)
head(rnd)

# Estimate the parameters of the skew stable distribution given
# the generated sample:

# Using the McCulloch's estimator:
pars_init <- stable_fit_init(rnd)

# Using the Koutrouvelis' estimator, with McCulloch estimation
# as a starting point:
pars_est_K <- stable_fit_koutrouvelis(rnd, pars_init)

# Using maximum likelihood estimator:
pars_est_ML <- stable_fit_mle(rnd, pars_est_K)

# Using modified maximum likelihood estimator (see [1]):
pars_est_ML2 <- stable_fit_mle2d(rnd, pars_est_K)

```

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stable\_fit

*Methods for parameter estimation of skew stable distributions.*


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**Description**

A set of functions are provided that perform the parameter estimation of skew stable distributions with different methods.

**Usage**

```
stable_fit_init(rnd, parametrization = 0L)
```

```
stable_fit_koutrouvelis(rnd, pars_init = as.numeric(c()), parametrization = 0L)
```

**Arguments**

<code>rnd</code>	Random sample
<code>parametrization</code>	Parametrization used for the skew stable distribution, as defined by JP Nolan (1997). By default, <code>parametrization = 0</code> .
<code>pars_init</code>	Vector with an initial estimation of the parameters. <code>pars_init = c(alpha, beta, sigma, mu)</code> , where <ul style="list-style-type: none"> <li>• <code>alpha</code>: shape / stability parameter, with <math>0 &lt; \alpha \leq 2</math>.</li> <li>• <code>beta</code>: skewness parameter, with <math>-1 \leq \beta \leq 1</math>.</li> <li>• <code>sigma</code>: scale parameter, with <math>0 &lt; \sigma</math>.</li> <li>• <code>mu</code>: location parameter, with <code>mu</code> real.</li> </ul>

**Details**

- `stable_fit_init()` uses McCulloch's method of quantiles [3]. This is usually a good initialization for the rest of the methods.
- `stable_fit_koutrouvelis()` implements Koutrouvellis' method based on the characteristic function [4].
- `stable_fit_mle()` implements a Maximum likelihood estimation.
- `stable_fit_mle2()` implements a modified maximum likelihood estimation as described in [1].

**Value**

A numeric vector.

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**References**

- [1] Royuela-del-Val J, Simmross-Wattenberg F, Alberola López C (2017). `libstable`: Fast, Parallel and High-Precision Computation of alpha-stable Distributions in R, C/C++ and MATLAB. *Journal of Statistical Software*, 78(1), 1-25. doi:10.18637/jss.v078.i01
- [2] Chambers JM, Mallows CL, Stuck BW (1976). A Method for Simulating Stable Random Variables. *Journal of the American Statistical Association*, 71(354), 340-344. doi:10.1080/01621459.1976.10480344.
- [3] McCulloch JH (1986). Simple Consistent Estimators of Stable Distribution Parameters. *Communications in Statistics - Simulation and Computation*, 15(4), 1109-1136. doi:10.1080/03610918608812563.
- [4] Koutrouvelis IA (1981). An Iterative Procedure for the Estimation of the Parameters of Stable Laws. *Communications in Statistics - Simulation and Computation*, 10(1), 17-28. doi:10.1080/03610918108812189.
- [5] Nolan JP (1997). Numerical Calculation of Stable Densities and Distribution Functions. *Stochastic Models*, 13(4) 759-774. doi:10.1080/15326349708807450.

**Examples**

```
# Set alpha, beta, sigma and mu stable parameters in a vector
pars <- c(1.5, 0.9, 1, 0)

# Generate random values
set.seed(1)
rnd <- stable_rnd(100, pars)
head(rnd)

# Estimate the parameters of the skew stable distribution given
# the generated sample:

# Using the McCulloch's estimator:
pars_init <- stable_fit_init(rnd)

# Using the Koutrouvelis' estimator, with McCulloch estimation
# as a starting point:
pars_est_K <- stable_fit_koutrouvelis(rnd, pars_init)

# Using maximum likelihood estimator:
pars_est_ML <- stable_fit_mle(rnd, pars_est_K)

# Using modified maximum likelihood estimator (see [1]):
pars_est_ML2 <- stable_fit_mle2d(rnd, pars_est_K)
```

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stable\_pdf\_and\_cdf      *PDF and CDF of a skew stable distribution.*

---

**Description**

Evaluate the PDF or the CDF of the skew stable distribution with parameters  $\text{pars} = c(\text{alpha}, \text{beta}, \text{sigma}, \text{mu})$  at the points given in  $x$ .

*parametrization* argument specifies the parametrization used for the distribution as described by JP Nolan (1997). The default value is *parametrization* = 0.

*tol* sets the relative error tolerance (precision) to *tol*. The default value is  $\text{tol} = 1e-12$ .

**Usage**

```
stable_pdf(x, pars, parametrization = 0L, tol = 1e-12)
```

**Arguments**

$x$	Vector of points where the pdf will be evaluated.
$\text{pars}$	Vector with an initial estimation of the parameters. $\text{pars\_init} = c(\text{alpha}, \text{beta}, \text{sigma}, \text{mu})$ , where <ul style="list-style-type: none"> <li>• <math>\text{alpha}</math>: shape / stability parameter, with <math>0 &lt; \text{alpha} \leq 2</math>.</li> </ul>

- beta: skewness parameter, with  $-1 \leq \beta \leq 1$ .
- sigma: scale parameter, with  $0 < \sigma$ .
- mu: location parameter, with mu real.

parametrization

Parametrization used for the skew stable distribution, as defined by JP Nolan (1997). By default, parametrization = 0.

tol

Relative error tolerance (precision) of the calculated values. By default, tol = 1e-12.

### Value

A numeric vector.

### Author(s)

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### References

Nolan JP (1997). Numerical Calculation of Stable Densities and Distribution Functions. *Stochastic Models*, 13(4) 759-774.

### Examples

```
pars <- c(1.5, 0.9, 1, 0)
x <- seq(-5, 10, 0.001)

pdf <- stable_pdf(x, pars)
cdf <- stable_cdf(x, pars)

plot(x, pdf, type = "l")
```

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stable\_q

*Quantile function of skew stable distributions*

---

### Description

Evaluate the quantile function ( $CDF^{-1}$ ) of the skew stable distribution with parameters `pars = c(alpha, beta, sigma, mu)` at the points given in `p`.

*parametrization* argument specifies the parametrization used for the distribution as described by JP Nolan (1997). The default value is *parametrization* = 0.

*tol* sets the relative error tolerance (precision) to *tol*. The default value is `tol = 1e-12`.

**Usage**

```
stable_q(p, pars, parametrization = 0L, tol = 1e-12)
```

**Arguments**

**p** Vector of points where the quantile function will be evaluated, with  $0 < p[i] < 1.0$

**pars** Vector with an initial estimation of the parameters. `pars_init = c(alpha, beta, sigma, mu)`, where

- alpha: shape / stability parameter, with  $0 < \alpha \leq 2$ .
- beta: skewness parameter, with  $-1 \leq \beta \leq 1$ .
- sigma: scale parameter, with  $0 < \sigma$ .
- mu: location parameter, with mu real.

**parametrization** Parametrization used for the skew stable distribution, as defined by JP Nolan (1997). By default, `parametrization = 0`.

**tol** Relative error tolerance (precision) of the calculated values. By default, `tol = 1e-12`.

**Value**

A numeric vector.

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stable\_rnd

*Skew stable distribution random sample generation.*

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**Description**

`stable_rnd(N, pars)` generates  $N$  random samples of a skew stable distribution with parameters `pars = c(alpha, beta, sigma, mu)` using the Chambers, Mallows, and Stuck (1976) method.

**Usage**

```
stable_rnd(N, pars, parametrization = 0L)
```

**Arguments**

N	Number of values to generate.
pars	Vector with an initial estimation of the parameters. <code>pars_init = c(alpha, beta, sigma, mu)</code> , where <ul style="list-style-type: none"><li>• alpha: shape / stability parameter, with <math>0 &lt; \alpha \leq 2</math>.</li><li>• beta: skewness parameter, with <math>-1 \leq \beta \leq 1</math>.</li><li>• sigma: scale parameter, with <math>0 &lt; \sigma</math>.</li><li>• mu: location parameter, with mu real.</li></ul>
parametrization	Parametrization used for the skew stable distribution, as defined by JP Nolan (1997). By default, <code>parametrization = 0</code> .

**Value**

A numeric vector.

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**References**

Chambers JM, Mallows CL, Stuck BW (1976). A Method for Simulating Stable Random Variables. *Journal of the American Statistical Association*, 71(354), 340-344. doi:10.1080/01621459.1976.10480344.

**Examples**

```
N <- 1000
pars <- c(1.25, 0.95, 1.0, 0.0)
rnd <- stable_rnd(N, pars)

hist(rnd)
```



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