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Title Symmetric Tempered Stable Distributions

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Description Contains methods for simulation and for evaluating the pdf, cdf, and quantile functions for symmetric stable, symmetric classical tempered stable, and symmetric power tempered stable distributions.

License GPL (>= 3)

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`SymTS-package` *Symmetric Tempered Stable Distributions*

Description

Contains methods for simulation and for evaluating the pdf, cdf, and quantile functions for symmetric stable, symmetric classical tempered stable, and symmetric power tempered stable distributions.

Details

The DESCRIPTION file:

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Author:	Michael Grabchak <mgrabcha@uncc.edu> and Lijuan Cao <lcao2@uncc.edu>
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Author(s)

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References

M. Grabchak (2016). Tempered Stable Distributions: Stochastic Models for Multiscale Processes. Springer, Cham.

S. T. Rachev, Y. S. Kim, M. L. Bianchi, and F. J. Fabozzi (2011). Financial Models with Levy Processes and Volatility Clustering. Wiley, Chichester.

J. Rosinski (2007). Tempering stable processes. Stochastic Processes and Their Applications, 117(6):677-707.

G. Samorodnitsky and M. Taqqu (1994). Stable Non-Gaussian Random Processes: Stochastic Models with Infinite Variance. Chapman & Hall, Boca Raton.

`dCTS` *PDF of CTS Distribution*

Description

Evaluates the pdf for the symmetric classical tempered stable distribution. When alpha=0 this is the symmetric variance gamma distribution.

Usage

```
dCTS(x, alpha, c = 1, ell = 1, mu = 0)
```

Arguments

`x`	Vector of points.
`alpha`	Number in [0,2)
`c`	Parameter c >0
`ell`	Parameter ell>0
`mu`	Location parameter, any real number

Details

The integration is preformed using the QAWF method in the GSL library for C. For this distribution the Rosinski measure R(dx) = c*delta_ell(dx) + c*delta_(-ell)(dx), where delta is the delta function. The Levy measure is M(dx) = c*ell^(alpha) *e^(-x/ell)*x^(-1-alpha) dx. The characteristic function is, for alpha not equal 0,1:

f(t) = exp(2*c*gamma(-alpha)*(1+ell^2 t^2)^(alpha/2)*(cos(alpha*atan(ell*t))-1)) *e^(i*t*mu),

for alpha = 1 it is

f(t) = (1+ell^2 t^2)^c*exp(-2*c*ell*t*atan(ell*t)) *e^(i*t*mu),

and for alpha=0 it is

f(t) = (1+t^2 ell^2)^(-c) *e^(i*t*mu).

Note

When alpha=0 and c<=.5, the pdf is unbounded. It is infinite at mu and the method returns Inf in that case. This does not affect pCTS, qCTS, or rCTS.

Author(s)

Michael Grabchak and Lijuan Cao

References

M. Grabchak (2016). Tempered Stable Distributions: Stochastic Models for Multiscale Processes. Springer, Cham.

Examples

```
x = (-10:10)/10
dCTS(x,.5)
```

---

dPowTS — *PDF of PowTS Distribution*

Description

Evaluates the pdf for the symmetric power tempered stable distribution.

Usage

```
dPowTS(x, alpha, c = 1, ell = 1, mu = 0)
```

Arguments

`x`	Vector of points
`alpha`	Number in [0,2)
`c`	Parameter c >0
`ell`	Parameter ell>0
`mu`	Location parameter, any real number

Details

The integration is preformed using the QAWF method in the GSL library for C. For this distribution the Rosinski measure R(dx) = c*(alpha+ell+1)*(alpha+ell)*(1+|x|)^(-2-alpha-ell)(dx).

Note

We do not allow for the case alpha=0 and c<=.5*(1+ell), as, in this case, the pdf is unbounded. This does not affect pPowTS, qPowTS, or rPowTS.

Author(s)

Michael Grabchak and Lijuan Cao

References

M. Grabchak (2016). Tempered Stable Distributions: Stochastic Models for Multiscale Processes. Springer, Cham.

Examples

```
x = (-10:10)/10
dPowTS(x,.5)
```

`dSaS` *PDF of Symmetric Stable Distribution*

Description

Evaluates the pdf for the symmetric alpha stable distribution. For alpha=1 this is the Cauchy distribution.

Usage

```
dSaS(x, alpha, c = 1, mu = 0)
```

Arguments

`x`	Vector of points.
`alpha`	Index of stability; Number in (0,2)
`c`	Scale parameter, c>0
`mu`	Location parameter, any real number

Details

The integration is preformed using the QAWF method in the GSL library for C. The characteristic function is

f(t) = e^(-c |t|^alpha) *e^(i*t*mu).

Author(s)

Michael Grabchak and Lijuan Cao

References

G. Samorodnitsky and M. Taqqu (1994). Stable Non-Gaussian Random Processes: Stochastic Models with Infinite Variance. Chapman & Hall, Boca Raton.

Examples

```
x = (-10:10)/10
dSaS(x,.5)
```

---

pCTS *CDF of CTS Distribution*

Description

Evaluates the cdf for the symmetric classical tempered stable distribution. When alpha=0 this is the symmetric variance gamma distribution.

Usage

```
pCTS(x, alpha, c = 1, ell = 1, mu = 0)
```

Arguments

`x`	Vector of probabilities.
`alpha`	Number in [0,2)
`c`	Parameter c >0
`ell`	Parameter ell>0
`mu`	Location parameter, any real number

Details

For details about this distribution see the the describtion of dCTS.

Author(s)

Michael Grabchak and Lijuan Cao

References

M. Grabchak (2016). Tempered Stable Distributions: Stochastic Models for Multiscale Processes. Springer, Cham.

Examples

```
x = (-10:10)/10
pCTS(x,.5)
```

pPowTS *PDF of PowTS Distribution*

Description

Evaluates the cdf for the symmetric power tempered stable distribution.

Usage

```
pPowTS(x, alpha, c = 1, ell = 1, mu = 0)
```

Arguments

`x`	Vector of probabilities.
`alpha`	Number in [0,2)
`c`	Parameter c >0
`ell`	Parameter ell>0
`mu`	Location parameter, any real number

Details

The integration is preformed using the QAWF method in the GSL library for C. For this distribution the Rosinski measure R(dx) = c*(alpha+ell+1)*(alpha+ell)*(1+|x|)^(-2-alpha-ell)(dx).

Author(s)

Michael Grabchak and Lijuan Cao

References

M. Grabchak (2016). Tempered Stable Distributions: Stochastic Models for Multiscale Processes. Springer, Cham.

Examples

```
x = (-10:10)/10
pPowTS(x,.5)
```

pSaS *CDF of Symmetric Stable Distribution*

Description

Evaluates the cdf for the symmetric alpha stable distribution. For alpha=1 this is the Cauchy distribution.

Usage

```
pSaS(x, alpha, c = 1, mu = 0)
```

Arguments

x	Vector of probabilities.
alpha	Index of stability; Number in (0,2)
c	Scale parameter, c>0
mu	Location parameter, any real number

Details

The integration is preformed using the QAWF method in the GSL library for C. The characteristic function is

f(t) = e^(-c |t|^alpha) *e^(i*t*mu).

Author(s)

Michael Grabchak and Lijuan Cao

References

G. Samorodnitsky and M. Taqqu (1994). Stable Non-Gaussian Random Processes: Stochastic Models with Infinite Variance. Chapman & Hall, Boca Raton.

Examples

```
x = (-10:10)/10
pSaS(x,.5)
```

`qCTS` *Quantile Function of CTS Distribution*

Description

Evaluates the quantile function for the symmetric classical tempered stable distribution. When alpha=0 this is the symmetric variance gamma distribution.

Usage

```
qCTS(x, alpha, c = 1, ell = 1, mu = 0)
```

Arguments

`x`	Vector of quantiles.
`alpha`	Number in [0,2)
`c`	Parameter c >0
`ell`	Parameter ell>0
`mu`	Location parameter, any real number

Details

For details about this distribution see the the describtion of dCTS.

Author(s)

Michael Grabchak and Lijuan Cao

References

M. Grabchak (2016). Tempered Stable Distributions: Stochastic Models for Multiscale Processes. Springer, Cham.

Examples

```
x = (1:9)/10
qCTS(x,.5)
```

qPowTS *Quantile Function of PowTS Distribution*

Description

Evaluates the quantile function for the symmetric power tempered stable distribution.

Usage

```
qPowTS(x, alpha, c = 1, ell = 1, mu = 0)
```

Arguments

x	Vector of quantiles.
alpha	Number in [0,2)
c	Parameter c >0
ell	Parameter ell>0
mu	Location parameter, any real number

Author(s)

Michael Grabchak and Lijuan Cao

References

M. Grabchak (2016). Tempered Stable Distributions: Stochastic Models for Multiscale Processes. Springer, Cham.

Examples

```
x = (1:9)/10
qPowTS(x,.5)
```

qSaS *Quantile Function of Symmetric Stable Distribution*

Description

Evaluates the quantile function for the symmetric alpha stable distribution. For alpha=1 this is the Cauchy distribution.

Usage

```
qSaS(x, alpha, c = 1, mu = 0)
```

Arguments

x	Vector of points.
alpha	Index of stability; Number in (0,2)
c	Scale parameter, c>0
mu	Location parameter, any real number

Details

The characteristic function is

f(t) = e^(-c |t|^alpha) *e^(i*t*mu).

Author(s)

Michael Grabchak and Lijuan Cao

References

G. Samorodnitsky and M. Taqqu (1994). Stable Non-Gaussian Random Processes: Stochastic Models with Infinite Variance. Chapman & Hall, Boca Raton.

Examples

```
x = (1:9)/10
qSaS(x,.5)
```

---

rCTS *Simulation from CTS Distribution*

Description

Simulates from the symmetric classical tempered stable distribution. When alpha=0 this is the symmetric variance gamma distribution. The simulation is performed by numerically evaluating the quantile function.

Usage

```
rCTS(r, alpha, c = 1, ell = 1, mu = 0)
```

Arguments

r	Number of observations.
alpha	Number in [0,2)
c	Parameter c >0
ell	Parameter ell>0
mu	Location parameter, any real number

Details

For details about this distribution see the the describtion of dCTS.

Author(s)

Michael Grabchak and Lijuan Cao

References

M. Grabchak (2016). Tempered Stable Distributions: Stochastic Models for Multiscale Processes. Springer, Cham.

Examples

```
rCTS(10,.5)
```

---

rPowTS *Simulation from PowTS Distribution*

Description

Simulates from the symmetric power tempered stable distribution. The simulation is performed by numerically evaluating the quantile function.

Usage

```
rPowTS(r, alpha, c = 1, ell = 1, mu = 0)
```

Arguments

`r`	Number of observations.
`alpha`	Number in [0,2)
`c`	Parameter c >0
`ell`	Parameter ell>0
`mu`	Location parameter, any real number

Details

For this distribution the Rosinski measure R(dx) = c*(alpha+ell+1)*(alpha+ell)*(1+|x|)^(-2-alpha-ell)(dx).

Author(s)

Michael Grabchak and Lijuan Cao

References

M. Grabchak (2016). Tempered Stable Distributions: Stochastic Models for Multiscale Processes. Springer, Cham.

Examples

```
pPowTS(10,.5)
```

`rSaS` *Simulation from Symmetric Stable Distribution*

Description

Simulates from the symmetric alpha stable distribution. When alpha=1 this is the Cauchy distribution. The simulation is performed using a well-known approah. See for instance Proposition 1.7.1 in Samorodnitsky and Taqqu (1994).

Usage

```
rSaS(r, alpha, c = 1, mu = 0)
```

Arguments

`r`	Number of observations.
`alpha`	Index of stability; Number in (0,2)
`c`	Scale parameter, c>0
`mu`	Location parameter, any real number

Details

The characteristic function is

f(t) = e^(-c |t|^alpha)*e^(i*t*mu).

Author(s)

Michael Grabchak and Lijuan Cao

References

G. Samorodnitsky and M. Taqqu (1994). Stable Non-Gaussian Random Processes: Stochastic Models with Infinite Variance. Chapman & Hall, Boca Raton.

Examples

```
rSaS(10,.5)
```

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