Package ‘QBAsyDist’

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Title Asymmetric Distributions and Quantile Estimation

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Description Provides the local polynomial maximum likelihood estimates for the location and scale functions as well as the semiparametric quantile estimates in the generalized quantile-based asymmetric distributional setting. These functions are useful for any member of the generalized quantile-based asymmetric family of distributions.

Depends R (>= 3.4)

License GPL (>= 2)

Encoding UTF-8

LazyData true

Imports ald (>= 1.2), zipfR (>= 0.6-10), GoFKernel (>= 2.1-1), Deriv (>= 3.8.5), nloptr (>= 1.2.1), quantreg (>= 5.38), locpol (>= 0.7-0), scdensity (>= 1.0.2)

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NeedsCompilation no

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`AEPD` *Quantile-based asymmetric exponential power distribution*

Description

Density, cumulative distribution function, quantile function and random sample generation from the quantile-based asymmetric exponential power distribution (AEPD) studied in Gijbels et al. (2019b). An alternative form of the density AEPD is also studied in Komunjer (2007).

Usage

```
dAEPD(y, mu, phi, alpha, p)

pAEPD(q, mu, phi, alpha, p)

qAEPD(beta, mu, phi, alpha, p)

rAEPD(n, mu, phi, alpha, p)
```

Arguments

y, q	These are each a vector of quantiles.
mu	This is the location parameter μ.
phi	This is the scale parameter ϕ.
alpha	This is the index parameter α.
p	This is the shape parameter, which must be positive.
beta	This is a vector of probabilities.
n	This is the number of observations, which must be a positive integer that has length 1.

Value

dAEPD provides the density, pAEPD provides the cumulative distribution function, qAEPD provides the quantile function, and rAEPD generates a random sample from the quantile-based asymmetric exponential power distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019b). Quantile estimation in a generalized asymmetric distributional setting. To appear in *Springer Proceedings in Mathematics & Statistics, Proceedings of 'SMSA 2019', the 14th Workshop on Stochastic Models, Statistics and their Application*, Dresden, Germany, in March 6–8, 2019. Editors: Ansgar Steland, Ewaryst Rafajlowicz, Ostap Okhrin.

Komunjer, I., (2007). Asymmetric power distribution: theory and applications to risk measurement. *Journal of Applied Econometrics*, **22**(5), 891-921.

Examples

```
# Quantile-based asymmetric exponential power distribution
# Density
rnum<-rnorm(100)
dAEPD(y=rnum,mu=0,phi=1,alpha=.5,p=2)

# Distribution function
pAEPD(q=rnum,mu=0,phi=1,alpha=.5,p=2)

# Quantile function
beta<-c(0.25,0.5,0.75)
qAEPD(beta=beta,mu=0,phi=1,alpha=.5,p=2)
```

```
# random sample generation
rAEPD(n=100,mu=0,phi=1,alpha=.5,p=2)
```

ALaD *Quantile-based asymmetric Laplace distribution*

Description

Density, cumulative distribution function, quantile function and random sample generation for the quantile-based asymmetric Laplace distribution (ALaD) discussed in Yu and Zhang (2005) and Gijbels et al. (2019a).

Usage

```
dALaD(y, mu, phi, alpha)

pALaD(q, mu, phi, alpha)

qALaD(beta, mu, phi, alpha)

rALaD(n, mu, phi, alpha)
```

Arguments

y, q	These are each a vector of quantiles.
mu	This is the location parameter μ.
phi	This is the scale parameter ϕ.
alpha	This is the index parameter α.
beta	This is a vector of probabilities.
n	This is the number of observations, which must be a positive integer that has length 1.

Value

dALaD provides the density, pALaD provides the cumulative distribution function, qALaD provides the quantile function, and rALaD generates a random sample from the quantile-based asymmetric Laplace distribution. The length of the result is determined by n for rALaD, and is the maximum of the lengths of the numerical arguments for the other functions.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Yu., K, and Zhang, J. (2005). A three-parameter asymmetric Laplace distribution and its extension. *Communications in Statistics–Theory and Methods*, **34**(9-10), 1867–1879.

See Also

dQBAD, pQBAD, qQBAD, rQBAD

Examples

```
# Density
rnum<-rnorm(100)
dALaD(y=rnum,mu=0,phi=1,alpha=.5)

# Distribution function
 pALaD(q=rnum,mu=0,phi=1,alpha=.5)

# Quantile function
beta<-c(0.25,0.5,0.75)
qALaD(beta=beta,mu=0,phi=1,alpha=.5)

# random sample generation
rALaD(n=100,mu=0,phi=1,alpha=.5)
```

ALoD *Quantile-based asymmetric logistic distribution*

Description

Density, cumulative distribution function, quantile function and random sample generation from the quantile-based asymmetric logistic distribution (ALoD) proposed in Gijbels et al. (2019a).

Usage

```
dALoD(y, mu, phi, alpha)

pALoD(q, mu, phi, alpha)

qALoD(beta, mu, phi, alpha)

rALoD(n, mu, phi, alpha)
```

Arguments

y, q	These are each a vector of quantiles.
mu	This is the location parameter μ.
phi	This is the scale parameter ϕ.
alpha	This is the index parameter α.
beta	This is a vector of probabilities.
n	This is the number of observations, which must be a positive integer that has length 1.

Value

dALoD provides the density, pALoD provides the cumulative distribution function, qALoD provides the quantile function, and rALoD generates a random sample from the quantile-based asymmetric logistic distribution. The length of the result is determined by n for rALoD, and is the maximum of the lengths of the numerical arguments for the other functions.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

See Also

dQBAD, pQBAD, qQBAD, rQBAD

Examples

```
# Quantile-based asymmetric logistic distribution (ALoD)
# Density
rnum<-rnorm(100)
dALoD(y=rnum,mu=0,phi=1,alpha=.5)

# Distribution function
pALoD(q=rnum,mu=0,phi=1,alpha=.5)

# Quantile function
beta<-c(0.25,0.5,0.75)
qALoD(beta=beta,mu=0,phi=1,alpha=.5)

# random sample generation
rALoD(n=100,mu=0,phi=1,alpha=.5)
```

AND *Quantile-based asymmetric normal distribution*

Description

Density, cumulative distribution function, quantile function and random sample generation from the quantile-based asymmetric normal distribution (AND) introduced in Gijbels et al. (2019a).

Usage

```
dAND(y, mu, phi, alpha)

pAND(q, mu, phi, alpha)
```

```
qAND(beta, mu, phi, alpha)

rAND(n, mu, phi, alpha)
```

Arguments

y, q	These are each a vector of quantiles.
mu	This is the location parameter μ.
phi	This is the scale parameter ϕ.
alpha	This is the index parameter α.
beta	This is a vector of probabilities.
n	This is the number of observations, which must be a positive integer that has length 1.

Value

dAND provides the density, pAND provides the cumulative distribution function, qAND provides the quantile function, and rAND generates a random sample from the quantile-based asymmetric normal distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

See Also

dQBAD, pQBAD, qQBAD, rQBAD

Examples

```
# Quantile-based asymmetric normal distribution (AND)
# Density
rnum<-rnorm(100)
dAND(y=rnum,mu=0,phi=1,alpha=.5)

# Distribution function
pAND(q=rnum,mu=0,phi=1,alpha=.5)

# Quantile function
beta<-c(0.25,0.5,0.75)
qAND(beta=beta,mu=0,phi=1,alpha=.5)

# random sample generation
rAND(n=100,mu=0,phi=1,alpha=.5)
```

ATD *Quantile-based asymmetric Student's-t distribution*

Description

Density, cumulative distribution function, quantile function and random sample generation from the quantile-based asymmetric Student's-t distribution (ATD) proposed in Gijbels et al. (2019a).

Usage

```
dATD(y, mu, phi, alpha, nu)

pATD(q, mu, phi, alpha, nu)

qATD(beta, mu, phi, alpha, nu)

rATD(n, mu, phi, alpha, nu)
```

Arguments

y, q	These are each a vector of quantiles.
mu	This is the location parameter μ.
phi	This is the scale parameter ϕ.
alpha	This is the index parameter α.
nu	This is the degrees of freedom parameter ν, which must be positive.
beta	This is a vector of probabilities.
n	This is the number of observations, which must be a positive integer that has length 1.

Value

dATD provides the density, pATD provides the cumulative distribution function, qATD provides the quantile function, and rATD generates a random sample from the quantile-based asymmetric Student's-t distribution. The length of the result is determined by n for rATD, and is the maximum of the lengths of the numerical arguments for the other functions.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

See Also

dQBAD, pQBAD, qQBAD, rQBAD

Examples

```
# Quantile-based asymmetric Student's-\eqn{t} distribution (ATD)
# Density
rnum<-rnorm(100)
dATD(rnum,mu=0,phi=1,alpha=0.5,nu=10)

# Distribution function
pATD(rnum,mu=0,phi=1,alpha=0.5,nu=10)

# Quantile function
beta<-c(0.25,0.5,0.75)
qATD(beta=beta,mu=0,phi=1,alpha=.5,nu=10)

# random sample generation
rATD(n=100,mu=0,phi=1,alpha=.5,nu=10)
```

---

bone.data — *Dataset concerning the actual measurements of bone density in adolescents*

Description

A detailed description of this dataset is available in https://web.stanford.edu/~hastie/ElemStatLearn/datasets/bone.data and discussed in Friedman et al. (2001) and Takeuchi et al. (2006).

Usage

```
bone.data
```

Format

A data frame with 485 rows and 4 variables:

idnum ID of adolescent.

age Age of adolescent.

gender Gender of adolescent.

spnbmd Relative Change in the actual measurements of bone density (BMD).

References

Friedman, J., Hastie, T. and Tibshirani, R. (2001). *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, Springer series in statistics New York, USA

Takeuchi, I., Le, Q. V., Sears, T. D., and Smola, A. J. (2006). Nonparametric quantile estimation, *Journal of Machine Learning Research*, Vol 7, pp. 1231–1264.

Examples

```
data(bone.data)
y=bone.data$spnbmd
x=bone.data$age
plot(x,y)
```

GAD *Generalized quantile-based asymmetric family*

Description

Density, cumulative distribution function, quantile function and random sample generation from the generalized quantile-based asymmetric family of densities defined in Gijbels et al. (2019b).

Usage

```
dGAD(y, eta, phi, alpha, f, g)

pGAD(q, eta, phi, alpha, F, g)

qGAD(beta, eta, phi, alpha, F, g, QF = NULL, lower = -Inf,
  upper = Inf)

rGAD(n, eta, phi, alpha, F, g, lower = -Inf, upper = Inf, QF = NULL)
```

Arguments

`y, q`	These are each a vector of quantiles.
`eta`	This is the location parameter η.
`phi`	This is the scale parameter ϕ.
`alpha`	This is the index parameter α.
`f`	This is the reference density function f which is a standard version of a unimodal and symmetric around 0 density.
`g`	This is the "link" function. The function g is to be differentiated. Therefore, g must be written as a function. For example, g<-function(y){log(y)} for log link function.
`F`	This is the cumulative distribution function F of the unimodal and symmetric around 0 reference density function f.
`beta`	This is a vector of probabilities.
`QF`	This is the quantile function of the reference density f.
`lower`	This is the lower limit of the domain (support of the random variable) $f^g_\alpha(y;\eta,\phi)$, default -Inf.
`upper`	This is the upper limit of the domain (support of the random variable) $f^g_\alpha(y;\eta,\phi)$, default Inf.
`n`	This is the number of observations, which must be a positive integer that has length 1.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019b). Quantile estimation in a generalized asymmetric distributional setting. To appear in *Springer Proceedings in Mathematics & Statistics, Proceedings of 'SMSA 2019', the 14th Workshop on Stochastic Models, Statistics and their Application*, Dresden, Germany, in March 6–8, 2019. Editors: Ansgar Steland, Ewaryst Rafajlowicz, Ostap Okhrin.

Examples

```
# Example 1: Let F be a standard normal cumulative distribution function then
f_N<-function(s){dnorm(s, mean = 0,sd = 1)} # density function of N(0,1)
F_N<-function(s){pnorm(s, mean = 0,sd = 1)} # distribution function of N(0,1)
QF_N<-function(beta){qnorm(beta, mean = 0, sd = 1, lower.tail = TRUE, log.p = FALSE)}

# For identiy link function
g_id<-function(y){y}
# For log-link function
g_log<-function(y){log(y)}

rnum<-rnorm(100)
beta=c(0.25,0.50,0.75)

# Density
dGAD(y=rnorm(100),eta=10,phi=1,alpha=0.5,f=f_N,g=g_id) # For identity link
dGAD(y=rexp(100,0.1),eta=10,phi=1,alpha=0.5,f=f_N,g=g_log) # For log-link

# Distribution function
pGAD(q=rnorm(100),eta=0,phi=1,alpha=.5,F=F_N,g=g_id) # For identity link
pGAD(q=rexp(100,0.1),eta=10,phi=1,alpha=.5,F=F_N,g=g_log) # For log-link

# Quantile function
qGAD(beta=beta,eta=0,phi=1,alpha=0.5,F=F_N,g=g_id) # For identity link
qGAD(beta=beta,eta=10,phi=1,alpha=0.5,F=F_N,g=g_log,lower = 0, upper = Inf)  # For log-link

# random sample generation
rGAD(n=100,eta=0,phi=1,alpha=.5,F=F_N,g=g_id ,lower = -Inf, upper = Inf,QF=NULL) # For identity link
rGAD(n=100,eta=10,phi=1,alpha=.5,F=F_N,g=g_log ,lower =0, upper = Inf,QF=NULL)  # For log-link


# Example 2: Let F be a standard Laplace cumulative distribution function then
f_La<-function(s){0.5*exp(-abs(s))} # density function of Laplace(0,1)
F_La<-function(s){0.5+0.5*sign(s)*(1-exp(-abs(s)))} # distribution function of Laplace(0,1)
QF_La<-function(beta){-sign(beta-0.5)*log(1-2*abs(beta-0.5))}

# For identiy link function
g_log<-function(y){log(y)}
beta=c(0.25,0.50,0.75)

# Density
dGAD(y=rnorm(100),eta=10,phi=1,alpha=0.5,f=f_La,g=g_id) # For identity-link
dGAD(y=rexp(100,0.1),eta=10,phi=1,alpha=0.5,f=f_La,g=g_log) # For log-link

# Distribution function
```

```
pGAD(q=rnum,eta=0,phi=1,alpha=.5,F=F_La,g=g_id) # For identity-link
pGAD(q=rexp(100,0.1),eta=10,phi=1,alpha=.5,F=F_La,g=g_log) # For log-link

# Quantile function
qGAD(beta=beta,eta=0,phi=1,alpha=0.5,F=F_La,g=g_id,lower = -Inf, upper = Inf) # For identity link
qGAD(beta=beta,eta=10,phi=1,alpha=0.5,F=F_La,g=g_log,lower = 0, upper = Inf) # For log-link

# random sample generation
rGAD(n=100,eta=0,phi=1,alpha=.5,F=F_La,g=g_id) # For identity link
rGAD(n=100,eta=10,phi=1,alpha=.5,F=F_La,g=g_log ,lower =0, upper = Inf,QF=NULL)  # For log-link
```

GTEF *Generalized tick-exponential family*

Description

Density, cumulative distribution function, quantile function and random sample generation from the generalized tick-exponential family (GTEF) of densities discusse in Gijbels et al. (2019b).

Usage

```
dGTEF(y, eta, phi, alpha, p, g)

pGTEF(q, eta, phi, alpha, p, g)

qGTEF(beta, eta, phi, alpha, p, g, lower = -Inf, upper = Inf)

rGTEF(n, eta, phi, alpha, p, g, lower = -Inf, upper = Inf)
```

Arguments

`y, q`	These are each a vector of quantiles.
`eta`	This is the location parameter η.
`phi`	This is the scale parameter ϕ.
`alpha`	This is the index parameter α.
`p`	This is the shape parameter, which must be positive.
`g`	This is the "link" function. The function g is to be differentiated. Therefore, g must be written as a function. For example, g<-function(y){log(y)} for log link function.
`beta`	This is a vector of probabilities.
`lower`	This is the lower limit of the domain (support of the random variable) $f^g_\alpha(y;\eta,\phi)$, default -Inf.

upper — This is the upper limit of the domain (support of the random variable) $f_\alpha^g(y;\eta,\phi)$, default Inf.

n — This is the number of observations, which must be a positive integer that has length 1.

Value

dGTEF provides the density, pGTEF provides the cumulative distribution function, qGTEF provides the quantile function, and rGTEF generates a random sample from the generalized tick-exponential family of densities. The length of the result is determined by n for rGTEF, and is the maximum of the lengths of the numerical arguments for the other functions.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019b). Quantile estimation in a generalized asymmetric distributional setting. To appear in *Springer Proceedings in Mathematics & Statistics, Proceedings of 'SMSA 2019', the 14th Workshop on Stochastic Models, Statistics and their Application*, Dresden, Germany, in March 6–8, 2019. Editors: Ansgar Steland, Ewaryst Rafajlowicz, Ostap Okhrin.

Examples

```
# For identiy link function
y=rnorm(100)
g_id<-function(y){y}
dGTEF(y,eta=0,phi=1,alpha=0.5,p=2,g=g_id)

# cumulative distribution function
pGTEF(q=y,eta=10,phi=1,alpha=0.5,p=2,g=g_id)

# Quantile function
beta=c(0.25,0.5,0.75)
qGTEF(beta=beta,eta=10,phi=1,alpha=0.5,p=2,g=g_id)

# random sample generation
rGTEF(n=100,eta=10,phi=1,alpha=.5,p=2,g=g_id,lower = -Inf, upper = Inf)

# For log link function
y=rexp(100)
g_log<-function(y){log(y)}
dGTEF(y,eta=10,phi=1,alpha=0.5,p=2,g=g_log)

# cumulative distribution function
pGTEF(q=y,eta=10,phi=1,alpha=0.5,p=2,g=g_log)

# Quantile function
g_log<-function(y){log(y)}
#' beta=c(0.25,0.5,0.75)
qGTEF(beta=beta,eta=10,phi=1,alpha=0.5,p=2,g=g_log,lower = 0, upper = Inf)

# random sample generation
rGTEF(n=100,eta=10,phi=1,alpha=.5,p=2,g=g_log,lower = 0, upper = Inf)
```

`Hurricane` *Hurricane dataset for the North Atlantic region (up to 2017).*

Description

This is a dataset of the strongest hurricanes in the North Atlantic region. The dataset is a clean up version of the dataset `AL` which is available in the HURDAT package.

Usage

```
Hurricane
```

Format

A data frame with 1831 rows and 3 variables:

Year Year of the tropical cyclone occure (up to 2017)

Key Unique key identifying the tropical cyclone. Formatted like AABBCCCC where AA is Basin, BB is YearNum and CC is Year

WmaxST Maximum Wind Speed (in knots per hour) of the strongest hurricanes in the North Atlantic region

Examples

```
data(Hurricane)
y=Hurricane$WmaxST
x=Hurricane$Year
plot(x,y)
```

`LocomotorPerfor` *Data on locomotor performance in small and large terrestrial mammals.*

Description

A detailed description of these data is available in Iriarte-Diaz (2002). This dataset is also used in Gijbels et al. (2019c). For $n = 142$ species of mammals measurements on their body length, body mass (in kg) and maximum relative running speed were recorded. The maximum relative running speed measurement takes into account the body length of the mammals, and was obtained by dividing the maximum speed of the mammal species by its body length.

Usage

```
LocomotorPerfor
```

Format

A data frame with 142 rows and 2 variables:

Body_Mass The body mass of $n = 142$ species of mammals.

MRRS The maximum relative running speed measurement takes into account the body length of the mammals, and was obtained by dividing the maximum speed of the mammal species by its body length.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019c). Semiparametric quantile regression using quantile-based asymmetric family of densities. Manuscript.

Iriarte-Diaz, Jose (2002). Differential scaling of locomotor performance in small and large terrestrial mammals, *Journal of Experimental Biology*, **205**(18), 2897–2908.

Examples

```
data(LocomotorPerfor)
y=log(LocomotorPerfor$MRRS)
x=log(LocomotorPerfor$Body_Mass)
plot(x,y)
```

LogLikAEPD — *Log-likelihood function for the quantile-based asymmetric exponential power distribution (AEPD) of distributions.*

Description

Log-Likelihood function $\ell_n(\mu, \phi, \alpha, p) = \ln[L_n(\mu, \phi, \alpha, p)]$ in the quantile-based asymmetric exponential power distribution (AEPD) of densities defined in Gijbels et al. (2019b).

Usage

```
LogLikAEPD(y, mu, phi, alpha, p)
```

Arguments

y	This is a vector of quantiles.
mu	This is the location parameter μ.
phi	This is the scale parameter ϕ.
alpha	This is the index parameter α.
p	This is the shape parameter, which must be positive.

Value

LogLikAEPD provides the realized value of the Log-likelihood function of the quantile-based asymmetric exponential power distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019b). Quantile estimation in a generalized asymmetric distributional setting. To appear in *Springer Proceedings in Mathematics & Statistics, Proceedings of 'SMSA 2019', the 14th Workshop on Stochastic Models, Statistics and their Application*, Dresden, Germany, in March 6–8, 2019. Editors: Ansgar Steland, Ewaryst Rafajlowicz, Ostap Okhrin.

Examples

```
# Example
y<-rnorm(100)
LogLikAEPD(rexp(100,0.1),mu=10,phi=1,alpha=0.5,p=2)
```

LogLikALaD — *Log-likelihood function for the quantile-based asymmetric Laplace distribution.*

Description

Log-Likelihood function $\ell_n(\mu, \phi, \alpha) = \ln[L_n(\mu, \phi, \alpha)]$ of the quantile-based asymmetric Laplace distribution discussed in Gijbels et al. (2019a).

Usage

```
LogLikALaD(y, mu, phi, alpha)
```

Arguments

y	This is a vector of quantiles.
mu	This is the location parameter μ.
phi	This is the scale parameter ϕ.
alpha	This is the index parameter α.

Value

LogLikALaD provides the value of the Log-likelihood function of the quantile-based asymmetric Laplace distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example
y<-rnorm(100)
LogLikALaD(y,mu=0,phi=1,alpha=0.5)
```

LogLikALoD *Log-likelihood function for the quantile-based asymmetric logistic distribution.*

Description

The log-likelihood function $\ell_n(\mu, \phi, \alpha) = \ln[L_n(\mu, \phi, \alpha)]$ in the quantile-based asymmetric logistic distribution is presented in Gijbels et al. (2019a).

Usage

```
LogLikALoD(y, mu, phi, alpha)
```

Arguments

y	This is a vector of quantiles.
mu	This is the location parameter μ.
phi	This is the scale parameter ϕ.
alpha	This is the index parameter α.

Value

LogLikALoD provides the value of the Log-likelihood function of the quantile-based asymmetric logistic distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example
y<-rnorm(100)
LogLikALoD(y,mu=0,phi=1,alpha=0.5)
```

`LogLikAND` *Log-likelihood function for the quantile-based asymmetric normal distribution.*

Description

The log-likelihood function $\ell_n(\mu, \phi, \alpha) = \ln[L_n(\mu, \phi, \alpha)]$ in the quantile-based asymmetric normal distribution is presented in Gijbels et al. (2019a).

Usage

```
LogLikAND(y, mu, phi, alpha)
```

Arguments

`y`	This is a vector of quantiles.
`mu`	This is the location parameter μ.
`phi`	This is the scale parameter ϕ.
`alpha`	This is the index parameter α.

Value

`LogLikAND` provides the value of the Log-likelihood function of the quantile-based asymmetric normal distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example
y<-rnorm(100)
LogLikAND(y,mu=0,phi=1,alpha=0.5)
```

LogLikATD *Log-likelihood function for the quantile-based asymmetric Student's-t distribution.*

Description

The log-likelihood function $\ell_n(\mu, \phi, \alpha, \nu) = \ln[L_n(\mu, \phi, \alpha, \nu)]$ and parameter estimation of $\theta = (\mu, \phi, \alpha, \nu)$ in the quantile-based asymmetric Student's-t distribution by using the maximum likelihood estimation are discussed in Gijbels et al. (2019a).

Usage

```
LogLikATD(y, mu, phi, alpha, nu)
```

Arguments

y	This is a vector of quantiles.
mu	This is the location parameter μ.
phi	This is the scale parameter ϕ.
alpha	This is the index parameter α.
nu	This is the degrees of freedom parameter ν, which must be positive.

Value

LogLikATD provides the value of the Log-likelihood function of the quantile-based asymmetric Student's-t distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example
y<-rnorm(100)
LogLikATD(y,mu=0,phi=1,alpha=0.5,nu=10)
```

LogLikGAD *Log-likelihood function for the generalized quantile-based asymmetric family of distributions.*

Description

Log-Likelihood function $\ell_n(\eta, \phi, \alpha) = \ln[L_n(\eta, \phi, \alpha)]$ in the three parameter generalized quantile-based asymmetric family of densities defined in Gijbels et al. (2019b).

Usage

```
LogLikGAD(y, eta, phi, alpha, f, g)
```

Arguments

y	This is a vector of quantiles.
eta	This is the location parameter η.
phi	This is the scale parameter ϕ.
alpha	This is the index parameter α.
f	This is the reference density function f which is a standard version of a unimodal and symmetric around 0 density.
g	This is the "link" function. The function g is to be differentiated. Therefore, g must be written as a function. For example, g<-function(y){log(y)} for log link function.

Value

LogLikGAD provides the realized value of the Log-likelihood function of the generalized quantile-based asymmetric family of distributions.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019b). Quantile estimation in a generalized asymmetric distributional setting. To appear in *Springer Proceedings in Mathematics & Statistics, Proceedings of 'SMSA 2019', the 14th Workshop on Stochastic Models, Statistics and their Application*, Dresden, Germany, in March 6–8, 2019. Editors: Ansgar Steland, Ewaryst Rafajlowicz, Ostap Okhrin.

Examples

```
# Example 1: Let F be a standard normal cumulative distribution function then
f_N<-function(s){dnorm(s, mean = 0,sd = 1)} # density function of N(0,1)
y<-rnorm(100)
g_id<-function(y){y}
g_log<-function(y){log(y)}
LogLikGAD(y,eta=0,phi=1,alpha=0.5,f=f_N,g=g_id) # For identity-link
LogLikGAD(rexp(100,0.1),eta=10,phi=1,alpha=0.5,f=f_N,g=g_log) # For log-link
```

```
# Example 2: Let F be a standard Laplace cumulative distribution function then
f_La<-function(s){0.5*exp(-abs(s))} # density function of Laplace(0,1)
LogLikGAD(y,eta=0,phi=1,alpha=0.5,f=f_La,g=g_id) # For identity-link
LogLikGAD(rexp(100,0.1),eta=10,phi=1,alpha=0.5,f=f_La,g=g_log) # For log-link
```

LogLikGTEF *Log-likelihood function for the generalized tick-exponential family (GTEF) of distributions.*

Description

Log-Likelihood function $\ell_n(\eta, \phi, \alpha, p) = \ln[L_n(\eta, \phi, \alpha, p)]$ in the generalized tick-exponential family of densities discussed in Gijbels et al. (2019b).

Usage

```
LogLikGTEF(y, eta, phi, alpha, p, g)
```

Arguments

y	This is a vector of quantiles.
eta	This is the location parameter η.
phi	This is the scale parameter ϕ.
alpha	This is the index parameter α.
p	This is the shape parameter, which must be positive.
g	This is the "link" function. The function g is to be differentiated. Therefore, g must be written as a function. For example, g<-function(y){log(y)} for log link function.

Value

`LogLikGAD` provides the realized value of the Log-likelihood function of the generalized quantile-based asymmetric family of distributions.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019b). Quantile estimation in a generalized asymmetric distributional setting. To appear in *Springer Proceedings in Mathematics & Statistics, Proceedings of 'SMSA 2019', the 14th Workshop on Stochastic Models, Statistics and their Application*, Dresden, Germany, in March 6–8, 2019. Editors: Ansgar Steland, Ewaryst Rafajlowicz, Ostap Okhrin.

Examples

```
# Examples
y<-rnorm(100)
g_id<-function(y){y}
g_log<-function(y){log(y)}
LogLikGTEF(y,eta=0,phi=1,alpha=0.5,p=2,g=g_id) # For identity-link
LogLikGTEF(rexp(100,0.1),eta=10,phi=1,alpha=0.5,p=2,g=g_log) # For log-link
```

`LogLikQBAD` *Log-likelihood function for the quantile-based asymmetric family of distributions.*

Description

Log-Likelihood function $\ell_n(\mu,\phi,\alpha) = \ln[L_n(\mu,\phi,\alpha)]$ in the three parameter quantile-based asymmetric family of densities defined in Section 3.2 of Gijbels et al. (2019a).

Usage

```
LogLikQBAD(y, mu, phi, alpha, f)
```

Arguments

`y`	This is a vector of quantiles.
`mu`	This is the location parameter μ.
`phi`	This is the scale parameter ϕ.
`alpha`	This is the index parameter α.
`f`	This is the reference density function f which is a standard version of a unimodal and symmetric around 0 density.

Value

`LogLikQBAD` provides the realized value of the Log-likelihood function of quantile-based asymmetric family of distributions.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example 1: Let F be a standard normal cumulative distribution function then
f_N<-function(s){dnorm(s, mean = 0,sd = 1)} # density function of N(0,1)
y<-rnorm(100)
LogLikQBAD(y,mu=0,phi=1,alpha=0.5,f=f_N)

# Example 2: Let F be a standard Laplace cumulative distribution function then
f_La<-function(s){0.5*exp(-abs(s))} # density function of Laplace(0,1)
LogLikQBAD(y,mu=0,phi=1,alpha=0.5,f=f_La)
```

`LRTest` *Likelihood ratio test to test for symmetry.*

Description

The likelihood ratio test to test for symmetry, in the context of a framework of quantile-based asymmetric family of densities is discussed in Gijbels et al. (2019d).

Usage

```
LRTest(y, f)
```

Arguments

`y`	This is a vector of quantiles.
`f`	This is the reference density function f which is a standard version of a unimodal and symmetric around 0 density.

Value

The likelihood ratio test statistic with P-value.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019d). Test of symmetry and a quantile-based asymmetric family of densities, *Manuscript*.

Examples

```
# Example: Let F be a standard normal cumulative distribution function then
f_N<-function(s){dnorm(s, mean = 0,sd = 1)} # density function of N(0,1)
rnum=rnorm(100)
LRTest(rnum,f=f_N)
```

mleAEPD *Maximum likelihood estimation (MLE) for the quantile-based asymmetric exponential power distribution.*

Description

The log-likelihood function $\ell_n(\mu, \phi, \alpha, p) = \ln[L_n(\mu, \phi, \alpha, p)]$ and parameter estimation of $\theta = (\mu, \phi, \alpha, p)$ in the three parameter quantile-based asymmetric exponential power distribution by using the maximum likelihood estimation are discussed in Gijbels et al. (2019b).

Usage

```
mleAEPD(y)
```

Arguments

`y`	This is a vector of quantiles.

Value

The maximum likelihood estimate of parameter $\theta = (\mu, \phi, \alpha, p)$ of the quantile-based asymmetric exponential power distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019b). Quantile estimation in a generalized asymmetric distributional setting. To appear in *Springer Proceedings in Mathematics & Statistics, Proceedings of 'SMSA 2019', the 14th Workshop on Stochastic Models, Statistics and their Application*, Dresden, Germany, in March 6–8, 2019. Editors: Ansgar Steland, Ewaryst Rafajlowicz, Ostap Okhrin.

Examples

```
# Example
rnum=rnorm(100)
mleAEPD(rnum)
```

mleALaD *Maximum likelihood estimation (MLE) for the quantile-based asymmetric Laplace distribution.*

Description

The log-likelihood function $\ell_n(\mu, \phi, \alpha) = \ln[L_n(\mu, \phi, \alpha)]$ and parameter estimation of $\theta = (\mu, \phi, \alpha)$ in the quantile-based asymmetric Laplace distribution by using the maximum likelihood estimation are discussed in Gijbels et al. (2019a). See also in Yu and Zhang (2005). The linear programing (LP) algorithm is used to obtain a solution to the maximization problem. The LP algorithm can be found in Koenker (2005). See also `mleALD` in the Package **ald**.

Usage

```
mleALaD(y)
```

Arguments

`y` This is a vector of quantiles.

Value

The maximum likelihood estimate of parameter $\theta = (\mu, \phi, \alpha)$ of the quantile-based asymmetric Laplace distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Koenker, R. (2005). *Quantile Regression*. Cambridge University Press.

Yu., K, and Zhang, J. (2005). A three-parameter asymmetric Laplace distribution and its extension. *Communications in Statistics–Theory and Methods*, **34**(9-10), 1867–1879.

Examples

```
## Example:
y=rnorm(100)
mleALaD(y)
```

`mleALoD` *Maximum likelihood estimation (MLE) for the quantile-based asymmetric logistic distribution.*

Description

The log-likelihood function $\ell_n(\mu, \phi, \alpha) = \ln[L_n(\mu, \phi, \alpha)]$ and parameter estimation of $\theta = (\mu, \phi, \alpha)$ in the quantile-based asymmetric logistic distribution by using the maximum likelihood estimation are discussed in Gijbels et al. (2019a).

Usage

```
mleALoD(y)
```

Arguments

`y` This is a vector of quantiles.

Value

The maximum likelihood estimate of parameter $\theta = (\mu, \phi, \alpha)$ of the quantile-based asymmetric family of distributions.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example
rnum=rnorm(100)
mleALoD(rnum)
```

`mleAND` *Maximum likelihood estimation (MLE) for the quantile-based asymmetric normal distribution.*

Description

The log-likelihood function $\ell_n(\mu, \phi, \alpha) = \ln[L_n(\mu, \phi, \alpha)]$ and parameter estimation of $\theta = (\mu, \phi, \alpha)$ in the asymmetric normal distribution by using the maximum likelihood estimation are discussed in Gijbels et al. (2019a).

Usage

```
mleAND(y, alpha = NULL)
```

Arguments

`y`	This is a vector of quantiles.
`alpha`	This is the index parameter α.

Value

The maximum likelihood estimate of parameter $\theta = (\mu, \phi, \alpha)$ of the quantile-based asymmetric normal distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Maximum likelihood estimation
y=rnorm(100)
mleAND(y)
mleAND(y,alpha=0.5)
```

---

mleATD *Maximum likelihood estimation (MLE) for the quantile-based asymmetric Student's-t distribution.*

Description

The log-likelihood function $\ell_n(\mu, \phi, \alpha, \nu) = \ln[L_n(\mu, \phi, \alpha, \nu)]$ and parameter estimation of $\theta = (\mu, \phi, \alpha, \nu)$ in the quantile-based asymmetric Student's-t distribution. by using the maximum likelihood estimation are discussed in Gijbels et al. (2019a).

Usage

```
mleATD(y)
```

Arguments

y	This is a vector of quantiles.

Value

The maximum likelihood estimate of parameter $\theta = (\mu, \phi, \alpha, \nu)$ of the quantile-based asymmetric Student's-t distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example
y=rnorm(20)
mleATD(y)
```

mleGAD *Maximum likelihood estimation (MLE) for the generalized quantile-based asymmetric family of distributions (GAD).*

Description

The log-likelihood function $\ell_n(\eta, \phi, \alpha) = \ln[L_n(\eta, \phi, \alpha)]$ and parameter estimation of $\theta = (\eta, \phi, \alpha)$ in the three parameter generalized quantile-based asymmetric family of densities by using the maximum likelihood estimation are discussed in Gijbels et al. (2019b).

Usage

```
mleGAD(y, f, g, lower = -Inf, upper = Inf)
```

Arguments

y	This is a vector of quantiles.
f	This is the reference density function f which is a standard version of a unimodal and symmetric around 0 density.
g	This is the "link" function. The function g is to be differentiated. Therefore, g must be written as a function. For example, g<-function(y){log(y)} for log link function.
lower	This is the lower limit of the domain (support of the random variable) $f_\alpha^g(y; \eta, \phi)$, default -Inf.
upper	This is the upper limit of the domain (support of the random variable) $f_\alpha^g(y; \eta, \phi)$, default Inf.

Value

The maximum likelihood estimate of parameter $\theta = (\eta, \phi, \alpha)$ of the generalized quantile-based asymmetric family of densities

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019b). Quantile estimation in a generalized asymmetric distributional setting. To appear in *Springer Proceedings in Mathematics & Statistics, Proceedings of 'SMSA 2019', the 14th Workshop on Stochastic Models, Statistics and their Application*, Dresden, Germany, in March 6–8, 2019. Editors: Ansgar Steland, Ewaryst Rafajlowicz, Ostap Okhrin.

Examples

```
# Example 1: Let F be a standard normal cumulative distribution function then
f_N<-function(s){dnorm(s, mean = 0,sd = 1)} # density function of N(0,1)
y<-rnorm(100)
g_id<-function(y){y}
g_log<-function(y){log(y)}
mleGAD(y,f=f_N,g=g_id) # For identity-link
```

```
mleGAD(rexp(100,0.1),f=f_N,g=g_log,lower = 0, upper = Inf) # For log-link


# Example 2: Let F be a standard Laplace cumulative distribution function then
f_La<-function(s){0.5*exp(-abs(s))} # density function of Laplace(0,1)
mleGAD(y,f=f_La,g=g_id) # For identity-link
mleGAD(rexp(100,0.1),f=f_La,g=g_log,lower = 0, upper = Inf) # For log-link
```

`mleGTEF` *Maximum likelihood estimation (MLE) for the generalized tick-exponential family (GTEF) of distributions.*

Description

The log-likelihood function $\ell_n(\eta, \phi, \alpha, p) = \ln[L_n(\eta, \phi, \alpha, p)]$ and parameter estimation of $\theta = (\eta, \phi, \alpha, p)$ in the generalized tick-exponential family of distributions by using the maximum likelihood estimation are discussed in Gijbels et al. (2019b).

Usage

```
mleGTEF(y, g, lower = -Inf, upper = Inf)
```

Arguments

`y`	This is a vector of quantiles.
`g`	This is the "link" function. The function g is to be differentiated. Therefore, g must be written as a function. For example, g<-function(y){log(y)} for log link function.
`lower`	This is the lower limit of the domain (support of the random variable) $f_\alpha^g(y; \eta, \phi)$, default -Inf.
`upper`	This is the upper limit of the domain (support of the random variable) $f_\alpha^g(y; \eta, \phi)$, default Inf.

Value

The maximum likelihood estimate of parameter $\theta = (\eta, \phi, \alpha, p)$ of the generalized tick-exponential family of distributions.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019b). Quantile estimation in a generalized asymmetric distributional setting. To appear in *Springer Proceedings in Mathematics & Statistics, Proceedings of 'SMSA 2019', the 14th Workshop on Stochastic Models, Statistics and their Application*, Dresden, Germany, in March 6–8, 2019. Editors: Ansgar Steland, Ewaryst Rafajlowicz, Ostap Okhrin.

Examples

```
# Example
rnum=rnorm(100)
g_id<-function(y){y}
g_log<-function(y){log(y)}
mleGTEF(rnum,g_id) # For identity-link
mleGTEF(rexp(100),g_log,lower = 0, upper = Inf) # For log-link
```

---

mleQBAD *Maximum likelihood estimation (MLE) for the quantile-based asymmetric family of distributions.*

Description

The log-likelihood function $\ell_n(\mu, \phi, \alpha) = \ln[L_n(\mu, \phi, \alpha)]$ and parameter estimation of $\theta = (\mu, \phi, \alpha)$ in the three parameter quantile-based asymmetric family of densities by using the maximum likelihood estimation are discussed in Section 3.2 of Gijbels et al. (2019a).

Usage

```
mleQBAD(y, f, alpha = NULL)
```

Arguments

y	This is a vector of quantiles.
f	This is the reference density function f which is a standard version of a unimodal and symmetric around 0 density.
alpha	This is the index parameter α.

Value

The maximum likehood estimate of paramter $\theta = (\mu, \phi, \alpha)$ of the quantile-based asymmetric family of densities

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example 1: Let F be a standard normal cumulative distribution function then
f_N<-function(s){dnorm(s, mean = 0,sd = 1)} # density function of N(0,1)
rnum=rnorm(100)
mleQBAD(rnum,f=f_N)
mleQBAD(rnum,f=f_N,alpha=.5)
```

```
# Example 2: Let F be a standard Laplace cumulative distribution function then
f_La<-function(s){0.5*exp(-abs(s))} # density function of Laplace(0,1)
mleQBAD(rnum,f=f_La)
mleQBAD(rnum,f=f_La,alpha=.5)
```

---

momALaD *Method of moments (MoM) estimation for the quantile-based asymmetric Laplace distribution.*

Description

Parameter estimation in the quantile-based asymmetric Laplace distribution by using method of moments is studied in Gijbels et al. (2019a).

Usage

```
momALaD(y, alpha = NULL)
```

Arguments

y	This is a vector of quantiles.
alpha	This is the index parameter α. If α is unknown, the it should be NULL which is default option. In this case, the sample skewness will be used to estimate α. If α is known, then the value of α has to be specified in the function.

Value

momALaD provides the method of moments estimates of the unknown parameters of the distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example
y=rnorm(100)
momALaD(y=y,alpha=0.5) # If alpha is known with alpha=0.5
momALaD(y=y) # If alpha is unknown
```

momALoD *Method of moments (MoM) estimation for the quantile-based asymmetric logistic distribution.*

Description

Parameter estimation in the quantile-based asymmetric logistic distribution by using method of moments are studied in Gijbels et al. (2019a).

Usage

```
momALoD(y, alpha = NULL)
```

Arguments

- `y` This is a vector of quantiles.
- `alpha` This is the index parameter α. If α is unknown, indicate NULL which is the default option. In this case, the sample skewness will be used to estimate α. If α is known, then the value of α has to be specified in the function.

Value

`momALoD` provides the method of moments estimates of the unknown parameters of the distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example
y=rnorm(100)
momALoD(y=y,alpha=0.5) # If alpha is known with alpha=0.5
momALoD(y=y) # If alpha is unknown
```

momAND *Method of moments (MoM) estimation for the quantile-based asymmetric normal distribution.*

Description

Parameter estimation in the quantile-based asymmetric normal distribution by using method of moments are discussed in Gijbels et al. (2019a).

Usage

```
momAND(y, alpha = NULL)
```

Arguments

y	This is a vector of quantiles.
alpha	This is the index parameter α. If α is unknown, indicate NULL which is the default option. In this case, the sample skewness will be used to estimate α. If α is known, then the value of α has to be specified in the function.

Value

momAND provides the method of moments estimates of the unknown parameters of the distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example
y=rnorm(100)
momAND(y=y,alpha=0.5) # If alpha is known wtih alpha=0.5
momAND(y=y) # If alpha is unknown
```

momATD *Method of moments (MoM) estimation for the quantile-based asymmetric Student's-t distribution.*

Description

Parameter estimation in the quantile-based asymmetric Student's-t distribution by using method of moments are discussed in Gijbels et al. (2019a). We here used the first four sample moments to estimate parameter $\theta = (\mu, \phi, \alpha, \nu)$ under the assumption that the first four population moments exist, which needs to assume $\nu > 4$.

Usage

```
momATD(y, alpha = NULL)
```

Arguments

y	This is a vector of quantiles.
alpha	This is the index parameter α. If α is unknown, indicate NULL which is the default option. In this case, the sample skewness will be used to estimate α. If α is known, then the value of α has to be specified in the function.

Value

momATD provides the method of moments estimates of the unknown parameters of the distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example
y=rnorm(100)
momATD(y=y,alpha=0.5) # If alpha is known with alpha=0.5
momATD(y=y) # If alpha is unknown
```

momentALaD *Moments estimation for the quantile-based asymmetric Laplace distribution.*

Description

Mean, variance, skewness, kurtosis and moments about the location parameter (i.e., αth quantile) of the quantile-based asymmetric Laplace distribution studied in Gijbels et al. (2019a) useful for quantile regression with location parameter equal to μ, scale parameter ϕ and index parameter α.

Usage

```
meanALaD(mu, phi, alpha)

varALaD(mu, phi, alpha)

skewALaD(alpha)

kurtALaD(alpha)

momentALaD(phi, alpha, r)
```

Arguments

mu	This is the location parameter μ.
phi	This is the scale parameter ϕ.
alpha	This is the index parameter α.
r	This is a value which is used to calculate rth moment about μ.

Value

meanALaD provides the mean, varALaD provides the variance, skewALaD provides the skewness, kurtALaD provides the kurtosis, and momentALaD provides the rth moment about the location parameter μ of the quantile-based asymmetric Laplace distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example
meanALaD(mu=0,phi=1,alpha=0.5)
varALaD(mu=0,phi=1,alpha=0.5)
skewALaD(alpha=0.5)
```

```
kurtALaD(alpha=0.5)
momentALaD(phi=1,alpha=0.5,r=1)
```

`momentALoD` *Moments estimation for the quantile-based asymmetric logistic distribution.*

Description

Mean, variance, skewness, kurtosis and moments about the location parameter (i.e., αth quantile) of the quantile-based asymmetric logistic distribution defined in Gijbels et al. (2019a) useful for quantile regression with location parameter equal to μ, scale parameter ϕ and index parameter α.

Usage

```
meanALoD(mu, phi, alpha)

varALoD(mu, phi, alpha)

skewALoD(alpha)

kurtALoD(alpha)

momentALoD(phi, alpha, r)
```

Arguments

mu	This is the location parameter μ.
phi	This is the scale parameter ϕ.
alpha	This is the index parameter α.
r	This is a value which is used to calculate the rth moment about μ.

Value

`meanALoD` provides the mean, `varALoD` provides the variance, `skewALoD` provides the skewness, `kurtALoD` provides the kurtosis, and `momentALoD` provides the rth moment about the location parameter μ of the quantile-based asymmetric logistic distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example
meanALoD(mu=0,phi=1,alpha=0.5)
varALoD(mu=0,phi=1,alpha=0.5)
skewALoD(alpha=0.5)
kurtALoD(alpha=0.5)
momentALoD(phi=1,alpha=0.5,r=1)
```

---

momentAND — *Moments estimation for the quantile-based asymmetric normal distribution.*

Description

Mean, variance, skewness, kurtosis and moments about the location parameter (i.e., αth quantile) of the quantile-based asymmetric normal distribution introduced in Gijbels et al. (2019a) useful for quantile regression with location parameter equal to μ, scale parameter ϕ and index parameter α.

Usage

```
meanAND(mu, phi, alpha)

varAND(mu, phi, alpha)

skewAND(alpha)

kurtAND(alpha)

momentAND(phi, alpha, r)
```

Arguments

mu	This is the location parameter μ.
phi	This is the scale parameter ϕ.
alpha	This is the index parameter α.
r	This is a value which is used to calculate rth moment about μ.

Value

meanAND provides the mean, varAND provides the variance, skewAND provides the skewness, kurtAND provides the kurtosis, and momentAND provides the rth moment about the location parameter μ of the quantile-based asymmetric normal distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example
meanAND(mu=0,phi=1,alpha=0.5)
varAND(mu=0,phi=1,alpha=0.5)
skewAND(alpha=0.5)
kurtAND(alpha=0.5)
momentAND(phi=1,alpha=0.5,r=1)
```

---

momentATD — *Moments estimation for the quantile-based asymmetric Student's-t distribution.*

Description

Mean, variance, skewness, kurtosis and moments about the location parameter (i.e., αth quantile) of the quantile-based asymmetric Student's-t distribution defined in Gijbels et al. (2019a) useful for quantile regression with location parameter equal to μ, scale parameter ϕ and index parameter α.

Usage

```
meanATD(mu, phi, alpha, nu)

varATD(mu, phi, alpha, nu)

skewATD(alpha, nu)

kurtATD(alpha, nu)

momentATD(phi, alpha, nu, r)
```

Arguments

mu	This is the location parameter μ.
phi	This is the scale parameter ϕ.
alpha	This is the index parameter α.
nu	This is the degrees of freedom parameter ν, which must be positive.
r	This is a value which is used to calculate the rth moment $(r \in \{1, 2, 3, 4\})$ about μ.

Value

meanATD provides the mean, varATD provides the variance, skewATD provides the skewness, kurtATD provides the kurtosis, and momentATD provides the rth moment about the location parameter μ of the quantile-based asymmetric Student's-t distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example
meanATD(mu=0,phi=1,alpha=0.5,nu=10)
varATD(mu=0,phi=1,alpha=0.5,nu=10)
skewATD(alpha=0.5,nu=10)
kurtATD(alpha=0.5,nu=10)
momentATD(phi=1,alpha=0.5,nu=10,r=1)
```

---

momentQBAD — *Moment estimation for the quantile-based asymmetric family of distributions.*

Description

Mean, variance, skewness, kurtosis and moments about the location parameter (i.e., αth quantile) of the quantile-based asymmetric family of densities defined in Gijbels et al. (2019a) useful for quantile regression with location parameter equal to μ, scale parameter ϕ and index parameter α.

Usage

```
mu_k(f, k)

gamma_k(f, k)

meanQBAD(mu, phi, alpha, mu_1)

varQBAD(mu, phi, alpha, mu_1, mu_2)

skewQBAD(alpha, mu_1, mu_2, mu_3)

kurtQBAD(alpha, mu_1, mu_2, mu_3, mu_4)

momentQBAD(phi, alpha, f, r)
```

Arguments

f — This is the reference density function f which is a standard version of a unimodal and symmetric around 0 density.

k — This is an integer value ($k = 1, 2, 3, \ldots$) for calculating $\mu_k = \int_0^\infty 2s^k f(s)ds$ and $\gamma_k = \int_0^\infty s^{k-1} \frac{[f'(s)]^2}{f(s)} ds$.

mu — This is the location parameter μ.

phi — This is the scale parameter ϕ.

alpha — This is the index parameter α.

mu_1 — This is the quantity $\int_0^\infty 2sf(s)ds$.

mu_2 — This is the quantity $\int_0^\infty 2s^2 f(s)ds$.

mu_3 — This is the quantity $\int_0^\infty 2s^3 f(s)ds$.

mu_4 — This is the quantity $\int_0^\infty 2s^4 f(s)ds$.

r — This is a value which is used to calculate the rth moment about μ.

Value

mu_k provides the quantity $\int_0^\infty 2s^k f(s)ds$, gamma_k provides the quantity $\int_0^\infty s^{k-1} \frac{[f'(s)]^2}{f(s)} ds$, meanQBAD provides the mean, varQBAD provides the variance, skewQBAD provides the skewness, kurtQBAD provides the kurtosis, and momentQBAD provides the rth moment about the location parameter μ of the asymmetric family of distributions.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example 1: Let F be a standard normal cumulative distribution function then
f_N<-function(s){dnorm(s, mean = 0,sd = 1)} # density function of N(0,1)
mu_k(f=f_N,k=1)
gamma_k(f=f_N,k=1)
mu.1_N=sqrt(2/pi)
mu.2_N=1
mu.3_N=2*sqrt(2/pi)
mu.4_N=4
meanQBAD(mu=0,phi=1,alpha=0.5,mu_1=mu.1_N)
varQBAD(mu=0,phi=1,alpha=0.5,mu_1=mu.1_N,mu_2=mu.2_N)
skewQBAD(alpha=0.5,mu_1=mu.1_N,mu_2=mu.2_N,mu_3=mu.3_N)
kurtQBAD(alpha=0.5,mu_1=mu.1_N,mu_2=mu.2_N,mu_3=mu.3_N,mu_4=mu.4_N)
momentQBAD(phi=1,alpha=0.5,f=f_N,r=1)


# Example 2: Let F be a standard Laplace cumulative distribution function then
f_La<-function(s){0.5*exp(-abs(s))} # density function of Laplace(0,1)
mu_k(f=f_La,k=1)
```

```
gamma_k(f=f_La,k=1)
mu.1_La=1
mu.2_La=2
mu.3_La=6
mu.4_La=24
meanQBAD(mu=0,phi=1,alpha=0.5,mu_1=mu.1_La)
varQBAD(mu=0,phi=1,alpha=0.5,mu_1=mu.1_La,mu_2=mu.2_La)
skewQBAD(alpha=0.5,mu_1=mu.1_La,mu_2=mu.2_La,mu_3=mu.3_La)
kurtQBAD(alpha=0.5,mu_1=mu.1_La,mu_2=mu.2_La,mu_3=mu.3_La,mu_4=mu.4_La)
momentQBAD(phi=1,alpha=0.5,f=f_La,r=1)
```

---

momQBAD — *Method of moments (MoM) estimation for the quantile-based asymmetric family of distributions.*

Description

Parameter estimation in the quantile-based asymmetric family of densities by using method of moments are discussed in Section 3.1 of Gijbels et al. (2019a).

Usage

```
momQBAD(y, f, alpha = NULL)
```

Arguments

y	This is a vector of quantiles.
f	This is the reference density function f which is a standard version of a unimodal and symmetric around 0 density.
alpha	This is the index parameter α. If α is unknown, indicate NULL which is default option. In this case, the sample skewness will be used to estimate α. If α is known, then the value of α has to be specified in the function.

Value

momQBAD provides the method of moments estimates of the unknown parameters of the distribution.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example 1: Let F be a standard normal cumulative distribution function then
f_N<-function(s){dnorm(s, mean = 0,sd = 1)} # density function of N(0,1)
y=rnorm(100)
momQBAD(y=y,f=f_N,alpha=0.5) # If alpha is known with alpha=0.5
momQBAD(y=y,f=f_N) # If alpha is unknown


# Example 2: Let F be a standard Laplace cumulative distribution function then
f_La<-function(s){0.5*exp(-abs(s))} # density function of Laplace(0,1)
momQBAD(y=y,f=f_La,alpha=0.5) # If alpha is known with alpha=0.5
momQBAD(y=y,f=f_La) # If alpha is unknown
```

NLRTest *Nonparametric likelihood ratio test to test for symmetry.*

Description

The nonparametric likelihood ratio test to test for symmetry is discussed in Gijbels et al. (2019d).

Usage

```
NLRTest(y, f = NULL, F = NULL, QF = NULL, method = c("smooth",
  "parametric"), nboot = 500)
```

Arguments

y	This is a vector of quantiles.
f	This is the reference density function f which is a standard version of a unimodal and symmetric around 0 density.
F	This is the cumulative distribution function F of a unimodal and symmetric around 0 reference density function f.
QF	This is the quantile function of the reference density f.
method	The method to be used for drawing bootstrap samples. The default method is a smooth bootstrap procedure. The density function f, the cumulative distribution function F and the quantile function QF are required for parametric bootstrap procedure. If QF is not given, then the numerical QF will be used.
nboot	The number of bootstrap samples desired. The default number is 500.

Value

The nonparametric likelihood ratio test statistic with bootstrap P-value.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019d). Test of symmetry and a quantile-based asymmetric family of densities, *Manuscript*.

Examples

```
# Example 1: Let F be a standard normal cumulative distribution function then
f_N<-function(s){dnorm(s, mean = 0,sd = 1)} # density function of N(0,1)
F_N<-function(s){pnorm(s, mean = 0,sd = 1)} # distribution function of N(0,1)
QF_N<-function(beta){qnorm(beta, mean = 0, sd = 1, lower.tail = TRUE, log.p = FALSE)}
# Example: STRength dataset
my.sample<-c(1.901,2.132,2.203,2.228,2.257,2.350,2.361,2.396,2.397,
             2.445,2.454,2.474,2.518,2.522,2.525,2.532,2.575,2.614,2.616,
             2.618,2.624,2.659,2.675,2.738,2.740,2.856,2.917,2.928,2.937,
             2.937,2.977,2.996,3.030,3.125,3.139,3.145,3.220,3.223,3.235,
            3.243,3.264,3.272,3.294,3.332,3.346,3.377,3.408,3.435,3.493,
             3.501,3.537,3.554,3.562,3.628,3.852,3.871,3.886,3.971,4.024,
             4.027,4.225,4.395,5.020)


NLRTest(my.sample,f=NULL,F=NULL,QF=NULL,method=c("smooth"),nboot=500)
NLRTest(my.sample,f=f_N,F=F_N,QF=QF_N,method=c("parametric"),nboot=500)
NLRTest(my.sample,f=f_N,F=F_N,QF=NULL,method=c("parametric"),nboot=500)
```

QBAD *Quantile-based asymmetric family of distributions*

Description

Density, cumulative distribution function, quantile function and random sample generation from the quantile-based asymmetric family of densities defined in Gijbels et al. (2019a).

Usage

```
dQBAD(y, mu, phi, alpha, f)

pQBAD(q, mu, phi, alpha, F)

qQBAD(beta, mu, phi, alpha, F, QF = NULL)

rQBAD(n, mu, phi, alpha, F, QF = NULL)
```

Arguments

y, q	These are each a vector of quantiles.
mu	This is the location parameter μ.
phi	This is the scale parameter ϕ.
alpha	This is the index parameter α.
f	This is the reference density function f which is a standard version of a unimodal and symmetric around 0 density.

F	This is the cumulative distribution function F of a unimodal and symmetric around 0 reference density function f.
beta	This is a vector of probabilities.
QF	This is the quantile function of the reference density f.
n	This is the number of observations, which must be a positive integer that has length 1.

Value

dQBAD provides the density, pQBAD provides the cumulative distribution function, qQBAD provides the quantile function, and rQBAD generates a random sample from the quantile-based asymmetric family of distributions. The length of the result is determined by n for rQBAD, and is the maximum of the lengths of the numerical arguments for the other functions.

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019a). On quantile-based asymmetric family of distributions: properties and inference. *International Statistical Review*, https://doi.org/10.1111/insr.12324.

Examples

```
# Example 1: Let F be a standard normal cumulative distribution function then
f_N<-function(s){dnorm(s, mean = 0,sd = 1)} # density function of N(0,1)
F_N<-function(s){pnorm(s, mean = 0,sd = 1)} # distribution function of N(0,1)
QF_N<-function(beta){qnorm(beta, mean = 0, sd = 1, lower.tail = TRUE, log.p = FALSE)}
rnum<-rnorm(100)
beta=c(0.25,0.50,0.75)

# Density
dQBAD(y=rnum,mu=0,phi=1,alpha=.5,f=f_N)

# Distribution function
pQBAD(q=rnum,mu=0,phi=1,alpha=.5,F=F_N)

# Quantile function
qQBAD(beta=beta,mu=0,phi=1,alpha=.5,F=F_N,QF=QF_N)
qQBAD(beta=beta,mu=0,phi=1,alpha=.5,F=F_N)

# random sample generation
rQBAD(n=100,mu=0,phi=1,alpha=.5,QF=QF_N)
rQBAD(n=100,mu=0,phi=1,alpha=.5,F=F_N)



# Example 2: Let F be a standard Laplace cumulative distribution function then
f_La<-function(s){0.5*exp(-abs(s))} # density function of Laplace(0,1)
F_La<-function(s){0.5+0.5*sign(s)*(1-exp(-abs(s)))} # distribution function of Laplace(0,1)
QF_La<-function(beta){-sign(beta-0.5)*log(1-2*abs(beta-0.5))}
rnum<-rnorm(100)
beta=c(0.25,0.50,0.75)
```

```
# Density
dQBAD(y=rnum,mu=0,phi=1,alpha=.5,f=f_La)

# Distribution function
pQBAD(q=rnum,mu=0,phi=1,alpha=.5,F=F_La)

# Quantile function
qQBAD(beta=c(0.25,0.50,0.75),mu=0,phi=1,alpha=.5,F=F_La,QF=QF_La)
qQBAD(beta=c(0.25,0.50,0.75),mu=0,phi=1,alpha=.5,F=F_La)

# random sample generation
rQBAD(n=100,mu=0,phi=1,alpha=.5,QF=QF_La)
rQBAD(n=100,mu=0,phi=1,alpha=.5,F=F_La)
```

SemiQRegALaD *Semiparametric quantile regression in quantile-based asymmetric Laplace distributional settings.*

Description

The local polynomial technique is used to estimate location and scale function of the quantile-based asymmetric Laplace distribution discussed in Gijbels et al. (2019c). The semiparametric quantile estimation technique is used to estimate βth conditional quantile function in quantile-based asymmetric Laplace distributional setting discussed in Gijbels et al. (2019b) and Gijbels et al. (2019c).

Usage

```
locpolALaD_x0(x, y, p1 = 1, p2 = 1, h, alpha = 0.5, x0,
  tol = 1e-08)

locpolALaD(x, y, p1 = 1, p2 = 1, h, alpha = 0.5, m = 101)

SemiQRegALaD(beta, x, y, p1 = 1, p2 = 1, h, alpha = NULL, m = 101)
```

Arguments

x	This a conditioning covariate.
y	The is a response variable.
p1	This is the order of the Taylor expansion for the location function (i.e.,$\mu(X)$) in local polynomial fitting technique. The default value is 1.
p2	This is the order of the Taylor expansion for the log of scale function (i.e., $\ln[\phi(X)]$) in local polynomial fitting technique. The default value is 1.
h	This is the bandwidth parameter h.

alpha	This is the index parameter α of the quantile-based asymmetric Laplace density. The default value is 0.5 in the codes code locpolALaD_x0 and code locpolALaD. The default value of α is NULL in the code SemiQRegALaD. In this case, the α will be estimated based on the residuals of local linear mean regression.
x0	This is a grid-point x_0 at which the function is to be estimated.
tol	the desired accuracy. See details in optimize.
m	This is the number of grid points at which the functions are to be evaluated. The default value is 101.
beta	This is a specific probability for estimating βth quantile function.

Value

The code locpolALaD_x0 provides the realized value of the local maximum likelihood estimator of $\widehat{\theta}_{rj}(x_0)$ for $(r \in \{1,2\}; j = 1,2,...,p_r)$ with the estimated approximate asymptotic bias and variance at the grind point x_0 discussed in Gijbels et al. (2019c).

The code locpolALaD provides the realized value of the local maximum likelihood estimator of $\widehat{\theta}_{r0}(x_0)$ for $(r \in \{1,2\})$ with the estimated approximate asymptotic bias and variance at all m grind points x_0 discussed in Gijbels et al. (2019c).

The code SemiQRegALaD provides the realized value of the βth conditional quantile estimator by using semiparametric quantile regression technique discussed in Gijbels et al. (2019b) and Gijbels et al. (2019c).

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019b). Quantile estimation in a generalized asymmetric distributional setting. To appear in *Springer Proceedings in Mathematics & Statistics, Proceedings of 'SMSA 2019', the 14th Workshop on Stochastic Models, Statistics and their Application*, Dresden, Germany, in March 6–8, 2019. Editors: Ansgar Steland, Ewaryst Rafajlowicz, Ostap Okhrin.

Gijbels, I., Karim, R. and Verhasselt, A. (2019c). Semiparametric quantile regression using quantile-based asymmetric family of densities. Manuscript.

Examples

```
data(Hurricane)
locpolALaD_x0(Hurricane$Year, Hurricane$WmaxST, p1=1,p2=1,h=2.18,
 alpha=0.16,x0=median(Hurricane$Year))


data(Hurricane)
locpolALaD(Hurricane$Year, Hurricane$WmaxST, p1=1,p2=1,h=2.18, alpha=0.16)


## For Hurricane Data
data(Hurricane)
Hurricane<-Hurricane[which(Hurricane$Year>1970),]

plot(Hurricane$Year,Hurricane$WmaxST)
```

```
h=2.181082
alpha=0.1649765
gridPoints=101
fit_ALaD <-locpolALaD(Hurricane$Year, Hurricane$WmaxST, p1=1,p2=1,h=h, alpha=alpha, m = gridPoints)
str(fit_ALaD)
par(mgp=c(2,.4,0),mar=c(5,4,4,1)+0.01)

# For phi plot
plot(fit_ALaD$x0,exp(fit_ALaD$theta_20),ylab=expression(widehat(phi)(x[0])),xlab="Year",
type="l",font.lab=2,cex.lab=1.5,bty="l",cex.axis=1.5,lwd =3)

## For theta2 plot
plot(fit_ALaD$x0,fit_ALaD$theta_20,ylab=expression(bold(widehat(theta[2]))(x[0])),
xlab="Year",type="l",col=c(1), lty=1, font.lab=1,cex.lab=1.5,bty="l",cex.axis=1.3,lwd =3)



#### Estimated Quantile lines by ALaD
par(mgp=c(2.5, 1, 0),mar=c(5,4,4,1)+0.01)
# X11()
plot(Hurricane$Year, Hurricane$WmaxST, xlab = "Year",ylim=c(20,210),
ylab = "Maximum Wind Spreed",font.lab=1,cex.lab=1.3,bty="l",pch=20,cex.axis=1.3)

lines(fit_ALaD$x0,fit_ALaD$theta_10, type='l',col=c(4),lty=1,lwd =3)

#####  Conditioanl Quantile line for ALaD

lines(fit_ALaD$x0,SemiQRegALaD(beta=0.50,Hurricane$Year, Hurricane$WmaxST,
p1=1,p2=1, h=h,alpha=alpha,m=gridPoints)$fit_beta_ALaD,type='l',col=c(1),lty=1,lwd =3)


lines(fit_ALaD$x0,SemiQRegALaD(beta=0.90,Hurricane$Year, Hurricane$WmaxST,
p1=1,p2=1, h=h,alpha=alpha,m=gridPoints)$fit_beta_ALaD,type='l',col=c(14),lty=1,lwd =3)
lines(fit_ALaD$x0,SemiQRegALaD(beta=0.95,Hurricane$Year, Hurricane$WmaxST,
p1=1,p2=1, h=h,alpha=alpha,m=gridPoints)$fit_beta_ALaD,type='l',col=c(19),lty=1,lwd =3)

# Add local linear mean regression line
library(locpol)
fit_mean<-locpol(WmaxST~Year, data=Hurricane,kernel=gaussK,deg=1,
xeval=NULL,xevalLen=101)

lines(fit_mean$lpFit[,1], fit_mean$lpFit[,2],type='l',col=c(2),lty=1,lwd =3)
axis(1, at = c(1975, 1985, 1995,2005,2015),cex.axis=1.3)
axis(2, at = c(25, 75, 125,175),cex.axis=1.3)

legend("topright", legend = c(expression(beta==0.1650), expression(beta==0.50),
"Mean line",expression(beta==0.90), expression(beta==0.95)), col = c(4,1,2,14,19),
 lty=c(1,1,1,1,1), inset = 0, lwd = 3,cex=1.2)
```

SemiQRegAND *Semiparametric quantile regression in quantile-based asymmetric normal distributional settings.*

Description

The local polynomial technique is used to estimate location and scale function of the quantile-based asymmetric normal distribution discussed in Gijbels et al. (2019c). The semiparametric quantile estimation technique is used to estimate βth conditional quantile function in quantile-based asymmetric normal distributional setting discussed in Gijbels et al. (2019b) and Gijbels et al. (2019c).

Usage

```
locpolAND_x0(x, y, p1 = 1, p2 = 1, h, alpha = 0.5, x0, tol = 1e-08)

locpolAND(x, y, p1, p2, h, alpha, m = 101)

SemiQRegAND(beta, x, y, p1 = 1, p2 = 1, h, alpha = NULL, m = 101)
```

Arguments

`x`	This a conditioning covariate.
`y`	The is a response variable.
`p1`	This is the order of the Taylor expansion for the location function (i.e.,$\mu(X)$) in local polynomial fitting technique. The default value is 1.
`p2`	This is the order of the Taylor expansion for the log of scale function (i.e., $\ln[\phi(X)]$) in local polynomial fitting technique. The default value is 1.
`h`	This is the bandwidth parameter h.
`alpha`	This is the index parameter α of the quantile-based asymmetric normal density. The default value is 0.5 in the codes code `locpolAND_x0` and code `locpolAND`. The default value of α is NULL in the code `SemiQRegAND`. In this case, α will be estimated based on the residuals from local linear mean regression.
`x0`	This is a grid-point x_0 at which the function is to be estimated.
`tol`	the desired accuracy. See details in `optimize`.
`m`	This is the number of grid points at which the functions are to be evaluated. The default value is 101.
`beta`	This is a specific probability for estimating βth quantile function.

Value

The code `locpolAND_x0` provides the realized value of the local maximum likelihood estimator of $\widehat{\theta}_{rj}(x_0)$ for $(r \in \{1,2\}; j = 1,2,...,p_r)$ with the estimated approximate asymptotic bias and variance at the grind point x_0 discussed in Gijbels et al. (2019c).

The code `locpolAND` provides the realized value of the local maximum likelihood estimator of $\widehat{\theta}_{r0}(x_0)$ for $(r \in \{1,2\})$ with the estimated approximate asymptotic bias and variance at all m grid points x_0 discussed in Gijbels et al. (2019c).

The code `SemiQRegAND` provides the realized value of the βth conditional quantile estimator by using semiparametric quantile regression technique discussed in Gijbels et al. (2019b) and Gijbels et al. (2019c).

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019b). Quantile estimation in a generalized asymmetric distributional setting. To appear in *Springer Proceedings in Mathematics & Statistics, Proceedings of 'SMSA 2019', the 14th Workshop on Stochastic Models, Statistics and their Application*, Dresden, Germany, in March 6–8, 2019. Editors: Ansgar Steland, Ewaryst Rafajlowicz, Ostap Okhrin.

Gijbels, I., Karim, R. and Verhasselt, A. (2019c). Semiparametric quantile regression using quantile-based asymmetric family of densities. Manuscript.

Examples

```
data(LocomotorPerfor)
x=log(LocomotorPerfor$Body_Mass)
y=log(LocomotorPerfor$MRRS)
h_ROT =  0.9030372
locpolAND_x0(x, y, p1=1,p2=1,h=h_ROT,alpha=0.50,x0=median(x))


data(LocomotorPerfor)
x=log(LocomotorPerfor$Body_Mass)
y=log(LocomotorPerfor$MRRS)
h_ROT =  0.9030372
locpolAND(x, y, p1=1,p2=1,h=h_ROT, alpha=0.50)


# Data
data(LocomotorPerfor)
x=log(LocomotorPerfor$Body_Mass)
y=log(LocomotorPerfor$MRRS)
h_ROT =  0.9030372
gridPoints=101
alpha= 0.5937
plot(x,y)
# location and scale functions estimation at the grid point x0
gridPoints=101
fit_AND <-locpolAND(x, y, p1=1,p2=1,h=h_ROT, alpha=alpha, m = gridPoints)
par(mgp=c(2,.4,0),mar=c(5,4,4,1)+0.01)

# For phi plot
plot(fit_AND$x0,exp(fit_AND$theta_20),ylab=expression(widehat(phi)(x[0])),
xlab="log(Body mass)",type="l",font.lab=2,cex.lab=1.5,
bty="l",cex.axis=1.5,lwd =3)
```

```
## For theta2 plot
plot(fit_AND$x0,fit_AND$theta_20,ylab=expression(bold(widehat(theta[2]))(x[0])),
xlab="log(Body mass)",type="l",col=c(1), lty=1, font.lab=1,cex.lab=1.5,
bty="l",cex.axis=1.3,lwd =3)



par(mgp=c(2.5, 1, 0),mar=c(5,4,4,1)+0.01)
# X11(width=7, height=7)
plot(x,y, ylim=c(0,4.5),xlab = "log(Body mass (kg))",
ylab = "log(Maximum relative running speed)",font.lab=1.5,
cex.lab=1.5,bty="l",pch=20,cex.axis=1.5)

lines(fit_AND$x0,fit_AND$theta_10, type='l',col=c(4),lty=6,lwd =3)
lines(fit_AND$x0,SemiQRegAND(beta=0.50,x, y,
p1=1,p2=1, h=h_ROT,alpha=alpha,m=gridPoints)$fit_beta_AND,
type='l',col=c(1),lty=5,lwd =3)
lines(fit_AND$x0,SemiQRegAND(beta=0.90,x, y,
p1=1,p2=1, h=h_ROT,alpha=alpha,m=gridPoints)$fit_beta_AND,type='l',col=c(14),lty=4,lwd =3)
lines(fit_AND$x0,SemiQRegAND(beta=0.10,x, y,
p1=1,p2=1, h=h_ROT,alpha=alpha,m=gridPoints)$fit_beta_AND,type='l',
col=c(19),lty=2,lwd =3)

legend("topright", legend = c(expression(beta==0.10),
                              expression(beta==0.50), expression(beta==0.5937),
                             expression(beta==0.90)), col = c(19,1,4,14), lty=c(2,5,6,4),
      adj = c(.07, 0.5),, inset = c(0.05, +0.01), lwd = 3,cex=1.2)
```

SemiQRegGALaD — *Semiparametric quantile regression in generalized Laplace distributional settings.*

Description

The local polynomial technique is used to estimate location and scale functions of the quantile-based asymmetric Laplace distribution as discussed in Gijbels et al. (2019c). Using these estimates, the quantile function of the generalized asymmetric Laplace distribution will be estimated. A detailed study can be found in Gijbels et al. (2019b).

Usage

```
SemiQRegGALaD(beta, x, y, p1 = 1, p2 = 1, h, alpha = NULL, g,
  lower = -Inf, upper = Inf, m = 101)
```

Arguments

`beta` This is a specific probability for estimating βth quantile function.

x	This is a conditioning covariate.
y	The is a response variable.
p1	This is the order of the Taylor expansion for the location function (i.e.,$\mu(X)$) in local polynomial fitting technique. The default value is 1.
p2	This is the order of the Taylor expansion for the log of scale function (i.e., $\ln[\phi(X)]$) in local polynomial fitting technique. The default value is 1.
h	This is the bandwidth parameter h.
alpha	This is the index parameter α of the generalized asymmetric Laplace density. The default value of α is NULL in the code SemiQRegGALaD. In this case, the α will be estimated based on the residuals form local linear mean regression.
g	This is the "link" function. The function g is to be differentiated. Therefore, g must be written as a function. For example, g<-function(y){log(y)} for log link function.
lower	This is the lower limit of the domain (support of the random variable) $f_\alpha^g(y;\eta,\phi)$, default -Inf.
upper	This is the upper limit of the domain (support of the random variable) $f_\alpha^g(y;\eta,\phi)$, default Inf.
m	This is the number of grid points at which the functions are to be evaluated. The default value is 101.

Value

The code SemiQRegGALaD provides the realized value of the βth conditional quantile estimator by using semiparametric quantile regression technique discussed in Gijbels et al. (2019b) and Gijbels et al. (2019c).

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019b). Quantile estimation in a generalized asymmetric distributional setting. To appear in *Springer Proceedings in Mathematics & Statistics, Proceedings of 'SMSA 2019', the 14th Workshop on Stochastic Models, Statistics and their Application*, Dresden, Germany, in March 6–8, 2019. Editors: Ansgar Steland, Ewaryst Rafajlowicz, Ostap Okhrin.

Gijbels, I., Karim, R. and Verhasselt, A. (2019c). Semiparametric quantile regression using quantile-based asymmetric family of densities. Manuscript.

Examples

```
data(LocomotorPerfor)
x=log(LocomotorPerfor$Body_Mass)
y=LocomotorPerfor$MRRS

# For log-link function
g_log<-function(y){log(y)}
h_ROT =  0.9030372
fit<-SemiQRegGALaD(beta=0.90,x,y,p1=1,p2=1,h=h_ROT,g=g_log,lower=0)
```

```
plot(x,y)
lines(fit$x0,fit$qf_g)
```

SemiQRegGAND *Semiparametric quantile regression in generalized normal distributional settings.*

Description

The local polynomial technique is used to estimate location and scale function of the quantile-based asymmetric normal distribution discussed in Gijbels et al. (2019b) and Gijbels et al. (2019c). Using these estimates, the quantile function of the generalized asymmetric normal distribution will be estimated. A detailed study can be found in Gijbels et al. (2019b).

Usage

```
SemiQRegGAND(beta, x, y, p1 = 1, p2 = 1, h, alpha = NULL, g,
  lower = -Inf, upper = Inf, m = 101)
```

Arguments

beta	This is a specific probability for estimating βth quantile function.
x	This is a conditioning covariate.
y	The is a response variable.
p1	This is the order of the Taylor expansion for the location function (i.e.,$\mu(X)$) in local polynomial fitting technique. The default value is 1.
p2	This is the order of the Taylor expansion for the log of scale function (i.e., $\ln[\phi(X)]$) in local polynomial fitting technique. The default value is 1.
h	This is the bandwidth parameter h.
alpha	This is the index parameter α of the generalized asymmetric normal density. The default value of α is NULL in the code SemiQRegGAND. In this case, the α will be estimated based on the residuals from local linear mean regression.
g	This is the "link" function. The function g is to be differentiated. Therefore, g must be written as a function. For example, g<-function(y){log(y)} for log link function.
lower	This is the lower limit of the domain (support of the random variable) $f_{\alpha}^{g}(y;\eta,\phi)$, default -Inf.
upper	This is the upper limit of the domain (support of the random variable) $f_{\alpha}^{g}(y;\eta,\phi)$, default Inf.
m	This is the number of grid points at which the functions are to be evaluated. The default value is 101.

Value

The code `SemiQRegGAND` provides the realized value of the βth conditional quantile estimator by using semiparametric quantile regression technique discussed in Gijbels et al. (2019b) and Gijbels et al. (2019c).

References

Gijbels, I., Karim, R. and Verhasselt, A. (2019b). Quantile estimation in a generalized asymmetric distributional setting. To appear in *Springer Proceedings in Mathematics & Statistics, Proceedings of 'SMSA 2019', the 14th Workshop on Stochastic Models, Statistics and their Application*, Dresden, Germany, in March 6–8, 2019. Editors: Ansgar Steland, Ewaryst Rafajlowicz, Ostap Okhrin.

Gijbels, I., Karim, R. and Verhasselt, A. (2019c). Semiparametric quantile regression using quantile-based asymmetric family of densities. Manuscript.

Examples

```
data(LocomotorPerfor)
x=log(LocomotorPerfor$Body_Mass)
y=LocomotorPerfor$MRRS

# For log-link function
g_log<-function(y){log(y)}
h_ROT =  0.9030372
fit<-SemiQRegGAND(beta=0.5,x,y,p1=1,p2=1,h=h_ROT,g=g_log,lower=0)
plot(x,y)
lines(fit$x0,fit$qf_g)
```

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