Package 'estimators'

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Title Parameter Estimation

Version 0.8.5

Description Implements estimation methods for parameters of common distribution families. The common d, p, q, r function family for each distribution is enriched with the ll, e, and v counterparts, computing the log-likelihood, performing estimation, and calculating the asymptotic variance - covariance matrix, respectively. Parameter estimation is performed analytically whenever possible.

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URL https://thechibo.github.io/estimators/

BugReports https://github.com/thechibo/estimators/issues

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R topics documented:

avar *Asymptotic Variance*

Description

Calculates the asymptotic variance (or variance - covariance matrix in the multidimensional case) of an estimator, given a specified family of distributions and the true parameter values.

Usage

```
avar(distr, type, ...)

vbern(prob, type = "mle")

vbinom(size, prob, type = "mle")

vcat(prob, type = "mle")

vdirichlet(alpha, type = "mle")

vexp(rate, type = "mle")

vgamma(shape, scale, type = "mle")

vgeom(prob, type = "mle")

vlaplace(mu, sigma, type = "mle")

vmultinom(size, prob, type = "mle")

vnbinom(size, prob, type = "mle")

vnorm(mean, sd, type = "mle")

vpois(lambda, type = "mle")

vweib(shape, scale, type = "mle")
```

Arguments

`distr`	A subclass of `Distribution`. The distribution family assumed.
`type`	character, case ignored. The estimator type (mle, me, or same).
`...`	extra arguments.
`alpha`, `mu`, `sigma`, `size`, `prob`, `shape`, `rate`, `scale`, `mean`, `sd`, `lambda`	numeric. Distribution parameters.

Value

A named matrix. The asymptotic covariance matrix of the estimator.

References

Ye, Z.-S. & Chen, N. (2017), Closed-form estimators for the gamma distribution derived from likelihood equations, The American Statistician 71(2), 177–181.

Van der Vaart, A. W. (2000), Asymptotic statistics, Vol. 3, Cambridge university press.

Tamae, H., Irie, K. & Kubokawa, T. (2020), A score-adjusted approach to closed-form estimators for the gamma and beta distributions, Japanese Journal of Statistics and Data Science 3, 543–561.

Mathal, A. & Moschopoulos, P. (1992), A form of multivariate gamma distribution, Annals of the Institute of Statistical Mathematics 44, 97–106.

Oikonomidis, I. & Trevezas, S. (2023), Moment-Type Estimators for the Dirichlet and the Multivariate Gamma Distributions, arXiv, https://arxiv.org/abs/2311.15025

See Also

avar_mle, avar_me, avar_same

Examples

```
# ------------------------------------------------------
# Beta Distribution Example
# ------------------------------------------------------

# Simulation
set.seed(1)
shape1 <- 1
shape2 <- 2
D <- Beta(shape1, shape2)
x <- r(D)(100)

# Likelihood - The ll Functions

llbeta(x, shape1, shape2)
ll(x, c(shape1, shape2), D)
ll(x, c(shape1, shape2), "beta")

# Point Estimation - The e Functions

ebeta(x, type = "mle")
ebeta(x, type = "me")
ebeta(x, type = "same")

mle(x, D)
me(x, D)
same(x, D)

estim(x, D, type = "mle")
```

```
# Asymptotic Variance - The v Functions

vbeta(shape1, shape2, type = "mle")
vbeta(shape1, shape2, type = "me")
vbeta(shape1, shape2, type = "same")

avar_mle(D)
avar_me(D)
avar_same(D)

avar(D, type = "mle")
```

`avar_me` *ME Asymptotic Variance*

Description

Calculates the asymptotic variance (or variance - covariance matrix in the multidimensional case) of the ME, given a specified family of distributions and the true parameter values.

Usage

```
avar_me(distr, ...)
```

Arguments

`distr`	A subclass of `Distribution`. The distribution family assumed.
`...`	extra arguments.

Value

A named matrix. The asymptotic covariance matrix of the estimator.

References

Ye, Z.-S. & Chen, N. (2017), Closed-form estimators for the gamma distribution derived from likelihood equations, The American Statistician 71(2), 177–181.

Van der Vaart, A. W. (2000), Asymptotic statistics, Vol. 3, Cambridge university press.

Tamae, H., Irie, K. & Kubokawa, T. (2020), A score-adjusted approach to closed-form estimators for the gamma and beta distributions, Japanese Journal of Statistics and Data Science 3, 543–561.

Mathal, A. & Moschopoulos, P. (1992), A form of multivariate gamma distribution, Annals of the Institute of Statistical Mathematics 44, 97–106.

Oikonomidis, I. & Trevezas, S. (2023), Moment-Type Estimators for the Dirichlet and the Multivariate Gamma Distributions, arXiv, https://arxiv.org/abs/2311.15025

See Also

avar, avar_mle, avar_same

Examples

```
# ------------------------------------------------------
# Beta Distribution Example
# ------------------------------------------------------

# Simulation
set.seed(1)
shape1 <- 1
shape2 <- 2
D <- Beta(shape1, shape2)
x <- r(D)(100)

# Likelihood - The ll Functions

llbeta(x, shape1, shape2)
ll(x, c(shape1, shape2), D)
ll(x, c(shape1, shape2), "beta")

# Point Estimation - The e Functions

ebeta(x, type = "mle")
ebeta(x, type = "me")
ebeta(x, type = "same")

mle(x, D)
me(x, D)
same(x, D)

estim(x, D, type = "mle")

# Asymptotic Variance - The v Functions

vbeta(shape1, shape2, type = "mle")
vbeta(shape1, shape2, type = "me")
vbeta(shape1, shape2, type = "same")

avar_mle(D)
avar_me(D)
avar_same(D)

avar(D, type = "mle")
```

`avar_mle` *MLE Asymptotic Variance*

Description

Calculates the asymptotic variance (or variance - covariance matrix in the multidimensional case) of the MLE, given a specified family of distributions and the true parameter values.

Usage

```
avar_mle(distr, ...)
```

Arguments

distr	A subclass of Distribution. The distribution family assumed.
...	extra arguments.

Value

A named matrix. The asymptotic covariance matrix of the estimator.

See Also

avar, avar_me, avar_same

Examples

```
# ------------------------------------------------------
# Beta Distribution Example
# ------------------------------------------------------

# Simulation
set.seed(1)
shape1 <- 1
shape2 <- 2
D <- Beta(shape1, shape2)
x <- r(D)(100)

# Likelihood - The ll Functions

llbeta(x, shape1, shape2)
ll(x, c(shape1, shape2), D)
ll(x, c(shape1, shape2), "beta")

# Point Estimation - The e Functions

ebeta(x, type = "mle")
ebeta(x, type = "me")
ebeta(x, type = "same")

mle(x, D)
me(x, D)
same(x, D)

estim(x, D, type = "mle")

# Asymptotic Variance - The v Functions

vbeta(shape1, shape2, type = "mle")
vbeta(shape1, shape2, type = "me")
```

```
vbeta(shape1, shape2, type = "same")

avar_mle(D)
avar_me(D)
avar_same(D)

avar(D, type = "mle")
```

`avar_same` *SAME Asymptotic Variance*

Description

Calculates the asymptotic variance (or variance - covariance matrix in the multidimensional case) of the SAME, given a specified family of distributions and the true parameter values.

Usage

```
avar_same(distr, ...)
```

Arguments

`distr`	A subclass of `Distribution`. The distribution family assumed.
`...`	extra arguments.

Value

A named matrix. The asymptotic covariance matrix of the estimator.

References

Ye, Z.-S. & Chen, N. (2017), Closed-form estimators for the gamma distribution derived from likelihood equations, The American Statistician 71(2), 177–181.

Van der Vaart, A. W. (2000), Asymptotic statistics, Vol. 3, Cambridge university press.

Tamae, H., Irie, K. & Kubokawa, T. (2020), A score-adjusted approach to closed-form estimators for the gamma and beta distributions, Japanese Journal of Statistics and Data Science 3, 543–561.

Mathal, A. & Moschopoulos, P. (1992), A form of multivariate gamma distribution, Annals of the Institute of Statistical Mathematics 44, 97–106.

Oikonomidis, I. & Trevezas, S. (2023), Moment-Type Estimators for the Dirichlet and the Multivariate Gamma Distributions, arXiv, https://arxiv.org/abs/2311.15025

See Also

avar, avar_mle, avar_me

Examples

```
# ------------------------------------------------------
# Beta Distribution Example
# ------------------------------------------------------

# Simulation
set.seed(1)
shape1 <- 1
shape2 <- 2
D <- Beta(shape1, shape2)
x <- r(D)(100)

# Likelihood - The ll Functions

llbeta(x, shape1, shape2)
ll(x, c(shape1, shape2), D)
ll(x, c(shape1, shape2), "beta")

# Point Estimation - The e Functions

ebeta(x, type = "mle")
ebeta(x, type = "me")
ebeta(x, type = "same")

mle(x, D)
me(x, D)
same(x, D)

estim(x, D, type = "mle")

# Asymptotic Variance - The v Functions

vbeta(shape1, shape2, type = "mle")
vbeta(shape1, shape2, type = "me")
vbeta(shape1, shape2, type = "same")

avar_mle(D)
avar_me(D)
avar_same(D)

avar(D, type = "mle")
```

Bern *Bernoulli Distribution*

Description

Bernoulli Distribution

Usage

```
Bern(prob = 0.5)

## S4 method for signature 'Bern'
d(x)

## S4 method for signature 'Bern'
p(x)

## S4 method for signature 'Bern'
qn(x)

## S4 method for signature 'Bern'
r(x)

## S4 method for signature 'Bern'
mean(x)

## S4 method for signature 'Bern'
median(x)

## S4 method for signature 'Bern'
mode(x)

## S4 method for signature 'Bern'
var(x)

## S4 method for signature 'Bern'
sd(x)

## S4 method for signature 'Bern'
skew(x)

## S4 method for signature 'Bern'
kurt(x)

## S4 method for signature 'Bern'
entro(x)

## S4 method for signature 'Bern'
finf(x)

## S4 method for signature 'numeric,numeric,Bern'
ll(x, prm, distr)

## S4 method for signature 'numeric,Bern'
mle(x, distr)
```

```
## S4 method for signature 'numeric,Bern'
me(x, distr)

## S4 method for signature 'Bern'
avar_mle(distr)

## S4 method for signature 'Bern'
avar_me(distr)
```

Arguments

x	an object of class Bern. If the function also has a distr argument, x is a numeric vector, a sample of observations.
prm, prob	numeric. The distribution parameter.
distr	an object of class Bern.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

See Also

dpqr, moments

Beta *Beta Distribution*

Description

Beta Distribution

Usage

```
Beta(shape1 = 1, shape2 = 1, ncp = 0)

## S4 method for signature 'Beta'
d(x)

## S4 method for signature 'Beta'
p(x)
```

```
## S4 method for signature 'Beta'
qn(x)

## S4 method for signature 'Beta'
r(x)

## S4 method for signature 'Beta'
mean(x)

## S4 method for signature 'Beta'
median(x)

## S4 method for signature 'Beta'
mode(x)

## S4 method for signature 'Beta'
var(x)

## S4 method for signature 'Beta'
sd(x)

## S4 method for signature 'Beta'
skew(x)

## S4 method for signature 'Beta'
kurt(x)

## S4 method for signature 'Beta'
entro(x)

## S4 method for signature 'Beta'
finf(x)

llbeta(x, shape1, shape2)

## S4 method for signature 'numeric,numeric,Beta'
ll(x, prm, distr)

## S4 method for signature 'numeric,Beta'
mle(x, distr, par0 = "same", method = "L-BFGS-B", lower = 1e-05, upper = Inf)

## S4 method for signature 'numeric,Beta'
me(x, distr)

## S4 method for signature 'numeric,Beta'
same(x, distr)
```

```
vbeta(shape1, shape2, type = "mle")

## S4 method for signature 'Beta'
avar_mle(distr)

## S4 method for signature 'Beta'
avar_me(distr)

## S4 method for signature 'Beta'
avar_same(distr)
```

Arguments

shape1, shape2, ncp	numeric. The distribution parameters.
x	an object of class Beta. If the function also has a distr argument, x is a numeric vector, a sample of observations.
prm	numeric. A vector including the distribution parameters.
distr	an object of class Beta.
par0, method, lower, upper	arguments passed to optim.
type	character, case ignored. The estimator type (mle, me, or same).

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

Binom *Binomial Distribution*

Description

Binomial Distribution

Usage

```
Binom(size = 1, prob = 0.5)

## S4 method for signature 'Binom'
d(x)

## S4 method for signature 'Binom'
p(x)

## S4 method for signature 'Binom'
qn(x)

## S4 method for signature 'Binom'
r(x)

## S4 method for signature 'Binom'
mean(x)

## S4 method for signature 'Binom'
var(x)

## S4 method for signature 'Binom'
sd(x)

## S4 method for signature 'Binom'
skew(x)

## S4 method for signature 'Binom'
kurt(x)

## S4 method for signature 'Binom'
finf(x)

## S4 method for signature 'numeric,numeric,Binom'
ll(x, prm, distr)

## S4 method for signature 'numeric,Binom'
mle(x, distr)

## S4 method for signature 'numeric,Binom'
me(x, distr)

## S4 method for signature 'Binom'
avar_mle(distr)

## S4 method for signature 'Binom'
avar_me(distr)
```

Arguments

size, prob	numeric. The distribution parameters.
x	an object of class Binom. If the function also has a distr argument, x is a numeric vector, a sample of observations.
prm	numeric. A vector including the distribution parameters.
distr	an object of class Binom.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

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calculus *Distribution Calculus*

Description

Distribution Calculus

Usage

```
## S4 method for signature 'Norm,Norm'
e1 + e2

## S4 method for signature 'numeric,Norm'
e1 + e2

## S4 method for signature 'Norm,numeric'
e1 + e2

## S4 method for signature 'Norm,Norm'
e1 - e2

## S4 method for signature 'numeric,Norm'
e1 - e2

## S4 method for signature 'Norm,numeric'
e1 - e2

## S4 method for signature 'numeric,Norm'
```

```
e1 * e2

## S4 method for signature 'Norm,numeric'
e1 * e2

## S4 method for signature 'Norm,numeric'
e1 / e2

## S4 method for signature 'Norm,logical'
sum(x, ..., na.rm = FALSE)

## S4 method for signature 'Norm'
exp(x)
```

Arguments

x, e1, e2	objects of subclass Distribution.
...	extra arguments.
na.rm	logical. Should missing values be removed?

Value

All calculations return Distribution objects (specifically, objects of a class that is a subclass of Distribution), accordingly to the property at hand.

Examples

```
# ------------------------------------------------------
# Distribution Calculus Example
# ------------------------------------------------------

library(estimators)

# Normal location - scale transformation
x <- Norm(mean = 2, sd = 3)
y <- 3 * x + 1 # Norm(mean = 7, sd = 9)

# Addition of two independent Normal random variables
x1 <- Norm(mean = 1, sd = 3)
x2 <- Norm(mean = 2, sd = 4)
x3 <- x1 + x2 # Norm(mean = 3, sd = 5)
```

Cat *Categorical Distribution*

Description

Categorical Distribution

Usage

```
Cat(prob = c(0.5, 0.5))

## S4 method for signature 'Cat'
d(x)

## S4 method for signature 'Cat'
r(x)

## S4 method for signature 'Cat'
mean(x)

## S4 method for signature 'Cat'
var(x)

## S4 method for signature 'Cat'
finf(x)

## S4 method for signature 'numeric,numeric,Cat'
ll(x, prm, distr)

## S4 method for signature 'numeric,Cat'
mle(x, distr)

## S4 method for signature 'numeric,Cat'
me(x, distr)

## S4 method for signature 'Cat'
avar_mle(distr)

## S4 method for signature 'Cat'
avar_me(distr)
```

Arguments

prob	numeric. The distribution parameters.
x	an object of class Cat. If the function also has a distr argument, x is a numeric vector, a sample of observations.
prm	numeric. A vector including the distribution parameters.
distr	an object of class Cat.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return

the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

Cauchy *Cauchy Distribution*

Description

Cauchy Distribution

Usage

```
Cauchy(location = 1, scale = 1)

## S4 method for signature 'Cauchy'
d(x)

## S4 method for signature 'Cauchy'
p(x)

## S4 method for signature 'Cauchy'
qn(x)

## S4 method for signature 'Cauchy'
r(x)

## S4 method for signature 'Cauchy'
median(x)

## S4 method for signature 'Cauchy'
mode(x)

## S4 method for signature 'Cauchy'
entro(x)

## S4 method for signature 'Cauchy'
finf(x)

## S4 method for signature 'numeric,numeric,Cauchy'
ll(x, prm, distr)
```

Arguments

`location, scale`
: numeric. The distribution parameters.

x	an object of class Cauchy. If the function also has a distr argument, x is a numeric vector, a sample of observations.
prm	numeric. A vector including the distribution parameters.
distr	an object of class Cauchy.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

Chisq *Chi-Square Distribution*

Description

Chi-Square Distribution

Usage

```
Chisq(df = 1, ncp = 0)

## S4 method for signature 'Chisq'
d(x)

## S4 method for signature 'Chisq'
p(x)

## S4 method for signature 'Chisq'
qn(x)

## S4 method for signature 'Chisq'
r(x)

## S4 method for signature 'Chisq'
mean(x)

## S4 method for signature 'Chisq'
var(x)

## S4 method for signature 'Chisq'
```

```
sd(x)

## S4 method for signature 'Chisq'
skew(x)

## S4 method for signature 'Chisq'
kurt(x)
```

Arguments

df, ncp	numeric. The distribution parameters.
x	an object of class Chisq. If the function also has a distr argument, x is a numeric vector, a sample of observations.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

Dir *Dirichlet Distribution*

Description

Dirichlet Distribution

Usage

```
Dir(alpha = c(1, 1))

## S4 method for signature 'Dir'
d(x)

## S4 method for signature 'Dir'
r(x)

## S4 method for signature 'Dir'
mean(x)

## S4 method for signature 'Dir'
mode(x)
```

```
## S4 method for signature 'Dir'
var(x)

## S4 method for signature 'Dir'
entro(x)

## S4 method for signature 'Dir'
finf(x)

## S4 method for signature 'matrix,numeric,Dir'
ll(x, prm, distr)

## S4 method for signature 'matrix,Dir'
mle(x, distr, par0 = "same", method = "L-BFGS-B", lower = 1e-05, upper = Inf)

## S4 method for signature 'matrix,Dir'
me(x, distr)

## S4 method for signature 'matrix,Dir'
same(x, distr)

## S4 method for signature 'Dir'
avar_mle(distr)

## S4 method for signature 'Dir'
avar_me(distr)

## S4 method for signature 'Dir'
avar_same(distr)
```

Arguments

`alpha`	numeric. The distribution parameters.
`x`	an object of class `Dir`. If the function also has a `distr` argument, `x` is a numeric vector, a sample of observations.
`prm`	numeric. A vector including the distribution parameters.
`distr`	an object of class `Dir`.
`par0, method, lower, upper`	arguments passed to optim.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return

the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

`Distributions` *Distribution S4 Classes*

Description

A collection of classes that provide a flexible and structured way to work with probability distributions.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

`dpqr` *The d p q r Functions*

Description

Four generic functions that take a distribution object (e.g. `Bern`) and return the density, cumulative probability, quantile, and random generator functions, respectively.

Usage

```
d(x, ...)

p(x, ...)

qn(x, ...)

r(x, ...)
```

Arguments

`x`	an object of subclass `Distribution`.
`...`	extra arguments.

Value

The d p q r functions return the density, cumulative probability, quantile, and random generator functions, respectively.

Examples

```
# ------------------------------------------------------
# Beta Distribution Example
# ------------------------------------------------------

library(estimators)

# Create the distribution
x <- Beta(3, 5)

# Density function
df <- d(x)
df(c(0.3, 0.8, 0.5))

# Probability function
pf <- p(x)
pf(c(0.3, 0.8, 0.5))

# Density function
qf <- qn(x)
qf(c(0.3, 0.8, 0.5))

# Random Generator function
rf <- r(x)
rf(5)
```

`estim` *Parameter Estimation*

Description

Estimates the parameters of a random sample according to a specified family of distributions.

Usage

```
estim(x, distr, type = "mle", ...)

ebern(x, type = "mle", ...)

ebeta(x, type = "mle", ...)

ebinom(x, type = "mle", ...)

ecat(x, type = "mle", ...)
```

```
edirichlet(x, type = "mle", ...)

eexp(x, type = "mle", ...)

egamma(x, type = "mle", ...)

egeom(x, type = "mle", ...)

elaplace(x, type = "mle", ...)

elnorm(x, type = "mle", ...)

emultinom(x, type = "mle", ...)

enbinom(x, type = "mle", ...)

enorm(x, type = "mle", ...)

epois(x, type = "mle", ...)

eunif(x, type = "mle", ...)

eweib(x, type = "mle", ...)
```

Arguments

x	numeric. A sample under estimation.
distr	A subclass of Distribution. The distribution family assumed.
type	character, case ignored. The estimator type (mle, me, or same).
...	extra arguments.

Value

numeric. The estimator produced by the sample.

References

Ye, Z.-S. & Chen, N. (2017), Closed-form estimators for the gamma distribution derived from likelihood equations, The American Statistician 71(2), 177–181.

Van der Vaart, A. W. (2000), Asymptotic statistics, Vol. 3, Cambridge university press.

Tamae, H., Irie, K. & Kubokawa, T. (2020), A score-adjusted approach to closed-form estimators for the gamma and beta distributions, Japanese Journal of Statistics and Data Science 3, 543–561.

Mathal, A. & Moschopoulos, P. (1992), A form of multivariate gamma distribution, Annals of the Institute of Statistical Mathematics 44, 97–106.

Oikonomidis, I. & Trevezas, S. (2023), Moment-Type Estimators for the Dirichlet and the Multivariate Gamma Distributions, arXiv, https://arxiv.org/abs/2311.15025

See Also

mle, me, same

Examples

```
# ------------------------------------------------
# Beta Distribution Example
# ------------------------------------------------

# Simulation
set.seed(1)
shape1 <- 1
shape2 <- 2
D <- Beta(shape1, shape2)
x <- r(D)(100)

# Likelihood - The ll Functions

llbeta(x, shape1, shape2)
ll(x, c(shape1, shape2), D)
ll(x, c(shape1, shape2), "beta")

# Point Estimation - The e Functions

ebeta(x, type = "mle")
ebeta(x, type = "me")
ebeta(x, type = "same")

mle(x, D)
me(x, D)
same(x, D)

estim(x, D, type = "mle")

# Asymptotic Variance - The v Functions

vbeta(shape1, shape2, type = "mle")
vbeta(shape1, shape2, type = "me")
vbeta(shape1, shape2, type = "same")

avar_mle(D)
avar_me(D)
avar_same(D)

avar(D, type = "mle")
```

Exp *Exponential Distribution*

Description

Exponential Distribution

Usage

```
Exp(rate = 1)

## S4 method for signature 'Exp'
d(x)

## S4 method for signature 'Exp'
p(x)

## S4 method for signature 'Exp'
qn(x)

## S4 method for signature 'Exp'
r(x)

## S4 method for signature 'Exp'
mean(x)

## S4 method for signature 'Exp'
median(x)

## S4 method for signature 'Exp'
mode(x)

## S4 method for signature 'Exp'
var(x)

## S4 method for signature 'Exp'
sd(x)

## S4 method for signature 'Exp'
skew(x)

## S4 method for signature 'Exp'
kurt(x)

## S4 method for signature 'Exp'
entro(x)

## S4 method for signature 'Exp'
finf(x)

## S4 method for signature 'numeric,numeric,Exp'
ll(x, prm, distr)
```

```
## S4 method for signature 'numeric,Exp'
mle(x, distr)

## S4 method for signature 'numeric,Exp'
me(x, distr)

## S4 method for signature 'Exp'
avar_mle(distr)

## S4 method for signature 'Exp'
avar_me(distr)
```

Arguments

rate	numeric. The distribution parameters.
x	an object of class Exp. If the function also has a distr argument, x is a numeric vector, a sample of observations.
prm	numeric. A vector including the distribution parameters.
distr	an object of class Exp.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

Fisher *Fisher Distribution*

Description

Fisher Distribution

Usage

```
Fisher(df1 = 1, df2 = 1, ncp = 0)

## S4 method for signature 'Fisher'
d(x)

## S4 method for signature 'Fisher'
```

```
p(x)

## S4 method for signature 'Fisher'
qn(x)

## S4 method for signature 'Fisher'
r(x)

## S4 method for signature 'Fisher'
mean(x)

## S4 method for signature 'Fisher'
mode(x)

## S4 method for signature 'Fisher'
var(x)

## S4 method for signature 'Fisher'
sd(x)

## S4 method for signature 'Fisher'
skew(x)
```

Arguments

df1, df2, ncp	numeric. The distribution parameters.
x	an object of class Fisher. If the function also has a distr argument, x is a numeric vector, a sample of observations.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

Gam *Gamma Distribution*

Description

Gamma Distribution

Usage

```
Gam(shape = 1, scale = 1)

## S4 method for signature 'Gam'
d(x)

## S4 method for signature 'Gam'
p(x)

## S4 method for signature 'Gam'
qn(x)

## S4 method for signature 'Gam'
r(x)

## S4 method for signature 'Gam'
mean(x)

## S4 method for signature 'Gam'
var(x)

## S4 method for signature 'Gam'
sd(x)

## S4 method for signature 'Gam'
skew(x)

## S4 method for signature 'Gam'
kurt(x)

## S4 method for signature 'Gam'
entro(x)

## S4 method for signature 'Gam'
finf(x)

## S4 method for signature 'numeric,numeric,Gam'
ll(x, prm, distr)

## S4 method for signature 'numeric,Gam'
mle(x, distr, par0 = "same", method = "L-BFGS-B", lower = 1e-05, upper = Inf)

## S4 method for signature 'numeric,Gam'
me(x, distr)

## S4 method for signature 'numeric,Gam'
same(x, distr)
```

```
## S4 method for signature 'Gam'
avar_mle(distr)

## S4 method for signature 'Gam'
avar_me(distr)

## S4 method for signature 'Gam'
avar_same(distr)
```

Arguments

shape, scale	numeric. The distribution parameters.
x	an object of class Gam. If the function also has a distr argument, x is a numeric vector, a sample of observations.
prm	numeric. A vector including the distribution parameters.
distr	an object of class Gam.
par0, method, lower, upper	arguments passed to optim.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

Geom *Geometric Distribution*

Description

Geometric Distribution

Usage

```
Geom(prob = 0.5)

## S4 method for signature 'Geom'
d(x)

## S4 method for signature 'Geom'
p(x)
```

```
## S4 method for signature 'Geom'
qn(x)

## S4 method for signature 'Geom'
r(x)

## S4 method for signature 'Geom'
mean(x)

## S4 method for signature 'Geom'
mode(x)

## S4 method for signature 'Geom'
var(x)

## S4 method for signature 'Geom'
sd(x)

## S4 method for signature 'Geom'
skew(x)

## S4 method for signature 'Geom'
kurt(x)

## S4 method for signature 'Geom'
entro(x)

## S4 method for signature 'Geom'
finf(x)

## S4 method for signature 'numeric,numeric,Geom'
ll(x, prm, distr)

## S4 method for signature 'numeric,Geom'
mle(x, distr)

## S4 method for signature 'numeric,Geom'
me(x, distr)

## S4 method for signature 'Geom'
avar_mle(distr)

## S4 method for signature 'Geom'
avar_me(distr)
```

Arguments

prob	numeric. The distribution parameters.

x	an object of class Geom. If the function also has a distr argument, x is a numeric vector, a sample of observations.
prm	numeric. A vector including the distribution parameters.
distr	an object of class Geom.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

---

idigamma *Polygamma Functions*

Description

This set of functions revolve around the polygamma functions.

Usage

```
idigamma(x)

Ddigamma(x, y)

Dtrigamma(x, y)

gammap(x, p, log = FALSE)
```

Arguments

x, y	numeric. The points to evaluate the function.
p	integer. The p-variate Gamma function.
log	logical. Should the logarithm of the result be returned?

Value

numeric. The evaluated function.

Functions

- `idigamma()`: inverse digamma function.
- `Ddigamma()`: digamma difference function.
- `Dtrigamma()`: trigamma difference function.
- `gammap()`: p-variate gamma function

Examples

```
idigamma(2)
Ddigamma(2, 3)
Dtrigamma(2, 3)
gammap(1:3, 3)
```

`Laplace` *Laplace Distribution*

Description

Laplace Distribution

Usage

```
Laplace(mu = 0, sigma = 1)

## S4 method for signature 'Laplace'
d(x)

## S4 method for signature 'Laplace'
p(x)

## S4 method for signature 'Laplace'
qn(x)

## S4 method for signature 'Laplace'
r(x)

## S4 method for signature 'Laplace'
mean(x)

## S4 method for signature 'Laplace'
median(x)

## S4 method for signature 'Laplace'
mode(x)

## S4 method for signature 'Laplace'
```

```
var(x)

## S4 method for signature 'Laplace'
sd(x)

## S4 method for signature 'Laplace'
skew(x)

## S4 method for signature 'Laplace'
kurt(x)

## S4 method for signature 'Laplace'
entro(x)

## S4 method for signature 'Laplace'
finf(x)

## S4 method for signature 'numeric,numeric,Laplace'
ll(x, prm, distr)

## S4 method for signature 'numeric,Laplace'
mle(x, distr)

## S4 method for signature 'numeric,Laplace'
me(x, distr)

## S4 method for signature 'Laplace'
avar_mle(distr)

## S4 method for signature 'Laplace'
avar_me(distr)
```

Arguments

mu, sigma	numeric. The distribution parameters.
x	an object of class Laplace. If the function also has a distr argument, x is a numeric vector, a sample of observations.
prm	numeric. A vector including the distribution parameters.
distr	an object of class Laplace.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the

corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

`large_metrics` *Large Sample Metrics*

Description

This function performs Monte Carlo simulations to estimate the asymptotic variance - covariance matrix, characterizing the large sample behavior of an estimator. The function evaluates the metrics as a function of a single parameter, keeping the other ones constant. See Details.

Usage

```
large_metrics(D, prm, est = c("same", "me", "mle"), ...)
```

Arguments

`D`	A subclass of `Distribution`. The distribution family of interest.
`prm`	A list containing three elements (name, pos, val). See Details.
`est`	character. The estimator of interest. Can be a vector.
`...`	extra arguments.

Details

The distribution `D` is used to specify an initial distribution. The list `prm` contains details concerning a single parameter that is allowed to change values. The quantity of interest is evaluated as a function of this parameter.

Specifically, `prm` includes three elements named "name", "pos", and "val". The first two elements determine the exact parameter that changes, while the third one is a numeric vector holding the values it takes. For example, in the case of the Multivariate Gamma distribution, `D <- MGamma(shape = c(1, 2), scale = 3)` and `prm <- list(name = "shape", pos = 2, val = seq(1, 1.5, by = 0.1))` means that the evaluation will be performed for the MGamma distributions with shape parameters `(1, 1)`, `(1, 1.1)`, ..., `(1, 1.5)` and scale `3`. Notice that the initial shape parameter `2` in `D` is not utilized in the function.

Value

A data.frame with columns "Row", "Col", "Parameter", "Estimator", and "Value".

See Also

small_metrics, plot_small_metrics, plot_large_metrics

Examples

```
D <- Beta(shape1 = 1, shape2 = 2)

prm <- list(name = "shape1",
            pos = NULL,
            val = seq(0.5, 2, by = 0.5))

x <- large_metrics(D, prm,
                   est = c("mle", "me", "same"))

plot_large_metrics(x)
```

---

ll *Log-Likelihood*

Description

These functions calculate the log-likelihood of an IID sample for specific values of the distribution parameters. See Details.

Usage

```
ll(x, prm, distr, ...)

## S4 method for signature 'ANY,ANY,character'
ll(x, prm, distr, ...)

llbern(x, prob)

llbinom(x, size, prob)

llcat(x, prob)

llcauchy(x, location, scale)

lldirichlet(x, alpha)

llexp(x, rate)

llgamma(x, shape, scale)

llgeom(x, prob)

lllaplace(x, mu, sigma)
```

```
lllnorm(x, meanlog, sdlog)

llMultinom(x, size, prob)

llnbinom(x, size, prob)

llnorm(x, mean, sd)

llpois(x, lambda)

llunif(x, min, max)

llweib(x, shape, scale)
```

Arguments

x	numeric. A sample under estimation.
prm	numeric. A vector of the distribution parameters.
distr	A subclass of Distribution. The distribution family assumed.
...	extra arguments.
location, alpha, mu, sigma, meanlog, sdlog, min, max, size, prob, shape, rate, scale, mean, sd, lambda	numeric. Distribution parameters.

Details

The log-likelihood functions are provided in two forms: the ll<name> distribution-specific version that follows the base R conventions, and the S4 generic ll.

Value

Numeric. The value of the log-likelihood function.

Lnorm *Lnorm Distribution*

Description

Lnorm Distribution

Usage

```
Lnorm(meanlog = 0, sdlog = 1)

## S4 method for signature 'Lnorm'
d(x)

## S4 method for signature 'Lnorm'
```

```
p(x)

## S4 method for signature 'Lnorm'
qn(x)

## S4 method for signature 'Lnorm'
r(x)

## S4 method for signature 'Lnorm'
mean(x)

## S4 method for signature 'Lnorm'
median(x)

## S4 method for signature 'Lnorm'
mode(x)

## S4 method for signature 'Lnorm'
var(x)

## S4 method for signature 'Lnorm'
sd(x)

## S4 method for signature 'Lnorm'
skew(x)

## S4 method for signature 'Lnorm'
kurt(x)

## S4 method for signature 'Lnorm'
entro(x)

## S4 method for signature 'Lnorm'
finf(x)

## S4 method for signature 'numeric,numeric,Lnorm'
ll(x, prm, distr)

## S4 method for signature 'numeric,Lnorm'
mle(x, distr)

## S4 method for signature 'numeric,Lnorm'
me(x, distr)

## S4 method for signature 'Lnorm'
avar_mle(distr)

## S4 method for signature 'Lnorm'
```

```
avar_me(distr)
```

Arguments

meanlog, sdlog	numeric. The distribution parameters.
x	an object of class Lnorm. If the function also has a distr argument, x is a numeric vector, a sample of observations.
prm	numeric. A vector including the distribution parameters.
distr	an object of class Lnorm.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

---

me *Moment Estimation*

Description

Calculates the ME under the assumption the sample observations are independent and identically distributed (iid) according to a specified family of distributions.

Usage

```
me(x, distr, ...)

## S4 method for signature 'ANY,character'
me(x, distr, ...)
```

Arguments

x	numeric. A sample under estimation.
distr	A subclass of Distribution. The distribution family assumed.
...	extra arguments.

Value

numeric. The estimator produced by the sample.

References

Ye, Z.-S. & Chen, N. (2017), Closed-form estimators for the gamma distribution derived from likelihood equations, The American Statistician 71(2), 177–181.

Van der Vaart, A. W. (2000), Asymptotic statistics, Vol. 3, Cambridge university press.

Tamae, H., Irie, K. & Kubokawa, T. (2020), A score-adjusted approach to closed-form estimators for the gamma and beta distributions, Japanese Journal of Statistics and Data Science 3, 543–561.

Mathal, A. & Moschopoulos, P. (1992), A form of multivariate gamma distribution, Annals of the Institute of Statistical Mathematics 44, 97–106.

Oikonomidis, I. & Trevezas, S. (2023), Moment-Type Estimators for the Dirichlet and the Multivariate Gamma Distributions, arXiv, https://arxiv.org/abs/2311.15025

See Also

estim, mle, same

Examples

```
# ------------------------------------------------------
# Beta Distribution Example
# ------------------------------------------------------

# Simulation
set.seed(1)
shape1 <- 1
shape2 <- 2
D <- Beta(shape1, shape2)
x <- r(D)(100)

# Likelihood - The ll Functions

llbeta(x, shape1, shape2)
ll(x, c(shape1, shape2), D)
ll(x, c(shape1, shape2), "beta")

# Point Estimation - The e Functions

ebeta(x, type = "mle")
ebeta(x, type = "me")
ebeta(x, type = "same")

mle(x, D)
me(x, D)
same(x, D)

estim(x, D, type = "mle")

# Asymptotic Variance - The v Functions

vbeta(shape1, shape2, type = "mle")
vbeta(shape1, shape2, type = "me")
```

```
vbeta(shape1, shape2, type = "same")

avar_mle(D)
avar_me(D)
avar_same(D)

avar(D, type = "mle")
```

`mle` *Maximum Likelihood Estimation*

Description

Calculates the MLE under the assumption the sample observations are independent and identically distributed (iid) according to a specified family of distributions.

Usage

```
mle(x, distr, ...)

## S4 method for signature 'ANY,character'
mle(x, distr, ...)
```

Arguments

`x`	numeric. A sample under estimation.
`distr`	A subclass of `Distribution`. The distribution family assumed.
`...`	extra arguments.

Value

numeric. The estimator produced by the sample.

References

Ye, Z.-S. & Chen, N. (2017), Closed-form estimators for the gamma distribution derived from likelihood equations, The American Statistician 71(2), 177–181.

Van der Vaart, A. W. (2000), Asymptotic statistics, Vol. 3, Cambridge university press.

Tamae, H., Irie, K. & Kubokawa, T. (2020), A score-adjusted approach to closed-form estimators for the gamma and beta distributions, Japanese Journal of Statistics and Data Science 3, 543–561.

Mathal, A. & Moschopoulos, P. (1992), A form of multivariate gamma distribution, Annals of the Institute of Statistical Mathematics 44, 97–106.

Oikonomidis, I. & Trevezas, S. (2023), Moment-Type Estimators for the Dirichlet and the Multivariate Gamma Distributions, arXiv, https://arxiv.org/abs/2311.15025

See Also

estim, me, same

Examples

```
# ------------------------------------------------------
# Beta Distribution Example
# ------------------------------------------------------

# Simulation
set.seed(1)
shape1 <- 1
shape2 <- 2
D <- Beta(shape1, shape2)
x <- r(D)(100)

# Likelihood - The ll Functions

llbeta(x, shape1, shape2)
ll(x, c(shape1, shape2), D)
ll(x, c(shape1, shape2), "beta")

# Point Estimation - The e Functions

ebeta(x, type = "mle")
ebeta(x, type = "me")
ebeta(x, type = "same")

mle(x, D)
me(x, D)
same(x, D)

estim(x, D, type = "mle")

# Asymptotic Variance - The v Functions

vbeta(shape1, shape2, type = "mle")
vbeta(shape1, shape2, type = "me")
vbeta(shape1, shape2, type = "same")

avar_mle(D)
avar_me(D)
avar_same(D)

avar(D, type = "mle")
```

`moments` *Moments - Parametric Quantities of Interest*

Description

A set of functions that calculate the theoretical moments (expectation, variance, skewness, excess kurtosis) and other important parametric functions (median, mode, entropy, Fisher information) of a distribution.

Usage

```
moments(x)

mean(x, ...)

median(x, na.rm = FALSE, ...)

mode(x)

var(x, y = NULL, na.rm = FALSE, use)

sd(x, na.rm = FALSE)

skew(x, ...)

kurt(x, ...)

entro(x, ...)

finf(x, ...)
```

Arguments

`x`	an object of a `Distribution` subclass.
`...`	extra arguments.
`y, use, na.rm`	arguments in `mean` and `var` standard methods from the `stats` package not used here.

Details

The `moments()` function automatically finds the available methods for a given distribution and results all of the results in a list.

Not all functions are available for distributions; for example, the `sd()` is available only for univariate distributions.

Value

Numeric, either vector or matrix depending on the moment and the distribution. Function `moments()` returns a list of all available methods.

Examples

```
# ------------------------------------------------------
# Beta Distribution Example
# ------------------------------------------------------

library(estimators)

# Create the distribution
x <- Beta(3, 5)

# List of all available moments
mom <- moments(x)

# Expectation
mean(x)
mom$mean

# Variance and Standard Deviation
var(x)
sd(x)

# Skewness and Excess Kurtosis
skew(x)
kurt(x)

# Entropy
entro(x)

# Fisher Information Matrix
finf(x)
```

`Multinom` *Multinomial Distribution*

Description

Multinomial Distribution

Usage

```
Multinom(size = 1, prob = c(0.5, 0.5))

## S4 method for signature 'Multinom'
d(x)

## S4 method for signature 'Multinom'
r(x)

## S4 method for signature 'Multinom'
```

```
mean(x)

## S4 method for signature 'Multinom'
var(x)

## S4 method for signature 'Multinom'
finf(x)

## S4 method for signature 'matrix,numeric,Multinom'
ll(x, prm, distr)

## S4 method for signature 'matrix,Multinom'
mle(x, distr)

## S4 method for signature 'matrix,Multinom'
me(x, distr)

## S4 method for signature 'Multinom'
avar_mle(distr)

## S4 method for signature 'Multinom'
avar_me(distr)
```

Arguments

size, prob	numeric. The distribution parameters.
x	an object of class Multinom. If the function also has a distr argument, x is a numeric vector, a sample of observations.
prm	numeric. A vector including the distribution parameters.
distr	an object of class Multinom.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

Nbinom *Negative Binomial Distribution*

Description

Negative Binomial Distribution

Usage

```
Nbinom(size = 1, prob = 0.5)

## S4 method for signature 'Nbinom'
d(x)

## S4 method for signature 'Nbinom'
p(x)

## S4 method for signature 'Nbinom'
qn(x)

## S4 method for signature 'Nbinom'
r(x)

## S4 method for signature 'Nbinom'
mean(x)

## S4 method for signature 'Nbinom'
mode(x)

## S4 method for signature 'Nbinom'
var(x)

## S4 method for signature 'Nbinom'
sd(x)

## S4 method for signature 'Nbinom'
skew(x)

## S4 method for signature 'Nbinom'
kurt(x)

## S4 method for signature 'Nbinom'
finf(x)

## S4 method for signature 'numeric,numeric,Nbinom'
ll(x, prm, distr)

## S4 method for signature 'numeric,Nbinom'
mle(x, distr)

## S4 method for signature 'numeric,Nbinom'
me(x, distr)
```

```
## S4 method for signature 'Nbinom'
avar_mle(distr)

## S4 method for signature 'Nbinom'
avar_me(distr)
```

Arguments

size, prob	numeric. The distribution parameters.
x	an object of class Nbinom. If the function also has a distr argument, x is a numeric vector, a sample of observations.
prm	numeric. A vector including the distribution parameters.
distr	an object of class Nbinom.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

Norm *Normal Distribution*

Description

Normal Distribution

Usage

```
Norm(mean = 0, sd = 1)

## S4 method for signature 'Norm'
d(x)

## S4 method for signature 'Norm'
p(x)

## S4 method for signature 'Norm'
qn(x)

## S4 method for signature 'Norm'
```

```
r(x)

## S4 method for signature 'Norm'
mean(x)

## S4 method for signature 'Norm'
median(x)

## S4 method for signature 'Norm'
mode(x)

## S4 method for signature 'Norm'
var(x)

## S4 method for signature 'Norm'
sd(x)

## S4 method for signature 'Norm'
skew(x)

## S4 method for signature 'Norm'
kurt(x)

## S4 method for signature 'Norm'
entro(x)

## S4 method for signature 'Norm'
finf(x)

## S4 method for signature 'numeric,numeric,Norm'
ll(x, prm, distr)

## S4 method for signature 'numeric,Norm'
mle(x, distr)

## S4 method for signature 'numeric,Norm'
me(x, distr)

## S4 method for signature 'Norm'
avar_mle(distr)

## S4 method for signature 'Norm'
avar_me(distr)
```

Arguments

mean, sd	numeric. The distribution parameters.
x	an object of class Norm. If the function also has a distr argument, x is a numeric

	vector, a sample of observations.
prm	numeric. A vector including the distribution parameters.
distr	an object of class Norm.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

---

plot_large_metrics *Plot Large Sample Metrics*

Description

This function provides an easy way to illustrate the output of large_metrics(), using the ggplot2 package. A grid of line charts is created for each element of the asymptotic variance - covariance matrix. Each estimator is plotted with a different color and linetype. The plot can be saved in pdf format.

Usage

```
plot_large_metrics(
  x,
  colors = NULL,
  title = NULL,
  save = FALSE,
  path = NULL,
  name = "myplot.pdf",
  width = 15,
  height = 8
)
```

Arguments

x	A data.frame. The result of small_metrics().
colors	character. The colors to be used in the plot.
title	character. The plot title.
save	logical. Should the plot be saved?
path	A path to the directory in which the plot will be saved.

name	character. The name of the output pdf file.
width	numeric. The plot width in inches.
height	numeric. The plot height in inches.

Value

The plot is returned invisibly in the form of a ggplot object.

See Also

small_metrics, large_metrics, plot_small_metrics

Examples

```
D <- Beta(shape1 = 1, shape2 = 2)

prm <- list(name = "shape1",
            pos = NULL,
            val = seq(0.5, 2, by = 0.5))

x <- small_metrics(D, prm,
                   est = c("mle", "me", "same"),
                   obs = c(20, 50),
                   sam = 1e2,
                   seed = 1)

plot_small_metrics(x)
```

---

plot_small_metrics *Plot Small Sample Metrics*

Description

This function provides an easy way to illustrate the output of small_metrics(), using the ggplot2 package. A grid of line charts is created for each metric and sample size. Each estimator is plotted with a different color and linetype. The plot can be saved in pdf format.

Usage

```
plot_small_metrics(
  x,
  colors = NULL,
  title = NULL,
  save = FALSE,
  path = NULL,
  name = "myplot.pdf",
```

```
  width = 15,
  height = 8
)
```

Arguments

x	A data.frame. The result of `small_metrics()`.
colors	character. The colors to be used in the plot.
title	character. The plot title.
save	logical. Should the plot be saved?
path	A path to the directory in which the plot will be saved.
name	character. The name of the output pdf file.
width	numeric. The plot width in inches.
height	numeric. The plot height in inches.

Value

The plot is returned invisibly in the form of a `ggplot` object.

See Also

small_metrics, large_metrics, plot_large_metrics

Examples

```
D <- Beta(shape1 = 1, shape2 = 2)

prm <- list(name = "shape1",
            pos = NULL,
            val = seq(0.5, 2, by = 0.5))

x <- small_metrics(D, prm,
                   est = c("mle", "me", "same"),
                   obs = c(20, 50),
                   sam = 1e2,
                   seed = 1)

plot_small_metrics(x)
```

Pois *Poisson Distribution*

Description

Poisson Distribution

Usage

```
Pois(lambda = 1)

## S4 method for signature 'Pois'
d(x)

## S4 method for signature 'Pois'
p(x)

## S4 method for signature 'Pois'
qn(x)

## S4 method for signature 'Pois'
r(x)

## S4 method for signature 'Pois'
mean(x)

## S4 method for signature 'Pois'
var(x)

## S4 method for signature 'Pois'
sd(x)

## S4 method for signature 'Pois'
skew(x)

## S4 method for signature 'Pois'
kurt(x)

## S4 method for signature 'Pois'
finf(x)

## S4 method for signature 'numeric,numeric,Pois'
ll(x, prm, distr)

## S4 method for signature 'numeric,Pois'
mle(x, distr)
```

```
## S4 method for signature 'numeric,Pois'
me(x, distr)

## S4 method for signature 'Pois'
avar_mle(distr)

## S4 method for signature 'Pois'
avar_me(distr)
```

Arguments

lambda	numeric. The distribution parameters.
x	an object of class Pois. If the function also has a distr argument, x is a numeric vector, a sample of observations.
prm	numeric. A vector including the distribution parameters.
distr	an object of class Pois.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

---

same *Score - Adjusted Moment Estimation*

Description

Calculates the SAME under the assumption the sample observations are independent and identically distributed (iid) according to a specified family of distributions.

Usage

```
same(x, distr, ...)

## S4 method for signature 'ANY,character'
same(x, distr, ...)
```

Arguments

x	numeric. A sample under estimation.
distr	A subclass of Distribution. The distribution family assumed.
...	extra arguments.

Value

numeric. The estimator produced by the sample.

References

Ye, Z.-S. & Chen, N. (2017), Closed-form estimators for the gamma distribution derived from likelihood equations, The American Statistician 71(2), 177–181.

Van der Vaart, A. W. (2000), Asymptotic statistics, Vol. 3, Cambridge university press.

Tamae, H., Irie, K. & Kubokawa, T. (2020), A score-adjusted approach to closed-form estimators for the gamma and beta distributions, Japanese Journal of Statistics and Data Science 3, 543–561.

Mathal, A. & Moschopoulos, P. (1992), A form of multivariate gamma distribution, Annals of the Institute of Statistical Mathematics 44, 97–106.

Oikonomidis, I. & Trevezas, S. (2023), Moment-Type Estimators for the Dirichlet and the Multivariate Gamma Distributions, arXiv, https://arxiv.org/abs/2311.15025

See Also

estim, mle, me

Examples

```
# ------------------------------------------------------
# Beta Distribution Example
# ------------------------------------------------------

# Simulation
set.seed(1)
shape1 <- 1
shape2 <- 2
D <- Beta(shape1, shape2)
x <- r(D)(100)

# Likelihood - The ll Functions

llbeta(x, shape1, shape2)
ll(x, c(shape1, shape2), D)
ll(x, c(shape1, shape2), "beta")

# Point Estimation - The e Functions

ebeta(x, type = "mle")
ebeta(x, type = "me")
ebeta(x, type = "same")

mle(x, D)
me(x, D)
same(x, D)

estim(x, D, type = "mle")
```

```
# Asymptotic Variance - The v Functions

vbeta(shape1, shape2, type = "mle")
vbeta(shape1, shape2, type = "me")
vbeta(shape1, shape2, type = "same")

avar_mle(D)
avar_me(D)
avar_same(D)

avar(D, type = "mle")
```

`small_metrics` *Small Sample Metrics*

Description

This function performs Monte Carlo simulations to estimate the main metrics (bias, variance, and RMSE) characterizing the small sample behavior of an estimator. The function evaluates the metrics as a function of a single parameter, keeping the other ones constant. See Details.

Usage

```
small_metrics(
  D,
  prm,
  est = c("same", "me", "mle"),
  obs = c(20, 50, 100),
  sam = 10000,
  seed = 1,
  ...
)
```

Arguments

`D`	A subclass of `Distribution`. The distribution family of interest.
`prm`	A list containing three elements (name, pos, val). See Details.
`est`	character. The estimator of interest. Can be a vector.
`obs`	numeric. The size of each sample. Can be a vector.
`sam`	numeric. The number of Monte Carlo samples used to estimate the metrics.
`seed`	numeric. Passed to `set.seed()` for reproducibility.
`...`	extra arguments.

Details

The distribution `D` is used to specify an initial distribution. The list `prm` contains details concerning a single parameter that is allowed to change values. The quantity of interest is evaluated as a function of this parameter.

Specifically, `prm` includes three elements named "name", "pos", and "val". The first two elements determine the exact parameter that changes, while the third one is a numeric vector holding the values it takes. For example, in the case of the Multivariate Gamma distribution, `D <- MGamma(shape = c(1, 2), scale = 3)` and `prm <- list(name = "shape", pos = 2, val = seq(1, 1.5, by = 0.1))` means that the evaluation will be performed for the MGamma distributions with shape parameters `(1, 1)`, `(1, 1.1)`, ..., `(1, 1.5)` and scale `3`. Notice that the initial shape parameter `2` in `D` is not utilized in the function.

Value

For the small sample, a data.frame with columns named "Parameter", "Observations", "Estimator", "Metric", and "Value". For the large sample, a data.frame with columns "Row", "Col", "Parameter", "Estimator", and "Value".

See Also

plot_small_metrics large_metrics, plot_large_metrics

Examples

```
D <- Beta(shape1 = 1, shape2 = 2)

prm <- list(name = "shape1",
            pos = NULL,
            val = seq(0.5, 2, by = 0.5))

x <- small_metrics(D, prm,
                   est = c("mle", "me", "same"),
                   obs = c(20, 50),
                   sam = 1e2,
                   seed = 1)

plot_small_metrics(x)
```

Stud *Student Distribution*

Description

Student Distribution

Usage

```
Stud(df = 1, ncp = 0)

## S4 method for signature 'Stud'
d(x)

## S4 method for signature 'Stud'
p(x)

## S4 method for signature 'Stud'
qn(x)

## S4 method for signature 'Stud'
r(x)

## S4 method for signature 'Stud'
mean(x)

## S4 method for signature 'Stud'
median(x)

## S4 method for signature 'Stud'
mode(x)

## S4 method for signature 'Stud'
var(x)

## S4 method for signature 'Stud'
sd(x)

## S4 method for signature 'Stud'
skew(x)

## S4 method for signature 'Stud'
kurt(x)
```

Arguments

`df, ncp`	numeric. The distribution parameters.
`x`	an object of class `Stud`. If the function also has a `distr` argument, `x` is a numeric vector, a sample of observations.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return

the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

`Unif` *Uniform Distribution*

Description

Uniform Distribution

Usage

```
Unif(min = 0, max = 1)

## S4 method for signature 'Unif'
d(x)

## S4 method for signature 'Unif'
p(x)

## S4 method for signature 'Unif'
qn(x)

## S4 method for signature 'Unif'
r(x)

## S4 method for signature 'Unif'
mean(x)

## S4 method for signature 'Unif'
var(x)

## S4 method for signature 'Unif'
sd(x)

## S4 method for signature 'Unif'
skew(x)

## S4 method for signature 'Unif'
kurt(x)

## S4 method for signature 'Unif'
entro(x)

## S4 method for signature 'numeric,numeric,Unif'
```

```
ll(x, prm, distr)

## S4 method for signature 'numeric,Unif'
mle(x, distr)

## S4 method for signature 'numeric,Unif'
me(x, distr)
```

Arguments

min, max	numeric. The distribution parameters.
x	an object of class Unif. If the function also has a distr argument, x is a numeric vector, a sample of observations.
prm	numeric. A vector including the distribution parameters.
distr	an object of class Unif.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

Weib *Weibull Distribution*

Description

Weibull Distribution

Usage

```
Weib(shape = 1, scale = 1)

## S4 method for signature 'Weib'
d(x)

## S4 method for signature 'Weib'
p(x)

## S4 method for signature 'Weib'
qn(x)
```

```
## S4 method for signature 'Weib'
r(x)

## S4 method for signature 'Weib'
mean(x)

## S4 method for signature 'Weib'
median(x)

## S4 method for signature 'Weib'
mode(x)

## S4 method for signature 'Weib'
var(x)

## S4 method for signature 'Weib'
sd(x)

## S4 method for signature 'Weib'
skew(x)

## S4 method for signature 'Weib'
kurt(x)

## S4 method for signature 'Weib'
entro(x)

## S4 method for signature 'numeric,numeric,Weib'
ll(x, prm, distr)

## S4 method for signature 'numeric,Weib'
mle(x, distr, par0 = "same", method = "L-BFGS-B", lower = 1e-05, upper = Inf)

## S4 method for signature 'numeric,Weib'
me(x, distr)

## S4 method for signature 'Weib'
avar_mle(distr)

## S4 method for signature 'Weib'
avar_me(distr)
```

Arguments

shape, scale	numeric. The distribution parameters.
x	an object of class Weib. If the function also has a distr argument, x is a numeric vector, a sample of observations.
prm	numeric. A vector including the distribution parameters.

`distr` an object of class `Weib`.

`par0, method, lower, upper`
arguments passed to optim.

Value

The dpqr family of functions return the evaluated density, cumulative probability, quantile, and random sample, respectively. The moments family of functions return the appropriate theoretical moment, as calculated by the distribution true parameters. The ll function returns the evaluated log-likelihood, given a sample and the theoretical parameters. The estim family of functions return the estimated parameters of the distribution, given a sample. The avar family of functions return the asymptotic variance or variance - covariance matrix (if there are two or more parameters) of the corresponding estimation method. Calculus performed on Distribution objects returns a Distribution object of the appropriate class and with the appropriate parameters.

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