Package ‘bsgof’

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Title Birnbaum-Saunders Goodness-of-Fit Test

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Depends R (>= 4.0)

Description Performs goodness of fit test for the Birnbaum-Saunders distribution and provides the maximum likelihood estimate and the method-of-moments estimate. For more details, see Park and Wang (2013) <arXiv:2308.10150>. This work was supported by the National Research Foundation of Korea (NRF) grants funded by the Korea government (MSIT) (No. 2022R1A2C1091319, RS-2023-00242528).

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BS *The Birnbaum-Saunders distribution*

Description

Density, distribution function, quantile function and random generation for the Birnbaum-Saunders distribution with alpha (shape) and beta (scale)

Usage

```
dbs(x, alpha = 1, beta = 1, log = FALSE)
pbs(q, alpha = 1, beta = 1, lower.tail = TRUE, log.p = FALSE)
qbs(p, alpha = 1, beta = 1, lower.tail = TRUE, log.p = FALSE)
rbs(n, alpha = 1, beta = 1)
```

Arguments

`x,q`	vector of quantiles.
`p`	vector of probabilities.
`n`	number of observations.
`alpha`	shape parameter.
`beta`	scale parameter.
`log, log.p`	logical; if `TRUE`, probabilities p are given as log(p).
`lower.tail`	logical; if `TRUE` (default), probabilities are $P[X \le x]$ otherwise, $P[X > x]$.

Details

The Birnbaum-Saunders distribution was proposed by Birnbaum and Saunders (1969) and its probability density function and cumulative distribution function are given by

$$f(x) = \frac{1}{\sqrt{2\pi}} \exp\left[-\frac{1}{2\alpha^2}\left(\frac{x}{\beta} + \frac{\beta}{x} - 2\right)\right] \frac{x^{-\frac{3}{2}}(x+\beta)}{2\alpha\sqrt{\beta}}$$

and

$$F(x) = \Phi\Big[\frac{1}{\alpha}\Big(\sqrt{\frac{x}{\beta}} - \sqrt{\frac{\beta}{x}}\Big)\Big],$$

where $x > 0$, $\alpha > 0$, and $\beta > 0$.

Value

`dbs` gives the density, `pbs` gives the distribution function, `qbs` gives the quantile function, and `rbs` generates random deviates.

Author(s)

Chanseok Park

References

Birnbaum, Z. W. and Saunders, S. C. (1969). A new family of life distributions. J. Appl. Probab. 6(2): 637-652.

Examples

```
dbs(1.5,  alpha=0.5, beta=1.5)
exp( dbs(1.5, alpha=0.5, beta=1.5, log=TRUE) )

pbs(2.5,  alpha=0.5, beta=1.5)
1 - pbs(2.5, alpha=0.5,beta=1.5, lower.tail = FALSE, log.p = FALSE)
1 - exp( pbs(2.5, alpha=0.5,beta=1.5, lower.tail = FALSE, log.p = TRUE) )

qbs(0.1, alpha=0.5, beta=1.5)
qbs(0.9, alpha=0.5, beta=1.5, lower.tail = FALSE, log.p = FALSE)
qbs(log(0.1), alpha=0.5, beta=1.5, lower.tail = TRUE,  log.p = TRUE)
qbs(log(0.9), alpha=0.5, beta=1.5, lower.tail = FALSE, log.p = TRUE)

rbs(n=10, alpha=0.5, beta=1.5)
```

---

bs.mle — *Maximum likelihood estimates of Birnbaum-Saunders distribution*

Description

Calculates the maximum likelihood estimates of Birnbaum-Saunders distribution.

Usage

```
bs.mle(x)
```

Arguments

x	a numeric vector of observations.

Details

The Birnbaum-Saunders distribution has the probability density function

$$f(x) = \frac{1}{\sqrt{2\pi}} \exp\left[-\frac{1}{2\alpha^2}\left(\frac{x}{\beta} + \frac{\beta}{x} - 2\right)\right] \frac{x^{-\frac{3}{2}}(x+\beta)}{2\alpha\sqrt{\beta}}$$

where $x > 0$, $\alpha > 0$, and $\beta > 0$. The parameters are estimated using the maximum likelihood method.

Value

An object of class `"bs.estimate"`, a list with parameter estimates.

Author(s)

Chanseok Park

References

Birnbaum, Z. W. and Saunders, S. C. (1969). Estimation for a Family of Life Distributions with Applications to Fatigue. J. Appl. Probab. 6(2): 328-347.

See Also

bs.mme for the parameter estimation using the methof of moments.

Examples

```
# Aluminum-Coupons data set from Birnbaum and Saunders (1969).
data = c(0.37, 0.706, 0.716, 0.746, 0.785, 0.797, 0.844, 0.855, 0.858,
0.886, 0.886, 0.93, 0.96, 0.988, 0.99, 1, 1.01, 1.016, 1.018,
1.02, 1.055, 1.085, 1.102, 1.102, 1.108, 1.115, 1.12, 1.134,
1.14, 1.199, 1.2, 1.2, 1.203, 1.222, 1.235, 1.238, 1.252, 1.258,
1.262, 1.269, 1.27, 1.29, 1.293, 1.3, 1.31, 1.313, 1.315, 1.33,
1.355, 1.39, 1.416, 1.419, 1.42, 1.42, 1.45, 1.452, 1.475, 1.478,
1.481, 1.485, 1.502, 1.505, 1.513, 1.522, 1.522, 1.53, 1.54,
1.56, 1.567, 1.578, 1.594, 1.602, 1.604, 1.608, 1.63, 1.642,
1.674, 1.73, 1.75, 1.75, 1.763, 1.768, 1.781, 1.782, 1.792, 1.82,
1.868, 1.881, 1.89, 1.893, 1.895, 1.91, 1.923, 1.94, 1.945, 2.023,
2.1, 2.13, 2.215, 2.268, 2.44)

bs.mle(data)
```

---

bs.mme *Methof-of-moments estimates of Birnbaum-Saunders distribution*

Description

Calculates the methof-of-moments estimates of Birnbaum-Saunders distribution.

Usage

```
bs.mme(x)
```

Arguments

x	a numeric vector of observations.

Details

The Birnbaum-Saunders distribution has the probability density function

$$f(x) = \frac{1}{\sqrt{2\pi}} \exp\left[-\frac{1}{2\alpha^2}\left(\frac{x}{\beta} + \frac{\beta}{x} - 2\right)\right] \frac{x^{-\frac{3}{2}}(x+\beta)}{2\alpha\sqrt{\beta}}$$

where $x > 0$, $\alpha > 0$, and $\beta > 0$.

The parameters are estimated using the methof-of-moments estimates method.

Value

An object of class `"bs.estimate"`, a list with parameter estimates.

Author(s)

Chanseok Park

References

Birnbaum, Z. W. and Saunders, S. C. (1969). Estimation for a Family of Life Distributions with Applications to Fatigue. J. Appl. Probab. 6(2): 328-347.

See Also

`bs.mle` for the parameter estimation using the maximum likelihood method.

Examples

```
# Aluminum-Coupons data set from Birnbaum and Saunders (1969).
data = c(0.37, 0.706, 0.716, 0.746, 0.785, 0.797, 0.844, 0.855, 0.858,
0.886, 0.886, 0.93, 0.96, 0.988, 0.99, 1, 1.01, 1.016, 1.018,
1.02, 1.055, 1.085, 1.102, 1.102, 1.108, 1.115, 1.12, 1.134,
1.14, 1.199, 1.2, 1.2, 1.203, 1.222, 1.235, 1.238, 1.252, 1.258,
1.262, 1.269, 1.27, 1.29, 1.293, 1.3, 1.31, 1.313, 1.315, 1.33,
1.355, 1.39, 1.416, 1.419, 1.42, 1.42, 1.45, 1.452, 1.475, 1.478,
1.481, 1.485, 1.502, 1.505, 1.513, 1.522, 1.522, 1.53, 1.54,
1.56, 1.567, 1.578, 1.594, 1.602, 1.604, 1.608, 1.63, 1.642,
1.674, 1.73, 1.75, 1.75, 1.763, 1.768, 1.781, 1.782, 1.792, 1.82,
1.868, 1.881, 1.89, 1.893, 1.895, 1.91, 1.923, 1.94, 1.945, 2.023,
2.1, 2.13, 2.215, 2.268, 2.44)

bs.mme(data)
```

`bs.plot` *Birnbaum-Saunders Probability Plot*

Description

`bs.plot` produces a Birnbaum-Saunders probability plot.

Usage

```
bs.plot(x, plot.it=TRUE, a, col.line="black", lty.line=1,
     xlim=NULL, ylim=NULL, main=NULL, sub=NULL, xlab=NULL, ylab="Probability", ...)
```

Arguments

`x`	a numeric vector of data values. Missing values are allowed.
`plot.it`	logical. Should the result be plotted?
`a`	the offset fraction to be used; typically in (0,1). See `ppoints`.
`col.line`	the color of the straight line.
`lty.line`	the line type of the straight line.
`xlim`	the x limits of the plot.
`ylim`	the y limits of the plot.
`main`	a main title for the plot, see also `title`.
`sub`	a sub title for the plot.
`xlab`	a label for the x axis, defaults to a description of x.
`ylab`	a label for the y axis, defaults to "Probability".
`...`	graphical parameters.

Details

The Birnbaum-Saunders probability plot is based on the linearization proposed by Chang and Tang (1994).

Value

A list with the following components:

`x`	The sorted data
`w`	sqrt(x)*qnorm(p)

Author(s)

Chanseok Park

References

Chang, D. S and Tang, L. C. (1994). Graphical analysis for Birnbaum-Saunders distribution. Microelectronics Reliability 34: 17-22.

Birnbaum, Z. W. and Saunders, S. C. (1969). Estimation for a Family of Life Distributions with Applications to Fatigue. J. Appl. Probab. 6(2): 328-347.

See Also

qqnorm, qqplot.

wp.plot for the Weibull probability plot in package **weibullness**.

Examples

```
# Data set from Birnbaum and Saunders (1969).
attach(BSdata)
data = psi21k
bs.plot(data)

# Adding cosmetic lines
bs.plot(data, main="BS probability plot", lty.line=2, pch=3, col.line="red")

ticklabels=c(0.01, seq(0.1,0.9,by=0.1), seq(0.91,0.99,by=0.01) )
qn = quantile(data, probs=ticklabels)
ticksat= qnorm(ticklabels)* sqrt( qn )
hline =  qnorm( ticklabels  ) *  sqrt( qn )

abline( h=hline,    col=gray(0.5), lty=3, lwd=0.6 )
abline( v=  seq(0, 2500, by=100), col=gray(0.5), lty=3, lwd=0.5 )

abline( h= qnorm(0.5)*sqrt(median(data)), col=gray(0.1), lty=1, lwd=0.6 )
abline( v= median(data), col=gray(0.1), lty=1, lwd=0.6 )
```

---

bs.plot.quantiles *Quantile values of Birnbaum-Saunders distribution*

Description

Quantiles for the goodness of fit test for the Birnbaum-Saunders distribution from the probability plot. They are obtained from the sample correlation from the Birnbaum-Saunders probability plot. Monte Carlo iteration is 1E08.

Usage

```
bs.plot.quantiles
```

Format

This data frame contains 998 rows and 1001 columns.

Value

Quantile values between zero and one.

Author(s)

Chanseok Park

References

Park, C. and M. Wang (2023). A goodness-of-fit test for the Birnbaum-Saunders distribution based on the probability plot. *ArXiv e-prints*, 2308.10150.
doi: 10.48550/arXiv.2308.10150

`bs.test` *The Birnbaum-Saunders goodness-of-fit test from the probability plot*

Description

Performs goodness-of-fit test for the Birnbaum-Saunders distribution

Usage

```
bs.test(x, a)
bs.test.pvalue(r, n)
bs.test.critical(alpha, n)
```

Arguments

`x`	a numeric vector of data values. Missing values are allowed, but the number of non-missing values must be between 3 and 1000.
`a`	the offset fraction to be used; typically in (0,1). See `ppoints`.
`r`	the sample correlation coefficient from the Birnbaum-Saunders probability plot; r is in (0,1).
`n`	the sample size.
`alpha`	the significance level.

Details

Using the sample correlation coefficeint from the Birnbaum-Saunders probability plot, it performs the goodness fit test for the Birnbaum-Saunders distribution.

Value

A list with class "htest" containing the following components:

`statistic`	the value of the test statistic (sample correlation from the Birnbaum-Saunders probability plot)
`p.value`	the p-value for the test.
`sample.size`	sample size (missing observations are deleted).
`method`	a character string indicating the goodness fit test for the Birnbaum-Saunders distribution.
`data.name`	a character string giving the name(s) of the data.

Author(s)

Chanseok Park

References

Park, C. and M. Wang (2023). A goodness-of-fit test for the Birnbaum-Saunders distribution based on the probability plot. *ArXiv e-prints*, 2308.10150.
doi: 10.48550/arXiv.2308.10150

See Also

`ks.test` for performing a one- or two-sample Kolmogorov-Smirnov test.
`shapiro.test` for performing the Shapiro-Wilk test of normality.
`wp.test`{weibullness} for performing the Weibullness test.

Examples

```
# For the goodness of fit test
x = c(1.2, 2.0, 3.3)
bs.test(x)

# p.value with r (sample correlation from the probability plot) and n (sample size) are given
bs.test.pvalue(r=0.6, n=10)

# Critical value with alpha (significane level) and n (sample size).
bs.test.critical(alpha=0.01, n=10)
```

`BSdata` *Data set*

Description

`psi21k`, `psi26k`, and `psi31k` are from Birnbaum and Saunders (1969). The fatigue lifetimes of aluminum specimens exposed to a maximum stress of 21,000 psi, 26,000 psi, 31,000 psi, respectively.

`bearings` is from McCool (1974). The fatigue lifetimes (in hours) of ten bearings.

`fatigue` is from Brown and Miller (1978). The fatigue lifetimes of cylindrical specimens subjected to combined torsional and axial loads over constant-amplitude cycles until failure.

`repair` is from Hsieh (1990). This is a maintenance data set on active repair times (in hours) for an airborne communications transceiver.

Usage

```
BSdata
```

References

Birnbaum, Z. W. and Saunders, S. C. (1969). A new family of life distributions. J. Appl. Probab. 6(2): 637-652.

McCool, J. I. (1974). Inferential techniques for Weibull populations. Aerospace Research Laboratories Report ARL T R74-0180, Wright-Patterson Air Force Base, Dayton, OH.

Rieck, J. R. and Nedelman, J. (1991). A Log-Linear Model for the Birnbaum-Saunders Distribution. Technometrics. 33, 51-60.

Brown, M. W. and Miller, K. J. (1978). Biaxial Fatigue Data. Report CEMR1/78. University of Sheffield, Dept. of Mechanical Engineering.

Hsieh, H. K. (1990). Estimating the Critical Time of Inverse Gaussian Hazard Rate. IEEE Transactions on Reliability, 39(10): 342-345.

Examples

```
# Attach data sets
attach(BSdata)
psi21k
psi26k
psi31k
bearings
fatigue
repair
```

`print.bs.estimate` *Print the estimated values*

Description

Printing objects of class "bs.estimate".

Value

No return value, printing objects of class

See Also

bs.mle, bs.mme, `print`

`print.bs.test.critical.value` *Print the critical value for bs.test*

Description

Printing objects of class "bs.test.critical.value".

Value

No return value, printing objects of class

See Also

bs.test.critical, `print`

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