

Package ‘weibullness’

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Title Goodness-of-Fit Test for Weibull Distribution (Weibullness)

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Imports methods

Suggests bsgof

Description Conducts a goodness-of-fit test for the Weibull distribution (referred to as the weibullness test) and furnishes parameter estimations for both the two-parameter and three-parameter Weibull distributions. Notably, the threshold parameter is derived through correlation from the Weibull plot. Additionally, this package conducts goodness-of-fit assessments for the exponential, Gumbel, and inverse Weibull distributions, accompanied by parameter estimations.

For more details, see Park (2017) <[doi:10.23055/ijietap.2017.24.4.2848](https://doi.org/10.23055/ijietap.2017.24.4.2848)>,

Park (2018) <[doi:10.1155/2018/6056975](https://doi.org/10.1155/2018/6056975)>, and Park (2023) <[doi:10.3390/math11143156](https://doi.org/10.3390/math11143156)>.

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Contents

ep.plot	2
ep.test	4
ep.test.critical	5
ep.test.pvalue	6
Exponential.ANOVA.Quantiles	7
gp.plot	8
gp.test	9
gp.test.critical	10
gp.test.pvalue	11
gumbel.gp	12
Gumbel.Plot.Quantiles	13
inverseWeibull	14
invweibull.mle	15
IW.Plot.Quantiles	16
iwp.plot	17
iwp.test	18
iwp.test.critical	19
iwp.test.pvalue	21
Wdata	22
weibull.ic	23
weibull.mle	24
Weibull.Plot.Quantiles	26
weibull.rm	27
weibull.threshold	28
weibull.wp	29
wp.plot	30
wp.test	32
wp.test.critical	33
wp.test.pvalue	34
Index	36

ep.plot	<i>Exponential Probability Plot</i>
---------	-------------------------------------

Description

ep.plot produces an exponential probability plot.

Usage

```
ep.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 exponential probability plot is based on taking the logarithm of the exponential cumulative distribution function.

Value

A list with the following components:

x	The sorted data
y	$-\log(1 - \text{ppoints}(n, a = a))$

Author(s)

Chanseok Park

See Also

[plot](#), [qqnorm](#), [qqplot](#), [wp.plot](#), [iwp.plot](#).
[bs.plot](#) for the Birnbaum-Saunders probability plot in package [bsgof](#).

Examples

```
x = rexp(50)
# With cosmetic lines
ep.plot(x, main="Exponential Probability Plot", col.line="red", lty.line=1, pch=3)
hline = -log(1 - c(0.01, (1:9)/10, 0.99))
abline( h=hline, col=gray(0.1), lty=3, lwd=0.5 )
abline( v=seq(0, 5, by=0.5), col=gray(0.1), lty=3, lwd=0.5 )
```

ep.test	<i>The Exponential Goodness-of-Fit Test from the Exponential Probability Plot</i>
---------	---

Description

Performs Goodness-of-fit test for the exponential distribution using the sample correlation from the exponential probability plot.

Usage

```
ep.test(x, a)
```

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 <code>ppoints()</code> .

Details

The exponential goodness-of-fit test is constructed using the sample correlation which is calculated using the associated exponential probability plot. The critical value is then looked up in `Exponential.Plot.Quantiles`. There is `print` method for class "htest".

Value

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

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

Author(s)

Chanseok Park

References

Shapiro, S. S. and M. B. Wilk (1972). An Analysis of Variance Test for the Exponential Distribution (Complete Samples). *Technometrics*, **14**(2), 355-370.

See Also

[ks.test](#) for performing the Kolmogorov-Smirnov test for the goodness of fit test of two samples.
[shapiro.test](#) for performing the Shapiro-Wilk test for normality.
[wp.test](#) for performing the Weibullness test based on the Weibull probability plot.

Examples

```
# For Exponential GOF.  
# Dataset from Section 2.5 of Shapiro and Wilk (1972).  
x = c(6, 1, -4, 8, -2, 5, 0)  
ep.test(x)
```

ep.test.critical	<i>Critical Value for the Exponential Goodness-of-Fit test</i>
------------------	--

Description

Calculates the critical value for the Weibullness test

Usage

```
ep.test.critical(alpha, n)
```

Arguments

alpha	the significance level.
n	the sample size.

Details

This function calculates the critical value for the Weibullness test which is constructed using the sample correlation from the associated Weibull plot. The critical value is then looked up in `Weibull.Plot.Quantiles`. There is `print` method for class `"ep.test.critical"`.

Value

A list with class `"ep.test.critical"` containing the following components:

sample.size	sample size (missing observations are deleted).
alpha	significance level.
critical.value	critical value.
data.name	a character string giving the name(s) of the data.

Author(s)

Chanseok Park

See Also

[ks.test](#) for performing the Kolmogorov-Smirnov test for the goodness of fit test of two samples.
[shapiro.test](#) for performing the Shapiro-Wilk test for normality.
[wp.test](#) for performing the Weibullness test.

Examples

```
# Critical value with alpha (significance level) and n (sample size).
ep.test.critical(alpha=0.0982, n=7)
```

ep.test.pvalue	<i>The p-value for the Exponential Goodness-of-Fit Test</i>
----------------	---

Description

Calculates the p-value for the exponential goodness-of-fit test which is based on the sample correlation from the exponential probability plot.

Usage

```
ep.test.pvalue(w, n)
```

Arguments

w	the ANOVA test statistic; w is in (0,1).
n	the sample size.

Details

The p-value for the exponential goodness-of-fit test which is based on the sample correlation from the exponential probability plot. There is [print](#) method for class "htest".

Value

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

statistic	the value of the test statistic (sample correlation from the exponential probability plot)
p.value	the p-value for the test.
method	a character string indicating the exponential probability test.

Author(s)

Chanseok Park

References

Shapiro, S. S. and M. B. Wilk (1972). An Analysis of Variance Test for the Exponential Distribution (Complete Samples). *Technometrics*, **14**(2), 355-370.

See Also

[ks.test](#) for performing the Kolmogorov-Smirnov test for the goodness of fit test of two samples.
[shapiro.test](#) for performing the Shapiro-Wilk test for normality.
[wp.test](#) for performing the Weibullness test.

Examples

```
# p.value with w (ANOVA statistic) and n (sample size).  
ep.test.pvalue(w=0.35593, n=7)
```

Exponential.ANOVA.Quantiles

Exponential quantile values

Description

Quantiles for the exponential goodness-of-fit test. They are obtained from the sample correlation from ANOVA test for exponential distribution. The number of Monte Carlo iterations is 1E08.

Dataset representing the quantiles and the associated critical values for the Weibullness test. They were obtained by conducting Monte Carlo simulations where the sample correlation coefficients were calculated based on ANOVA test for exponential distribution. We used 1.0E08 Monte Carlo iterations in the simulation.

Usage

```
Exponential.ANOVA.Quantiles
```

Format

This data frame contains 998 rows and 1001 columns.

`gp.plot`*Gumbel Probability Plot*

Description

`gp.plot` produces a Gumbel probability plot.

Usage

```
gp.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

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

Details

The Gumbel probability plot is based on taking the logarithm of the Gumbel cumulative distribution function twice.

Value

A list with the following components:

<code>x</code>	The sorted data
<code>y</code>	$-\log(-\log(\text{ppoints}(n,a=a)))$

Author(s)

Chanseok Park

See Also

[plot](#), [qqnorm](#), [qqplot](#), [wp.plot](#), [iwp.plot](#), [ep.plot](#).
[bs.plot](#) for the Birnbaum-Saunders probability plot in package **bsgof**.

Examples

```
x = c(-3.16, -3.07, -2.24, -1.8, -1.48, -0.92, -0.87, -0.41, -0.06, 1.15)
# With cosmetic lines
gp.plot(x, main="Gumbel Probability Plot", col.line="red",
        xlab="Lifetimes of bearings", lty.line=1, pch=3)
hline = -log(-log(c( (1:5)/100, (1:9)/10)))
abline( h=hline, col=gray(0.1), lty=3, lwd=0.5 )
abline( v=seq(-4, 2,by=0.5), col=gray(0.1), lty=3, lwd=0.5 )
```

gp.test

*Gumbel Goodness-of-Fit Test from a Gumbel Probability Plot***Description**

Performs the statistical goodness-of-fit test for the Gumbel distribution using the sample correlation from the Gumbel probability plot.

Usage

```
gp.test(x, a)
```

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()`.

Details

The Gumbel goodness-of-fit test is constructed using the sample correlation which is calculated using the associated Gumbel probability plot. The critical value is then looked up in `Gumbel.Plot.Quantiles`. There is `print` method for class "hctest".

Value

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

<code>statistic</code>	the value of the test statistic (sample correlation from the Gumbel probability plot)
<code>p.value</code>	the p-value for the test.
<code>sample.size</code>	sample size (missing observations are deleted).
<code>method</code>	a character string indicating the Gumbel goodness-of-fit test.
<code>data.name</code>	a character string giving the name(s) of the data.

Author(s)

Chanseok Park

References

Kinnison, R. (1989). Correlation Coefficient Goodness-of-Fit Test for the Extreme-Value Distribution. *The American Statistician*, **43**(2), 98-100.

Vogel, R. M. and C. N. Kroll (1989). Low-Flow Frequency Analysis Using Probability-Plot Correlation Coefficients. *Journal of Water Resources Planning and Management*, **115**, 338-357.

See Also

[ks.test](#) for performing the Kolmogorov-Smirnov test for the goodness of fit test of two samples.

[shapiro.test](#) for performing the Shapiro-Wilk test for normality.

[wp.test](#) for performing the Weibullness test.

Examples

```
# Gumbel goodness-of-fit test.  
x = c(-3.16, -3.07, -2.24, -1.8, -1.48, -0.92, -0.87, -0.41, -0.06, 1.15)  
gp.test(x)
```

gp.test.critical

Critical Value for the Gumbel Goodness-of-Fit Test

Description

Calculates the critical value for the Gumbel goodness-of-fit test

Usage

```
gp.test.critical(alpha, n)
```

Arguments

alpha the significance level.

n the sample size.

Details

This function calculates the critical value for the Gumbel Goodness-of-Fit test which is constructed using the sample correlation from the associated Gumbel probability plot. The critical value is then looked up in Gumbel.Plot.Quantiles. There is [print](#) method for class "gp.test.critical".

Value

A list with class "gp.test.critical" containing the following components:

sample.size sample size (missing observations are deleted).
 alpha significance level.
 critical.value critical value.
 data.name a character string giving the name(s) of the data.

Author(s)

Chanseok Park

References

Kinnison, R. (1989). Correlation Coefficient Goodness-of-Fit Test for the Extreme-Value Distribution. *The American Statistician*, **43**(2), 98-100.

Vogel, R. M. and C. N. Kroll (1989). Low-Flow Frequency Analysis Using Probability-Plot Correlation Coefficients. *Journal of Water Resources Planning and Management*, **115**, 338-357.

See Also

[ks.test](#) for performing the Kolmogorov-Smirnov test for the goodness of fit test of two samples.

[wp.test](#) for performing the Weibullness test.

[shapiro.test](#) for performing the Shapiro-Wilk test for normality.

Examples

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

gp.test.pvalue	<i>The p-value for the Gumbel goodness-of-Fit Test</i>
----------------	--

Description

Calculates the p-value for the Gumbel goodness-of-fit test which is based on the sample correlation from the Gumbel probability plot.

Usage

```
gp.test.pvalue(r, n)
```

Arguments

r the sample correlation coefficient from the Gumbel probability plot; r is in (0,1).
 n the sample size.

Details

The p-value for the Gumbel goodness-of-fit test which is based on the sample correlation from the Gumbel probability plot. There is `print` method for class "htest".

Value

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

statistic	the value of the test statistic (sample correlation from the Gumbel probability plot)
p.value	the p-value for the test.
method	a character string indicating the Gumbel goodness-of-fit test.

Author(s)

Chanseok Park

References

Kinnison, R. (1989). Correlation Coefficient Goodness-of-Fit Test for the Extreme-Value Distribution. *The American Statistician*, **43**(2), 98-100.

Vogel, R. M. and C. N. Kroll (1989). Low-Flow Frequency Analysis Using Probability-Plot Correlation Coefficients. *Journal of Water Resources Planning and Management*, **115**, 338-357.

See Also

[ks.test](#) for performing the Kolmogorov-Smirnov test for the goodness of fit test of two samples.
[wp.test](#) for performing the Weibullness test. [shapiro.test](#) for performing the Shapiro-Wilk test for normality.

Examples

```
# p.value with r (sample correlation from the Gumbel probability plot) and n (sample size).
gp.test.pvalue(r=0.98504, n=10)
```

gumbel.gp

Estimate of location and scale parameters of the Gumbel distribution

Description

Calculates the estimates of the location and scale parameters from the Gumbel probability plot.

Usage

```
gumbel.gp(x, n, a)
```

Arguments

- x a numeric vector of observations.
n The number of observations is needed if there is right-censoring.
a the offset fraction to be used; typically in (0,1). See `ppoints`.

Details

`gumbel.gp` obtains the estimates of the location and scale parameters using the intercept and slope estimates from the Gumbel probability plot.

Value

An object of class "gumbel.estimate", a list with two parameter estimates

Author(s)

Chanseok Park

See Also

[weibull.wp](#) for the parameter estimation using the Weibull plot.

Examples

```
x = c(-2.73, 11.69, 34.85, 7.97, -0.86, 17.46, 9.69, -7.14, 14.86, 16.85)
gumbel.gp(x)
```

Gumbel.Plot.Quantiles *Gumbel quantile values*

Description

Quantiles for the Gumbel goodness-of-fit test. They are obtained from the sample correlation from the Gumbel probability plot. The number of Monte Carlo iterations is 1E08.

Dataset representing the quantiles and the associated critical values for the Gumbel goodness-of-fit test. They were obtained by conducting Monte Carlo simulations where the sample correlation coefficients were calculated based on the Gumbel probability plot. We used 1.0E08 Monte Carlo iterations in the simulation.

Usage

```
Gumbel.Plot.Quantiles
```

Format

This data frame contains 998 rows and 1001 columns.

inverseWeibull *The inverse Weibull distribution*

Description

Density function, distribution function, quantile function, random generation, raw moments and limited moments for the Inverse Weibull distribution with parameters shape and scale.

Usage

```
dinvweibull(x, shape, scale = 1, log = FALSE)
pinvweibull(q, shape, scale = 1, lower.tail = TRUE, log.p = FALSE)
qinvweibull(p, shape, scale = 1, lower.tail = TRUE, log.p = FALSE)
rinvweibull(n, shape, scale = 1)
```

Arguments

x, q	vector of quantiles.
p	vector of probabilities.
n	number of observations. If <code>length(n) > 1</code> , the length is taken to be the number required.
shape, scale	parameters. Must be positive.
log, log.p	logical; if TRUE, probabilities or densities p are given as $\log(p)$.
lower.tail	logical; if TRUE (default), probabilities are $P[X \leq x]$, otherwise, $P[X > x]$.

Details

The probability density function of the inverse Weibull distribution with parameters shape = β and scale = θ is given by

$$f(x) = \frac{\beta(\theta/x)^\beta e^{-(\theta/x)^\beta}}{x}$$

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

The cumulative distribution function is given by

$$F(X) = \exp(-(\theta/x)^\beta)$$

Value

`dinvweibull` gives the density, `pinvweibull` gives the distribution function, `qinvweibull` gives the quantile function, and `rinvweibull` generates random deviates.

Author(s)

Chanseok Park

Examples

```
x = (-1):2
names(x) = letters[1:4]
dinvweibull(x, shape=2)
exp( dinvweibull(x, shape=2, log=TRUE) )

pinvweibull (1, shape=2)
exp(pinvweibull (1, shape=2, log=TRUE))

q = c(-1,0,1,2)
qinvweibull ( pinvweibull (q, shape=2), shape=2 )
```

invweibull.mle	<i>Maximum likelihood estimates of the two-parameter inverse Weibull distribution</i>
----------------	---

Description

Calculates the maximum likelihood estimates of the two-parameter Weibull distribution.

Usage

```
invweibull.mle(x, interval, tol = .Machine$double.eps^0.25, maxiter = 1000, trace = 0)
```

Arguments

x	a numeric vector of observations.
interval	a vector containing the end-points of the interval to be estimated for the shape parameter.
tol	the desired accuracy (convergence tolerance).
maxiter	the maximum number of iterations.
trace	integer number; if positive, tracing information is produced. Higher values giving more details.

Details

The two-parameter inverse Weibull distribution has the cumulative distribution function

$$F(X) = \exp(-(\theta/x)^\beta)$$

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

The shape (β) and scale (θ) parameters are estimated by calling `weibull.mle` on the reciprocally transformed data. The maximum likelihood estimation on the the reciprocally transformed data is performed using the method by Farnum and Booth (1997). If `interval` is missing, the interval is given by the method in Farnum and Booth (1997).

Convergence is declared either if $f(x) == 0$ or the change in x for one step of the algorithm is less than `tol` (see also `uniroot`).

If the algorithm does not converge in `maxiter` steps, a warning is printed and the current approximation is returned (see also `uniroot`).

Value

An object of class "weibull.estimate", a list with two parameter estimates.

Author(s)

Chanseok Park

References

Farnum, N. R. and P. Booth (1997). Uniqueness of Maximum Likelihood Estimators of the 2-Parameter Weibull Distribution. *IEEE Transactions on Reliability*, **46**, 523-525.

Examples

```
# Three-parameter Weibull
data = c(355,725,884,462,1092,190,166,172,188,224,267,298,355,471,
        154,101,76,811,80,249,752,305,301,386,667,212,186,127,
        121,214,242,237,355,210,253,400,401,514,211,285)
invweibull.mle(data)
```

IW.Plot.Quantiles

Inverse Weibull quantile values

Description

Quantiles for the inverse Weibullness Test. They are obtained from the sample correlation from the inverse Weibull plot. The number of Monte Carlo iterations is 1E08.

Dataset representing the quantiles and the associated critical values for the inverse Weibullness test. They were obtained by conducting Monte Carlo simulations where the sample correlation coefficients were calculated based on the inverse Weibull plot. We used 1.0E08 Monte Carlo iterations in the simulation.

Usage

```
IW.Plot.Quantiles
```

Format

This data frame contains 998 rows and 1001 columns.

References

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice* 24(4), 376-391.
doi: [10.2305/ijietap.2017.24.4.2848](https://doi.org/10.2305/ijietap.2017.24.4.2848)

iwp.plot	<i>Inverse Weibull Probability Plot</i>
----------	---

Description

iwp.plot produces an inverse Weibull probability plot.

Usage

```
iwp.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 inverse Weibull probability plot is based on taking the logarithm of the inverse Weibull cumulative distribution function twice.

Value

A list with the following components:

x	The sorted data
y	$-\log(-\log(\text{ppoints}(n,a=a)))$

Author(s)

Chanseok Park

See Also[plot](#), [qqnorm](#), [qqplot](#), [wp.plot](#).**Examples**

```
x = c(0.38, 0.41, 1.2, 0.52, 0.69, 0.89, 0.67, 1.59, 0.55, 0.59)
iwp.plot( x )

# With cosmetic lines
iwp.plot(x, main="Inverse Weibull Probability Plot", col.line="red",
        xlab="Lifetimes of bearings", lty.line=1, pch=3)
hline = -log(-log( c( (1:5)/100, (1:9)/10 ) ))
abline( h=hline, col=gray(0.1), lty=3, lwd=0.5 )
abline( v= seq(0, 2,by=0.1), col=gray(0.1), lty=3, lwd=0.5 )
```

*iwp.test**Weibullness Test from a inverse Weibull Plot*

Description

Performs the statistical test of inverse Weibullness (Goodness-of-fit test for the inverse Weibull distribution) using the sample correlation from the inverse Weibull plot.

Usage

```
iwp.test(x, a)
```

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\(\)](#).

Details

The inverse Weibullness test is constructed using the sample correlation which is calculated using the associated inverse Weibull plot. The critical value is then looked up in [IW.Plot.Quantiles](#). There is [print](#) method for class "htest".

Value

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

statistic	the value of the test statistic (sample correlation from the inverse Weibull plot)
p.value	the p-value for the test.
sample.size	sample size (missing observations are deleted).
method	a character string indicating the inverse Weibullness test.
data.name	a character string giving the name(s) of the data.

Author(s)

Chanseok Park

References

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice*, **24**(4), 376-391.

doi: [10.23055/ijietap.2017.24.4.2848](https://doi.org/10.23055/ijietap.2017.24.4.2848)

Vogel, R. M. and C. N. Kroll (1989). Low-Flow Frequency Analysis Using Probability-Plot Correlation Coefficients. *Journal of Water Resources Planning and Management*, **115**, 338-357.

See Also

[wp.test](#) for performing the Weibullness test.

[ks.test](#) for performing the Kolmogorov-Smirnov test for the goodness of fit test of two samples.

[shapiro.test](#) for performing the Shapiro-Wilk test for normality.

Examples

```
# For inverse Weibullness hypothesis test.  
attach(Wdata)  
iwp.test(urinary)
```

iwp.test.critical

Critical Value for the inverse Weibullness Test

Description

Calculates the critical value for the inverse Weibullness test

Usage

```
iwp.test.critical(alpha, n)
```

Arguments

alpha	the significance level.
n	the sample size.

Details

This function calculates the critical value for the inverse Weibullness test which is constructed using the sample correlation from the associated inverse Weibull plot. The critical value is then looked up in `IW.Plot.Quantiles`. There is `print` method for class `"iwp.test.critical"`.

Value

A list with class `"iwp.test.critical"` containing the following components:

sample.size	sample size (missing observations are deleted).
alpha	significance level.
critical.value	critical value.
data.name	a character string giving the name(s) of the data.

Author(s)

Chanseok Park

References

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice*, **24**(4), 376-391.
doi: [10.23055/ijietap.2017.24.4.2848](https://doi.org/10.23055/ijietap.2017.24.4.2848)

Vogel, R. M. and C. N. Kroll (1989). Low-Flow Frequency Analysis Using Probability-Plot Correlation Coefficients. *Journal of Water Resources Planning and Management*, **115**, 338-357.

See Also

[ks.test](#) for performing the Kolmogorov-Smirnov test for the goodness of fit test of two samples.

[shapiro.test](#) for performing the Shapiro-Wilk test for normality.

Examples

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

iwp.test.pvalue	<i>The p-value for the inverse Weibullness Test</i>
-----------------	---

Description

Calculates the p-value for the inverse Weibullness test which is based on the sample correlation from the inverse Weibull plot.

Usage

```
iwp.test.pvalue(r, n)
```

Arguments

r	the sample correlation coefficient from the Weibull plot; r is in (0,1).
n	the sample size.

Details

The p-value for the inverse Weibullness test which is based on the sample correlation from the inverse Weibull plot. There is `print` method for class "hctest".

Value

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

statistic	the value of the test statistic (sample correlation from the Weibull plot)
p.value	the p-value for the test.
method	a character string indicating the inverse Weibullness test.

Author(s)

Chanseok Park

References

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice*, **24**(4), 376-391.
doi: [10.23055/ijietap.2017.24.4.2848](https://doi.org/10.23055/ijietap.2017.24.4.2848)

Vogel, R. M. and C. N. Kroll (1989). Low-Flow Frequency Analysis Using Probability-Plot Correlation Coefficients. *Journal of Water Resources Planning and Management*, **115**, 338-357.

See Also

[ks.test](#) for performing the Kolmogorov-Smirnov test for the goodness of fit test of two samples.
[shapiro.test](#) for performing the Shapiro-Wilk test for normality.

Examples

```
# p.value with r (sample correlation from the inverse Weibull plot) and n (sample size).
iwp.test.pvalue(r=0.6, n=10)
```

Wdata

Dataset

Description

bearings: It is from Lieblein and Zelen (1956). These data are deep-groove ball bearings failure times (number of millions of revolutions) in endurance tests.

glassfiber1.5 and glassfiber15: They are from Smith and Naylor (1987). These datasets are from experimental data for the strength of glass fiber of length 1.5cm and 15cm, respectively.

urinary: It is from Santiago and Smith (2013). It is about the days in between discharge of males in nosocomial urinary tract infections in patients.

radiotherapy and radio.chemotherapy: They are from Finkelstein, D. M. (1986) and Lindsey, J. C. and L. M. Ryan (1998). These data are interval-censored observations from a study of patients with breast cancer. The measurement is the time to cosmetic deterioration of the breast for women who received radiotherapy and women who received radio-chemotherapy.

Usage

Wdata

References

Lieblein, J. and M. Zelen (1956). Statistical Investigation of the Fatigue Life of Deep-Groove Ball Bearings. *Journal of Research of the National Bureau of Standards*, 57 (5), 273-316.

Smith, R. L. and J. C. Naylor (1987). A comparison of maximum likelihood and Bayesian estimators for the three-parameter Weibull distribution. *Journal of the Royal Statistical Society. Series C (Applied Statistics)*, 36 (3), 358-369.

Santiago, E. and J. Smith (2013). Control Charts Based on the Exponential Distribution: Adapting Runs Rules for the t Chart, *Quality Engineering*, 25 (2), 85-96.

Finkelstein, D. M. (1986), A proportional hazards model for interval-censored failure time data. *Biometrics*, 42, 845-865.

Lindsey, J. C. and L. M. Ryan (1998). Tutorial in biostatistics: Methods for interval-censored data. *Stat. Med.*, 17, 219-238.

Examples

```
# Attach datasets
attach(Wdata)
bearings
glassfiber1.5
glassfiber15
```

urinary
radiotherapy
radio.chemotherapy

weibull.ic

Maximum likelihood estimates with interval censoring

Description

Calculates the maximum likelihood estimates with interval censoring using the EM Algorithm.

Usage

```
weibull.ic(X, start=c(1,1), maxits=10000, eps=1E-5)
```

Arguments

X	a numeric matrix (n x 2) of observations.
start	a starting value.
maxits	the maximum number of iterations.
eps	the desired accuracy (convergence tolerance).

Details

The expectation-maximization(EM) algorithm is used for estimating the parameters with interval-censored data.

Value

Calculates the maximum likelihood estimates with interval-censored data

Author(s)

Chanseok Park

References

Park, C. (2023). A Note on Weibull Parameter Estimation with Interval Censoring Using the EM Algorithm. *Mathematics*, **11**(14), 3156.
doi: [10.3390/math11143156](https://doi.org/10.3390/math11143156)

Lawless, J. F. (2003). *Statistical Models and Methods for Lifetime Data*, 2nd ed.; John Wiley & Sons: New York, NY.

See Also

[weibull.wp](#) for the parameter estimation using the Weibull plot with full observations. [weibull.mle](#) for the parameter estimation using the maximum likelihood method with full observations.

Examples

```
attach(Wdata)
weibull.ic(radio.chemotherapy)

# Two-parameter Weibull with full observations
weibull.ic( cbind(bearings,bearings) )

# Two-parameter Weibull with full observations (using weibull.mle)
weibull.mle(bearings, threshold=0)
```

weibull.mle

Maximum likelihood estimates of three-parameter Weibull distribution

Description

Calculates the maximum likelihood estimates of three-parameter Weibull distribution.

Usage

```
weibull.mle(x, threshold, interval, interval.threshold, extendInt="downX",
            a, tol = .Machine$double.eps^0.25, maxiter = 1000, trace = 0)
```

Arguments

x	a numeric vector of observations.
threshold	the threshold parameter value.
interval	a vector containing the end-points of the interval to be estimated for the shape parameter.
interval.threshold	a vector containing the end-points of the interval to be estimated for the threshold parameter.
extendInt	character string specifying if the interval c(left,right) should be extended or directly produce an error when f() has no differing signs at the endpoints. The default, "downX", keep lowering the the left end of the interval so that f() has different signs. See uniroot .
a	the offset fraction to be used; typically in (0,1).
tol	the desired accuracy (convergence tolerance).
maxiter	the maximum number of iterations.
trace	integer number; if positive, tracing information is produced. Higher values giving more details.

Details

The three-parameter Weibull distribution has the cumulative distribution function

$$F(x) = 1 - \exp \left[- \left(\frac{x - \theta}{\beta} \right)^\alpha \right],$$

where $x > \theta$. The shape (α) and scale (β) parameters are estimated using the maximum likelihood. The maximum likelihood estimation is performed using the method by Farnum and Booth (1997). If the threshold (θ) is missing, it is estimated by `weibull.threshold`. If `threshold=0`, then `weibull.mle` calculates the maximum likelihood estimates of the two-parameter Weibull distribution.

If `interval` is missing, the interval is given by the method in Farnum and Booth (1997).

If `interval.threshold` is missing, the interval is initially given by $(\min(x) - \text{sd}(x), \min(x))$. If this interval does not include the estimate, its lower bound is extended (see also `uniroot`).

The choice of `a` follows `ppoints` function.

Convergence is declared either if $f(x) == 0$ or the change in x for one step of the algorithm is less than `tol` (see also `uniroot`).

If the algorithm does not converge in `maxiter` steps, a warning is printed and the current approximation is returned (see also `uniroot`).

Value

An object of class "weibull.estimate", a list with two parameter estimates (if `threshold` is given) or three-parameter estimates.

Author(s)

Chanseok Park

References

Park, C. (2018). A Note on the Existence of the Location Parameter Estimate of the Three-Parameter Weibull Model Using the Weibull Plot. *Mathematical Problems in Engineering*, **2018**, 6056975.

doi: [10.1155/2018/6056975](https://doi.org/10.1155/2018/6056975)

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice*, **24**(4), 376-391.

doi: [10.23055/ijietap.2017.24.4.2848](https://doi.org/10.23055/ijietap.2017.24.4.2848)

Farnum, N. R. and P. Booth (1997). Uniqueness of Maximum Likelihood Estimators of the 2-Parameter Weibull Distribution. *IEEE Transactions on Reliability*, **46**, 523-525.

See Also

`weibull.wp` for the parameter estimation using the Weibull plot.

`weibull.rm` for robust parameter estimation using the repeated median method.

`weibull.threshold` for the estimate of the threshold parameter.

`fitdistr` for maximum-likelihood fitting of univariate distributions in package **MASS**.

Examples

```
# Three-parameter Weibull
data = c(355,725,884,462,1092,190,166,172,188,224,267,298,355,471,
        154,101,76,811,80,249,752,305,301,386,667,212,186,127,
        121,214,242,237,355,210,253,400,401,514,211,285)
weibull.mle(data)

# Two-parameter Weibull
weibull.mle(data, threshold=0)
```

Weibull.Plot.Quantiles

Weibull quantile values

Description

Quantiles for the Weibullness Test. They are obtained from the sample correlation from the Weibull plot. The number of Monte Carlo iterations is 1E08.

Dataset representing the quantiles and the associated critical values for the Weibullness test. They were obtained by conducting Monte Carlo simulations where the sample correlation coefficients were calculated based on the Weibull plot. We used 1.0E08 Monte Carlo iterations in the simulation.

Usage

```
Weibull.Plot.Quantiles
```

Format

This data frame contains 998 rows and 1001 columns.

References

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice* 24(4), 376-391.
doi: [10.23055/ijietap.2017.24.4.2848](https://doi.org/10.23055/ijietap.2017.24.4.2848)

weibull.rm	<i>Robust estimate of shape and scale parameters of Weibull using the repeated median method</i>
------------	--

Description

Calculates the estimates of the shape and scale parameters.

Usage

```
weibull.rm(x, a)
```

Arguments

`x` a numeric vector of observations.
`a` the offset fraction to be used; typically in (0,1). See `ppoints`.

Details

`weibull.rm` obtains the robust estimates of the shape and scale parameters using the intercept and slope estimates using the repeated median method from the Weibull plot.

Value

An object of class "weibull.estimate", a list with two parameter estimates

Author(s)

Chanseok Park

References

Siegel, A. F. (1982). Robust Regression Using Repeated Medians. *Biometrika*, **69**, 242-244.

See Also

[weibull.mle](#) for the parameter estimation using the maximum likelihood method.
[weibull.wp](#) for the parameter estimation using the Weibull plot.
[fitdistr](#) for maximum-likelihood fitting of univariate distributions in package **MASS**.

Examples

```
data = c(355, 725, 884, 462, 1092, 190, 166, 172, 188, 224, 267, 298, 355, 471,
        154, 101, 76, 811, 80, 249, 752, 305, 301, 386, 667, 212, 186, 127,
        121, 214, 242, 237, 355, 210, 253, 400, 401, 514, 211, 285)
weibull.rm(data)
```

weibull.threshold	<i>Estimate of threshold parameter of three-parameter Weibull distribution</i>
-------------------	--

Description

Calculates the estimate of the threshold parameter.

Usage

```
weibull.threshold(x, a, interval.threshold, extendInt="downX")
```

Arguments

x	a numeric vector of observations.
a	the offset fraction to be used; typically in (0,1).
interval.threshold	a vector containing the end-points of the interval to be estimated for the threshold parameter.
extendInt	character string specifying if the interval c(left,right) should be extended or directly produce an error when f() has no differing signs at the endpoints. The default, "downX", keep lowering the the left end of the interval so that f() has different signs. See uniroot .

Details

The three-parameter Weibull distribution has the cumulative distribution function

$$F(x) = 1 - \exp \left[- \left(\frac{x - \theta}{\beta} \right)^\alpha \right],$$

where $x > \theta$. The threshold parameter (θ) is estimated by maximizing the correlation function from the Weibull plot.

The choice of a follows [ppoints](#) function.

If interval.threshold is missing, the interval is initially given by $(\min(x) - \text{sd}(x), \min(x))$. If this interval does not include the estimate, its lower bound is extended (see also [uniroot](#)).

Value

weibull.threshold returns a numeric value.

Author(s)

Chanseok Park

References

Park, C. (2018). A Note on the Existence of the Location Parameter Estimate of the Three-Parameter Weibull Model Using the Weibull Plot. *Mathematical Problems in Engineering*, **2018**, 6056975.

doi: [10.1155/2018/6056975](https://doi.org/10.1155/2018/6056975)

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice*, **24**(4), 376-391.

doi: [10.23055/ijietap.2017.24.4.2848](https://doi.org/10.23055/ijietap.2017.24.4.2848)

See Also

[weibull.mle](#) for the maximum likelihood estimate.

[weibull.wp](#) for the parameter estimation using the Weibull plot.

Examples

```
# Data
data = c(355,725,884,462,1092,190,166,172,188,224,267,298,355,471,
        154,101,76,811,80,249,752,305,301,386,667,212,186,127,
        121,214,242,237,355,210,253,400,401,514,211,285)
weibull.threshold(data)
```

weibull.wp	<i>Estimate of shape and scale parameters of Weibull using the Weibull plot</i>
------------	---

Description

Calculates the estimates of the shape and scale parameters.

Usage

```
weibull.wp(x, n, a)
```

Arguments

x	a numeric vector of observations.
n	The number of observations is needed if there is right-censoring.
a	the offset fraction to be used; typically in (0,1). See <code>ppoints</code> .

Details

`weibull.wp` obtains the estimates of the shape and scale parameters using the intercept and slope estimates from the Weibull plot.

Value

An object of class "weibull.estimate", a list with two parameter estimates

Author(s)

Chanseok Park

References

Park, C. (2018). A Note on the Existence of the Location Parameter Estimate of the Three-Parameter Weibull Model Using the Weibull Plot. *Mathematical Problems in Engineering*, **2018**, 6056975.

doi: [10.1155/2018/6056975](https://doi.org/10.1155/2018/6056975)

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice*, **24**(4), 376-391.

doi: [10.2305/ijietap.2017.24.4.2848](https://doi.org/10.2305/ijietap.2017.24.4.2848)

See Also

[weibull.mle](#) for the parameter estimation using the maximum likelihood method.

[weibull.rm](#) for robust parameter estimation using the repeated median method.

[fitdistr](#) for maximum-likelihood fitting of univariate distributions in package **MASS**.

Examples

```
data = c(355,725,884,462,1092,190,166,172,188,224,267,298,355,471,
        154,101,76,811,80,249,752,305,301,386,667,212,186,127,
        121,214,242,237,355,210,253,400,401,514,211,285)
weibull.wp(data)
```

wp.plot

Weibull Plot

Description

wp.plot produces a Weibull plot.

Usage

```
wp.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 Weibull plot is based on taking the logarithm of the Weibull cumulative distribution function twice. The horizontal axis is logarithmic.

Value

A list with the following components:

x	The sorted data
y	$\log(-\log(1-\text{ppoints}(n,a)))$

Author(s)

Chanseok Park

See Also

[plot](#), [qqnorm](#), [qqplot](#), [iwp.plot](#), [ep.plot](#).
[bs.plot](#) for the Birnbaum-Saunders probability plot in package [bsgof](#).

Examples

```
attach(Wdata)

wp.plot(bearings)

# With cosmetic lines
wp.plot(bearings, main="Weibull Plot", col.line="red",
        xlab="Lifetimes of bearings", lty.line=1, pch=3)
hline = log(-log(1- c( (1:5)/100, (1:9)/10) ))
abline( h=hline, col=gray(0.1), lty=3, lwd=0.5 )
abline( v=seq(15, 200,by=5), col=gray(0.1), lty=3, lwd=0.5 )
```

`wp.test`*Weibullness Test from a Weibull Plot*

Description

Performs the statistical test of Weibullness (Goodness-of-fit test for the Weibull distribution) using the sample correlation from the Weibull plot.

Usage

```
wp.test(x, a)
```

Arguments

<code>x</code>	a numeric vector of data values. Missing values are allowed, but the number of non-missing values must be between 3 and 1000.
<code>a</code>	the offset fraction to be used; typically in (0,1). See <code>ppoints()</code> .

Details

The Weibullness test is constructed using the sample correlation which is calculated using the associated Weibull plot. The critical value is then looked up in `Weibull.Plot.Quantiles`. There is [print](#) method for class "htest".

Value

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

<code>statistic</code>	the value of the test statistic (sample correlation from the Weibull plot)
<code>p.value</code>	the p-value for the test.
<code>sample.size</code>	sample size (missing observations are deleted).
<code>method</code>	a character string indicating the Weibullness test.
<code>data.name</code>	a character string giving the name(s) of the data.

Author(s)

Chanseok Park

References

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice*, **24**(4), 376-391.
doi: [10.23055/ijietap.2017.24.4.2848](https://doi.org/10.23055/ijietap.2017.24.4.2848)

Vogel, R. M. and C. N. Kroll (1989). Low-Flow Frequency Analysis Using Probability-Plot Correlation Coefficients. *Journal of Water Resources Planning and Management*, **115**, 338-357.

See Also

[ks.test](#) for performing the Kolmogorov-Smirnov test for the goodness of fit test of two samples.
[shapiro.test](#) for performing the Shapiro-Wilk test for normality.

Examples

```
# For Weibullness hypothesis test.  
attach(Wdata)  
wp.test(urinary)
```

wp.test.critical	<i>Critical Value for the Weibullness Test</i>
------------------	--

Description

Calculates the critical value for the Weibullness test

Usage

```
wp.test.critical(alpha, n)
```

Arguments

alpha	the significance level.
n	the sample size.

Details

This function calculates the critical value for the Weibullness test which is constructed using the sample correlation from the associated Weibull plot. The critical value is then looked up in `Weibull.Plot.Quantiles`. There is `print` method for class `"wp.test.critical"`.

Value

A list with class `"wp.test.critical"` containing the following components:

sample.size	sample size (missing observations are deleted).
alpha	significance level.
critical.value	critical value.
data.name	a character string giving the name(s) of the data.

Author(s)

Chanseok Park

References

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice*, **24**(4), 376-391.

doi: [10.23055/ijietap.2017.24.4.2848](https://doi.org/10.23055/ijietap.2017.24.4.2848)

Vogel, R. M. and C. N. Kroll (1989). Low-Flow Frequency Analysis Using Probability-Plot Correlation Coefficients. *Journal of Water Resources Planning and Management*, **115**, 338-357.

See Also

[ks.test](#) for performing the Kolmogorov-Smirnov test for the goodness of fit test of two samples.

[shapiro.test](#) for performing the Shapiro-Wilk test for normality.

Examples

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

wp.test.pvalue

The p-value for the Weibullness Test

Description

Calculates the p-value for the Weibullness test which is based on the sample correlation from the Weibull plot.

Usage

```
wp.test.pvalue(r, n)
```

Arguments

r the sample correlation coefficient from the Weibull plot; r is in (0,1).
n the sample size.

Details

The p-value for the Weibullness test which is based on the sample correlation from the Weibull plot. There is [print](#) method for class "htest".

Value

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

statistic the value of the test statistic (sample correlation from the Weibull plot)
p.value the p-value for the test.
method a character string indicating the Weibullness test.

Author(s)

Chanseok Park

References

Park, C. (2017). Weibullness test and parameter estimation of the three-parameter Weibull model using the sample correlation coefficient. *International Journal of Industrial Engineering - Theory, Applications and Practice*, **24**(4), 376-391.

doi: [10.23055/ijietap.2017.24.4.2848](https://doi.org/10.23055/ijietap.2017.24.4.2848)

Vogel, R. M. and C. N. Kroll (1989). Low-Flow Frequency Analysis Using Probability-Plot Correlation Coefficients. *Journal of Water Resources Planning and Management*, **115**, 338-357.

See Also

[ks.test](#) for performing the Kolmogorov-Smirnov test for the goodness of fit test of two samples.

[shapiro.test](#) for performing the Shapiro-Wilk test for normality.

Examples

```
# p.value with r (sample correlation from the Weibull plot) and n (sample size).  
wp.test.pvalue(r=0.6, n=10)
```

Index

- * **Gumbel probability plot**
 - gp.test, 9
 - gp.test.critical, 10
 - gp.test.pvalue, 11
 - gumbel.gp, 12
 - Gumbel.Plot.Quantiles, 13
- * **Weibull plot**
 - Weibull.Plot.Quantiles, 26
 - weibull.rm, 27
 - weibull.threshold, 28
 - weibull.wp, 29
 - wp.test, 32
 - wp.test.critical, 33
 - wp.test.pvalue, 34
- * **critical value**
 - ep.test.critical, 5
 - gp.test.critical, 10
 - iwp.test.critical, 19
 - wp.test.critical, 33
- * **datasets**
 - Exponential.ANOVA.Quantiles, 7
 - Gumbel.Plot.Quantiles, 13
 - IW.Plot.Quantiles, 16
 - Wdata, 22
 - Weibull.Plot.Quantiles, 26
- * **distribution**
 - inverseWeibull, 14
- * **exponential probability plot**
 - ep.test, 4
 - ep.test.critical, 5
- * **hypothesis test**
 - ep.test, 4
 - gp.test, 9
 - iwp.test, 18
 - wp.test, 32
- * **interval censored**
 - weibull.ic, 23
- * **inverse Weibull plot**
 - IW.Plot.Quantiles, 16
 - iwp.test, 18
 - iwp.test.critical, 19
 - iwp.test.pvalue, 21
- * **maximum likelihood estimator**
 - invweibull.mle, 15
 - weibull.ic, 23
 - weibull.mle, 24
- * **p-value**
 - ep.test.pvalue, 6
 - gp.test.pvalue, 11
 - iwp.test.pvalue, 21
 - wp.test.pvalue, 34
- * **parameter estimate**
 - gumbel.gp, 12
 - invweibull.mle, 15
 - weibull.ic, 23
 - weibull.mle, 24
 - weibull.rm, 27
 - weibull.threshold, 28
 - weibull.wp, 29
- * **robust**
 - weibull.rm, 27
- bearings (Wdata), 22
- bs.plot, 3, 9, 31
- dinvweibull (inverseWeibull), 14
- ep.plot, 2, 9, 31
- ep.test, 4
- ep.test.critical, 5
- ep.test.pvalue, 6
- Exponential.ANOVA.Quantiles, 7
- fitdistr, 25, 27, 30
- glassfiber1.5 (Wdata), 22
- glassfiber15 (Wdata), 22
- gp.plot, 8
- gp.test, 9
- gp.test.critical, 10

gp.test.pvalue, 11
gumbel.gp, 12
Gumbel.Plot.Quantiles, 13

inverse.Weibull.Plot.Quantiles
 (IW.Plot.Quantiles), 16
inverseWeibull, 14
invweibull.mle, 15
IW.Plot.Quantiles, 16
iwp.plot, 3, 9, 17, 31
iwp.test, 18
iwp.test.critical, 19
iwp.test.pvalue, 21

ks.test, 5–7, 10–12, 19–21, 33–35

pinweibull (inverseWeibull), 14
plot, 3, 9, 18, 31
ppoints, 3, 8, 17, 25, 28, 31
print, 4–6, 9, 10, 12, 18, 20, 21, 32–34

qinvweibull (inverseWeibull), 14
qqnorm, 3, 9, 18, 31
qqplot, 3, 9, 18, 31

radio.chemotherapy (Wdata), 22
radiotherapy (Wdata), 22
rinweibull (inverseWeibull), 14

shapiro.test, 5–7, 10–12, 19–21, 33–35

title, 3, 8, 17, 31

uniroot, 16, 24, 25, 28
urinary (Wdata), 22

Wdata, 22
weibull.ic, 23
weibull.mle, 15, 23, 24, 27, 29, 30
Weibull.Plot.Quantiles, 26
weibull.rm, 25, 27, 30
weibull.threshold, 25, 28
weibull.wp, 13, 23, 25, 27, 29, 29
weibullness (wp.test), 32
wp.plot, 3, 9, 18, 30
wp.test, 5–7, 10–12, 19, 32
wp.test.critical, 33
wp.test.pvalue, 34