Package ‘exptest’

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Title Tests for Exponentiality

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`ahsanullah.exp.test` *Test for exponentiality based on Ahsanullah characterization*

Description

Performs test for the composite hypothesis of exponentiality based on the Ahsanullah characterization, see Volkova and Nikitin (2013).

Usage

```
ahsanullah.exp.test(x, simulate.p.value=FALSE, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`simulate.p.value`	a logical value indicating whether to compute p-values by Monte Carlo simulation.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The test is based on the following statistic:

$$I_n = \int_0^\infty (H_n(t) - G_n(t))dF_n(t),$$

where F_n is the empirical distribution function,

$$H_n(t) = \frac{1}{n^2}\sum_{i,j=1}^{n} 1\{|X_i - X_j| < t\}, \quad t \geq 0,$$

$$G_n(t) = \frac{1}{n^2}\sum_{i,j=1}^{n} 1\{2\min(X_i, X_j) < t\}, \quad t \geq 0.$$

Under exponentiality, one has

$$\sqrt{n}I_n \xrightarrow{d} \mathcal{N}\left(0, \frac{647}{4725}\right)$$

(see Volkova and Nikitin (2013)).

Value

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

`statistic`	the value of the test statistic.
`p.value`	the p-value for the test.
`method`	the character string "Test for exponentiality based on Ahsanullah characterization".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov and Ruslan Pusev

References

Volkova K. Yu., Nikitin Ya. Yu. (2013): Exponentiality tests based on Ahsanullah's characterization and their efficiency. — Zap. Nauchn. Sem. POMI, vol. 412, pp. 69–87 (in Russian); to be transl. in J. Math. Sci. (N.Y.).

Examples

```
ahsanullah.exp.test(rexp(25))
ahsanullah.exp.test(rgamma(25,2))
```

`atkinson.exp.test` *Atkinson test for exponentiality*

Description

Performs Atkinson test for the composite hypothesis of exponentiality, see e.g. Mimoto and Zitikis (2008).

Usage

```
atkinson.exp.test(x, p=0.99, simulate.p.value=FALSE, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`p`	a parameter of the test (see below).
`simulate.p.value`	a logical value indicating whether to compute p-values by Monte Carlo simulation.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The Atkinson test for exponentiality is based on the following statistic:

$$T_n(p) = \sqrt{n}\left|\frac{\left(n^{-1}\sum_{i=1}^{n} X_i^p\right)^{1/p}}{\overline{X}} - (\Gamma(1+p))^{\frac{1}{p}}\right|.$$

The statistic is asymptotically normal: $T_n(p) \to \left|N(0, \sigma^2(p))\right|$, where

$$\sigma^2(p) = (\Gamma(1+p))^{\frac{2}{p}}\left(-1 - \frac{1}{p^2} + \frac{\Gamma(1+2p)}{p^2\Gamma^2(1+p)}\right).$$

Value

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

`statistic`	the value of the Atkinson statistic.
`p.value`	the p-value for the test.
`method`	the character string "Atkinson test for exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov and Ruslan Pusev

References

Mimoto, N. and Zitikis, R. (2008): The Atkinson index, the Moran statistic, and testing exponentiality. — J. Japan Statist. Soc., vol. 38, pp. 187–205.

Examples

```
atkinson.exp.test(rexp(100))
atkinson.exp.test(rchisq(100,3))
```

`co.exp.test` *Test for exponentiality of Cox and Oakes*

Description

Performs Cox and Oakes test for the composite hypothesis of exponentiality, see e.g. Henze and Meintanis (2005, Sec. 2.5).

Usage

```
co.exp.test(x, simulate.p.value=FALSE, nrepl=2000)
```

Arguments

`x` a numeric vector of data values.

`simulate.p.value` a logical value indicating whether to compute p-values by Monte Carlo simulation.

`nrepl` the number of replications in Monte Carlo simulation.

Details

The Cox and Oakes test is a test for the composite hypothesis of exponentiality. The test statistic is

$$CO_n = n + \sum_{j=1}^{n} (1 - Y_j) \log Y_j,$$

where $Y_j = X_j/\overline{X}$. $(6/n)^{1/2}(CO_n/\pi)$ is asymptotically standard normal (see, e.g., Henze and Meintanis (2005, Sec. 2.5)).

Value

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

`statistic` the value of the Cox and Oakes statistic.

`p.value` the p-value for the test.

`method` the character string "Test for exponentiality based on the statistic of Cox and Oakes".

`data.name` a character string giving the name(s) of the data.

Author(s)

Alexey Novikov, Ruslan Pusev and Maxim Yakovlev

References

Henze, N. and Meintanis, S.G. (2005): Recent and classical tests for exponentiality: a partial review with comparisons. — Metrika, vol. 61, pp. 29–45.

Examples

```
co.exp.test(rexp(100))
co.exp.test(runif(100, min = 0, max = 1))
```

cvm.exp.test *Cramer-von Mises test for exponentiality*

Description

Performs Cramer-von Mises test for the composite hypothesis of exponentiality, see e.g. Henze and Meintanis (2005, Sec. 2.1).

Usage

```
cvm.exp.test(x, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The Cramer-von Mises test for exponentiality is based on the following statistic:

$$\omega_n^2 = \int_0^\infty (F_n(x) - (1 - \exp(-x)))^2 \exp(-x) dx,$$

where F_n is the empirical distribution function of the scaled data $Y_j = X_j/\overline{X}$. The p-value is computed by Monte Carlo simulation.

Value

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

`statistic`	the value of the Cramer-von Mises statistic.
`p.value`	the p-value for the test.
`method`	the character string "Cramer-von Mises test for exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Ruslan Pusev and Maxim Yakovlev

References

Henze, N. and Meintanis, S.G. (2005): Recent and classical tests for exponentiality: a partial review with comparisons. — Metrika, vol. 61, pp. 29–45.

Examples

```
cvm.exp.test(rexp(100))
cvm.exp.test(runif(100, min = 50, max = 100))
```

`deshpande.exp.test` *Deshpande test for exponentiality*

Description

Performs Deshpande test for the composite hypothesis of exponentiality, see Deshpande (1983).

Usage

```
deshpande.exp.test(x, b=0.44, simulate.p.value=FALSE, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`b`	a parameter of the test (see below).
`simulate.p.value`	a logical value indicating whether to compute p-values by Monte Carlo simulation.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The test is based on the following statistic:

$$J = \frac{1}{n(n-1)} \sum_{i \neq j} 1\{x_i > b x_j\}.$$

Under exponentiality, one has

$$\sqrt{n}(J - \frac{1}{b+1}) \xrightarrow{d} \mathcal{N}\left(0, 4\zeta_1\right),$$

where

$$\zeta_1 = \frac{1}{4}\left(1 + \frac{b}{b+2} + \frac{1}{2b+1} + \frac{2(1-b)}{b+1} - \frac{2b}{b^2+b+1} - \frac{4}{(b+1)^2}\right)$$

(see Deshpande (1983)).

Value

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

`statistic`	the value of the test statistic.
`p.value`	the p-value for the test.
`method`	the character string "Deshpande test for exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov and Ruslan Pusev

References

Deshpande J.V. (1983): A class of tests for exponentiality against increasing failure rate average alternatives. — Biometrika, vol. 70, pp. 514–518.

Examples

```
deshpande.exp.test(rexp(100))
deshpande.exp.test(rweibull(100,1.5))
```

---

ep.exp.test *Test for exponentiality of Epps and Pulley*

Description

Performs Epps and Pulley test for the composite hypothesis of exponentiality, see e.g. Henze and Meintanis (2005, Sec. 2.8.1).

Usage

```
ep.exp.test(x, simulate.p.value=FALSE, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`simulate.p.value`	a logical value indicating whether to compute p-values by Monte Carlo simulation.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The Epps and Pulley test is a test for the composite hypothesis of exponentiality. The test statistic is

$$EP_n = (48n)^{1/2}\left(\frac{1}{n}\sum_{j=1}^{n}\exp(-Y_j) - \frac{1}{2}\right),$$

where $Y_j = X_j/\overline{X}$. EP_n is asymptotically standard normal (see, e.g., Henze and Meintanis (2005, Sec. 2.8.1).

Value

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

`statistic`	the value of the Epps and Pulley statistic.
`p.value`	the p-value for the test.
`method`	the character string "The test for exponentiality of Epps and Pulley".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov, Ruslan Pusev and Maxim Yakovlev

References

Henze, N. and Meintanis, S.G. (2005): Recent and classical tests for exponentiality: a partial review with comparisons. — Metrika, vol. 61, pp. 29–45.

Examples

```
ep.exp.test(rexp(100))
ep.exp.test(runif(100, min = 0, max = 1))
```

`epstein.exp.test` *Epstein test for exponentiality*

Description

Performs Epstein test for the composite hypothesis of exponentiality, see e.g. Ascher (1990).

Usage

```
epstein.exp.test(x, simulate.p.value=FALSE, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`simulate.p.value`	a logical value indicating whether to compute p-values by Monte Carlo simulation.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The test is based on the following statistic:

$$EPS_n = \frac{2n\left(\log\left(n^{-1}\sum_{i=1}^{n} D_i\right) - n^{-1}\sum_{i=1}^{n}\log(D_i)\right)}{1+(n+1)/(6n)},$$

where $D_i = (n-i+1)(X_{(i)} - X_{(i-1)})$, $X_{(0)} = 0$ and $X_{(1)} \leq \ldots \leq X_{(n)}$ are the order statistics. Under exponentiality, EPS is approximately distributed as a chi-square with $n-1$ degrees of freedom.

Value

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

`statistic`	the value of the test statistic.
`p.value`	the p-value for the test.
`method`	the character string "Epstein test for exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov, Ruslan Pusev and Maxim Yakovlev

References

Ascher, S. (1990): A survey of tests for exponentiality. — Communications in Statistics – Theory and Methods, vol. 19, pp. 1811–1825.

Examples

```
epstein.exp.test(rexp(100))
epstein.exp.test(rweibull(100,2))
```

`frozini.exp.test` *Frozini test for exponentiality*

Description

Performs Frozini test for the composite hypothesis of exponentiality, see e.g. Frozini (1987).

Usage

```
frozini.exp.test(x, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The Frozini test for exponentiality is based on the following statistic:

$$B_n = \frac{1}{\sqrt{n}} \sum_{i=1}^{n} \left| 1 - \exp(-X_{(i)}/\overline{X}) - \frac{i - 0.5}{n} \right|.$$

The p-value is computed by Monte Carlo simulation.

Value

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

`statistic`	the value of the Frozini statistic.
`p.value`	the p-value for the test.
`method`	the character string "Frozini test for exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov and Ruslan Pusev

References

Frozini, B.V. (1987): On the distribution and power of a goodness-of-fit statistic with parametric and nonparametric applications, "Goodness-of-fit". (Ed. by Revesz P., Sarkadi K., Sen P.K.) — Amsterdam-Oxford-New York: North-Holland. — Pp. 133–154.

Examples

```
frozini.exp.test(rexp(100))
frozini.exp.test(rchisq(100,2))
```

`gini.exp.test` *Test for exponentiality based on the Gini statistic*

Description

Performs test for the composite hypothesis of exponentiality based on the Gini statistic, see e.g. Gail and Gastwirth (1978).

Usage

```
gini.exp.test(x, simulate.p.value=FALSE, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`simulate.p.value`	a logical value indicating whether to compute p-values by Monte Carlo simulation.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The test is based on the Gini statistic

$$G_n = \frac{\sum_{i,j=1}^{n} |X_i - X_j|}{2n(n-1)\overline{X}}.$$

Under exponentiality, the normalized statistic $(12(n-1))^{1/2}(G_n - 0.5)$ is asymptotically standard normal (see, e.g., Gail and Gastwirth (1978)).

Value

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

`statistic`	the value of the Gini statistic.
`p.value`	the p-value for the test.
`method`	the character string "Test for exponentiality based on the Gini statistic".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov, Ruslan Pusev and Maxim Yakovlev

References

Gail, M.H. and Gastwirth, J.L. (1978): A scale-free goodness-of-fit test for the exponential distribution based on the Gini statistic. — J. R. Stat. Soc. Ser. B, vol. 40, No. 3, pp. 350–357.

Examples

```
gini.exp.test(rexp(100))
gini.exp.test(runif(100, min = 0, max = 1))
```

gnedenko.exp.test *Gnedenko F-test of exponentiality*

Description

Performs Gnedenko F-test for the composite hypothesis of exponentiality, see e.g. Ascher (1990).

Usage

```
gnedenko.exp.test(x, R=length(x)/2, simulate.p.value=FALSE, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`R`	a parameter of the test (see below).
`simulate.p.value`	a logical value indicating whether to compute p-values by Monte Carlo simulation.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The test is based on the following statistic:

$$Q_n(R) = \frac{\sum_{i=1}^{R} D_i/R}{\sum_{i=R+1}^{n} D_i/(n-R)},$$

where $D_i = (n-i+1)(X_{(i)} - X_{(i-1)})$, $X_{(0)} = 0$ and $X_{(1)} \leq \ldots \leq X_{(n)}$ are the order statistics. Under exponentiality, $Q_n(R)$ has an F distribution with $2R$ and $2(n-R)$ degrees of freedom.

Value

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

`statistic`	the value of the test statistic.
`p.value`	the p-value for the test.
`method`	the character string "Gnedenko's F-test of exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov, Ruslan Pusev and Maxim Yakovlev

References

Ascher, S. (1990): A survey of tests for exponentiality. — Communications in Statistics – Theory and Methods, vol. 19, pp. 1811–1825.

Examples

```
gnedenko.exp.test(rexp(100))
gnedenko.exp.test(rweibull(100,2))
```

---

harris.exp.test — *Harris modification of Gnedenko F-test*

Description

Performs Harris modification of Gnedenko F-test for the composite hypothesis of exponentiality, see e.g. Ascher (1990).

Usage

```
harris.exp.test(x, R=length(x)/4, simulate.p.value=FALSE, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`R`	a parameter of the test (see below).
`simulate.p.value`	a logical value indicating whether to compute p-values by Monte Carlo simulation.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The test is based on the following statistic:

$$Q_n(R) = \frac{\left(\sum_{i=1}^{R} D_i + \sum_{i=n-R+1}^{n} D_i\right)/(2R)}{\sum_{i=R+1}^{n-R} D_i/(n-2R)},$$

where $D_i = (n-i+1)(X_{(i)} - X_{(i-1)})$, $X_{(0)} = 0$ and $X_{(1)} \leq \ldots \leq X_{(n)}$ are the order statistics. Under exponentiality, $Q_n(R)$ has an F distribution with $4R$ and $2(n-2R)$ degrees of freedom.

Value

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

`statistic`	the value of the test statistic.
`p.value`	the p-value for the test.
`method`	the character string "Harris modification of Gnedenko F-test".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov, Ruslan Pusev and Maxim Yakovlev

References

Ascher, S. (1990): A survey of tests for exponentiality. — Communications in Statistics – Theory and Methods, vol. 19, pp. 1811–1825.

Examples

```
harris.exp.test(rexp(100))
harris.exp.test(rlnorm(100))
```

---

hegazy1.exp.test *Hegazy-Green test for exponentiality*

Description

Performs Hegazy-Green test for the composite hypothesis of exponentiality, see e.g. Hegazy and Green (1975).

Usage

```
hegazy1.exp.test(x, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The Hegazy-Green test for exponentiality is based on the following statistic:

$$T_1 = n^{-1} \sum \left| X_{(i)} + \ln \left(1 - \frac{i}{n+1} \right) \right|.$$

The p-value is computed by Monte Carlo simulation.

Value

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

`statistic`	the value of the Hegazy-Green statistic.
`p.value`	the p-value for the test.
`method`	the character string "Hegazy-Green test for exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov and Ruslan Pusev

References

Hegazy, Y. A. S. and Green, J. R. (1975): Some new goodness-of-fit tests using order statistics. — Journal of the Royal Statistical Society. Series C (Applied Statistics), vol. 24, pp. 299–308.

Examples

```
hegazy1.exp.test(rexp(100))
hegazy1.exp.test(rweibull(100,1.5))
```

`hegazy2.exp.test` *Hegazy-Green test for exponentiality*

Description

Performs Hegazy-Green test for the composite hypothesis of exponentiality, see e.g. Hegazy and Green (1975).

Usage

```
hegazy2.exp.test(x, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The Hegazy-Green test for exponentiality is based on the following statistic:

$$T_2 = n^{-1} \sum \left(X_{(i)} + \ln \left(1 - \frac{i}{n+1} \right) \right)^2 .$$

The p-value is computed by Monte Carlo simulation.

Value

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

`statistic`	the value of the Hegazy-Green statistic.
`p.value`	the p-value for the test.
`method`	the character string "Hegazy-Green test for exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov and Ruslan Pusev

References

Hegazy, Y. A. S. and Green, J. R. (1975): Some new goodness-of-fit tests using order statistics. — Journal of the Royal Statistical Society. Series C (Applied Statistics), vol. 24, pp. 299–308.

Examples

```
hegazy2.exp.test(rexp(100))
hegazy2.exp.test(rweibull(100,1.5))
```

---

hollander.exp.test *Hollander-Proshan test for exponentiality*

Description

Performs Hollander-Proshan test for the composite hypothesis of exponentiality, see Hollander and Proshan (1972).

Usage

```
hollander.exp.test(x, simulate.p.value=FALSE, nrepl=2000)
```

Arguments

x	a numeric vector of data values.
simulate.p.value	a logical value indicating whether to compute p-values by Monte Carlo simulation.
nrepl	the number of replications in Monte Carlo simulation.

Details

The test is based on the following statistic:

$$J_n = \frac{1}{n(n-1)(n-2)} \sum_{i \neq j,k; j<k} 1\{x_i > x_j + x_k\}.$$

Under exponentiality, one has

$$\sqrt{n}(J_n - \frac{1}{4}) \xrightarrow{d} \mathcal{N}\left(0, frac5432\right).$$

(see Hollander and Proshan (1972)).

Value

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

`statistic`	the value of the test statistic.
`p.value`	the p-value for the test.
`method`	the character string "Hollander-Proshan test for exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov and Ruslan Pusev

References

Hollander M., Proshan F. (1972): Testing whether new is better than used. — Ann. Math. Stat., vol. 43, pp. 1136–1146.

Examples

```
hollander.exp.test(rexp(25))
hollander.exp.test(rgamma(25,2))
```

`kimber.exp.test` *Kimber-Michael test for exponentiality*

Description

Performs Kimber-Michael test for the composite hypothesis of exponentiality, see e.g. Michael (1983), Kimber (1985).

Usage

```
kimber.exp.test(x, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The Kimber-Michael test for exponentiality is based on the following statistic:

$$D = \max_i |r_i - s_i|,$$

where

$$s_i = \frac{2}{\pi} \arcsin \sqrt{1 - \exp(-X_{(i)}/\overline{X})}, \qquad r_i = \frac{2}{\pi} \arcsin \sqrt{(i - 0.5)/n}.$$

The p-value is computed by Monte Carlo simulation.

Value

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

`statistic`	the value of the Kimber-Michael statistic.
`p.value`	the p-value for the test.
`method`	the character string "Kimber-Michael test for exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov and Ruslan Pusev

References

Kimber, A.C. (1985): Tests for the exponential, Weibull and Gumbel distributions based on the stabilized probability plot. — Biometrika, vol. 72, pp. 661–663.

Michael, J.R. (1983): The stabilized probability plot. — Biometrika, vol. 70, pp. 11–17.

Examples

```
kimber.exp.test(rexp(100))
kimber.exp.test(rchisq(100,2))
```

`kochar.exp.test` *Kochar test for exponentiality*

Description

Performs Kochar test for the composite hypothesis of exponentiality, see e.g. Kochar (1985).

Usage

```
kochar.exp.test(x, simulate.p.value=FALSE, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`simulate.p.value`	a logical value indicating whether to compute p-values by Monte Carlo simulation.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The Kochar test for exponentiality is based on the following statistic:

$$T = \sqrt{\frac{108n}{17}} \frac{\sum_{i=1}^{n} J(i/(n+1))X_{(i)}}{\sum_{i=1}^{n} X_i},$$

where

$$J(u) = 2(1-u)[1-\log(1-u)] - 1.$$

The statistic T is asymptotically standard normal.

Value

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

`statistic`	the value of the Kochar statistic.
`p.value`	the p-value for the test.
`method`	the character string "Kochar test for exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov and Ruslan Pusev

References

Kochar, S.C. (1985): Testing exponenttality against monotone failure rate average. — Communications in Statistics – Theory and Methods, vol. 14, pp. 381–392.

Examples

```
kochar.exp.test(rexp(100))
kochar.exp.test(rchisq(100,1))
```

`ks.exp.test` *Kolmogorov-Smirnov test for exponentiality*

Description

Performs Kolmogorov-Smirnov test for the composite hypothesis of exponentiality, see e.g. Henze and Meintanis (2005, Sec. 2.1).

Usage

```
ks.exp.test(x, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The Kolmogorov-Smirnov test for exponentiality is based on the following statistic:

$$KS_n = \sup_{x \geq 0} |F_n(x) - (1 - \exp(-x))|,$$

where F_n is the empirical distribution function of the scaled data $Y_j = X_j/\overline{X}$. The p-value is computed by Monte Carlo simulation.

Value

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

`statistic`	the value of the Kolmogorov-Smirnov statistic.
`p.value`	the p-value for the test.
`method`	the character string "Kolmogorov-Smirnov test for exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Ruslan Pusev and Maxim Yakovlev

References

Henze, N. and Meintanis, S.G. (2005): Recent and classical tests for exponentiality: a partial review with comparisons. — Metrika, vol. 61, pp. 29–45.

Examples

```
ks.exp.test(rexp(100))
ks.exp.test(runif(100, min = 50, max = 100))
```

`lorenz.exp.test` *Lorenz test for exponentiality*

Description

Performs Lorenz test for the composite hypothesis of exponentiality, see e.g. Gail and Gastwirth (1978).

Usage

```
lorenz.exp.test(x, p=0.5, simulate.p.value=FALSE, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`p`	a parameter of the test (see below).
`simulate.p.value`	a logical value indicating whether to compute p-values by Monte Carlo simulation.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The Lorenz test for exponentiality is based on the following statistic:

$$L = \sum_{i=1}^{np} X_{(i)} / \sum_{i=1}^{n} X_{(i)}$$

The statistic $\sqrt{n}(L - p - (1-p)\log(1-p))$ is asymptotically standard normal.

Value

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

`statistic`	the value of the Lorenz statistic.
`p.value`	the p-value for the test.
`method`	the character string "Lorenz test for exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov and Ruslan Pusev

References

Gail, M.H. and Gastwirth, J.L. (1978): A scale-free goodness-of-fit test for the exponential distribution based on the Lorenz curve. — Journal of the American Statistical Association, vol. 73, pp. 787–793.

Examples

```
lorenz.exp.test(rexp(100))
lorenz.exp.test(rchisq(100,7))
```

`moran.exp.test` *Moran test for exponentiality*

Description

Performs Moran test for the composite hypothesis of exponentiality, see e.g. Moran (1951) and Tchirina (2005).

Usage

```
moran.exp.test(x, simulate.p.value=FALSE, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`simulate.p.value`	a logical value indicating whether to compute p-values by Monte Carlo simulation.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The Moran test for exponentiality is based on the following statistic:

$$T_n^+ = \gamma + \frac{1}{n}\sum_{i=1}^{n}\log\frac{X_i}{\overline{X}},$$

where γ is Euler-Mascheroni constant. The statistic is asymptotically normal:

$$\sqrt{n}\,T_n^+ \to N\left(0, \frac{\pi^2}{6} - 1\right).$$

Value

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

`statistic`	the value of the Moran statistic.
`p.value`	the p-value for the test.
`method`	the character string "Moran test for exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov and Ruslan Pusev

References

Moran, P.A.P. (1951): The random division of an interval–Part II. — Journal of the Royal Statistical Society. Series B (Methodological), vol. 13, pp. 147-150.

Tchirina, A.V. (2005): Bahadur efficiency and local optimality of a test for exponentiality based on the Moran statistics. — Journal of Mathematical Sciences, vol. 127, No. 1, pp. 1812–1819.

Examples

```
moran.exp.test(rexp(100))
moran.exp.test(rchisq(100,3))
```

`pietra.exp.test` *Test for exponentiality based on the Pietra statistic*

Description

Performs test for the composite hypothesis of exponentiality based on the Pietra statistic, see e.g. Ascher (1990).

Usage

```
pietra.exp.test(x, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The test is based on the Pietra statistic

$$P_n = \sum_{i=1}^{n} \frac{|X_i - \overline{X}|}{2n\overline{X}}.$$

The p-value is computed by Monte Carlo simulation.

Value

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

`statistic`	the value of the Pietra statistic.
`p.value`	the p-value for the test.
`method`	the character string "Test for exponentiality based on the Pietra statistic".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Ruslan Pusev and Maxim Yakovlev

References

Ascher, S. (1990): A survey of tests for exponentiality. — Communications in Statistics – Theory and Methods, vol. 19, pp. 1811–1825.

Examples

```
pietra.exp.test(rexp(100))
pietra.exp.test(runif(100, min = 50, max = 100))
```

`rossberg.exp.test` *Test for exponentiality based on Rossberg characterization*

Description

Performs test for the composite hypothesis of exponentiality based on the Rossberg characterization, see Volkova (2010).

Usage

```
rossberg.exp.test(x)
```

Arguments

`x`	a numeric vector of data values.

Details

The test is based on the following statistic:

$$S_n = \int_0^\infty (H_n(t) - G_n(t)) dF_n(t),$$

where F_n is the empirical distribution function,

$$H_n(t) = (C_n^3)^{-1} \sum_{1 \le i < j < k \le n} 1\{X_{2,\{i,j,k\}} - X_{1,\{i,j,k\}} < t\}, \quad t \ge 0,$$

$$G_n(t) = (C_n^2)^{-1} \sum_{1 \le i < j \le n} 1\{\min(X_i, X_j) < t\}, \quad t \ge 0.$$

Here $X_{s,\{i,j,k\}}$, $s = 1, 2$, denotes the sth order statistic of X_i, X_j, X_k. The p-value is computed from the limit null distribution. Under exponentiality, one has

$$\sqrt{n} S_n \xrightarrow{d} \mathcal{N}\left(0, \frac{52}{1125}\right)$$

(see, Volkova (2010)).

Value

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

`statistic`	the value of the test statistic.
`p.value`	the p-value for the test.
`method`	the character string "Test for exponentiality based on Rossberg characterization".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Ruslan Pusev and Maxim Yakovlev

References

Volkova, K.Yu. (2010): On asymptotic efficiency of exponentiality tests based on Rossberg characterization. — J. Math. Sci., vol. 167, No. 4, pp. 486–494.

Examples

```
rossberg.exp.test(rexp(25))
rossberg.exp.test(runif(25, min = 50, max = 100))
```

`shapiro.exp.test` *Shapiro-Wilk test for exponentiality*

Description

Performs Shapiro-Wilk test for the composite hypothesis of exponentiality, see e.g. Shapiro and Wilk (1972).

Usage

```
shapiro.exp.test(x, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The Shapiro-Wilk test for exponentiality is based on the following statistic:

$$W = \frac{n(\overline{X} - X_{(1)})^2}{(n-1)\sum_{i=1}^{n}(X_i - \overline{X})^2}.$$

The p-value is computed by Monte Carlo simulation.

Value

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

`statistic`	the value of the Shapiro-Wilk statistic.
`p.value`	the p-value for the test.
`method`	the character string "Shapiro-Wilk test for exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Alexey Novikov and Ruslan Pusev

References

Shapiro, S.S. and Wilk, M.B. (1972): An analysis of variance test for the exponential distribution (complete samples). — Technometrics, vol. 14, pp. 355-370.

Examples

```
shapiro.exp.test(rexp(100))
shapiro.exp.test(rchisq(100,1))
```

`we.exp.test` *WE test for exponentiality*

Description

Performs the WE test for the composite hypothesis of exponentiality, see e.g. Ascher (1990).

Usage

```
we.exp.test(x, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The test is based on the following statistic

$$WE = \sum_{i=1}^{n}(X_i - \overline{X})^2 / \left(\sum_{i=1}^{n} X_i\right)^2.$$

The p-value is computed by Monte Carlo simulation.

Value

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

`statistic`	the value of the WE test statistic.
`p.value`	the p-value for the test.
`method`	the character string "WE test for exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Ruslan Pusev and Maxim Yakovlev

References

Ascher, S. (1990): A survey of tests for exponentiality. — Communications in Statistics – Theory and Methods, vol. 19, pp. 1811–1825.

Examples

```
we.exp.test(rexp(100))
we.exp.test(runif(100, min = 50, max = 100))
```

`ww.exp.test` *Wong and Wong test for exponentiality*

Description

Performs Wong and Wong test for the composite hypothesis of exponentiality, see e.g. Ascher (1990).

Usage

```
ww.exp.test(x, nrepl=2000)
```

Arguments

`x`	a numeric vector of data values.
`nrepl`	the number of replications in Monte Carlo simulation.

Details

The test is based on the following statistic:

$$Q = X_{(n)}/X_{(1)},$$

where $X_{(1)}$ and $X_{(n)}$ are the smallest and the largest order statistics respectively. The p-value is computed by Monte Carlo simulation.

Value

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

`statistic`	the value of the statistic of the test.
`p.value`	the p-value for the test.
`method`	the character string "Wong and Wong test for exponentiality".
`data.name`	a character string giving the name(s) of the data.

Author(s)

Ruslan Pusev and Maxim Yakovlev

References

Ascher, S. (1990): A survey of tests for exponentiality. — Communications in Statistics – Theory and Methods, vol. 19, pp. 1811–1825.

Examples

```
ww.exp.test(rexp(100))
ww.exp.test(abs(rcauchy(100)))
```

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