Package ‘AEP’

October 12, 2022

Type Package

Title Statistical Modelling for Asymmetric Exponential Power Distribution

Date 2022-09-07

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Description Developed for Computing the probability density function, cumulative distribution function, random generation, estimating the parameters of asymmetric exponential power distribution, and robust regression analysis with error term that follows asymmetric exponential power distribution. The asymmetric exponential power distribution studied here is a special case of that introduced by Dongming and Zinde-Walsh (2009) <doi:10.1016/j.jeconom.2008.09.038>.

Encoding UTF-8

Depends R(>= 3.3.0)

Repository CRAN

Version 0.1.4

NeedsCompilation no

Date/Publication 2022-09-07 07:50:25 UTC

R topics documented:

daep *Computing the probability density function (pdf) of asymmetric exponential power (AEP) distribution.*

Description

The pdf of AEP distribution given by

$$f_X(x|\Theta) = \frac{1}{2\sigma\Gamma\big(1+\frac{1}{\alpha}\big)} \exp\Bigg\{-\Bigg|\frac{\mu-x}{\sigma(1-\epsilon)}\Bigg|^{\alpha}\Bigg\}, \quad x<\mu,$$

$$f_X(x|\Theta) = \frac{1}{2\sigma\Gamma\big(1+\frac{1}{\alpha}\big)} \exp\Bigg\{-\Bigg|\frac{x-\mu}{\sigma(1+\epsilon)}\Bigg|^{\alpha}\Bigg\}, \quad x\geq\mu,$$

where $-\infty < x < +\infty$, $\Theta = (\alpha, \sigma, \mu, \epsilon)^T$ with $0 < \alpha \leq 2$, $\sigma > 0$, $-\infty < \mu < \infty$, $-1 < \epsilon < 1$, and

$$\Gamma(u) = \int_0^{+\infty} x^{u-1} \exp\big\{-x\big\} dx,\ u > 0.$$

Usage

```
daep(x, alpha, sigma, mu, epsilon, log = FALSE)
```

Arguments

`x`	Vector of observation of requested random realizations.
`alpha`	Tail thickness parameter.
`sigma`	Scale parameter.
`mu`	Location parameter.
`epsilon`	Skewness parameter.
`log`	If `TRUE`, then `log`$\big(f_X(x|\Theta)\big)$ is returned.

Details

The AEP distribution is a special case of asymmetric exponential power distribution studied by Dongming and Zinde-Walsh (2009) when $p_1 = p_2 = \alpha$. Also, note that if $\epsilon = 0$, then the AEP distribution turns into a normal distribution with mean μ and standard deviation $\sqrt{2}\sigma$. When $\alpha = 2$, the AEP distribution is a slight variant of epsilon-skew-normal distribution introduced by Mudholkar and Huston (2001).

Value

Computed pdf of AEP distribution at points of vector x.

Author(s)

Mahdi Teimouri

References

Z. Dongming and V. Zinde-Walsh, 2009. Properties and estimation of asymmetric exponential power distribution, *Journal of Econometrics*, 148(1), 86-99.

G. S. Mudholkar and A. D. Huston, 2001. The epsilon-skew-normal distribution for analyzing near-normal data, *Journal of Statistical Planning and Inference*, 83, 291-309.

Examples

```
daep(x = 2, alpha = 1.5, sigma = 1, mu = 0, epsilon = 0.5, log = FALSE)
```

`fitaep` *Estimating the parameters of AEP distribution through the expectation-maximization (EM) algorithm*

Description

Estimates the parameters of AEP distribution.

Usage

```
fitaep(x, initial = FALSE, starts)
```

Arguments

`x`	Vector of observations.
`initial`	By default is `FALSE`. If the initial values are given by user, then set `initial=TRUE`.
`starts`	If initial values `starts=`$\left(\alpha^{(0)}, \sigma^{(0)}, \mu^{(0)}, \epsilon^{(0)}\right)$, are given by user, i.e., `initial=TURE`, then vector `starts` must contain the initial values of the parameter vector, i.e., for starting the EM algorithm.

Value

A list of objects in two parts as

1. The EM estimator for the parameters of AEP distribution.
2. A sequence of goodness-of-fit measures consist of Akaike Information Criterion (`AIC`), Consistent Akaike Information Criterion (`CAIC`), Bayesian Information Criterion (`BIC`), Hannan-Quinn information criterion (`HQIC`), Anderson-Darling (`AD`), Cram\'eer-von Misses (`CVM`), Kolmogorov-Smirnov (`KS`), and log-likelihood (`log-likelihood`) statistics.

Author(s)

Mahdi Teimouri

References

A. P. Dempster, N. M. Laird, and D. B. Rubin, 1977. Maximum likelihood from incomplete data via the EM algorithm, *Journal of the Royal Statistical Society Series B*, 39, 1-38.

Examples

```
x <- raep(n=50, alpha=.8, sigma=1, mu=0, epsilon=0.5)
fitaep(x, initial = FALSE, starts)
```

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paep — *Computing the cumulative distribution function (cdf) of asymmetric exponential power (AEP) distribution.*

Description

Computes the cdf of AEP distribution given by

$$F_X(x|\Theta) = \frac{1-\epsilon}{2} - \frac{1-\epsilon}{2\Gamma\big(1+\frac{1}{\alpha}\big)}\gamma\Big(\Big|\frac{\mu-x}{\sigma(1-\epsilon)}\Big|^{\alpha}, \frac{1}{\alpha}\Big), \;\; x < \mu,$$

$$F_X(x|\Theta) = \frac{1-\epsilon}{2} + \frac{1+\epsilon}{2\Gamma\big(1+\frac{1}{\alpha}\big)}\gamma\Big(\Big|\frac{x-\mu}{\sigma(1+\epsilon)}\Big|^{\alpha}, \frac{1}{\alpha}\Big), \;\; x \geq \mu,$$

where $-\infty < x < +\infty$, $\Theta = (\alpha, \sigma, \mu, \epsilon)^T$ with $0 < \alpha \leq 2$, $\sigma > 0$, $-\infty < \mu < \infty$, and $-1 < \epsilon < 1$.

Usage

```
paep(x, alpha, sigma, mu, epsilon, log.p = FALSE, lower.tail = TRUE)
```

Arguments

`x`	Vector of observations.
`alpha`	Tail thickness parameter.
`sigma`	Scale parameter.
`mu`	Location parameter.
`epsilon`	Skewness parameter.
`log.p`	If `TRUE`, then $\log\big(F_X(x|\Theta)\big)$ is returned.
`lower.tail`	If `FALSE`, then $1 - F_X(x|\Theta)$ is returned.

Value

Computed cdf of AEP distribution at points of vector x.

Author(s)

Mahdi Teimouri

Examples

```
paep(x = 2, alpha = 1.5, sigma = 1, mu = 0, epsilon = 0.5, log.p = FALSE, lower.tail = TRUE)
```

plasma	*Plasma survival data*

Description

The plasma survival data contains the Survival times of plasma cell myeloma for 112 patients, see Carbone et al. (1967).

Usage

```
data(plasma)
```

Format

A text file with four columns.

References

P. P. Carbone, L. E. Kellerhouse, and E. A. Gehan. 1967. Plasmacytic myeloma: A study of the relationship of survival to various clinical manifestations and anomalous protein type in 112 patients. *The American Journal of Medicine*, 42 (6), 937-48.

qaep	*Computing the quantile function of asymmetric exponential power (AEP) distribution.*

Description

Computes the quantile function of AEP distribution given by

$$F_X^{-1}(u|\Theta) = \mu - \sigma(1-\epsilon)\left[\frac{\gamma\left(\frac{1-\epsilon-2u}{1-\epsilon}, \frac{1}{\alpha}\right)}{\Gamma\left(\frac{1}{\alpha}\right)}\right]^{\frac{1}{\alpha}}, \;\; u \leq \frac{1-\epsilon}{2},$$

$$F_X^{-1}(u|\Theta) = \mu + \sigma(1+\epsilon)\left[\frac{\gamma\left(\frac{2u+\epsilon-1}{1+\epsilon}, \frac{1}{\alpha}\right)}{\Gamma\left(\frac{1}{\alpha}\right)}\right]^{\frac{1}{\alpha}}, \;\; u > \frac{1-\epsilon}{2}.$$

where $-\infty < x < +\infty$, $\Theta = (\alpha, \sigma, \mu, \epsilon)^T$ with $0 < \alpha \leq 2, \sigma > 0$, $-\infty < \mu < \infty$, $-1 < \epsilon < 1$, and

$$\gamma(u, \nu) = \int_0^u t^{\nu-1} \exp\{-t\} dt, \; \nu > 0.$$

Usage

```
qaep(u, alpha, sigma, mu, epsilon)
```

Arguments

`u`	Numeric vector with values in $(0, 1)$ whose quantiles are desired.
`alpha`	Tail thickness parameter.
`sigma`	Scale parameter.
`mu`	Location parameter.
`epsilon`	Skewness parameter.

Value

A vector of length `n`, consists of the random generated values from AEP distribution.

Author(s)

Mahdi Teimouri

Examples

```
qaep(runif(1), alpha = 1.5, sigma = 1, mu = 0, epsilon = 0.5)
```

`raep` *Simulating realizations from the asymmetric exponential power (AEP) distribution*

Description

Simulates realizations from AEP distribution.

Usage

```
raep(n, alpha, sigma, mu, epsilon)
```

Arguments

`n`	Number of requested realizations.
`alpha`	Tail thickness parameter.
`sigma`	Scale parameter.
`mu`	Location parameter.
`epsilon`	Skewness parameter.

Value

A vector of length `n`, consists of the random generated values from AEP distribution.

Author(s)

Mahdi Teimouri

Examples

```
raep(n = 100, alpha = 1.5, sigma = 1, mu = 0, epsilon = 0.5)
```

`regaep` *Robust linear regression analysis when error term follows AEP distribution*

Description

Estimates parameters of the multiple linear regression model through EM algorithm when error term follows AEP distribution. The regression model is given by

$$y_i = \beta_0 + \beta_1 x_{i1} + \cdots + \beta_k x_{ik} + \nu_i,\ i = 1, \cdots, n,$$

where $\boldsymbol{\beta} = \left(\beta_0, \beta_1, \cdots, \beta_k\right)^T$ are the regression coefficients and ν_i is the error term follows a zero-location AEP distibution.

Usage

```
regaep(y, x)
```

Arguments

`y`	Vector of response observations of length n.
`x`	An $n \times k$ array of covariate(s).

Value

A list of estimated regression coefficients, summary of residuals, F statistic, R-square (R^2), adjusted R-square, and inverted observed Fisher information matrix.

Author(s)

Mahdi Teimouri

References

A. P. Dempster, N. M. Laird, and D. B. Rubin, 1977. Maximum likelihood from incomplete data via the EM algorithm, *Journal of the Royal Statistical Society Series B*, 39, 1-38.

Examples

```
x <- seq(-5, 5, 0.1)
y <- 2 + 2*x + raep( length(x), alpha = 1, sigma = 0.5, mu = 0, epsilon = 0.5)
regaep(y, x)
```

`welcome`	*Starting message when loading AEP*

Description

It contains a welcome message for users of AEP.

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