Package 'RobustANOVA'

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Type Package

Title Robust One-Way ANOVA Tests under Heteroscedasticity and Nonnormality

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Description Robust tests (RW, RPB and RGF) are provided for testing the equality of several long-tailed symmetric (LTS) means when the variances are unknown and arbitrary. RW, RPB and RGF tests are robust versions of Welch's F test proposed by Welch (1951) <doi:10.2307/2332579>, parametric bootstrap test proposed by Krishnamoorthy et. al (2007) <doi:10.1016/j.csda.2006.09.039>; and generalized F test proposed by Weerahandi (1995) <doi:10.2307/2532947>;, respectively. These tests are based on the modified maximum likelihood (MML) estimators proposed by Tiku(1967, 1968) <doi:10.2307/2333859>, <doi:10.1080/01621459.1968.11009228>.

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Contents

peak_discharge *Peak Disharge Data*

Description

The "peak discharge data" first given by Montgomery (2005) consists of four different methods of estimating flood flow frequency.

Usage

```
peak_discharge
```

Value

obs	Flood flow frequency (in cubic feet per second)
methods	Methods of estimating flood flow frequency.

Author(s)

Gamze Guven

References

D. C. Montgomery. Design and analysis of experiments. John wiley & sons, 2005.

Examples

```
library(RobustANOVA)
peak_discharge$obs;
peak_discharge$methods;
```

RGF *Robust Generalized F Test based on MML estimators*

Description

Computes the p-value of the robust generalized F (RGF) test for the equality of means of several long-tailed symmetric (LTS) distributions when the variances are unknown and arbitrary.

Usage

```
RGF(formula, data, alpha, verbose = TRUE, p_shape, repn)
```

Arguments

formula	a formula of the form left-hand-side(lhs) ~ right-hand-side(rhs). lhs shows the observed values and rhs shows the group corresponding to the observed values.
data	data frame containing the variables in the formula.
alpha	the level of significance. Default is set to alpha = 0.05.
verbose	a logical for printing output to R console.
p_shape	shape parameter of the LTS distribution.
repn	replication number for performing the RGF test.

Details

RGF test based on modifed maximum likelihood (MML) estimators is proposed as a robust alternative to generalized F (GF) test proposed by Weerahandi (1995). See also Tiku (1967, 1968) for the details of MML estimators. The p-value for the RGF test is based on the replication number in the algorithm given by Guven et. al (2022).

Value

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

p.value	the p-value for the RGF test.
alpha	the level of significance.
method	a character string "Robust Generalized F Test based on MML Estimators" indicating which test is used.
data	a data frame containing the variables.
formula	a formula of the form left-hand-side(lhs) ~ right-hand-side(rhs). lhs shows the observed values and rhs shows the group corresponding to the observed values.

Author(s)

Gamze Guven <gamzeguven@ogu.edu.tr>

References

G. Guven, S. Acitas and B. Senoglu, B. RobustANOVA: An R Package for one-way ANOVA under heteroscedasticity and nonnormality. *Under review*, 2022.

M. L. Tiku. Estimating the mean and standard deviation from a censored normal sample. *Biometrika*, 54:155-165, 1967.

M. L. Tiku. Estimating the parameters of log-normal distribution from censored samples. *Journal of the American Statistical Association*, 63(321): 134-140, 1968.

S. Weerahandi. Anova under unequal error variances. *Biometrics*, 51(2): 589-599, 1995.

Examples

```
library(RobustANOVA)

RGF(obs ~ methods, data = peak_discharge, alpha = 0.05, verbose = TRUE, p_shape=2.3, repn=5000)
```

RPB *Robust Parametric Bootstrap Test based on MML estimators*

Description

Computes the p-value of the robust parametric bootstrap (RPB) test for the equality of means of several long-tailed symmetric (LTS) distributions when the variances are unknown and arbitrary.

Usage

```
RPB(formula, data, alpha , verbose = TRUE, p_shape, repn)
```

Arguments

formula	a formula of the form left-hand-side(lhs) ~ right-hand-side(rhs). lhs shows the observed values and rhs shows the group corresponding to the observed values.
data	data frame containing the variables in the formula.
alpha	the level of significance. Default is set to alpha = 0.05.
verbose	a logical for printing output to R console.
p_shape	shape parameter of the LTS distribution.
repn	replication number for performing the RPB test.

Details

RPB test based on modifed maximum likelihood (MML) estimators is proposed as a robust alternative to parametric bootstrap (PB) test proposed by Krishnamoorthy et. al (2007). See also Tiku (1967, 1968) for the details of MML estimators. The p-value for the RPB test is based on the replication number in the algorithm given by Guven et. al (2022).

Value

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

p.value	the p-value for the RPB test.
alpha	the level of significance.
method	a character string "Robust Parametric Bootstrap Test based on MML Estimators" indicating which test is used.
data	a data frame containing the variables.
formula	a formula of the form left-hand-side(lhs) ~ right-hand-side(rhs). lhs shows the observed values and rhs shows the group corresponding to the observed values.

Author(s)

Gamze Guven <gamzeguven@ogu.edu.tr>

References

G. Guven, S. Acitas, and B. Senoglu, B. RobustANOVA: An R Package for one-way ANOVA under heteroscedasticity and nonnormality. *Under review*, 2022.

K. Krishnamoorthy, F. Lu, and T. Mathew. A parametric bootstrap approach for anova with unequal variances: Fixed and random models. *Computational Statistics & Data Analysis*, 51(12): 5731-5742,2007.

M. L. Tiku. Estimating the mean and standard deviation from a censored normal sample. *Biometrika*, 54:155-165, 1967.

M. L. Tiku. Estimating the parameters of log-normal distribution from censored samples. *Journal of the American Statistical Association*, 63(321): 134-140, 1968.

Examples

```
library(RobustANOVA)

RPB(obs ~ methods, data = peak_discharge, alpha = 0.05, verbose = TRUE, p_shape=2.3, repn=5000)
```

RW *Robust Welch Test based on MML Estimators*

Description

Computes the observed value of robust Welch (RW) test, degrees of freedoms (numerator and denominator) and the corresponding p-value for the equality of means of several long-tailed symmetric (LTS) distributions when the variances are unknown and arbitrary.

Usage

```
RW(formula, data, alpha=0.05, verbose = TRUE, p_shape)
```

Arguments

formula	a formula of the form left-hand-side(lhs) ~ right-hand-side(rhs). lhs shows the observed values and rhs shows the group corresponding to the observed values.
data	data frame containing the variables in the formula.
alpha	the level of significance. Default is set to alpha = 0.05.
verbose	a logical for printing output to R console.
p_shape	shape parameter of the LTS distribution

Details

RW test based on modifed maximum likelihood (MML) estimators is proposed as a robust alternative to Welch's F test (Welch, 1951). The test statistic is formulated as follows

$$RW = \frac{T(\hat{\mu}_1, \ldots, \hat{\mu}_a; \hat{\sigma}_1^2, \ldots, \hat{\sigma}_a^2)/(a-1)}{1 + (2(a-2)/(3\nu_1))}$$

where

$$T(\hat{\mu}_1, \ldots, \hat{\mu}_a; \hat{\sigma}_1^2, \ldots, \hat{\sigma}_a^2) = \sum_{i=1}^{a} \frac{M_i}{\hat{\sigma}_i^2}\hat{\mu}_i^2 - \frac{(\sum_{i=1}^{a} M_i\hat{\mu}_i/\hat{\sigma}_i^2)^2}{\sum_{i=1}^{a} M_i/\hat{\sigma}_i^2},$$

$$\nu_1 = [\frac{3}{a^2-1}\sum_{i=1}^{a}\frac{1}{n_i-1}(1-(M_i/\hat{\sigma}_i^2)/(\sum_{j=1}^{a} M_j/\hat{\sigma}_j^2))^2]^{-1},$$

$\hat{\mu}_i$ and $\hat{\sigma}_i$ (i=1,2,...,a) are the MML estimators of the location and scale parameters, respectively, see Tiku (1967, 1968) for the details of MML estimators.

The null hypothesis is rejected if the computed RW statistic is higher than the $(1-\alpha)$th quantile of the F distribution with a-1 and ν_1 degrees of freedom.

For further details, see Guven et al. (2022).

Value

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

statistic	the observed value of the RW test statistic.
dfs	the numerator and the denominator degrees of freedom of the approximate F distribution.
p.value	the p-value for the RW test.
alpha	the level of significance.
method	a character string "Robust Welch Test based on MML Estimators" indicating which test is used.
data	a data frame containing the variables.
formula	a formula of the form left-hand-side(lhs) ~ right-hand-side(rhs). lhs shows the observed values and rhs shows the group corresponding to the observed values.

Author(s)

Gamze Guven <gamzeguven@ogu.edu.tr>

References

G. Guven, S. Acitas, and B. Senoglu, B. RobustANOVA: An R Package for one-way ANOVA under heteroscedasticity and nonnormality. *Under review*, 2022.

M. L. Tiku. Estimating the mean and standard deviation from a censored normal sample. *Biometrika*, 54:155-165, 1967.

M. L. Tiku. Estimating the parameters of log-normal distribution from censored samples. *Journal of the American Statistical Association*, 63(321): 134-140, 1968.

B. L. Welch. On the comparison of several mean values: an alternative approach. *Biometrika*, 38(3): 330-336, 1951.

Examples

```
library(RobustANOVA)

RW(obs ~ methods, data = peak_discharge, alpha = 0.05, verbose = TRUE, p_shape=2.3)
```

Index