Package 'varequal'

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Title Tests and Measures for Homoscedasticity

Version 0.0.1

Description Provides statistical methods for assessing homoscedasticity (equality of variances) across groups. The package implements classical and robust tests for variance homogeneity, together with supporting measures and utilities for exploratory analysis and hypothesis testing. These tools can be used as diagnostic procedures prior to analyses that assume equal variances.

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Contents

`Ansari_Bradley_test` *Ansari-Bradley Test of Homogeneity of Variances*

Description

Performs Ansari-Bradley test to assess the null hypothesis that the variances are equal across all groups (samples) defined by the independent variable.

Usage

```
Ansari_Bradley_test(
  data,
  formula,
  alpha = 0.05,
  silent = FALSE,
  summary = FALSE,
  misc = FALSE
)
```

Arguments

`data`	A data frame containing the variables specified in the formula.
`formula`	A formula of the form `DV ~ IV`, where `DV` is the dependent (response) variable and `IV` is the independent (grouping) variable.
`alpha`	A numeric value specifying the significance level. Must be between 0 and 1. Default is 0.05.
`silent`	A logical value. If `FALSE` (default), results are printed to the console. If `TRUE`, no output is printed.
`summary`	A logical value (default: `FALSE`). If `TRUE`, a summary table for the input data is returned.
`misc`	A logical value. If `FALSE` (default), only essential parameters are returned. If `TRUE`, additional auxiliary parameters are included in the output.

Details

This function is based on Conover et al. (1981) and uses an approximate chi-square test. Results may be inaccurate for small total sample sizes (N < 20) or when there are many tied values.

Value

A list containing the test statistics, p-value, degrees of freedom, and optionally a summary table and/or auxiliary parameters, depending on the values of `summary` and `misc`.

References

Ansari, A. R., & Bradley, R. A. (1960). Rank-sum tests for dispersions. The Annals of Mathematical Statistics, 31, 1174–1189.

Conover, W. J., Johnson, M. E., & Johnson, M. M. (1981). A comparative study of tests for homogeneity of variances, with applications to the outer continental shelf bidding data. Technometrics, 23, 351–361. https://doi.org/10.1080/00401706.1981.10487680

See Also

stats::ansari.test

Examples

```
df0 <- CYCB1[[1]]
out <- Ansari_Bradley_test(df0, cells ~ grp)
boxplot(cells ~ grp, df0, horizontal = TRUE)
points(x = df0$cells, y = jitter(as.numeric(df0$grp), amount = 0.15))
```

Bartlett_test *Bartlett's Test of Homogeneity of Variances*

Description

Performs Bartlett's test to assess the null hypothesis that variances are equal across all groups (samples) defined by the independent variable. This test assumes that the data within each group are normally distributed and is sensitive to departures from normality.

Usage

```
Bartlett_test(
  data,
  formula,
  alpha = 0.05,
  silent = FALSE,
  summary = FALSE,
  misc = FALSE
)
```

Arguments

`data`	A data frame containing the variables specified in the formula.
`formula`	A formula of the form `DV ~ IV`, where `DV` is the dependent (response) variable and `IV` is the independent (grouping) variable.
`alpha`	A numeric value specifying the significance level. Must be between 0 and 1. Default is 0.05.
`silent`	A logical value. If `FALSE` (default), results are printed to the console. If `TRUE`, no output is printed.
`summary`	A logical value (default: `FALSE`). If `TRUE`, a summary table for the input data is returned.
`misc`	A logical value. If `FALSE` (default), only essential parameters are returned. If `TRUE`, additional auxiliary parameters are included in the output.

Value

A list containing the test statistics, p-value, degrees of freedom, and optionally a summary table and/or auxiliary parameters, depending on the values of `summary` and `misc`.

References

Bartlett, M. S. (1937). Properties of sufficiency and statistical tests. Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences, 160(901), 268–282. https://doi.org/10.1098/rspa.1937.0109

Montgomery, D. C. (2017). Experiments with a single factor: The analysis of variance. In Design and analysis of experiments (9th ed., pp. 82–83). John Wiley & Sons. ISBN: 9781119299363

See Also

stats::bartlett.test

Examples

```
df0 <- roGFP[[1]]
out <- Bartlett_test(df0, ro ~ grp)
boxplot(ro ~ grp, df0, horizontal = TRUE)
points(x = df0$ro, y = jitter(as.numeric(df0$grp), amount = 0.15))
```

`Brown_Forsythe_test` *Brown-Forsythe Test of Homogeneity of Variances*

Description

Performs Brown-Forsythe test to assess the null hypothesis that the variances are equal across all groups (samples) defined by the independent variable.

Usage

```
Brown_Forsythe_test(
  data,
  formula,
  alpha = 0.05,
  silent = FALSE,
  summary = FALSE,
  misc = FALSE,
  transform = function(x) abs(x - stats::median(x)),
  method = c("MBF", "BF")
)
```

Arguments

data	A data frame containing the variables specified in the formula.
formula	A formula of the form DV ~ IV, where DV is the dependent (response) variable and IV is the independent (grouping) variable.
alpha	A numeric value specifying the significance level. Must be between 0 and 1. Default is 0.05.
silent	A logical value. If FALSE (default), results are printed to the console. If TRUE, no output is printed.
summary	A logical value (default: FALSE). If TRUE, a summary table for the input data is returned.
misc	A logical value. If FALSE (default), only essential parameters are returned. If TRUE, additional auxiliary parameters are included in the output.
transform	A function used to transform the response variable into deviations from a specified location measure.
method	A character specifying either "MBF" (default) or "BF".

Details

transform The concept is similar to ANOVA procedure (transform the response variable to residuals before analysis). Possible transformation are:

- y' = |yi - ybar| (default)
- y' = (yi - ybar) ^ 2
- y' = ln((yi - ybar) ^ 2)
- y' = sqrt(|yi - ybar|)

The ybar could be either mean, median (default), or trimmed-mean.

method

- "BF": The original Brown–Forsythe test proposed by Brown and Forsythe (1974), a modification of Levene's test that uses the median instead of the mean.
- "MBF" The modified Brown–Forsythe test proposed by Mehrotra (1997), which adjusts the degrees of freedom and consequently yields an approximate F-distribution of F(f1, f2) rather than F(k - 1, N - k). Compared with the original version (BF), this modification tends to reduce the Type I error rate at the cost of a higher Type II error rate.

Value

A list containing the test statistics, p-value, degrees of freedom, and optionally a summary table and/or auxiliary parameters, depending on the values of `summary` and `misc`.

References

Brown, M. B., & Forsythe, A. B. (1974). Robust tests for the equality of variances. Journal of the American Statistical Association, 69(346), 364–367. https://doi.org/10.1080/01621459.1974.10482955

Mehrotra, D. V. (1997). Improving the Brown–Forsythe solution to the generalized Behrens–Fisher problem. Communications in Statistics—Simulation and Computation, 26, 1139–1145. https://doi.org/10.1080/0361091970

See Also

Levene_test

Examples

```
df0 <- roGFP[[1]]
out <- Brown_Forsythe_test(df0, ro ~ grp)
boxplot(ro ~ grp, df0, horizontal = TRUE)
points(x = df0$ro, y = jitter(as.numeric(df0$grp), amount = 0.15))
```

---

check_var_equal *Homogeneity of variance test*

Description

A wrapper function for the homoscedasticity tests available in this package.

Usage

```
check_var_equal(
  data,
  formula,
  alpha = 0.05,
  method = "LV",
  silent = FALSE,
  ...
)
```

Arguments

`data`	A data frame or a list of numeric vectors.
`formula`	Formula (default: NULL). If `data` is a data frame, define the val ~ group.
`alpha`	Significance threshold, range from 0 to 1 (default: 0.05).

method	Character (default: "LV"). Abbreviation specifying the normality test to perform. Available options are c("AB", "BL", "FK", "LG", "LV", "MBF", "OB", "OM").
silent	A logical value. If FALSE (default), results are printed to the console. If TRUE, no output is printed.
...	Additional arguments passed to the selected test function.

Details

The method argument specifies the statistical procedure used to assess whether group variances are equal.

Available methods are:

- "AB": Ansari-Bradley test A rank-based nonparametric test for homogeneity of scale (dispersion) across groups. It is often used as an alternative to the F-test when data are non-normal. However, the Fligner–Killeen test is generally more robust and is recommended for this purpose.
- "BL": Bartlett test A classical parametric test for assessing homoscedasticity across multiple groups. It is highly sensitive to outliers and deviations from normality. When the data are normally distributed and free of outliers, it is the most robust and powerful tests for equality of variances.
- "FK": Fligner–Killeen test A rank-based nonparametric test for homogeneity of variances across groups. It is based on absolute deviations from the median and is highly robust to non-normality and outliers.
- "LG": 't Lam's G test An extension of Cochran's C test used to evaluate the internal consistency of variances. Although primarily designed as a variance outlier detection method rather than a formal test of homoscedasticity (such as Levene's or Bartlett's test), it can be used informally to assess variance homogeneity across groups. Its robustness is particularly strong under normality and in the absence of outliers.
- "LV": Levene's test A classical test for equality of variances based on an ANOVA framework. This implementation uses the median as the center (instead of the mean), making it more robust to non-normality and outliers.
- "MBF": Brown–Forsythe test (modified by Mehrotra) A robust modification of Levene's test proposed by Brown and Forsythe. The degrees of freedom are further adjusted following Mehrotra's correction, improving performance under non-normality and in the presence of outliers.
- "OB": O'Brien test A variance homogeneity test similar in spirit to Levene's test, based on transformed observations designed to reduce sensitivity to non-normality.
- "OM": O'Neill–Mathews test A modified Levene-type procedure that uses a weighted least squares approach.

In all methods, the null hypothesis is that group variances are equal.

Value

A list.

Examples

```
check_var_equal(roGFP[[1]], ro ~ grp, method = "LV")
```

`CYCB1` *Cell number*

Description

A dataset containing cortex cell counts within the meristematic zone of roots in an *Arabidopsis thaliana* transgenic plant (CYCB1;3-GFP).

Usage

```
CYCB1
```

Format

A list containing three data frames, each representing a different experimental batch:

TEMP Air temperature in degrees Celsius

RGF1 Concentration of RGF1 peptide hormone treatment (0 nM, 5 nM)

treatment TEMP x RGF1 -> 4 groups of treatments

grp Handy labels for each treatment (A, B, C, D)

cells Number of meristematic root cells

`Fligner_Killeen_test` *Fligner-Killeen Test of Homogeneity of Variances*

Description

Performs Fligner-Killeen test to assess the null hypothesis that the variances are equal across all groups (samples) defined by the independent variable.

Usage

```
Fligner_Killeen_test(
  data,
  formula,
  alpha = 0.05,
  silent = FALSE,
  summary = FALSE,
  misc = FALSE
)
```

Arguments

`data`	A data frame containing the variables specified in the formula.
`formula`	A formula of the form `DV ~ IV`, where `DV` is the dependent (response) variable and `IV` is the independent (grouping) variable.
`alpha`	A numeric value specifying the significance level. Must be between 0 and 1. Default is 0.05.
`silent`	A logical value. If `FALSE` (default), results are printed to the console. If `TRUE`, no output is printed.
`summary`	A logical value (default: `FALSE`). If `TRUE`, a summary table for the input data is returned.
`misc`	A logical value. If `FALSE` (default), only essential parameters are returned. If `TRUE`, additional auxiliary parameters are included in the output.

Value

A list containing the test statistics, p-value, degrees of freedom, and optionally a summary table and/or auxiliary parameters, depending on the values of `summary` and `misc`.

References

Fligner, M. A., & Killeen, T. J. (1976). Distribution-free two-sample tests for scale. Journal of the American Statistical Association, 71(353), 210–213. https://doi.org/10.1080/01621459.1976.10481517

Conover, W. J., Johnson, M. E., & Johnson, M. M. (1981). A comparative study of tests for homogeneity of variances, with applications to the outer continental shelf bidding data. Technometrics, 23, 351–361. https://doi.org/10.1080/00401706.1981.10487680

See Also

stats::fligner.test

Examples

```
df0 <- CYCB1[[1]]
out <- Fligner_Killeen_test(df0, cells ~ grp)
boxplot(cells ~ grp, df0, horizontal = TRUE)
points(x = df0$cells, y = jitter(as.numeric(df0$grp), amount = 0.15))
```

`is_var_equal` *Homogeneity of variance test*

Description

A convenient wrapper that returns a logical value indicating whether variances across groups are equal. It makes its decision based on the results of several homoscedasticity tests, including the modified Brown–Forsythe (MBF), Fligner–Killeen (FK), 't Lam's G (LG), Levene's (LV), and O'Neill–Mathews (OM) tests.

Usage

```
is_var_equal(
  data,
  formula = NULL,
  alpha = 0.05,
  sensitivity = 3,
  summary = FALSE
)
```

Arguments

data	A data frame or a list of numeric vectors.
formula	Formula (default: NULL). If data is a data frame, define the val ~ group.
alpha	Significance threshold, range from 0 to 1 (default: 0.05).
sensitivity	Numeric, range from 1 to 5 (default: 3). The greater the value, the greater chance to consider as variance not equal.
summary	Logical (default: FALSE). If TRUE, show the summary table.

Value

A boolean value or a list if the summary is set to TRUE.

Examples

```
is_var_equal(roGFP[[1]], ro ~ grp)
```

Lam_G_test *'t Lam's G Test of Homogeneity of Variances*

Description

Performs Lam's G test, an extension of Cochran's C test, to evaluate the internal consistency of variances. Although it is primarily a variance outlier test rather than a "true" homoscedasticity test such as Levene's test or Bartlett's test, it can still be used conceptually to assess the homogeneity of variances across groups.

Usage

```
Lam_G_test(
  data,
  formula,
  alpha = 0.05,
  alternative = c("two.sided", "less", "greater"),
  silent = FALSE,
  summary = FALSE,
  misc = FALSE
)
```

Arguments

data	A data frame containing the variables specified in the formula.
formula	A formula of the form DV ~ IV, where DV is the dependent (response) variable and IV is the independent (grouping) variable.
alpha	A numeric value specifying the significance level. Must be between 0 and 1. Default is 0.05.
alternative	Character (default: "two.sided"). Specifies the alternative hypothesis. Available options are c("two.sided", "less", "greater").
silent	A logical value. If FALSE (default), results are printed to the console. If TRUE, no output is printed.
summary	A logical value (default: FALSE). If TRUE, a summary table for the input data is returned.
misc	A logical value. If FALSE (default), only essential parameters are returned. If TRUE, additional auxiliary parameters are included in the output.

Details

Note: Under normally distributed data and moderate sample sizes ($8 < n < 20$), Lam's G test performs comparably to Bartlett's test. For small sample sizes ($n < 8$), it appears to outperform several alternative tests, providing a favorable balance between Type I and Type II error rates. In contrast, some alternative methods achieve lower Type I error rates at the cost of substantially higher Type II error rates. Note that this test is highly sensitive to outliers.

Value

A list containing the test statistics, p-value, degrees of freedom, and optionally a summary table and/or auxiliary parameters, depending on the values of summary and misc.

References

'T Lam, R. U. E. (2010). Scrutiny of variance results for outliers: Cochran's test optimized. Analytica Chimica Acta, 659(1–2), 68–84. https://doi.org/10.1016/j.aca.2009.11.032

See Also

Brown_Forsythe_test

Examples

```
df0 <- roGFP[[1]]
out <- Lam_G_test(df0, ro ~ grp)
boxplot(ro ~ grp, df0, horizontal = TRUE)
points(x = df0$ro, y = jitter(as.numeric(df0$grp), amount = 0.15))
```

Levene_test *Levene's Test of Homogeneity of Variances*

Description

Performs Levene's test to assess the null hypothesis that the variances are equal across all groups (samples) defined by the independent variable.

Usage

```
Levene_test(
  data,
  formula,
  alpha = 0.05,
  silent = FALSE,
  summary = FALSE,
  misc = FALSE,
  transform = function(x) abs(x - stats::median(x))
)
```

Arguments

data	A data frame containing the variables specified in the formula.
formula	A formula of the form DV ~ IV, where DV is the dependent (response) variable and IV is the independent (grouping) variable.
alpha	A numeric value specifying the significance level. Must be between 0 and 1. Default is 0.05.
silent	A logical value. If FALSE (default), results are printed to the console. If TRUE, no output is printed.
summary	A logical value (default: FALSE). If TRUE, a summary table for the input data is returned.
misc	A logical value. If FALSE (default), only essential parameters are returned. If TRUE, additional auxiliary parameters are included in the output.
transform	A function used to transform the response variable into deviations from a specified location measure.

Details

transform: The concept is similar to ANOVA procedure (transform the response variable to residuals before analysis). Possible transformation are:

- y' = |yi - ybar| (default)
- y' = (yi - ybar) ^ 2
- y' = ln((yi - ybar) ^ 2)
- y' = sqrt(|yi - ybar|)

The ybar could be either mean, median (default), or trimmed-mean.

Value

A list containing the test statistics, p-value, degrees of freedom, and optionally a summary table and/or auxiliary parameters, depending on the values of `summary` and `misc`.

References

Levene, H. (1960). Robust tests for equality of variances. In I. Olkin (Ed.), Contributions to probability and statistics: Essays in honor of Harold Hotelling (pp. 278–292). Stanford University Press.

Sharma, D., & Kibria, B. M. G. (2013). On some test statistics for testing homogeneity of variances: A comparative study. Journal of Statistical Computation and Simulation, 83, 1944–1963. https://doi.org/10.1080/00949655.2012.675336

Zhou, Y., Zhu, Y., & Wong, W. K. (2023). Statistical tests for homogeneity of variance for clinical trials and recommendations. Contemporary Clinical Trials Communications, 33, 101119. https://doi.org/10.1016/j.conctc.2023.101119

See Also

Brown_Forsythe_test

Examples

```
df0 <- roGFP[[1]]
out <- Levene_test(df0, ro ~ grp)
boxplot(ro ~ grp, df0, horizontal = TRUE)
points(x = df0$ro, y = jitter(as.numeric(df0$grp), amount = 0.15))
```

O.Brien_test *O'Brien's Test of Homogeneity of Variances*

Description

Performs O'Brien's test to assess the null hypothesis that the variances are equal across all groups (samples) defined by the independent variable.

Usage

```
O.Brien_test(
  data,
  formula,
  alpha = 0.05,
  silent = FALSE,
  summary = FALSE,
  misc = FALSE,
  transform = function(x) (x - stats::median(x))^2
)
```

Arguments

`data`	A data frame containing the variables specified in the formula.
`formula`	A formula of the form `DV ~ IV`, where `DV` is the dependent (response) variable and `IV` is the independent (grouping) variable.
`alpha`	A numeric value specifying the significance level. Must be between 0 and 1. Default is 0.05.
`silent`	A logical value. If `FALSE` (default), results are printed to the console. If `TRUE`, no output is printed.
`summary`	A logical value (default: `FALSE`). If `TRUE`, a summary table for the input data is returned.
`misc`	A logical value. If `FALSE` (default), only essential parameters are returned. If `TRUE`, additional auxiliary parameters are included in the output.
`transform`	A function used to transform the response variable into deviations from a specified location measure.

Details

`transform`: The concept is similar to ANOVA procedure (transform the response variable to residuals before analysis). Possible transformation are:

- y' = |yi - ybar|
- y' = (yi - ybar) ^ 2 (default)
- y' = ln((yi - ybar) ^ 2)
- y' = sqrt(|yi - ybar|)

The `ybar` could be either mean, median (default), or trimmed-mean.

Note: This test is often regarded as conservative and may have relatively low power to detect heteroscedasticity. The Levene and Brown-Forsythe tests are generally preferred for assessing the homogeneity of variances.

Value

A list containing the test statistics, p-value, degrees of freedom, and optionally a summary table and/or auxiliary parameters, depending on the values of `summary` and `misc`.

References

O'Brien, R. G. (1981). A simple test for variance effects in experimental designs. Psychological Bulletin, 89(3), 570–574. https://doi.org/10.1037/0033-2909.89.3.570

See Also

[Brown_Forsythe_test][Levene_test][O.Neill_Mathews_test]

Examples

```
df0 <- CYCB1[[1]]
out <- O.Brien_test(df0, cells ~ grp)
boxplot(cells ~ grp, df0, horizontal = TRUE)
points(x = df0$cells, y = jitter(as.numeric(df0$grp), amount = 0.15))
```

O.Neill_Mathews_test *O'Neill-Mathews Test of Homogeneity of Variances*

Description

Performs O'Neill-Mathews test to assess the null hypothesis that the variances are equal across all groups (samples) defined by the independent variable.

Usage

```
O.Neill_Mathews_test(
  data,
  formula,
  alpha = 0.05,
  silent = FALSE,
  summary = FALSE,
  misc = FALSE,
  transform = function(x) abs(x - stats::median(x))
)
```

Arguments

data	A data frame containing the variables specified in the formula.
formula	A formula of the form DV ~ IV, where DV is the dependent (response) variable and IV is the independent (grouping) variable.
alpha	A numeric value specifying the significance level. Must be between 0 and 1. Default is 0.05.
silent	A logical value. If FALSE (default), results are printed to the console. If TRUE, no output is printed.
summary	A logical value (default: FALSE). If TRUE, a summary table for the input data is returned.
misc	A logical value. If FALSE (default), only essential parameters are returned. If TRUE, additional auxiliary parameters are included in the output.
transform	A function used to transform the response variable into deviations from a specified location measure.

Details

`transform`: The concept is similar to ANOVA procedure (transform the response variable to residuals before analysis). Possible transformation are:

- y' = |yi - ybar| (default)
- y' = (yi - ybar) ^ 2
- y' = ln((yi - ybar) ^ 2)
- y' = sqrt(|yi - ybar|)

The `ybar` could be either mean, median (default), or trimmed-mean.

Value

A list containing the test statistics, p-value, degrees of freedom, and optionally a summary table and/or auxiliary parameters, depending on the values of `summary` and `misc`.

References

O'Neill, M. E., & Mathews, K. (2000). Theory & Methods: A Weighted Least Squares Approach to Levene's Test of Homogeneity of Variance. Australian & New Zealand Journal of Statistics, 42(1), 81–100. https://doi.org/10.1111/1467-842X.00109

See Also

[Levene_test][Brown_Forsythe_test][O.Brien_test]

Examples

```
df0 <- roGFP[[1]]
out <- O.Neill_Mathews_test(df0, ro ~ grp)
boxplot(ro ~ grp, df0, horizontal = TRUE)
points(x = df0$ro, y = jitter(as.numeric(df0$grp), amount = 0.15))
```

`roGFP` *RO index*

Description

A dataset containing the reduced–oxidized (RO) index computed from confocal fluorescence images of roots of an *Arabidopsis thaliana* transgenic plant (cytRGX–roGFP2).

Usage

```
roGFP
```

Format

A list containing three data frames, each representing a different experimental batch:

TEMP Air temperature in degrees Celsius (22C and 31C)

RGF1 Concentration of RGF1 peptide hormone treatment (0nM, 5nM)

treatment TEMP x RGF1 -> 4 groups of treatments

grp Handy labels for each treatment (A, B, C, D)

ro Redox index ranging from -1 (reduced) to 1 (oxidized)

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