

# Package ‘doex’

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**Type** Package

**Title** The One-Way Heteroscedastic ANOVA Tests

**Version** 1.2

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**Description** Contains the heteroscedastic ANOVA tests for normal and two-parameter exponential distributed populations. For normal distributions, Alexander-Govern test by Alexander and Govern (1994) <doi:10.2307/1165140>, Alvandi et al. Generalized F test by Alvandi et al. (2012) <doi:10.1080/03610926.2011.573160>, Approximate F test by Asiribo and Gurland (1990) <doi:10.1080/03610929008830427>, Box F test by Box (1954) <doi:10.1214/aoms/1177728786>, Brown-Forsythe test by Brown and Forsythe (1974) <doi:10.2307/1267501>, B2 test by Ozdemir and Kurt (2006) <<http://sjam.selcuk.edu.tr/sjam/article/view/174>>, Cochran F test by Cochran (1937) <<https://www.jstor.org/stable/pdf/2984123.pdf>>, Fiducial Approach test by Li et al. (2011) <doi:10.1016/j.csda.2010.12.009>, Generalized F test by Weerandi (1995) <doi:10.2307/2532947>, Johansen F test by Johansen (1980) <doi:10.1093/biomet/67.1.85>, Modified Brown-Forsythe test by Mehrotra (1997) <doi:10.1080/03610919708813431>, Modified Welch test by Hartung et al. (2002) <doi:10.1007/s00362-002-0097-8>, One-Stage test by Chen and Chen (1998) <doi:10.1080/03610919808813501>, One-Stage Range test by Chen and Chen (2000) <doi:10.1080/01966324.2000.10737505>, Parametric Bootstrap test by Krishnamoorthy et al. (2007) <doi:10.1016/j.csda.2006.09.039>, Permutation F test by Berry and Mielke (2002) <doi:10.2466/pr0.2002.90.2.495>, Scott-Smith test by Scott and Smith (1971) <doi:10.2307/2346757>, Welch test by Welch (1951) <doi:10.2307/2332579>, and Weir-Aspin test by Aspin (1948) <doi:10.1093/biomet/35.1-2.88>. These tests are used to test the equality of group means under unequal variance. Also, a modified version of Generalized F-test is improved to test the equality of non-normal group means under unequal variances and a revised version of Generalized F-test is given to test the equality of non-normal group means caused by skewness. Furthermore, it consists some procedures for testing equality of several two-parameter exponentially distributed population means under unequal scale parameters such as generalized p-value, parametric bootstrap and fiducial approach test by Malekzadeh and Jafari (2019) <doi:10.1080/03610918.2018.1538452>. There is also Hsieh test by Hsieh (1986) <doi:10.2307/1270452> for testing equality of location parameters of two-parameter exponentially distributed populations under unequal scale parameters.

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**Arguments**

data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.

**Value**

test.statistic	the test statistic of the Alexander-Govern test
p.value	the p-value of the Alexander-Govern test

**Author(s)**

Mustafa CAVUS

**References**

Alexander, R.A., Govern, D.M. (1994) A new and simpler approximation for ANOVA under variance heterogeneity, *Journal of Educational Statistics*, 19(2), 91-101.

**Examples**

```
library(doeX)
AG(hybrid$data, hybrid$species)
```

---

AGF

*Alvandi et al. Generalized F-test*


---

**Description**

This function performs Alvandi et al. Generalized F-test.

**Usage**

```
AGF(data, group, rept)
```

**Arguments**

data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.
rept	The loop size to perform the test.

**Value**

pvalue	the p-value of the Alvandi et al. Generalized F-test
--------	--

**Author(s)**

Mustafa CAVUS

**References**

Sadooghi-Alvandi, S.M., Jafari, A.A., Mardani-Fard, H.A. (2012) One-way ANOVA with unequal variances, *Communications in Statistics: Theory and Methods*, 41, 4200-4221.

**Examples**

```
library(doex)
AGF(hybrid$data, hybrid$species, 10000)
```

---

B2

*B-square test*

---

**Description**

This function performs B-square test.

**Usage**

```
B2(alpha, data, group)
```

**Arguments**

alpha	significance level of the test.
data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.

**Value**

p. value	the p-value of the B-square test
----------	----------------------------------

**Author(s)**

Mustafa CAVUS

**References**

Özdemir, A.F. and Kurt, S. (2006) One way fixed effect analysis of variance under variance heterogeneity and a solution proposal, *Selçuk Journal of Applied Mathematics*, 7(2), 81-90.

**Examples**

```
library(doex)
B2(0.05, hybrid$data, hybrid$species)
```

---

BF

*Brown-Forsythe test*

---

### **Description**

This function performs Brown-Forsythe test.

### **Usage**

```
BF(data, group)
```

### **Arguments**

`data` A vector containing the observations to which the treatments are randomly assigned.

`group` A numerical or character vector indicating the treatment/control groups.

### **Value**

`pvalue` the p-value of the Brown-Forsythe test

### **Author(s)**

Mustafa CAVUS

### **References**

Brown, M.B. and Forsythe, A.B. (1974) The small sample behavior of some statistics which test the equality of several means, *Technometrics*, 16, 129–132.

### **Examples**

```
library(doex)
BF(hybrid$data, hybrid$species)
```

---

BX

*Box F-test*

---

### **Description**

This function performs Box F-test.

### **Usage**

```
BX(data, group)
```

**Arguments**

`data` A vector containing the observations to which the treatments are randomly assigned.

`group` A numerical or character vector indicating the treatment/control groups.

**Value**

`pvalue` the p-value of the Box F-test

**Author(s)**

Mustafa CAVUS

**References**

Box, G.E.P. (1954) Some theorems on quadratic forms applied in the study of analysis of variance problems, *Annals of Mathematical Statistics*, 25, 290-302.

**Examples**

```
library(doeX)
BX(hybrid$data, hybrid$species)
```

---

CF

*Cochran F-test*


---

**Description**

This function performs Cochran F-test.

**Usage**

```
CF(data, group)
```

**Arguments**

`data` A vector containing the observations to which the treatments are randomly assigned.

`group` A numerical or character vector indicating the treatment/control groups.

**Value**

`pvalue` the p-value of the Cochran F-test

**Author(s)**

Mustafa CAVUS

**References**

Cochran, W.G. (1937) Problems arising in the analysis of a series of similar experiments, Journal of the Royal Statistical Society, 4, 102-118.

**Examples**

```
library(doex)
CF(hybrid$data, hybrid$species)
```

---

 component

*Component data*


---

**Description**

Component data is a complete dataset consists lifetimes of a component which is produced by four different suppliers. The lifetimes of the component distribute as the two-parameter exponential distribution.

**Usage**

```
component
```

**Value**

lifetime	A set of data on lifetimes of the components obtained from the different suppliers.
supplier	A set of suppliers produce the components.

**Author(s)**

Mustafa CAVUS

**Examples**

```
library(doex)
component$supplier;
component$lifetime;
```



---

FA	<i>Fiducial Approach test</i>
----	-------------------------------

---

**Description**

This function performs Fiducial Approach test.

**Usage**

```
FA(data, group, rept)
```

**Arguments**

data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.
rept	The loop size to perform the test.

**Value**

pvalue	the p-value of the Fiducial Approach test
--------	---

**Author(s)**

Mustafa CAVUS

**References**

Li, X., Wang, J. and Liang, H. (2011) Comparison of several means: a fiducial based approach, Computational Statistics and Data Analysis, 55, 1993-2002.

**Examples**

```
library(doex)  
FA(hybrid$data, hybrid$species)
```

---

`fa_exp`*Fiducial Approach test for Two Parameter Exponential Distributions*

---

**Description**

This function performs Fiducial Approach test for two-parameter exponential distributed populations.

**Usage**

```
fa_exp(data,group,rept)
```

**Arguments**

<code>data</code>	A vector containing the observations to which the treatments are randomly assigned.
<code>group</code>	A numerical or character vector indicating the treatment/control groups.
<code>rept</code>	The loop size to perform the test.

**Value**

<code>pvalue</code>	the p-value of the Fiducial Approach test for two-parameter exponential distributed populations
---------------------	---

**Author(s)**

Mustafa CAVUS

**References**

Malekzadeh, A. and Jafari, A. A. (2019) Inference on the equality means of several two-parameter exponential distributions under progressively Type II censoring, Communications in Statistics - Simulation and Computation.

**Examples**

```
library(doex)
fa_exp(component$lifetime,component$supplier)
```

---

GF *Generalized F-test*

---

**Description**

This function performs Generalized F-test.

**Usage**

```
GF(data, group, rept)
```

**Arguments**

data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.
rept	The loop size to perform the test.

**Value**

pvalue	the p-value of the Generalized F-test
--------	---------------------------------------

**Author(s)**

Mustafa CAVUS

**References**

Weerahandi, S.(1994) ANOVA under unequal error variances, *Biometrics*, 51, 589-599.

**Examples**

```
library(doex)
GF(hybrid$data, hybrid$species)
```

---

gpv\_exp *Generalized p-value test for Two-Parameter Exponential Distributions*

---

**Description**

This function performs Generalized p-value test for two-parameter exponential distributed populations.

**Usage**

```
gpv_exp(data, group, rept)
```

**Arguments**

data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.
rept	The loop size to perform the test.

**Value**

pvalue	the p-value of the Generalized p-value test for two-parameter exponential distributed populations
--------	---

**Author(s)**

Mustafa CAVUS

**References**

Malekzadeh, A. and Jafari, A. A. (2019) Inference on the equality means of several two-parameter exponential distributions under progressively Type II censoring, Communications in Statistics - Simulation and Computation.

**Examples**

```
library(dox)
gpv_exp(component$lifetime, component$supplier)
```

---

HS

*Hsieh test for Two Parameter Exponential Distributions*

---

**Description**

This function performs Hsieh test for two-parameter exponential distributed populations.

**Usage**

```
HS(data, group)
```

**Arguments**

data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.

**Value**

pvalue	the p-value of the Hsieh test
--------	-------------------------------

**Author(s)**

Mustafa CAVUS

**References**

Hsieh, H.K. (1986) An exact test for comparing location parameters of k exponential distributions with unequal scales based on type II censored data, *Technometrics*, 28, 157-164.

**Examples**

```
library(doex)
HS(component$lifetime,component$supplier)
```

---

 hybrid

---

*Hybrid data*


---

**Description**

Hybrid data is taken from Weerahandi (1995) where the goal is to compare four means of corn yields by four hybrids: A, B, C, D.

An agricultural research scientist is interested in comparing four hybrids of corn. The four corn hybrids were planted in a random order in 22 plots of equal size and fairly homogeneous soil conditions. A set of data on yield from corn hybrids obtained from the experiment.

The usual P-value based on the assumption of equal population within hybrid variances (F statistic 1.841) is 0.176, thus leading to acceptance of the null hypothesis of equal means. It is however clear from the values of the sample standard deviations that the assumption of equal population variances may not be tenable for this data set.

**Usage**

```
hybrid
```

**Value**

data	A set of data on yield from corn hybrids obtained from the experiment.
species	A set of corn hybrids.

**Author(s)**

Mustafa CAVUS

**References**

Weerahandi, S. (1995) *Exact Statistical Methods for Data Analysis*. New York: Springer.

**Examples**

```
library(doex)
hybrid$data;
hybrid$species;
```

---

JF

*Johansen F-test*

---

**Description**

This function performs Johansen F-test.

**Usage**

```
JF(data, group)
```

**Arguments**

data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.

**Value**

pvalue	the p-value of the Johansen F-test
--------	------------------------------------

**Author(s)**

Mustafa CAVUS

**References**

Johansen, S. (1980) The Welch-James approximation to the distribution of the residual sum of squares in a weighted linear regression, *Biometrika*, 67(1), 58-92.

**Examples**

```
library(doex)
JF(hybrid$data, hybrid$species)
```

---

MBF *Modified Brown-Forsythe test*

---

**Description**

This function performs modified Brown-Forsythe test.

**Usage**

```
MBF(data, group)
```

**Arguments**

`data` A vector containing the observations to which the treatments are randomly assigned.

`group` A numerical or character vector indicating the treatment/control groups.

**Value**

`pvalue` the p-value of the modified Brown-Forsythe test

**Author(s)**

Mustafa CAVUS

**References**

Mehrotra, D.V. (1997) Improving the Brown-Forsythe solution to the generalized Behrens-Fisher problem, 26(3), 1139-1145.

**Examples**

```
library(doex)
MBF(hybrid$data, hybrid$species)
```

---

MGF *Modified generalized F-test*

---

**Description**

This function performs the modified generalized F-test.

**Usage**

```
MGF(data, group, rept)
```

**Arguments**

data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.
rept	The loop size to perform the test.

**Value**

pvalue	the p-value of the modified generalized F-test
--------	--

**Author(s)**

Mustafa CAVUS

**References**

Cavus, M., Yazici, B. and Sezer, A. (2017) Modified tests for comparison of group means under heteroskedasticity and non-normality caused by outlier(s), Hacettepe Journal of Mathematics and Statistics, 46 (3), 492-510.

**Examples**

```
library(doex)
MGF(hybrid$data, hybrid$species)
```

---

MW

*Modified Welch Test*

---

**Description**

This function performs adjusted Welch test.

**Usage**

```
MW(data, group)
```

**Arguments**

data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.

**Value**

tstat	the test statistic of the adjusted Welch test
pvalue	the p-value of the adjusted Welch test



**Author(s)**

Mustafa CAVUS

**References**

Hartung, J., Argaç, D. and Makambi, K. (2002) Small sample properties of tests on homogeneity in one-way ANOVA and meta-analysis, *Statistical Papers*, 41, 197-235.

**Examples**

```
library(doex)
MW(hybrid$data, hybrid$species)
```

---

OS

*One Stage test*

---

**Description**

This function performs Chen's one stage test.

**Usage**

```
OS(data, group, nout, rept)
```

**Arguments**

data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.
nout	an integer
rept	The loop size to perform the test.

**Value**

pvalue	the p-value of Chen's one stage test
--------	--------------------------------------

**Author(s)**

Mustafa CAVUS

**References**

Chen, S.Y. and Chen, H.J. (1998) Single-stage analysis of variance under heteroscedasticity, *Communications in Statistics - Simulation and Computation*, 27(3), 641-666.

**Examples**

```
library(doex)
OS(hybrid$data, hybrid$species, 1, 10000)
```

---

OSR	<i>One Stage Range test</i>
-----	-----------------------------

---

**Description**

This function performs One Stage Range test.

**Usage**

```
OSR(data,group,nout,rept)
```

**Arguments**

data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.
nout	an integer
rept	The loop size to perform the test.

**Value**

pvalue	the p-value of the One Stage Range test
--------	---

**Author(s)**

Mustafa CAVUS

**References**

Chen, S.Y. and Chen, H.J. (2000) A Range Test for the Equality of Means when Variances are Unequal, American Journal of Mathematical and Management Sciences, 20:1-2, 145-170.

**Examples**

```
library(doex)  
OSR(hybrid$data,hybrid$species,1,10000)
```

---

outly	<i>Outlier generation function</i>
-------	------------------------------------

---

**Description**

This function generates the outlier(s) by Interquartile range approach.

**Usage**

```
outly(ndata,noutlier,meand,var,dif,alpha,normality.status,skewn.status)
```

**Arguments**

ndata	sample size of the data without outlier(s).
noutlier	number of outlier(s) in data.
meand	mean of the data.
vard	variance of the data.
dif	distance level of outlier(s) from the whiskers.
alpha	significance level for the normality test.
normality.status	a logical operator controls the normality of data with outlier. "TRUE" for normal and "FALSE" for non-normal
skewn.status	a logical operator controls the skewness of the data with outlier. "0" for symmetric, "1" for right-skewed and "-1" for left-skewed.

**Value**

data	the vector contains the generated data with outlier(s)
outlier	the vector contains the generated outlier(s)
normality.test	the result of the Shapiro-Wilk normality test for the generated data

**Author(s)**

Mustafa CAVUS

**References**

Alexander, R.A., Govern, D.M. (1994) A new and simpler approximation for ANOVA under variance heterogeneity, *Journal of Educational Statistics*, 19(2), 91-101.

**Examples**

```
library(doex)
outly(8,2,2,0.05,FALSE)
```

---

PB *Parametric Bootstrap test*

---

**Description**

This function performs Parametric Bootstrap test.

**Usage**

```
PB(data, group, rept)
```

**Arguments**

data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.
rept	The loop size to perform the test.

**Value**

pvalue	the p-value of the Parametric Bootstrap test
--------	--

**Author(s)**

Mustafa CAVUS

**References**

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

**Examples**

```
library(doex)  
PB(hybrid$data, hybrid$species)
```

---

pb_exp	<i>Parametric Bootstrap test for Two Parameter Exponential Distributions</i>
--------	--

---

**Description**

This function performs Parametric Bootstrap test for two-parameter exponential distributed populations.

**Usage**

```
pb_exp(data,group,rept)
```

**Arguments**

data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.
rept	The loop size to perform the test.

**Value**

pvalue	the p-value of the Parametric Bootstrap test for two-parameter exponential distributed populations
--------	--

**Author(s)**

Mustafa CAVUS

**References**

Malekzadeh, A. and Jafari, A. A. (2019) Inference on the equality means of several two-parameter exponential distributions under progressively Type II censoring, Communications in Statistics - Simulation and Computation.

**Examples**

```
library(doex)
pb_exp(component$lifetime,component$supplier)
```

---

PF *Permutation F-test*

---

**Description**

This function performs Permutation F-test.

**Usage**

```
PF(data,group,rept)
```

**Arguments**

data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.
rept	The loop size to perform the test.

**Value**

pvalue	the p-value of the Permutation F-test
--------	---------------------------------------

**Author(s)**

Mustafa CAVUS

**References**

Berry, K.J. and Mielke, P.W. (2002) The Fisher-Pitman permutation test: an attractive alternative to the f test, Psychological Reports, 90, 495-502.

**Examples**

```
library(doex)  
PF(hybrid$data,hybrid$species,1000)
```

---

RGF	<i>Revised generalized F-test</i>
-----	-----------------------------------

---

**Description**

This function performs the revised generalized F-test.

**Usage**

```
RGF(data, group, rept)
```

**Arguments**

data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.
rept	The loop size to perform the test.

**Value**

pvalue	the p-value of the revised generalized F-test
--------	---

**Author(s)**

Mustafa CAVUS

**References**

Cavus, M., Yazici, B. and Sezer, A. (2019) A revised generalized F-test for testing equality of group means under non-normality caused by skewness (under review).

**Examples**

```
library(doex)  
RGF(hybrid$data, hybrid$species)
```

---

SS	<i>Scott-Smith Test</i>
----	-------------------------

---

**Description**

This function performs adjusted Scott-Smith test.

**Usage**

```
SS(data, group)
```

**Arguments**

data	A vector containing the observations to which the treatments are randomly assigned.
group	A numerical or character vector indicating the treatment/control groups.

**Value**

pvalue	the p-value of the Scott-Smith test
--------	-------------------------------------

**Author(s)**

Mustafa CAVUS

**References**

Scott, A. and Smith, T. (1971) Interval estimates for linear combinations of means, *Applied Statistics*, 20, 276–285.

**Examples**

```
library(dox)  
SS(hybrid$data, hybrid$species)
```

---

WA	<i>Welch-Aspin test</i>
----	-------------------------

---

**Description**

This function performs the Welch-Aspin test.

**Usage**

```
WA(data, group)
```





**References**

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

**Examples**

```
library(doex)  
WE(hybrid$data, hybrid$species)
```

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