

# Package ‘npANCOVA’

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**Type** Package

**Title** Nonparametric ANCOVA Methods

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**Description** Nonparametric methods for analysis of covariance (ANCOVA) are distribution-free and provide a flexible statistical framework for situations where the assumptions of parametric ANCOVA are violated or when the response variable is ordinal. This package implements several well-known nonparametric ANCOVA procedures, including Quade, Puri and Sen, McSweeney and Porter, Burnett and Barr, Hettmansperger and McKean, Shirley, and Puri-Sen-Harwell-Serlin. The package provides user-friendly functions to apply these methods in practice.

These methods are described in Olejnik et al. (1985)

<[doi:10.1177/0193841X8500900104](https://doi.org/10.1177/0193841X8500900104)> and Harwell et al. (1988)

<[doi:10.1037/0033-2909.104.2.268](https://doi.org/10.1037/0033-2909.104.2.268)>.

**License** GPL-3

**URL** <https://github.com/MinaJahangiri/npANCOVA>

**BugReports** <https://github.com/MinaJahangiri/npANCOVA/issues>

**Depends** R (>= 4.0)

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|--------------|---------------------------------------------------------|
| Burnett_Barr | <i>Burnett and Barr Method for Nonparametric ANCOVA</i> |
|--------------|---------------------------------------------------------|

---

Description

Implements the Burnett and Barr rank-based method for ANCOVA. This method is suitable for models with one response, one covariate, and one grouping variable.

Usage

```
Burnett_Barr(data, formula)
```

Arguments

- data           A data frame containing the variables specified in the formula.
- formula       An object of class "formula": a symbolic description of the model to be fitted. The structure should be ‘response ~ covariate + group’.

Value

- A list containing the following components:
- regression\_equation** The summary of the fitted linear model.
  - anova** The ANOVA table from the fitted model.
  - data** The original data frame with added columns for ranks.

## References

- Burnett TD, Barr DRJE, Measurement P. A nonparametric analogy of analysis of covariance. 1977;37(2):341-8.
- Olejnik SF, Algina JJER. A review of nonparametric alternatives to analysis of covariance. 1985;9(1):51-83.

## Examples

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35)
)

# 2. Run the Burnett and Barr method
results <- Burnett_Barr(
  formula = response ~ covariate1 + group,
  data = data
)

# 3. View the results
print(results)
print(results$anova)
```

---

Harwell\_Serlin

*Harwell and Serlin Method for Nonparametric ANCOVA*


---

## Description

Performs the Harwell and Serlin method using ranked response and covariate variables.

## Usage

```
Harwell_Serlin(data, formula)
```

## Arguments

- |         |                                                                                                                                                |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------|
| data    | A data frame containing the variables specified in the formula.                                                                                |
| formula | An object of class "formula": a symbolic description of the model to be fitted. The structure should be 'response ~ covariate1 + ... + group'. |

**Value**

A list containing the following components:

**regression\_equation** The summary of the fitted linear model.

**anova** The ANOVA table from the fitted model.

**statistics** The Harwell-Serlin test statistic.

**df** The degrees of freedom for the test.

**p\_value** The p-value of the test.

**data** The original data frame with added columns for ranks.

**References**

Harwell MR, Serlin RCJPB. An empirical study of a proposed test of nonparametric analysis of covariance. 1988;104(2):268.

**Examples**

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35),
  covariate2 = c(12, 21, 24, 29, 34, 17, 2, 40, 38, 36, 8, 1, 9, 28, 16)
)

# 2. Run the Harwell and Serlin method
results <- Harwell_Serlin(
  formula = response ~ covariate1 + covariate2 + group,
  data = data
)

# 3. View the results
print(results$p_value)
print(paste("Statistic:", results$statistics, "df:", results$df, "P-value:", results$p_value))
```

---

Hettmansperger\_McKean *Hettmansperger and McKean Method for ANCOVA*

---

**Description**

Applies rank-based residual analysis for ANCOVA. This method involves fitting a model of the response on the covariate, calculating residuals, ranking them, and then performing an ANOVA on the (weighted) ranked residuals.

**Usage**

```
Hettmansperger_McKean(data, formula)
```

**Arguments**

|                      |                                                                                                                                                |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>data</code>    | A data frame containing the variables specified in the formula.                                                                                |
| <code>formula</code> | An object of class "formula": a symbolic description of the model to be fitted. The structure should be 'response ~ covariate1 + ... + group'. |

**Value**

A list containing the following components:

**regression\_equation\_covariate** The summary of the initial model fitting response on covariates.

**regression\_equation\_residuals** The summary of the model fitting weighted ranked residuals on the group.

**anova** The ANOVA table for the model based on weighted ranked residuals.

**group\_means** A data frame of the mean of weighted ranked residuals for each group.

**group\_sds** A data frame of the standard deviation of weighted ranked residuals for each group.

**data** The original data frame augmented with residuals, ranked residuals, and weighted ranked residuals.

**References**

Hettmansperger TP, McKean JWJT. A robust alternative based on ranks to least squares in analyzing linear models. 1977;19(3):275-84.

Hettmansperger TP, McKean JWJotASA. A geometric interpretation of inferences based on ranks in the linear model. 1983;78(384):885-93.

**Examples**

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35),
  covariate2 = c(12, 21, 24, 29, 34, 17, 2, 40, 38, 36, 8, 1, 9, 28, 16)
)

# 2. Run the Hettmansperger and McKean method
results <- Hettmansperger_McKean(
  formula = response ~ covariate1 + covariate2 + group,
  data = data
)

# 3. View the results
print(results)
print(results$anova)
```

---

 McSweeny\_Porter

---

*McSweeny and Porter Method for Nonparametric ANCOVA*


---

## Description

Performs rank-based ANCOVA with and without an interaction term between the covariates and the group.

## Usage

```
McSweeny_Porter(data, formula)
```

## Arguments

**data** A data frame containing the variables specified in the formula.

**formula** An object of class "formula": a symbolic description of the model to be fitted. The structure should be 'response ~ covariate1 + ... + group'.

## Value

A list containing the following components:

**regression\_equation\_covariate** Summary of the model with only covariates.

**regression\_equation\_covariate\_group** Summary of the model with covariates and group main effects.

**group\_effect** The result of an ANOVA test for group effect.

**interaction\_effect** The result of an ANOVA test for interaction effect between group and covariate variables.

**regression\_equation\_interaction** Summary of the model including the interaction term.

**data** The original data frame with added columns for ranks.

## References

McSweeney M, Porter AJOp. Small sample properties of nonparametric index of response and rank analysis of covariance. 1971;16.

Olejnik SF, Algina JJER. A review of nonparametric alternatives to analysis of covariance. 1985;9(1):51-83.

## Examples

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35),
  covariate2 = c(12, 21, 24, 29, 34, 17, 2, 40, 38, 36, 8, 1, 9, 28, 16)
```

```

)

# 2. Run the McSweeny and Porter method
results <- McSweeny_Porter(
  formula = response ~ covariate1 + covariate2 + group,
  data = data
)

# 3. View the results
print(results)
print(results$group_effect)
print(results$interaction_effect)

```

Puri\_Sen\_MB

*Puri and Sen Method with Biased Variance-Covariance Matrix for  
Nonparametric ANCOVA: Multiple Covariates*

## Description

Performs the Puri and Sen method for multiple covariates using a biased variance-covariance matrix.

## Usage

```
Puri_Sen_MB(data, formula)
```

## Arguments

|                |                                                                                                                                                |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>data</b>    | A data frame containing the variables specified in the formula.                                                                                |
| <b>formula</b> | An object of class "formula": a symbolic description of the model to be fitted. The structure should be 'response ~ covariate1 + ... + group'. |

## Value

A list containing the following components:

**residuals** A vector of residuals for each group.

**V** The biased variance-covariance matrix.

**inverse\_V** The inverse of the variance-covariance matrix.

**L\_statistic** The Puri and Sen L-statistic.

**df** The degrees of freedom for the test.

**p\_value** The corresponding p-value of the L-statistic.

**data** The original data frame with added columns for ranks.

References

Puri ML, Sen PKJAoMS. Analysis of covariance based on general rank scores. 1969;40(2):610-8.

Olejnik SF, Algina JJER. A review of nonparametric alternatives to analysis of covariance. 1985;9(1):51-83.

Examples

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35),
  covariate2 = c(12, 21, 24, 29, 34, 17, 2, 40, 38, 36, 8, 1, 9, 28, 16)
)

# 2. Run the Puri and Sen (MB) method
results <- Puri_Sen_MB(
  formula = response ~ covariate1 + covariate2 + group,
  data = data
)

# 3. View the results
print(results)
print(paste("Statistic:", results$L_statistic,"df:", results$df, "P-value:", results$p_value))
```

---

|             |                                                                                                                   |
|-------------|-------------------------------------------------------------------------------------------------------------------|
| Puri_Sen_MU | <i>Puri and Sen Method with Unbiased Variance-Covariance Matrix for Nonparametric ANCOVA: Multiple Covariates</i> |
|-------------|-------------------------------------------------------------------------------------------------------------------|

---

Description

Performs the Puri and Sen method for multiple covariates using an unbiased variance-covariance matrix.

Usage

```
Puri_Sen_MU(data, formula)
```

Arguments

- data                   A data frame containing the variables specified in the formula.
- formula               An object of class "formula": a symbolic description of the model to be fitted. The structure should be ‘response ~ covariate1 + ... + group’.



**Value**

A list containing the following components:

**residuals** A vector of residuals for each group.

**V** The unbiased variance-covariance matrix.

**inverse\_V** The inverse of the variance-covariance matrix.

**L\_statistic** The Puri and Sen L-statistic.

**df** The degrees of freedom for the test.

**p\_value** The corresponding p-value of the L-statistic.

**data** The original data frame with added columns for ranks.

**References**

Puri ML, Sen PKJAoMS. Analysis of covariance based on general rank scores. 1969;40(2):610-8.

Olejnik SF, Algina JJER. A review of nonparametric alternatives to analysis of covariance. 1985;9(1):51-83.

**Examples**

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35),
  covariate2 = c(12, 21, 24, 29, 34, 17, 2, 40, 38, 36, 8, 1, 9, 28, 16)
)

# 2. Run the Puri and Sen (MU) method
results <- Puri_Sen_MU(
  formula = response ~ covariate1 + covariate2 + group,
  data = data
)

# 3. View the results
print(results)
print(paste("Statistic:", results$L_statistic, "df:", results$df, "P-value:", results$p_value))
```

---

Puri\_Sen\_OB

---

*Puri and Sen Method with Biased Variance-Covariance Matrix for  
Nonparametric ANCOVA: One Covariate*


---

**Description**

Performs the Puri and Sen method for a single covariate using a biased variance-covariance matrix.

**Usage**

```
Puri_Sen_OB(data, formula)
```

**Arguments**

|                |                                                                                                                                         |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| <b>data</b>    | A data frame containing the variables specified in the formula.                                                                         |
| <b>formula</b> | An object of class "formula": a symbolic description of the model to be fitted. The structure should be 'response ~ covariate + group'. |

**Value**

A list containing the following components:

**residuals** A vector of residuals for each group.  
**V** The biased variance-covariance matrix.  
**inverse\_V** The inverse of the variance-covariance matrix.  
**L\_statistic** The Puri and Sen L-statistic.  
**df** The degrees of freedom for the test.  
**p\_value** The corresponding p-value of the L-statistic.  
**data** The original data frame with added columns for ranks.

**References**

Puri ML, Sen PKJAoMS. Analysis of covariance based on general rank scores. 1969;40(2):610-8.  
 Olejnik SF, Algina JJER. A review of nonparametric alternatives to analysis of covariance. 1985;9(1):51-83.

**Examples**

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35)
)

# 2. Run the Puri and Sen (OB) method
results <- Puri_Sen_OB(
  formula = response ~ covariate1 + group,
  data = data
)

# 3. View the results
print(results)
print(paste("Statistic:", results$L_statistic, "df:", results$df, "P-value:", results$p_value))
```

---

|             |                                                                                                             |
|-------------|-------------------------------------------------------------------------------------------------------------|
| Puri_Sen_OU | <i>Puri and Sen Method with Unbiased Variance-Covariance Matrix for Nonparametric ANCOVA: One Covariate</i> |
|-------------|-------------------------------------------------------------------------------------------------------------|

---

### Description

Performs the Puri and Sen method for a single covariate using an unbiased variance-covariance matrix.

### Usage

```
Puri_Sen_OU(data, formula)
```

### Arguments

|                |                                                                                                                                         |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| <b>data</b>    | A data frame containing the variables specified in the formula.                                                                         |
| <b>formula</b> | An object of class "formula": a symbolic description of the model to be fitted. The structure should be 'response ~ covariate + group'. |

### Value

A list containing the following components:

**residuals** A vector of residuals for each group.  
**V** The unbiased variance-covariance matrix.  
**inverse\_V** The inverse of the variance-covariance matrix.  
**L\_statistic** The Puri and Sen L-statistic.  
**df** The degrees of freedom for the test.  
**p\_value** The corresponding p-value of the L-statistic.  
**data** The original data frame with added columns for ranks.

### References

Puri ML, Sen PKJAoMS. Analysis of covariance based on general rank scores. 1969;40(2):610-8.  
 Olejnik SF, Algina JJER. A review of nonparametric alternatives to analysis of covariance. 1985;9(1):51-83.

### Examples

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35)
)
```

```
# 2. Run the Puri and Sen (OU) method
results <- Puri_Sen_OU(
  formula = response ~ covariate1 + group,
  data = data
)

# 3. View the results
print(results)
print(paste("Statistic:", results$L_statistic, "df:", results$df, "P-value:", results$p_value))
```

---

Quade

---

*Quade Method for Nonparametric ANCOVA*


---

## Description

Performs Quade's ANCOVA using ranked variables and analysis of residuals. The method fits a linear model of the ranked response on the ranked covariates, and then performs an ANOVA on the residuals of that model.

## Usage

```
Quade(data, formula)
```

## Arguments

|                      |                                                                                                                                                |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>data</code>    | A data frame containing the variables specified in the formula.                                                                                |
| <code>formula</code> | An object of class "formula": a symbolic description of the model to be fitted. The structure should be 'response ~ covariate1 + ... + group'. |

## Value

A list containing the following components:

**regression\_equation** Summary of the linear model regressing the ranked response on the ranked covariates.

**anova\_summary** The summary of the ANOVA model performed on the residuals.

**group\_means** A data frame of the mean of residuals for each group.

**group\_sds** A data frame of the standard deviation of residuals for each group.

**regression\_equation\_residuals** The summary of the model fitting residuals on the group.

**data** The original data frame augmented with ranked variables and residuals.

## References

Quade DJJotASA. Rank analysis of covariance. 1967;62(320):1187-200.

Olejnik SF, Algina JJER. A review of nonparametric alternatives to analysis of covariance. 1985;9(1):51-83.

## Examples

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35),
  covariate2 = c(12, 21, 24, 29, 34, 17, 2, 40, 38, 36, 8, 1, 9, 28, 16)
)

# 2. Run the Quade method
results <- Quade(
  formula = response ~ covariate1 + covariate2 + group,
  data = data
)

# 3. View the results
print(results)
print(results$anova_summary)
```

---

Shirley

---

*Shirley Method for Nonparametric ANCOVA*


---

## Description

Calculates group and interaction effects based on ranked response and covariate variables using changes in R-squared values between models.

## Usage

```
Shirley(data, formula)
```

## Arguments

|                |                                                                                                                                                |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>data</b>    | A data frame containing the variables specified in the formula.                                                                                |
| <b>formula</b> | An object of class "formula": a symbolic description of the model to be fitted. The structure should be 'response ~ covariate1 + ... + group'. |

## Value

A list containing components related to the group and interaction effects, including:

- statistics\_group** The test statistic for the main group effect.
- p\_value\_group** The p-value for the main group effect.
- df\_group** Degrees of freedom for the group effect.
- statistics\_interaction** The test statistic for the interaction effect.
- p\_value\_interaction** The p-value for the interaction effect.

**df\_interaction** Degrees of freedom for the interaction effect.

**regression\_equation\_covariate** Summary of the model with only covariates.

**regression\_equation\_covariate\_group** Summary of the model with covariates and group main effects.

**regression\_equation\_interaction** Summary of the model including the interaction term.

**data** The original data frame with added columns for ranks.

## References

Burnett TD, Barr DRJE, Measurement P. A nonparametric analogy of analysis of covariance. 1977;37(2):341-8.

Olejnik SF, Algina JJER. A review of nonparametric alternatives to analysis of covariance. 1985;9(1):51-83.

## Examples

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35),
  covariate2 = c(12, 21, 24, 29, 34, 17, 2, 40, 38, 36, 8, 1, 9, 28, 16)
)

# 2. Run the Shirley method
results <- Shirley(
  formula = response ~ covariate1 + covariate2 + group,
  data = data
)

# 3. View the results
print(results)
print(paste("Statistic:", results$statistics_group,
  "df_group:", results$df_group,
  "P-value:", results$p_value_group))

print(paste("Statistic:", results$statistics_interaction,
  "df_interaction:", results$df_interaction,
  "P-value:", results$p_value_interaction))
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