

Package ‘betaDelta’

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Title Confidence Intervals for Standardized Regression Coefficients

Version 1.0.7

Description Generates confidence intervals for standardized regression coefficients using delta method standard errors for models fitted by lm() as described in Yuan and Chan (2011) <[doi:10.1007/s11336-011-9224-6](https://doi.org/10.1007/s11336-011-9224-6)> and Jones and Waller (2015) <[doi:10.1007/s11336-013-9380-y](https://doi.org/10.1007/s11336-013-9380-y)>. The package can also be used to generate confidence intervals for differences of standardized regression coefficients and as a general approach to performing the delta method. A description of the package and code examples are presented in Pesigan, Sun, and Cheung (2023) <[doi:10.1080/00273171.2023.2201277](https://doi.org/10.1080/00273171.2023.2201277)>.

URL <https://github.com/jeksterslab/betaDelta>,

<https://jeksterslab.github.io/betaDelta/>

BugReports <https://github.com/jeksterslab/betaDelta/issues>

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Author Ivan Jacob Agaloos Pesigan [aut, cre, cph] (ORCID: <<https://orcid.org/0000-0003-4818-8420>>)

Maintainer Ivan Jacob Agaloos Pesigan <r.jeksterslab@gmail.com>

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BetaDelta

Estimate Standardized Regression Coefficients and the Corresponding Sampling Covariance Matrix

Description

Estimate Standardized Regression Coefficients and the Corresponding Sampling Covariance Matrix

Usage

```
BetaDelta(object, type = "mvn", alpha = c(0.05, 0.01, 0.001))
```

Arguments

- object Object of class `lm`.
- type Character string. If `type = "mvn"`, use the multivariate normal-theory approach. If `type = "adf"`, use the asymptotic distribution-free approach.
- alpha Numeric vector. Significance level α .

Value

Returns an object of class `betadelta` which is a list with the following elements:

call Function call.

args Function arguments.

lm_process Processed `lm` object.

gamma Asymptotic covariance matrix of the sample covariance matrix.

acov Asymptotic covariance matrix of the standardized slopes.

vcov Sampling covariance matrix of the standardized slopes.

est Vector of standardized slopes.

Author(s)

Ivan Jacob Agaloos Pesigan

References

Jones, J. A., & Waller, N. G. (2015). The normal-theory and asymptotic distribution-free (ADF) covariance matrix of standardized regression coefficients: Theoretical extensions and finite sample behavior. *Psychometrika*, 80(2), 365–378. doi:[10.1007/s113360139380y](https://doi.org/10.1007/s113360139380y)

Pesigan, I. J. A., Sun, R. W., & Cheung, S. F. (2023). betaDelta and betaSandwich: Confidence intervals for standardized regression coefficients in R. *Multivariate Behavioral Research*. doi:[10.1080/00273171.2023.2201277](https://doi.org/10.1080/00273171.2023.2201277)

Yuan, K.-H., & Chan, W. (2011). Biases and standard errors of standardized regression coefficients. *Psychometrika*, 76(4), 670–690. doi:[10.1007/s1133601192246](https://doi.org/10.1007/s1133601192246)

See Also

Other Beta Delta Functions: [DiffBetaDelta\(\)](#)

Examples

```
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = nas1982)
std <- BetaDelta(object)
# Methods -----
print(std)
summary(std)
coef(std)
vcov(std)
confint(std, level = 0.95)
```

`coef.betadelta` *Standardized Regression Slopes*

Description

Standardized Regression Slopes

Usage

```
## S3 method for class 'betadelta'
coef(object, ...)
```

Arguments

object	Object of class betadelta.
...	additional arguments.

Value

Returns a vector of standardized regression slopes.

Author(s)

Ivan Jacob Agaloos Pesigan

Examples

```
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = nas1982)
std <- BetaDelta(object)
coef(std)
```

`coef.deltamethod` *Estimates*

Description

Estimates

Usage

```
## S3 method for class 'deltamethod'
coef(object, ...)
```

Arguments

- object Object of class `deltamethod`.
- ... additional arguments.

Value

Returns a vector of estimates.

Author(s)

Ivan Jacob Agaloos Pesigan

Examples

```
object <- glm(
  formula = vs ~ wt + disp,
  family = "binomial",
  data = mtcars
)
def <- list("exp(wt)", "exp(disp)")
out <- DeltaGeneric(
  object = object,
  def = def,
  alpha = 0.05
)
coef(out)
```

coef.diffbetadelta Differences of Standardized Regression Slopes**Description**

Differences of Standardized Regression Slopes

Usage

```
## S3 method for class 'diffbetadelta'
coef(object, ...)
```

Arguments

- object Object of class `diffbetadelta`.
- ... additional arguments.

Value

Returns a vector of differences of standardized regression slopes.

Author(s)

Ivan Jacob Agaloos Pesigan

Examples

```
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = nas1982)
std <- BetaDelta(object)
diff <- DiffBetaDelta(std)
coef(diff)
```

confint.betadelta

Confidence Intervals for Standardized Regression Slopes

Description

Confidence Intervals for Standardized Regression Slopes

Usage

```
## S3 method for class 'betadelta'
confint(object, parm = NULL, level = 0.95, ...)
```

Arguments

- | | |
|--------|---|
| object | Object of class betadelta. |
| parm | a specification of which parameters are to be given confidence intervals, either a vector of numbers or a vector of names. If missing, all parameters are considered. |
| level | the confidence level required. |
| ... | additional arguments. |

Value

Returns a matrix of confidence intervals.

Author(s)

Ivan Jacob Agaloos Pesigan

Examples

```
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = nas1982)
std <- BetaDelta(object)
confint(std, level = 0.95)
```

confint.deltamethod *Confidence Intervals*

Description

Confidence Intervals

Usage

```
## S3 method for class 'deltamethod'  
confint(object, parm = NULL, level = 0.95, ...)
```

Arguments

- object** Object of class `deltamethod`.
- parm** a specification of which parameters are to be given confidence intervals, either a vector of numbers or a vector of names. If missing, all parameters are considered.
- level** the confidence level required.
- ...** additional arguments.

Value

Returns a matrix of confidence intervals.

Author(s)

Ivan Jacob Agaloos Pesigan

Examples

```
object <- glm(  
  formula = vs ~ wt + disp,  
  family = "binomial",  
  data = mtcars  
)  
def <- list("exp(wt)", "exp(disp)")  
out <- DeltaGeneric(  
  object = object,  
  def = def,  
  alpha = 0.05  
)  
confint(out, level = 0.95)
```

confint.diffbetadelta *Confidence Intervals for Differences of Standardized Regression Slopes*

Description

Confidence Intervals for Differences of Standardized Regression Slopes

Usage

```
## S3 method for class 'diffbetadelta'
confint(object, parm = NULL, level = 0.95, ...)
```

Arguments

- object** Object of class diffbetadelta.
- parm** a specification of which parameters are to be given confidence intervals, either a vector of numbers or a vector of names. If missing, all parameters are considered.
- level** the confidence level required.
- ...** additional arguments.

Value

Returns a matrix of confidence intervals.

Author(s)

Ivan Jacob Agaloos Pesigan

Examples

```
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = nas1982)
std <- BetaDelta(object)
diff <- DiffBetaDelta(std)
confint(diff)
```

<i>Delta</i>	<i>Delta Method</i>
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Description

Calculates delta method sampling variance-covariance matrix for a function of parameters using a numerical Jacobian.

Usage

```
Delta(
  coef,
  vcov,
  func,
  ...,
  theta = 0,
  alpha = c(0.05, 0.01, 0.001),
  z = TRUE,
  df = NULL
)
```

Arguments

coef	Numeric vector. Vector of parameters.
vcov	Numeric matrix. Matrix of sampling variance-covariance matrix of parameters.
func	R function. <ol style="list-style-type: none"> 1. The first argument x is the argument coef. 2. The function algebraically manipulates coef to return a new numeric vector. It is best to have a named vector as an output. 3. The function can take additional named arguments passed using
...	Additional arguments to pass to func .
theta	Numeric vector. Parameter values when the null hypothesis is true.
alpha	Numeric vector. Significance level/s.
z	Logical. If z = TRUE, use the standard normal distribution. If z = FALSE, use the t distribution.
df	Numeric. Degrees of freedom if z = FALSE.

Value

Returns an object of class **deltamethod** which is a list with the following elements:

- call** Function call.
- args** Function arguments.
- coef** Estimates.

vcov Sampling variance-covariance matrix.
jacobian Jacobian matrix.
fun Function used ("Delta").

Author(s)

Ivan Jacob Agaloos Pesigan

See Also

Other Delta Method Functions: [DeltaGeneric\(\)](#)

Examples

```
object <- glm(
  formula = vs ~ wt + disp,
  family = "binomial",
  data = mtcars
)
func <- function(x) {
  y <- exp(x)
  names(y) <- paste0("exp", "(", names(x), ")")
  y[-1]
}
Delta(
  coef = coef(object),
  vcov = vcov(object),
  func = func,
  alpha = 0.05
)
```

[DeltaGeneric](#)

Delta Method (Generic Object Input)

Description

Calculates delta method sampling variance-covariance matrix for a function of parameters using a numerical Jacobian.

Usage

```
DeltaGeneric(
  object,
  def,
  theta = 0,
  alpha = c(0.05, 0.01, 0.001),
  z = TRUE,
  df = NULL
)
```

Arguments

object	R object. Fitted model object with <code>coef</code> and <code>vcov</code> methods that return a named vector of estimated parameters and sampling variance-covariance matrix, respectively.
def	List of character strings. A list of defined functions of parameters. The string should be a valid R expression when parsed and should result a single value when evaluated.
theta	Numeric vector. Parameter values when the null hypothesis is true.
alpha	Numeric vector. Significance level/s.
z	Logical. If <code>z = TRUE</code> , use the standard normal distribution. If <code>z = FALSE</code> , use the t distribution.
df	Numeric. Degrees of freedom if <code>z = FALSE</code> .

Value

Returns an object of class `deltamethod` which is a list with the following elements:

- call** Function call.
- args** Function arguments.
- coef** Estimates.
- vcov** Sampling variance-covariance matrix.
- jacobian** Jacobian matrix.
- fun** Function used ("DeltaGeneric").

Author(s)

Ivan Jacob Agaloos Pesigan

See Also

Other Delta Method Functions: [Delta\(\)](#)

Examples

```
object <- glm(
  formula = vs ~ wt + disp,
  family = "binomial",
  data = mtcars
)
def <- list("exp(wt)", "exp(disp)")
DeltaGeneric(
  object = object,
  def = def,
  alpha = 0.05
)
```

DiffBetaDelta	<i>Estimate Differences of Standardized Slopes and the Corresponding Sampling Covariance Matrix</i>
---------------	---

Description

Estimate Differences of Standardized Slopes and the Corresponding Sampling Covariance Matrix

Usage

```
DiffBetaDelta(object, alpha = c(0.05, 0.01, 0.001))
```

Arguments

- object** Object of class `betadelta`, that is, the output of the [BetaDelta\(\)](#) function.
alpha Numeric vector. Significance level α .

Value

Returns an object of class `diffbetadelta` which is a list with the following elements:

- call** Function call.
- fit** The argument `object`.
- args** Function arguments.
- vcov** Sampling covariance matrix of differences of standardized slopes.
- est** Vector of differences of standardized slopes.

Author(s)

Ivan Jacob Agaloos Pesigan

See Also

Other Beta Delta Functions: [BetaDelta\(\)](#)

Examples

```
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = nas1982)
std <- BetaDelta(object)
diff <- DiffBetaDelta(std)
# Methods -----
print(diff)
summary(diff)
coef(diff)
vcov(diff)
confint(diff, level = 0.95)
```

nas1982

1982 National Academy of Sciences Doctoral Programs Data

Description

1982 National Academy of Sciences Doctoral Programs Data

Usage

nas1982

Format

Ratings of 46 doctoral programs in psychology in the USA with the following variables:

QUALITY Program quality ratings.

NFACUL Number of faculty members in the program.

NGRADS Number of program graduates.

PCTSUPP Percentage of program graduates who received support.

PCTGRT Percent of faculty members holding research grants.

NARTIC Number of published articles attributed to program faculty member.

PCTPUB Percent of faculty with one or more published article.

References

National Research Council. (1982). *An assessment of research-doctorate programs in the United States: Social and behavioral sciences*. doi:[10.17226/9781](https://doi.org/10.17226/9781). Reproduced with permission from the National Academy of Sciences, Courtesy of the National Academies Press, Washington, D.C.

print.betadelta

Print Method for an Object of Class betadelta

Description

Print Method for an Object of Class betadelta

Usage

```
## S3 method for class 'betadelta'  
print(x, alpha = NULL, digits = 4, ...)
```

Arguments

- x Object of class `betadelta`.
- alpha Numeric vector. Significance level α . If `alpha = NULL`, use the argument `alpha` used in `x`.
- digits Digits to print.
- ... additional arguments.

Value

Prints a matrix of standardized regression slopes, standard errors, test statistics, degrees of freedom, p-values, and confidence intervals.

Author(s)

Ivan Jacob Agaloos Pesigan

Examples

```
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = nas1982)
std <- BetaDelta(object)
print(std)
```

print.deltamethod *Print Method for an Object of Class `deltamethod`*

Description

Print Method for an Object of Class `deltamethod`

Usage

```
## S3 method for class 'deltamethod'
print(x, alpha = NULL, digits = 4, ...)
```

Arguments

- x Object of class `deltamethod`.
- alpha Numeric vector. Significance level α . If `alpha = NULL`, use the argument `alpha` used in `x`.
- digits Digits to print.
- ... additional arguments.

Value

Returns a matrix of coefficients, standard errors, test statistics, degrees of freedom (if `z = FALSE`), p-values, and confidence intervals.

Author(s)

Ivan Jacob Agaloos Pesigan

Examples

```
object <- glm(
  formula = vs ~ wt + disp,
  family = "binomial",
  data = mtcars
)
def <- list("exp(wt)", "exp(disp)")
out <- DeltaGeneric(
  object = object,
  def = def,
  alpha = 0.05
)
print(out)
```

print.diffbetadelta *Print Method for an Object of Class diffbetadelta*

Description

Print Method for an Object of Class diffbetadelta

Usage

```
## S3 method for class 'diffbetadelta'
print(x, alpha = NULL, digits = 4, ...)
```

Arguments

- x Object of class diffbetadelta.
- alpha Numeric vector. Significance level α . If alpha = NULL, use the argument alpha used in x.
- digits Digits to print.
- ... additional arguments.

Value

Prints a matrix of standardized regression slopes, standard errors, test statistics, degrees of freedom, p-values, and confidence intervals.

Author(s)

Ivan Jacob Agaloos Pesigan

Examples

```
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = nas1982)
std <- BetaDelta(object)
diff <- DiffBetaDelta(std)
print(diff)
```

summary.betadelta *Summary Method for an Object of Class betadelta*

Description

Summary Method for an Object of Class **betadelta**

Usage

```
## S3 method for class 'betadelta'
summary(object, alpha = NULL, digits = 4, ...)
```

Arguments

<code>object</code>	Object of class betadelta .
<code>alpha</code>	Numeric vector. Significance level α . If <code>alpha = NULL</code> , use the argument <code>alpha</code> used in <code>object</code> .
<code>digits</code>	Digits to print.
<code>...</code>	additional arguments.

Value

Returns a matrix of standardized regression slopes, standard errors, test statistics, degrees of freedom, p-values, and confidence intervals.

Author(s)

Ivan Jacob Agaloos Pesigan

Examples

```
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = nas1982)
std <- BetaDelta(object)
summary(std)
```

summary.deltamethod *Summary Method for an Object of Class deltamethod*

Description

Summary Method for an Object of Class deltamethod

Usage

```
## S3 method for class 'deltamethod'  
summary(object, alpha = NULL, digits = 4, ...)
```

Arguments

object	Object of class deltamethod.
alpha	Numeric vector. Significance level α . If $\alpha = \text{NULL}$, use the argument α used in object .
digits	Digits to print.
...	additional arguments.

Value

Returns a matrix of standardized regression slopes, standard errors, test statistics, degrees of freedom, p-values, and confidence intervals.

Author(s)

Ivan Jacob Agaloos Pesigan

Examples

```
object <- glm(  
  formula = vs ~ wt + disp,  
  family = "binomial",  
  data = mtcars  
)  
def <- list("exp(wt)", "exp(disp)")  
out <- DeltaGeneric(  
  object = object,  
  def = def,  
  alpha = 0.05  
)  
summary(out)
```

summary.diffbetadelta *Summary Method for an Object of Class diffbetadelta*

Description

Summary Method for an Object of Class `diffbetadelta`

Usage

```
## S3 method for class 'diffbetadelta'
summary(object, alpha = NULL, digits = 4, ...)
```

Arguments

<code>object</code>	Object of class <code>diffbetadelta</code> .
<code>alpha</code>	Numeric vector. Significance level α . If <code>alpha = NULL</code> , use the argument <code>alpha</code> used in <code>object</code> .
<code>digits</code>	Digits to print.
<code>...</code>	additional arguments.

Value

Returns a matrix of standardized regression slopes, standard errors, test statistics, degrees of freedom, p-values, and confidence intervals.

Author(s)

Ivan Jacob Agaloos Pesigan

Examples

```
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = nas1982)
std <- BetaDelta(object)
diff <- DiffBetaDelta(std)
summary(diff)
```

vcov.betadelta*Sampling Covariance Matrix of the Standardized Regression Slopes*

Description

Sampling Covariance Matrix of the Standardized Regression Slopes

Usage

```
## S3 method for class 'betadelta'  
vcov(object, ...)
```

Arguments

object Object of class betadelta.
... additional arguments.

Value

Returns a matrix of the variance-covariance matrix of standardized slopes.

Author(s)

Ivan Jacob Agaloos Pesigan

Examples

```
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = nas1982)  
std <- BetaDelta(object)  
vcov(std)
```

vcov.deltamethod*Sampling Covariance Matrix*

Description

Sampling Covariance Matrix

Usage

```
## S3 method for class 'deltamethod'  
vcov(object, ...)
```

Arguments

- object Object of class `deltamethod`.
 ... additional arguments.

Value

Returns a matrix of the variance-covariance matrix.

Author(s)

Ivan Jacob Agaloos Pesigan

Examples

```
object <- glm(  
  formula = vs ~ wt + disp,  
  family = "binomial",  
  data = mtcars  
)  
def <- list("exp(wt)", "exp(disp)")  
out <- DeltaGeneric(  
  object = object,  
  def = def,  
  alpha = 0.05  
)  
vcov(out)
```

vcov.diffbetadelta	<i>Sampling Covariance Matrix of Differences of Standardized Regression Slopes</i>
--------------------	--

Description

Sampling Covariance Matrix of Differences of Standardized Regression Slopes

Usage

```
## S3 method for class 'diffbetadelta'  
vcov(object, ...)
```

Arguments

- object Object of class `diffbetadelta`.
 ... additional arguments.

Value

Returns a matrix of the variance-covariance matrix of differences of standardized regression slopes.

Author(s)

Ivan Jacob Agaloos Pesigan

Examples

```
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = nas1982)
std <- BetaDelta(object)
diff <- DiffBetaDelta(std)
vcov(diff)
```

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