

# 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>

**License** MIT + file LICENSE

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### BetaDelta

*Estimate Standardized Regression Coefficients and the Corresponding Sampling Covariance Matrix*

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### 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  $\alpha$ .

**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

<code>object</code>	Object of class <code>betadelta</code> .
...	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 <code>deltamethod</code> .  |
| 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>
--------------	---------------------

---

### 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

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

<b>object</b>	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.
<b>def</b>	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.
<b>theta</b>	Numeric vector. Parameter values when the null hypothesis is true.
<b>alpha</b>	Numeric vector. Significance level/s.
<b>z</b>	Logical. If <code>z = TRUE</code> , use the standard normal distribution. If <code>z = FALSE</code> , use the t distribution.
<b>df</b>	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  $\alpha$ .

## 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  $\alpha$ . 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  $\alpha$ . 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**

<code>x</code>	Object of class <code>diffbetadelta</code> .
<code>alpha</code>	Numeric vector. Significance level $\alpha$ . If <code>alpha = NULL</code> , use the argument <code>alpha</code> used in <code>x</code> .
<code>digits</code>	Digits to print.
<code>...</code>	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 <b>betadelta</b> .
<code>alpha</code>	Numeric vector. Significance level $\alpha$ . 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 $\alpha$ . If $\alpha = \text{NULL}$ , use the argument $\alpha$ used in $\text{object}$ .
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 $\alpha$ . 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	<i>Sampling Covariance Matrix of the Standardized Regression Slopes</i>
----------------	---

---

**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	<i>Sampling Covariance Matrix</i>
------------------	-----------------------------------

---

**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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