

# Package ‘RMediation’

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**Type** Package

**Title** An R Package for Mediation Analysis Confidence Intervals

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**Depends** R (>= 2.11.0), base, MASS, lavaan, e1071

**Description** RMediation package provides functions to compute confidence intervals (CIs) for a well-defined nonlinear function of the model parameters (e.g., product of k coefficients) in single--level and multilevel structural equation models.

**License** GPL-2

**URL** <http://amp.gatech.edu/RMediation>  
<http://www.public.asu.edu/~davidpm/ripl/Prodclin>

**NeedsCompilation** yes

**Repository** CRAN

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## R topics documented:

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| RMediation-package | <i>RMediation: An R Package for Mediation Analysis Confidence Intervals</i> |
|--------------------|---|

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## Description

*RMediation* package provides functions to compute confidence intervals (CIs) for a well-defined nonlinear function of the model parameters (e.g., product of k coefficients) in single-level and multilevel structural equation models.

## Details

|           |            |
|-----------|------------|
| Package:  | RMediation |
| Type:     | Package    |
| Version:  | 1.1.3      |
| Date:     | 2014-3-6   |
| License:  | GPL-2      |
| LazyLoad: | yes        |

`medci` produces a CI for the product of two normal random variables using three methods: the distribution of the product of coefficients, Monte Carlo, and asymptotic normal theory with the multivariate-delta standard error (Asymptotic-Delta) method. `pprodnormal` produces percentiles for the distribution of product of two normal random variables. `qprodnormal` generates quantiles for the distribution of product of two normal random variables. `ci` produces a CI for a well-defined nonlinear function of the model parameters in single-level and multilevel structural equation models using the Monte Carlo and Asymptotic-Delta method.

## Note

The PRODCLIN programs may be downloaded from <http://www.public.asu.edu/~davidpm/ripl/Prodclin/>. A web application of the RMediation program is available from <http://amp.gatech.edu/RMediation>.

## Author(s)

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## References

- MacKinnon, D. P., Fritz, M. S., Williams, J., and Lockwood, C. M. (2007). Distribution of the product confidence limits for the indirect effect: Program PRODCLIN. *Behavior Research Methods*, **39**, 384–389.
- Meeker, W. and Escobar, L. (1994). An algorithm to compute the CDF of the product of two normal random variables. *Communications in Statistics: Simulation and Computation*, **23**, 271–280.

Tofighi, D. and MacKinnon, D. P. (2011). RMediation: An R package for mediation analysis confidence intervals. *Behavior Research Methods*, **43**, 692–700. doi:10.3758/s13428-011-0076-x

## See Also

[qprodnormal](#) [pprodnormal](#) [medci](#) [ci](#)

## Examples

```
medci(mu.x=.2,mu.y=.4,se.x=.1,se.y=.05,rho=0,alpha=.05)
pprodnormal(q=.4, mu.x=.5, mu.y=.3, se.x=.03, se.y=.08, rho=0)
qprodnormal(p=.1, mu.x=.5, mu.y=.3, se.x=.03, se.y=.8, rho=0)
ci(mu=c(b1=0,b2=0),Sigma=c(1,2,10), quant=~b1*b2)
ci(mu=c(b1=1,b2=.7,b3=.6, b4=.45), Sigma=c(.05,0,0,0,.05,0,0,.03,0,.03),
  quant=~b1*b2*b3*b4, type="all", plot=TRUE, plotCI=TRUE)
```

---

ci

*CI for a nonlinear function of coefficients estimates*


---

## Description

This function returns a  $(1 - \alpha)\%$  confidence interval (CI) for a well-defined nonlinear function of the coefficients in single-level and multilevel structural equation models. The `ci` function uses the Monte Carlo (`type="MC"`) and the asymptotic normal theory (`type="asympt"`) with the multivariate delta standard error (Asymptotic-Delta) method (Sobel, 1982) to compute a CI. In addition, for each of the methods, when a user specifies `plot=TRUE` and `plotCI=TRUE`, a plot of the sampling distribution of the quantity of interest in the `quant` argument and with an overlaid plot of the CI will be produced. When `type="all"` and `plot=TRUE`, two overlaid plots of the sampling distributions corresponding to each method will be produced; when `plotCI=TRUE`, then the overlaid plots of the CIs for both methods will be displayed as well.

## Usage

```
ci(mu, Sigma, quant, alpha = 0.05, type = "MC", plot = FALSE,
  plotCI = FALSE, n.mc = 1e+06, ...)
```

## Arguments

|                    |  |
|--------------------|--|
| <code>mu</code>    | a <a href="#">vector</a> of means (e.g., coefficient estimates) for the normal random variables. A user can assign a name to each mean value, e.g., <code>mu=c(b1=.1,b2=3)</code> ; otherwise, the coefficient names are assigned automatically as follows: <code>b1, b2, ...</code>   |
| <code>Sigma</code> | either a covariance matrix or a <a href="#">vector</a> that stacks all the columns of the lower triangle variance-covariance matrix one underneath the other.  |
| <code>quant</code> | quantity of interest, which is a nonlinear/linear function of the model parameters. Argument <code>quant</code> is a <a href="#">formula</a> that <b>must</b> start with the symbol "tilde" ( <code>~</code> ): e.g., <code>~b1*b2*b3*b4</code> . The names of coefficients must conform to the names provided in the argument <code>mu</code> or to the default names, i.e., <code>b1, b2, ...</code> |

|        |   |
|--------|---|
| alpha  | significance level for the CI. The default value is .05.  |
| type   | method used to compute a CI. It takes on the values "MC" (default) for Monte Carlo, "asympt" for Asymptotic-Delta, or "all" that produces CIs using both methods.   |
| plot   | when TRUE, plot the approximate sampling distribution of the quantity of interest using the specified method(s) in the argument type. The default value is FALSE. When type="all", superimposed density plots generated by both methods are displayed.  |
| plotCI | when TRUE, overlays a CI plot with error bars on the density plot of the sampling distribution of quant. When type="all", the superimposed CI plots generated by both methods are added to the density plots. Note that to obtain a CI plot, one must also specify plot="TRUE". The default value is FALSE. |
| n.mc   | Monte Carlo sample size. The default sample size is 1e+6.   |
| ...    | additional arguments.   |

### Value

When type is "MC" or "asympt", ci returns a [list](#) that contains:

|                     |  |
|---------------------|--|
| $(1 - \alpha)\%$ CI | a vector of lower and upper confidence limits,     |
| Estimate            | a point estimate of the quantity of interest,      |
| SE                  | standard error of the quantity of interest,        |
| MC Error            | When type="MC", error of the Monte Carlo estimate. |

When type="all", ci returns a [list](#) of two objects, each of which a [list](#) that contains the results produced by each method as described above.

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### References

Tofighi, D. and MacKinnon, D. P. (2011). RMediation: An R package for mediation analysis confidence intervals. *Behavior Research Methods*, **43**, 692–700. doi:10.3758/s13428-011-0076-x

### See Also

[medci RMediation-package](#)

### Examples

```
ci(mu=c(b1=1,b2=.7,b3=.6, b4= .45), Sigma=c(.05,0,0,0,.05,0,0,.03,0,.03),
  quant=~b1*b2*b3*b4, type="all", plot=TRUE, plotCI=TRUE)
```

---

 medci *Confidence Interval for the Mediated Effect*


---

**Description**

Produces confidence intervals for the mediated effect and the product of two normal random variables.

**Usage**

```
medci(mu.x, mu.y, se.x, se.y, rho = 0, alpha = 0.05, type = "prodclin",
      plot=FALSE, plotCI=FALSE, n.mc = 1e+05, ...)
```

**Arguments**

|        |   |
|--------|---|
| mu.x   | mean of $x$   |
| mu.y   | mean of $y$   |
| se.x   | standard error (deviation) of $x$   |
| se.y   | standard error (deviation) of $y$   |
| rho    | correlation between $x$ and $y$ , where $-1 < \rho < 1$ . The default value is 0.   |
| alpha  | significance level for the confidence interval. The default value is .05.   |
| type   | method used to compute confidence interval. It takes on the values "prodclin" (default), "DOP", "MC", "asymp" or "all".   |
| plot   | when TRUE, plots the distribution of n.mc data points from the distribution of product of two normal random variables using the density estimates provided by the function <code>density</code> . The default value is FALSE. |
| plotCI | when TRUE, overlays a confidence interval with error bars on the plot for the mediated effect. Note that to obtain the CI plot, one must also specify <code>plot="TRUE"</code> . The default value is FALSE.                  |
| n.mc   | when type="MC", n.mc determines the sample size for the Monte Carlo method. The default sample size is 1E5.   |
| ...    | additional arguments to be passed on to the function.   |

**Details**

This function returns a  $(1 - \alpha)\%$  confidence interval for the mediated effect (product of two normal random variables). To obtain a confidence interval using a specific method, the argument `type` should be specified. The default is `type="prodclin"`, which uses the PRODCLIN program described by MacKinnon et al. (2007). `type="DOP"` uses the code we wrote in R to implement the distribution of product of the coefficients method. Note that both `type="prodclin"` and `type="DOP"` use the method described by Meeker and Escobar (1994) to evaluate the CDF of the distribution of product. `type="MC"` uses the Monte Carlo approach to compute the confidence interval (Tofighi & MacKinnon, 2011). `type="asymp"` produces the asymptotic normal confidence interval. The standard error for the asymptotic normal confidence interval is based on the analytical results by Craig (1936). `type="all"` prints confidence intervals using all four options.

**Value**

A vector of lower confidence limit and upper confidence limit.

**Note**

The PRODCLIN programs may be downloaded from <http://www.public.asu.edu/~davidpm/ripl/Prodclin/>. A web application of the RMediation program is available from <http://amp.gatech.edu/RMediation>.

**Author(s)**

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**References**

Craig, C. C. (1936). On the frequency function of  $xy$ . *The Annals of Mathematical Statistics*, **7**, 1–15.

MacKinnon, D. P., Fritz, M. S., Williams, J., and Lockwood, C. M. (2007). Distribution of the product confidence limits for the indirect effect: Program PRODCLIN. *Behavior Research Methods*, **39**, 384–389.

Meeker, W. and Escobar, L. (1994). An algorithm to compute the CDF of the product of two normal random variables. *Communications in Statistics: Simulation and Computation*, **23**, 271–280.

Tofighi, D. and MacKinnon, D. P. (2011). RMediation: An R package for mediation analysis confidence intervals. *Behavior Research Methods*, **43**, 692–700. doi:10.3758/s13428-011-0076-x

**See Also**

[qprodnormal](#) [pprodnormal](#) [RMediation-package](#)

**Examples**

```
##produces CI using PRODCLIN and density plot of distribution of xy
medci(mu.x=.2, mu.y=.4, se.x=1, se.y=1, rho=0, alpha=.05,
      type="prodclin", plot=TRUE, plotCI=TRUE)
```

---

pprodnormal

*Percentile for the Distribution of Product of Two Normal Variables*

---

**Description**

Generates percentiles (100 based quantiles) for the distribution of product of two normal random variables and the mediated effect

**Usage**

```
pprodnormal(q, mu.x, mu.y, se.x=1, se.y=1, rho = 0, lower.tail=TRUE,
            type="prodclin", n.mc=1e5)
```

**Arguments**

|                         |  |
|-------------------------|--|
| <code>q</code>          | quantile or value of the product   |
| <code>mu.x</code>       | mean of $x$  |
| <code>mu.y</code>       | mean of $y$  |
| <code>se.x</code>       | standard error (deviation) of $x$  |
| <code>se.y</code>       | standard error (deviation) of $y$  |
| <code>rho</code>        | correlation between $x$ and $y$ , where $-1 < \rho < 1$ . The default value is 0.  |
| <code>lower.tail</code> | logical; if TRUE (default), the probability is $P[X * Y < q]$ ; otherwise, $P[X * Y > q]$  |
| <code>type</code>       | method used to compute $P[X * Y < q]$ . It takes on the values "prodclin" (default), "DOP", "MC", or "all".                            |
| <code>n.mc</code>       | when <code>type="MC"</code> , <code>n.mc</code> determines the sample size for the Monte Carlo method. The default sample size is 1E5. |

**Details**

This function returns the percentile (probability) and the associated error for the distribution of product of mediated effect (two normal random variables). To obtain a percentile using a specific method, the argument `type` should be specified. The default method is `type="prodclin"`, which uses the PRODCLIN program described by MacKinnon et al. (2007). `type="DOP"` uses the code we wrote in R. Note that both `type="prodclin"` and `type="DOP"` use the method described by Meeker and Escobar (1994) to evaluate the CDF of the distribution of product of two normal random variables. `type="MC"` uses the Monte Carlo approach (Tofighi & MacKinnon, 2011). `type="all"` prints percentiles using all three options. For methods `type="prodclin"` and `type="DOP"`, the error is the modulus of absolute error for the numerical integration (for more information see Meeker and Escobar, 1994). For `type="MC"`, the error refers to the Monte Carlo error.

**Value**

An object of the type `list` that contains the following values:

|                    |   |
|--------------------|---|
| <code>p</code>     | probability (percentile) corresponding to quantile <code>q</code> |
| <code>error</code> | estimate of the absolute error                                    |

**Note**

The PRODCLIN programs may be downloaded from <http://www.public.asu.edu/~davidpm/ripl/Prodclin/>. A web application of the RMediation program is available from <http://amp.gatech.edu/RMediation>.

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## References

MacKinnon, D. P., Fritz, M. S., Williams, J., and Lockwood, C. M. (2007). Distribution of the product confidence limits for the indirect effect: Program PRODCLIN. *Behavior Research Methods*, **39**, 384–389.

Meeker, W. and Escobar, L. (1994). An algorithm to compute the CDF of the product of two normal random variables. *Communications in Statistics: Simulation and Computation*, **23**, 271–280.

Tofighi, D. and MacKinnon, D. P. (2011). RMediation: An R package for mediation analysis confidence intervals. *Behavior Research Methods*, **43**, 692–700. doi:10.3758/s13428-011-0076-x

## See Also

[medci](#) [qprodnormal](#) [RMediation-package](#)

## Examples

```
pprodnormal(q=0, mu.x=.5, mu.y=.3, se.x=1, se.y=1, rho= 0, type="all")
```

---

qprodnormal

*Quantile for the Distribution of Product of Two Normal Variables*

---

## Description

Generates quantiles for the distribution of product of two normal random variables

## Usage

```
qprodnormal(p, mu.x, mu.y, se.x, se.y, rho=0, lower.tail=TRUE,
type="prodclin", n.mc=1e5)
```

## Arguments

|            |   |
|------------|---|
| p          | probability   |
| mu.x       | mean of $x$   |
| mu.y       | mean of $y$   |
| se.x       | standard error (deviation) of $x$   |
| se.y       | standard error (deviation) of $y$   |
| rho        | correlation between $x$ and $y$ , where $-1 < \rho < 1$ . The default value is 0.                           |
| lower.tail | logical; if TRUE (default), the probability is $P[X * Y < q]$ ; otherwise, $P[X * Y > q]$                   |
| type       | method used to compute $P[X * Y < q]$ . It takes on the values "prodclin" (default), "DOP", "MC", or "all". |
| n.mc       | when type="MC", n.mc determines the sample size of Monte Carlo method. The default sample size is 1E5.      |



## Details

This function returns a quantile and the associated error (accuracy) corresponding the requested percentile (probability)  $p$  of the distribution of product of mediated effect (product of two normal random variables). To obtain a quantile using a specific method, the argument `type` should be specified. The default method is `type="prodclin"`, which uses the PRODCLIN program described by MacKinnon et al. (2007). `type="DOP"` uses the code we wrote in R. Note that both `type="prodclin"` and `type="DOP"` use the method described by Meeker and Escobar (1994) to evaluate the CDF of the distribution of product of two normal variables. `type="MC"` uses the Monte Carlo approach (Tofighi & MacKinnon, 2011). `type="all"` prints quantiles using all three options. For methods `type="prodclin"` and `type="DOP"`, the error is the modulus of absolute error for the numerical integration (for more information see Meeker and Escobar, 1994). For `type="MC"`, the error refers to the Monte Carlo error.

## Value

An object of the type `list` that contains the following values:

|                    |   |
|--------------------|---|
| <code>q</code>     | quantile corresponding to probability $p$ |
| <code>error</code> | estimate of the absolute error            |

## Note

The PRODCLIN programs may be downloaded from <http://www.public.asu.edu/~davidpm/ripl/Prodclin/>. A web application of the RMediation program is available from <http://amp.gatech.edu/RMediation>.

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## References

- MacKinnon, D. P., Fritz, M. S., Williams, J., and Lockwood, C. M. (2007). Distribution of the product confidence limits for the indirect effect: Program PRODCLIN. *Behavior Research Methods*, **39**, 384–389.
- Meeker, W. and Escobar, L. (1994). An algorithm to compute the CDF of the product of two normal random variables. *Communications in Statistics: Simulation and Computation*, **23**, 271–280.
- Tofighi, D. and MacKinnon, D. P. (2011). RMediation: An R package for mediation analysis confidence intervals. *Behavior Research Methods*, **43**, 692–700. doi:10.3758/s13428-011-0076-x

## See Also

[medci pprodnormal RMediation-package](#)

**Examples**

```
##lower tail
qprodnormal(p=.1, mu.x=.5, mu.y=.3, se.x=1, se.y=1, rho=0, lower.tail =
TRUE, type="all")
##upper tail
qprodnormal(p=.1, mu.x=.5, mu.y=.3, se.x=1, se.y=1, rho=0, lower.tail =
FALSE, type="all")
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