# Package 'PowerUpR'

July 5, 2017

Type Package

Title R version of PowerUp!
Version 0.1.3.9000
<b>Date</b> 2017-07-04
Description Tools to calculate statistical power, minimum detectable effect size, and constrained optimal sample allocation for main and moderator effects in various randomized controlled trials (individual- or cluster-level randomization, and single-or multi-site), and for main effects in various regression discontinuity designs (individual- or cluster-level discontinuity, and single- or multi-site) with continuous outcomes.
<pre>URL https://github.com/metinbulus/PowerUpR</pre>
<pre>BugReports https://github.com/metinbulus/PowerUpR/issues</pre>
<b>Depends</b> nloptr(>= 1.0.4)
Suggests knitr, rmarkdown
VignetteBuilder knitr
License GPL (>= 3)
Author Metin Bulus [aut, cre, trl], Nianbo Dong [aut], Benjamin Kelcey [aut], Jessaca Spybrook [aut], Bang Le [aut]
Maintainer Metin Bulus <bullsmetin@gmail.com></bullsmetin@gmail.com>
R topics documented:
PowerUpR-package       3         compare.cosa       4         cosa.bcra3f2       5         cosa.bcra3r2       6         cosa.bcra4f3       8         cosa.bcra4r2       10         cosa.bcra4r3       12         cosa.bcrd3f2       14         cosa.bcrd3r2       16

2

cosa.bira2c1	18
cosa.bira2f1	19
osa.bira2r1	21
osa.bira3r1	23
osa.bira4r1	25
cosa.bird2f1	27
cosa.bird2r1	28
cosa.cra2r2	30
	32
	34
	36
	37
	39
	40
	41
	+1 43
	+5 45
	+3 46
	40 48
	50 50
	52
	54
	55
1	56
	57
	58
	59
	61
ndes.bcra4r3	62
ndes.bcrd3f2	63
ndes.bcrd3r2	65
ndes.bira2c1	66
ndes.bira2f1	67
ndes.bira2r1	68
ndes.bira3r1	69
ndes.bira4r1	71
ndes.bird2f1	72
	73
	75
	76
	 77
	, , 78
	79
	81
	81 82
	82 83
	83 84
	85
	86
	88
	89
ndes.mod2r.cra3r3	90

	mdes.mod3.cra3r3	91
	mdes.to.pctl	93
	mdes.to.power	93
	power.bcra3f2	94
	power.bcra3r2	95
	power.bcra4f3	97
	power.bcra4r2	98
	power.bcra4r3	99
	power.bcrd3f2	)1
	power.bcrd3r2	)2
	power.bira2c1	
	power.bira2f1	
	power.bira2r1	)5
	power.bira3r1	)7
	power.bira4r1	)8
	power.bird2f1	)9
	power.bird2r1	1
	power.cra2r2	
	power.cra3r3	
	power.cra4r4	
	power.crd2r2	
	power.crd3r3	
	power.ira1r1	
	power.ird1r1	
	power.mod1n.cra2r2	
	power.mod1n.cra3r3	
	power.mod1r.cra2r2	
	power.mod1r.cra3r3	
	power.mod2.cra2r2	
	power.mod2n.cra3r3	
	power.mod2r.cra3r3	
	power.mod3.cra3r3	
	power.to.mdes	
	PowerUpR-deprecated	31
Index	13	33

PowerUpR-package

PowerUpR: R version of PowerUp!

## Description

*PowerUp!* series consists of three excel-based applications that allows researchers to conduct statistical power analysis for main effects (download link: *PowerUp!*), moderator effects (download link: *PowerUp!-Moderator*) and mediator effects (download link: *PowerUp!-Mediator*) for various multilevel randomized experiments and quasi-experiments. For more information please refer to http://www.causalevaluation.org/.

4 compare.cosa

#### Author(s)

Maintainer: Metin Bulus <bulls.metin@gmail.com>

Authors:

- Nianbo Dong <dong.nianbo@rgmail.com>
- Benjamin Kelcey <br/> <br/>ben.kelcey@gmail.com>
- Jessaca K. Spybrook < jessaca.spybrook@wmich.edu>
- Bang T. Lee <bangthanh.le@wmich.edu>

compare.cosa

Compares COSA Solutions from Different Optimizers

## Description

compare. cosa compares COSA solutions from different optimizers for an object returned from one of the cosa functions.

## Usage

```
compare.cosa(x)
```

## Arguments

Χ

an object returned from one of the cosa functions.

## **Details**

compare. cosa compares COSA solutions from different optimizers for an object returned from one of the cosa functions by passing parameters through cosa function.

cosa.bcra3f2 5

cosa.bcra3f2	COSA Solver for Main Effect in Three-Level Fixed Effects Blocked
	Cluster Random Assignment Designs, Treatment at Level-2

## **Description**

cosa.bcra3f2 finds constrained optimal sample allocation (COSA) solutions for main effect in designs with three-levels where level-2 units are randomly assigned to treatment and control groups within level-3 units (fixed blocks). COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

## Usage

`		
	cn	marginal cost per level-1 unit.
	сJ	marginal cost per level-2 unit.
	сК	marginal cost per level-3 unit.
	cost	total cost or budget.
	n	harmonic mean of level-1 units across level-2 units (or simple average).
	J	harmonic mean of level-2 units across level-3 units (or simple average).
	K	level-3 sample size.
	P	average proportion of level-2 units randomly assigned to treatment within level-3 units.
	nJK0	vector with a length of three to specify starting values for level-1, level-2, and level-3 sample sizes.
	P0	starting value for average proportion of level-2 units randomly assigned to treatment within level-3 units.
	power	statistical power (1 - type II error).
	mdes	minimum detectable effect size.
	alpha	probability of type I error.
	two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
	constrain	one of the followings can be constrained at a specified cost or value: "cost", "power", or "mdes".
	optimizer	algorithm to find optimal sample sizes given total cost, power, or MDES. Available algorithms: "auglag_slsqp", "auglag_lbfgs", "auglag_mma" or "auglag_cobyla".

gm	grid multiplier to increase the range of sample sizes for approximate integer solutions.
ncase	number of approximate integer solutions to be exported.
rho2	proportion of variance in the outcome explained by level-2 units.
g2	number of covariates at level-2.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.

#### Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

#### See Also

```
mdes.bcra3f2, power.bcra3f2
```

## **Examples**

cosa.bcra3r2 COSA Solver for Main Effect in Three-Level Random Effects Blocked Cluster Random Assignment Designs, Treatment at Level-2

## Description

cosa.bcra3r2 finds constrained optimal sample allocation (COSA) solutions for main effect in designs with three-levels where level-2 units are randomly assigned to treatment and control groups within level-3 units (random blocks). COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

cosa.bcra3r2 7

#### Usage

#### **Arguments**

cn	marginal cost per level-1 unit.
сJ	marginal cost per level-2 unit.
cK	marginal cost per level-3 unit.

cost total cost or budget.

n harmonic mean of level-1 units across level-2 units (or simple average).

J harmonic mean of level-2 units across level-3 units (or simple average).

K level-3 sample size.

P average proportion of level-2 units randomly assigned to treatment within level-

3 units.

nJK0 vector with a length of three to specify starting values for level-1, level-2, and

level-3 sample sizes.

P0 starting value for average proportion of level-2 units randomly assigned to treat-

ment within level-3 units.

power statistical power (1 - type II error).

mdes minimum detectable effect size.

alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

constrain one of the followings can be constrained at a specified cost or value: "cost",

"power", or "mdes".

optimizer algorithm to find optimal sample sizes given total cost, power, or MDES. Avail-

able algorithms: "auglag\_slsqp", "auglag\_lbfgs", "auglag\_mma" or "auglag\_cobyla".

gm grid multiplier to increase the range of sample sizes for approximate integer

solutions.

ncase number of approximate integer solutions to be exported.

rho2 proportion of variance in the outcome explained by level-2 units. rho3 proportion of variance in the outcome explained by level-3 units.

omega3 treatment effect heterogeneity as ratio of treatment effect variance among level-3

units to the residual variance at level-3.

g3 number of covariates at level-3.

R12 proportion of level-1 variance in the outcome explained by level-1 covariates.
R22 proportion of level-2 variance in the outcome explained by level-2 covariates.
RT32 proportion of treatment effect variance among level-3 units explained by level-3

covariates.

#### Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

#### See Also

```
mdes.bcra3r2, power.bcra3r2
```

## **Examples**

cosa.bcra4f3

COSA Solver for Main Effect in Four-Level Fixed Effects Blocked Cluster Random Assignment Designs, Treatment at Level-3

## Description

cosa.bcra4f3 finds constrained optimal sample allocation (COSA) solutions for main effect in designs with four-levels where level-3 units are randomly assigned to treatment and control groups within level-4 units (fixed blocks). COSA can be found in the following forms, (i) under budgetary constraints given marginal costs (equal or unequal) per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

## Usage

#### **Arguments**

cn marginal cost per level-1 unit.
cJ marginal cost per level-2 unit.
cK marginal cost per level-3 unit.
cL marginal cost per level-4 unit.

cost total cost or budget.

harmonic mean of level-1 units across level-2 units (or simple average).
 harmonic mean of level-2 units across level-3 units (or simple average).
 harmonic mean of level-3 units across level-4 units (or simple average).

L number of level-4 units.

P average proportion of level-3 units randomly assigned to treatment within level-

4 units.

nJKL0 vector with a length of four to specify starting values for level-1, level-2, level-

3, and level-4 sample sizes.

P0 starting value for average proportion of level-3 units randomly assigned to treat-

ment within level-4 units.

power statistical power (1 - type II error).

mdes minimum detectable effect size.

alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

constrain one of the followings can be constrained at a specified cost or value: "cost",

"power", or "mdes".

optimizer algorithm to find optimal sample sizes given total cost, power, or MDES. Avail-

able algorithms: "auglag\_slsqp", "auglag\_lbfgs", "auglag\_mma" or "auglag\_cobyla".

gm grid multiplier to increase the range of sample sizes for approximate integer

solutions.

ncase number of approximate integer solutions to be exported.

rho2 proportion of variance in the outcome explained by level-2 units. rho3 proportion of variance in the outcome explained by level-3 units.

g3 number of covariates at level-3.

R12 proportion of level-1 variance in the outcome explained by level-1 covariates.
R22 proportion of level-2 variance in the outcome explained by level-2 covariates.
R32 proportion of level-3 variance in the outcome explained by level-3 covariates.

## Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

#### See Also

```
mdes.bcra4f3, power.bcra4f3
```

#### **Examples**

cosa.bcra4r2

COSA Solver for Main Effect in Four-Level Random Effects Block Random Assignment Designs, Treatment at Level-2

## Description

cosa.bcra4r2 finds constrained optimal sample allocation (COSA) solutions for main effect in designs with four-levels where level-2 units are randomly assigned to treatment and control groups within level-3 units (random blocks). COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

#### Usage

marginal cost per level-1 unit.

# **Arguments** cn

сJ	marginal cost per level-2 unit.
cK	marginal cost per level-3 unit.
cL	marginal cost per level-4 unit.
cost	total cost or budget.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	harmonic mean of level-3 units across level-4 units (or simple average).
L	number of level-4 units.

Ρ average proportion of level-2 units randomly assigned to treatment within level-3 units. nJKL0 vector with a length of four to specify starting values for level-1, level-2, level-3, and level-4 sample sizes. P0 starting value for average proportion of level-2 units randomly assigned to treatment within level-3 units. power statistical power (1 - type II error). mdes minimum detectable effect size. probability of type I error. alpha two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing. one of the followings can be constrained at a specified cost or value: "cost", constrain "power", or "mdes". algorithm to find optimal sample sizes given total cost, power, or MDES. Availoptimizer able algorithms: "auglag\_slsqp", "auglag\_lbfgs", "auglag\_mma" or "auglag\_cobyla". grid multiplier to increase the range of sample sizes for approximate integer gm solutions. number of approximate integer solutions to be exported. ncase rho2 proportion of variance in the outcome explained by level-2 units. proportion of variance in the outcome explained by level-3 units. rho3 rho4 proportion of variance in the outcome explained by level-4 units. treatment effect heterogeneity as ratio of treatment effect variance among level-3 omega3 units to the residual variance at level-3. omega4 treatment effect heterogeneity as ratio of treatment effect variance among level-4 units to the residual variance at level-4. g4 number of covariates at level-4. R12 proportion of level-1 variance in the outcome explained by level-1 covariates. proportion of level-2 variance in the outcome explained by level-2 covariates. R22 proportion of treatment effect variance among level-3 units explained by level-3 RT32 covariates. **RT42** proportion of treatment effect variance among level-4 units explained by level-4 covariates.

#### Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

#### See Also

```
mdes.bcra4r2, power.bcra4r2
```

#### **Examples**

cosa.bcra4r3

COSA Solver for Main Effect in Four-Level Random Effects Blocked Cluster Random Assignment Designs, Treatment at Level-3

#### **Description**

cosa.bcra4r3 finds constrained optimal sample allocation (COSA) solutions for main effect in designs with four-levels where level-3 units are randomly assigned to treatment and control groups within level-4 units (random blocks). COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

#### Usage

# **Arguments** cn

сJ	marginal cost per level-2 unit.
cK	marginal cost per level-3 unit.
cL	marginal cost per level-4 unit.
cost	total cost or budget.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	harmonic mean of level-3 units across level-4 units (or simple average).
L	number of level-4 units.

marginal cost per level-1 unit.

Ρ average proportion of level-3 units randomly assigned to treatment within level-4 units. nJKL0 vector with a length of four to specify starting values for level-1, level-2, level-3, and level-4 sample sizes. P0 starting value for average proportion of level-3 units randomly assigned to treatment within level-4 units. statistical power (1 - type II error). power minimum detectable effect size. mdes alpha probability of type I error. two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing. constrain one of the followings can be constrained at a specified cost or value: "cost", "power", or "mdes". optimizer algorithm to find optimal sample sizes given total cost, power, or MDES. Available algorithms: "auglag\_slsqp", "auglag\_lbfgs", "auglag\_mma" or "auglag\_cobyla". grid multiplier to increase the range of sample sizes for approximate integer gm solutions. ncase number of approximate integer solutions to be exported. rho2 proportion of variance in the outcome explained by level-2 units. proportion of variance in the outcome explained by level-3 units. rho3 rho4 proportion of variance in the outcome explained by level-4 units. treatment effect heterogeneity as ratio of treatment effect variance among level-4 omega4 units to the residual variance at level-4. g4 number of covariates at level-4. R12 proportion of level-1 variance in the outcome explained by level-1 covariates. R22 proportion of level-2 variance in the outcome explained by level-2 covariates. R32 proportion of level-3 variance in the outcome explained by level-3 covariates. **RT42** proportion of treatment effect variance among level-4 units explained by level-4

#### Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

covariates.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

#### See Also

mdes.bcra4r3, power.bcra4r3

14 cosa.bcrd3f2

#### **Examples**

cosa.bcrd3f2

COSA Solver for Three-Level Blocked Cluster Regression Discontinuity Design, Treatment Based on Discontinuity at Level-2 (Fixed Treatment Effect)

## Description

COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit while minimizing sampling variance fo the treatment effect, (ii) under power constraints given marginal costs per unit while minimizing the total cost, (ii) under MDES constraints given marginal costs per unit while minimizing the total cost, and (iv) under sample size constraints for one or more levels along with any of the i ii, or iii options.

## Usage

cn	marginal cost per level-1 unit.
сJ	marginal cost per level-2 unit.
cK	marginal cost per level-3 unit.
cost	total cost or budget.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
nJK0	vector with a length of three to specifiy starting values for level-1, level-2, and level-3 sample sizes.
power	statistical power (1 - type II error).
mdes	minimum detectable effect size.

cosa.bcrd3f2 15

alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
constrain	one of the followings can be constrained at a specified cost or value: "cost", "power", or "mdes".
optimizer	algorithm to find optimal sample sizes given total cost, power, or MDES. Available algorithms: "auglag_slsqp", "auglag_lbfgs", "auglag_mma" or "auglag_cobyla".
gm	grid multiplier to increase the range of sample sizes for approximate integer solutions.
ncase	number of approximate integer solutions to be exported.
rho2	proportion of variance in the outcome explained by level-2 units.
Р	average proportion of level-1 units randomly assigned to treatment within level-2 units.
RTZ	correlation between treatment status and assignment variable
k1	left truncation point (in standard deviation untis from full normal distribution mean).
k2	right truncation point (in standard deviation untis from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g2	number of covariates at level-2.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.

## Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

#### See Also

```
mdes.bcrd3f2, power.bcrd3f2
```

16 cosa.bcrd3r2

cosa.bcrd3r2	COSA Solver for Three-Level Blocked Cluster Regression Discontinuity Design, Treatment Based on Discontinuity at Level-2 (Random Treatment Effect)

## Description

COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit while minimizing sampling variance fo the treatment effect, (ii) under power constraints given marginal costs per unit while minimizing the total cost, (ii) under MDES constraints given marginal costs per unit while minimizing the total cost, and (iv) under sample size constraints for one or more levels along with any of the i ii, or iii options.

## Usage

cn	marginal cost per level-1 unit.
сJ	marginal cost per level-2 unit.
cK	marginal cost per level-3 unit.
cost	total cost or budget.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
nJK0	vector with a length of three to specify starting values for level-1, level-2, and level-3 sample sizes.
power	statistical power (1 - type II error).
mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
constrain	one of the followings can be constrained at a specified cost or value: "cost", "power", or "mdes".
optimizer	algorithm to find optimal sample sizes given total cost, power, or MDES. Available algorithms: "auglag_slsqp", "auglag_lbfgs", "auglag_mma" or "auglag_cobyla"
gm	grid multiplier to increase the range of sample sizes for approximate integer solutions.

cosa.bcrd3r2

ncase	number of approximate integer solutions to be exported.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
omega3	treatment effect heterogeneity as ratio of treatment effect variance among level-3 units to the residual variance at level-3.
Р	average proportion of level-1 units randomly assigned to treatment within level-2 units.
RTZ	correlation between treatment status and assignment variable
k1	left truncation point (in standard deviation untis from full normal distribution mean).
k2	right truncation point (in standard deviation untis from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g3	number of covariates at level-3.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
RT32	proportion of treatment effect variance among level-3 units explained by level-3 covariates.

## Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

#### See Also

```
mdes.bcrd3r2, power.bcrd3r2
```

18 cosa.bira2c1

cosa.bira2c1	COSA Solver for Main Effect in Two-Level Constant Effects Blocked
	Individual Random Assignment Designs, Treatment at Level-2

## Description

cosa.bira2c1 finds constrained optimal sample allocation (COSA) solutions for main effct in designs with two-levels where level-1 units are randomly assigned to treatment and control groups within level-2 units (school intercepts only). COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

## Usage

cn	marginal cost per level-1 unit.
сJ	marginal cost per level-2 unit.
cost	total cost or budget.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	level-2 sample size.
Р	average proportion of level-1 units randomly assigned to treatment within level-2 units.
nJ0	vector with a length of two to specifiy starting values for level-1 and level-2 sample sizes.
P0	starting value for average proportion of level-1 units randomly assigned to treatment within level-2 units.
constrain	one of the followings can be constrained at a specified cost or value: "cost", "power", or "mdes".
optimizer	algorithm to find optimal sample sizes given total cost, power, or MDES. Available algorithms: "auglag_slsqp", "auglag_lbfgs", "auglag_mma" or "auglag_cobyla".
gm	grid multiplier to increase the range of sample sizes for approximate integer solutions.
ncase	number of approximate integer solutions to be exported.
power	statistical power (1 - type II error).
mdes	minimum detectable effect size.
alpha	probability of type I error.

cosa.bira2f1

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

g1 number of covariates at level-1.

R12 proportion of level-1 variance in the outcome explained by level-1 covariates.

#### Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

#### See Also

```
mdes.bira2c1, power.bira2c1
```

## Examples

cosa.bira2f1 COSA Solver for Main Effect in Two-Level Fixed Effects Blocked Individual Random Assignment Designs, Treatment at Level-1

#### **Description**

cosa.bira2f1 finds constrained optimal sample allocation (COSA) solutions for main effect in designs with two-levels where level-1 units are randomly assigned to treatment and control groups within level-2 units (fixed blocks). COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

20 cosa.bira2f1

#### Usage

#### **Arguments**

cn marginal cost per level-1 unit.
cJ marginal cost per level-2 unit.

cost total cost or budget.

n harmonic mean of level-1 units across level-2 units (or simple average).

J level-2 sample size.

P average proportion of level-1 units randomly assigned to treatment within level-

2 units.

nJ0 vector with a length of two to specify starting values for level-1 and level-2

sample sizes.

P0 starting value for average proportion of level-1 units randomly assigned to treat-

ment within level-2 units.

constrain one of the followings can be constrained at a specified cost or value: "cost",

"power", or "mdes".

optimizer algorithm to find optimal sample sizes given total cost, power, or MDES. Avail-

 $able\ algorithms:\ "auglag\_slsqp",\ "auglag\_lbfgs",\ "auglag\_mma"\ or\ "auglag\_cobyla".$ 

gm grid multiplier to increase the range of sample sizes for approximate integer

solutions.

ncase number of approximate integer solutions to be exported.

power statistical power (1 - type II error).

mdes minimum detectable effect size.

alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

g1 number of covariates at level-1.

R12 proportion of level-1 variance in the outcome explained by level-1 covariates.

## Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round. optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

cosa.bira2r1 21

#### See Also

```
mdes.bira2f1, power.bira2f1
```

#### **Examples**

cosa.bira2r1

COSA Solver for Main Effect in Two-Level Random Effects Blocked Individual Random Assignment Designs, Individuals Randomized within Blocks

## **Description**

cosa.bira2r1 finds constrained optimal sample allocation (COSA) solutions for main effect in designs with two-levels where level-1 units are randomly assigned to treatment and control groups within level-2 units (random blocks). COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

## Usage

cn	marginal cost per level-1 unit.
сJ	marginal cost per level-2 unit.
cost	total cost or budget.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	level-2 sample size.
Р	average proportion of level-1 units randomly assigned to treatment within level-2 units.
nJ0	vector with a length of two to specifiy starting values for level-1 and level-2 sample sizes.
P0	starting value for average proportion of level-1 units randomly assigned to treatment within level-2 units.

22 cosa.bira2r1

power statistical power (1 - type II error).

mdes minimum detectable effect size.

alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

constrain one of the followings can be constrained at a specified cost or value: "cost",

"power", or "mdes".

optimizer algorithm to find optimal sample sizes given total cost, power, or MDES. Avail-

able algorithms: "auglag\_slsqp", "auglag\_lbfgs", "auglag\_mma" or "auglag\_cobyla".

gm grid multiplier to increase the range of sample sizes for approximate integer

solutions.

ncase number of approximate integer solutions to be exported.

rho2 proportion of variance in the outcome explained by level-2 units.

omega2 treatment effect heterogeneity as ratio of treatment effect variance among level-2

units to the residual variance at level-2.

g2 number of covariates at level-2.

R12 proportion of level-1 variance in the outcome explained by level-1 covariates.

RT22 proportion of treatment effect variance among level-2 units explained by level-2

covariates.

#### Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

#### See Also

```
mdes.bira2r1, power.bira2r1
```

cosa.bira3r1 23

cosa.bira3r1	COSA Solver for Main Effect in Three-Level Random Effects Blocked
	Individual Random Assignment Design, Individuals Randomized within Blocks

## **Description**

cosa.bira3r1 finds constrained optimal sample allocation (COSA) solutions for main effect in designs with three-levels where level-1 units are randomly assigned to treatment and control groups within level-2 units (random blocks). COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

## Usage

Θ,		
	cn	marginal cost per level-1 unit.
	сJ	marginal cost per level-2 unit.
	cK	marginal cost per level-3 unit.
	cost	total cost or budget.
	n	harmonic mean of level-1 units across level-2 units (or simple average).
	J	harmonic mean of level-2 units across level-3 units (or simple average).
	K	level-3 sample size.
	Р	average proportion of level-1 units randomly assigned to treatment within level-2 units.
	nJK0	vector with a length of three to specify starting values for level-1, level-2, and level-3 sample sizes.
	P0	starting value for average proportion of level-1 units randomly assigned to treatment within level-2 units.
	power	statistical power (1 - type II error).
	mdes	minimum detectable effect size.
	alpha	probability of type I error.
	two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
	constrain	one of the followings can be constrained at a specified cost or value: " $cost$ ", "power", or "mdes".

24 cosa.bira3r1

optimizer algorithm to find optimal sample sizes given total cost, power, or MDES. Available algorithms: "auglag\_slsqp", "auglag\_lbfgs", "auglag\_mma" or "auglag\_cobyla". grid multiplier to increase the range of sample sizes for approximate integer gm solutions. number of approximate integer solutions to be exported. ncase rho2 proportion of variance in the outcome explained by level-2 units. proportion of variance in the outcome explained by level-3 units. rho3 omega2 treatment effect heterogeneity as ratio of treatment effect variance among level-2 units to the residual variance at level-2. treatment effect heterogeneity as ratio of treatment effect variance among level-3 omega3 units to the residual variance at level-3. number of covariates at level-3. g3 R12 proportion of level-1 variance in the outcome explained by level-1 covariates. RT22 proportion of treatment effect variance among level-2 units explained by level-2 covariates.

Value

RT32

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

covariates.

exact optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

proportion of treatment effect variance among level-3 units explained by level-3

#### See Also

```
mdes.bira3r1, power.bira3r1
```

cosa.bira4r1 25

## Description

cosa.bira4r1 finds constrained optimal sample allocation (COSA) solutions for main effect in designs with four-levels where level-1 units are randomly assigned to treatment and control groups within level-2 units (random blocks). COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

## Usage

cn	marginal cost per level-1 unit.
сJ	marginal cost per level-2 unit.
cK	marginal cost per level-3 unit.
cL	marginal cost per level-4 unit.
cost	total cost or budget.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	harmonic mean of level-3 units across level-4 units (or simple average).
L	number of level-4 units.
Р	average proportion of level-1 units randomly assigned to treatment within level-2 units.
nJKL0	vector with a length of four to specify starting values for level-1, level-2, level-3, and level-4 sample sizes.
P0	starting value for average proportion of level-1 units randomly assigned to treatment within level-2 units.
power	statistical power (1 - type II error).
mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.

one of the followings can be constrained at a specified cost or value: "cost",

"power", or "mdes". algorithm to find optimal sample sizes given total cost, power, or MDES. Availoptimizer able algorithms: "auglag\_slsqp", "auglag\_lbfgs", "auglag\_mma" or "auglag\_cobyla". grid multiplier to increase the range of sample sizes for approximate integer gm solutions. ncase number of approximate integer solutions to be exported. rho2 proportion of variance in the outcome explained by level-2 units. proportion of variance in the outcome explained by level-3 units. rho3 rho4 proportion of variance in the outcome explained by level-4 units. treatment effect heterogeneity as ratio of treatment effect variance among level-2 omega2 units to the residual variance at level-2. treatment effect heterogeneity as ratio of treatment effect variance among level-3 omega3 units to the residual variance at level-3. treatment effect heterogeneity as ratio of treatment effect variance among level-4 omega4 units to the residual variance at level-4. number of covariates at level-4. g4 R12 proportion of level-1 variance in the outcome explained by level-1 covariates. proportion of treatment effect variance among level-2 units explained by level-2 RT22 covariates. RT32 proportion of treatment effect variance among level-3 units explained by level-3 covariates.

## Value

RT42

constrain

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

covariates.

exact optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round. optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

proportion of treatment effect variance among level-4 units explained by level-4

#### See Also

```
mdes.bira4r1, power.bira4r1
```

```
## Not run:
```

cosa.bird2f1 27

```
omega4=.50, omega3=.50, omega2=.50)
```

## End(Not run)

cosa.bird2f1

COSA Solver for Two-Level Blocked Individual Regression Discontinuity Design, Treatment Based on Discontinuity at Level-1 (Fixed Treatment Effect)

## **Description**

COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit while minimizing sampling variance fo the treatment effect, (ii) under power constraints given marginal costs per unit while minimizing the total cost, (ii) under MDES constraints given marginal costs per unit while minimizing the total cost, and (iv) under sample size constraints for one or more levels along with any of the i ii, or iii options.

## Usage

```
cosa.bird2f1(cn=0, cJ=0, cost=NULL,
    n=NULL, J=NULL, nJ0=c(10,10),
    constrain="power", optimizer="auglag_slsqp",
    gm=2, ncase=10,
    power=.80, mdes=.25, alpha=.05, two.tail=TRUE,
    P=.50, RTZ=NULL, k1=-6, k2=6, dist.Z="normal",
    g1=0, R12=0)
```

cn	marginal cost per level-1 unit.
сJ	marginal cost per level-2 unit.
cost	total cost or budget.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	number of level-2 units.
nJ0	vector with a length of two to specifiy starting values for level-1, and level-2 sample sizes.
power	statistical power (1 - type II error).
mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
constrain	one of the followings can be constrained at a specified cost or value: "cost", "power", or "mdes".
optimizer	algorithm to find optimal sample sizes given total cost, power, or MDES. Available algorithms: "auglag_slsqp", "auglag_lbfgs", "auglag_mma" or "auglag_cobyla".
gm	grid multiplier to increase the range of sample sizes for approximate integer solutions.

28 cosa.bird2r1

ncase	number of approximate integer solutions to be exported.
P	average proportion of level-1 units randomly assigned to treatment within level-2 units.
RTZ	correlation between treatment status and assignment variable
k1	left truncation point (in standard deviation untis from full normal distribution mean).
k2	right truncation point (in standard deviation untis from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g1	number of covariates at level-1.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.

#### Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

## See Also

```
mdes.bird2f1, power.bird2f1
```

## **Examples**

```
## Not run:
    cosa.bird2f1(mdes=0.728, cn=1, cJ=10, cost=560, constrain="cost")
## End(Not run)
```

cosa.bird2r1 COSA Solver for Two-Level Blocked Individual Regression Disconti-

nuity Design, Treatment Based on Discontinuity at Level-1 (Random

Treatment Effect)

## Description

COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit while minimizing sampling variance fo the treatment effect, (ii) under power constraints given marginal costs per unit while minimizing the total cost, (ii) under MDES constraints given marginal costs per unit while minimizing the total cost, and (iv) under sample size constraints for one or more levels along with any of the i ii, or iii options.

cosa.bird2r1 29

#### **Usage**

## **Arguments**

cn marginal cost per level-1 unit. cJ marginal cost per level-2 unit.

cost total cost or budget.

n harmonic mean of level-1 units across level-2 units (or simple average).

J number of level-2 units.

nJ0 vector with a length of two to specify starting values for level-1, and level-2

sample sizes.

power statistical power (1 - type II error).

mdes minimum detectable effect size.

alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

constrain one of the followings can be constrained at a specified cost or value: "cost",

"power", or "mdes".

optimizer algorithm to find optimal sample sizes given total cost, power, or MDES. Avail-

able algorithms: "auglag\_slsqp", "auglag\_lbfgs", "auglag\_mma" or "auglag\_cobyla".

gm grid multiplier to increase the range of sample sizes for approximate integer

solutions.

ncase number of approximate integer solutions to be exported.

rho2 proportion of variance in the outcome explained by level-2 units.

omega2 treatment effect heterogeneity as ratio of treatment effect variance among level-2

units to the residual variance at level-2.

P average proportion of level-1 units randomly assigned to treatment within level-

2 units.

RTZ correlation between treatment status and assignment variable

k1 left truncation point (in standard deviation untis from full normal distribution

mean).

k2 right truncation point (in standard deviation untis from full normal distribution

mean).

dist.Z distribution of assignment variable; either normal or uniform.

g2 number of covariates at level-2.

Proportion of level-1 variance in the outcome explained by level-1 covariates.

RT22 proportion of treatment effect variance among level-2 units explained by level-2

covariates.

30 cosa.cra2r2

#### Value

fun	function name.
parms	list of parameters used in the function.
nloptr	list of nloptr log and output.
exact.optim	exact solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).
round.optim	rounded solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

#### See Also

```
mdes.bird2r1, power.bird2r1
```

#### **Examples**

cosa.cra2r2 COSA Solver for Main Effect in Two-Level Cluster Random Assignment Design, Treatment at Level-2

## **Description**

cosa.cra2r2 finds constrained optimal sample allocation (COSA) solutions for main effect in designs with two-levels where level-2 units are randomly assigned to treatment and control groups. COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

## Usage

cosa.cra2r2

#### **Arguments**

cn marginal cost per level-1 unit.
cJ marginal cost per level-2 unit.

cost total cost or budget.

n harmonic mean of level-1 units across level-2 units (or simple average).

J level-2 sample size.

P proportion of level-2 units randomly assigned to treatment.

nJ0 vector with a length of two to specify starting values for level-1 and level-2

sample sizes.

P0 starting value for proportion of level-2 units randomly assigned to treatment.

constrain one of the followings can be constrained at a specified cost or value: "cost",

"power", or "mdes".

optimizer algorithm to find optimal sample sizes given total cost, power, or MDES. Avail-

able algorithms: "auglag\_slsqp", "auglag\_lbfgs", "auglag\_mma" or "auglag\_cobyla".

gm grid multiplier to increase the range of sample sizes for approximate integer

solutions.

ncase number of approximate integer solutions to be exported.

power statistical power (1 - type II error).

mdes minimum detectable effect size.

alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

rho2 proportion of variance in the outcome explained by level-2 units.

g2 number of covariates at level-2.

R12 proportion of level-1 variance in the outcome explained by level-1 covariates.
R22 proportion of level-2 variance in the outcome explained by level-2 covariates.

#### Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

## See Also

mdes.cra2r2, power.cra2r2

32 cosa.cra3r3

#### **Examples**

cosa.cra3r3

COSA Solver for Main Effect in Three-Level Cluster Random Assignment Designs, Treatment at Level-3

## **Description**

cosa.cra3r3 finds constrained optimal sample allocation (COSA) solutions for main effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups. COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

## Usage

## **Arguments**

mdes

cn	marginal cost per level-1 unit.
сJ	marginal cost per level-2 unit.
сК	marginal cost per level-3 unit.
cost	total cost or budget.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
Р	proportion of level-3 units randomly assigned to treatment.
nJK0	vector with a length of three to specify starting values for level-1, level-2, and level-3 sample sizes.
P0	starting value for proportion of level-3 units randomly assigned to treatment.
power	statistical power (1 - type II error).

minimum detectable effect size.

cosa.cra3r3

alpha probability of type I error. two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing. constrain one of the followings can be constrained at a specified cost or value: "cost", "power", or "mdes". algorithm to find optimal sample sizes given total cost, power, or MDES. Availoptimizer able algorithms: "auglag\_slsqp", "auglag\_lbfgs", "auglag\_mma" or "auglag\_cobyla". grid multiplier to increase the range of sample sizes for approximate integer gm solutions. number of approximate integer solutions to be exported. ncase proportion of variance in the outcome explained by level-2 units. rho2 rho3 proportion of variance in the outcome explained by level-3 units. g3 number of covariates at level-3. R12 proportion of level-1 variance in the outcome explained by level-1 covariates. R22 proportion of level-2 variance in the outcome explained by level-2 covariates. proportion of level-3 variance in the outcome explained by level-3 covariates. R32

## Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

## See Also

```
mdes.cra3r3, power.cra3r3
```

cosa.cra4r4	COSA Solver for Main Effect in Four-Level Cluster Random Assign-
	ment Designs, Treatment at Level-4

## Description

cosa.cra4r4 finds constrained optimal sample allocation (COSA) solutions for main effect in designs with four-levels where level-4 units are randomly assigned to treatment and control groups. COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

# Usage

cn	marginal cost per level-1 unit.
сJ	marginal cost per level-2 unit.
cK	marginal cost per level-3 unit.
cL	marginal cost per level-4 unit.
cost	total cost or budget.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	harmonic mean of level-3 units across level-4 units (or simple average).
L	number of level-4 units.
Р	proportion of level-4 units randomly assigned to treatment.
nJKL0	vector with a length of four to specify starting values for level-1, level-2, level-3, and level-4 sample sizes.
P0	starting value for proportion of level-4 units randomly assigned to treatment.
power	statistical power (1 - type II error).
mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
constrain	one of the followings can be constrained at a specified cost or value: "cost", "power", or "mdes".

optimizer	algorithm to find optimal sample sizes given total cost, power, or MDES. Available algorithms: "auglag_slsqp", "auglag_lbfgs", "auglag_mma" or "auglag_cobyla".
gm	grid multiplier to increase the range of sample sizes for approximate integer solutions.
ncase	number of approximate integer solutions to be exported.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
rho4	proportion of variance in the outcome explained by level-4 units.
g4	number of covariates at level-4.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
R32	proportion of level-3 variance in the outcome explained by level-3 covariates.
R42	proportion of level-4 variance in the outcome explained by level-4 covariates.

## Value

fun	function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

## See Also

```
mdes.cra4r4, power.cra4r4
```

36 cosa.crd2r2

cosa.crd2r2	COSA Solver for Two-Level Cluster Regression Discontinuity Design,
	Treatment Based on Discontinuity at Level-2

## **Description**

COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit while minimizing sampling variance fo the treatment effect, (ii) under power constraints given marginal costs per unit while minimizing the total cost, (ii) under MDES constraints given marginal costs per unit while minimizing the total cost, and (iv) under sample size constraints for one or more levels along with any of the i ii, or iii options.

## Usage

2 units.

cn	marginal cost per level-1 unit.
сJ	marginal cost per level-2 unit.
cost	total cost or budget.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
nJ0	vector with a length of two to specifiy starting values for level-1, and level-2 sample sizes.
power	statistical power (1 - type II error).
mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
constrain	one of the followings can be constrained at a specified cost or value: "cost", "power", or "mdes".
optimizer	algorithm to find optimal sample sizes given total cost, power, or MDES. Available algorithms: "auglag_slsqp", "auglag_lbfgs", "auglag_mma" or "auglag_cobyla".
gm	grid multiplier to increase the range of sample sizes for approximate integer solutions.
ncase	number of approximate integer solutions to be exported.
rho2	proportion of variance in the outcome explained by level-2 units.
Р	average proportion of level-1 units randomly assigned to treatment within level-

cosa.crd3r3 37

RTZ	correlation between treatment status and assignment variable
k1	left truncation point (in standard deviation untis from full normal distribution mean).
k2	right truncation point (in standard deviation untis from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g2	number of covariates at level-2.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.

#### Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

### See Also

```
mdes.crd2r2, power.crd2r2
```

# **Examples**

cosa.crd3r3 COSA Solver for Three-Level Cluster Regression Discontinuity Design, Treatment Based on Discontinuity at Level-3

# Description

COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit while minimizing sampling variance fo the treatment effect, (ii) under power constraints given marginal costs per unit while minimizing the total cost, (ii) under MDES constraints given marginal costs per unit while minimizing the total cost, and (iv) under sample size constraints for one or more levels along with any of the i ii, or iii options.

38 cosa.crd3r3

### Usage

### **Arguments**

cn marginal cost per level-1 unit.
cJ marginal cost per level-2 unit.
cK marginal cost per level-3 unit.

cost total cost or budget.

n harmonic mean of level-1 units across level-2 units (or simple average).

J harmonic mean of level-2 units across level-3 units (or simple average).

K level-3 sample size.

nJK0 vector with a length of three to specify starting values for level-1, level-2, and

level-3 sample sizes.

power statistical power (1 - type II error).

mdes minimum detectable effect size.

alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

constrain one of the followings can be constrained at a specified cost or value: "cost",

"power", or "mdes".

optimizer algorithm to find optimal sample sizes given total cost, power, or MDES. Avail-

able algorithms: "auglag\_slsqp", "auglag\_lbfgs", "auglag\_mma" or "auglag\_cobyla".

gm grid multiplier to increase the range of sample sizes for approximate integer

solutions.

ncase number of approximate integer solutions to be exported.

rho2 proportion of variance in the outcome explained by level-2 units. rho3 proportion of variance in the outcome explained by level-3 units.

P average proportion of level-1 units randomly assigned to treatment within level-

2 units.

RTZ correlation between treatment status and assignment variable

k1 left truncation point (in standard deviation untis from full normal distribution

mean).

k2 right truncation point (in standard deviation untis from full normal distribution

mean).

dist.Z distribution of assignment variable; either normal or uniform.

g3 number of covariates at level-3.

R12 proportion of level-1 variance in the outcome explained by level-1 covariates.
R22 proportion of level-2 variance in the outcome explained by level-2 covariates.
R32 proportion of level-3 variance in the outcome explained by level-3 covariates.

cosa.ira1r1 39

#### Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

#### See Also

```
mdes.crd3r3, power.crd3r3
```

### **Examples**

cosa.ira1r1 Sample Size Calculator for Main Effect in Individual Random Assign-

ment Designs, Completely Randomized Controlled Trials

### **Description**

cosa.ira1r1 calculates minimum required sample size for main effect in completely randomized controlled trials where individuals are randomly assigned to treatment or control groups.

# Usage

```
cosa.ira1r1(mdes=.25, power=.80, alpha=.05, two.tail=TRUE, n0=10, tol=.10, P=.50, g1=0, R12=0)
```

# Arguments

power statistical power (1 - type II error).

mdes minimum detectable effect size.

alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

n0 starting value for sample size.

tol tolerance.

40 cosa.ird1r1

P average proportion of units randomly assigned to treatment.

g1 number of covariates.

R12 proportion of variance in the outcome explained by covariates.

## Value

fun function name.

parms list of parameters used in the function.

n sample size.

#### See Also

```
mdes.ira1r1, power.ira1r1
```

#### **Examples**

cosa.ird1r1

COSA for Main Effect in Individual Regression Discontinuity Design

# Description

cosa.ird1r1 calculates constrained optimal sample for main effect in individual regression discontinuity design.

## Usage

```
cosa.ird1r1(mdes=.25, power=.80, alpha=.05, two.tail=TRUE, n0=10, tol=.10, P=.50, RTZ=NULL, k1=-6, k2=6, dist.Z="normal", g1=0, R12=0)
```

# Arguments

 $\mathsf{RTZ}$ 

power	statistical power (1 - type II error).
mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
n0	starting value for sample size.
tol	tolerance.
Р	average proportion of units randomly assigned to treatment.

correlation between treatment status and assignment variable.

cosa.mod1n.cra2r2 41

k1	left truncation point (in standard deviation until from full normal distribution mean).
k2	right truncation point (in standard deviation untis from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g1	number of covariates.
R12	proportion of variance in the outcome explained by covariates.

## Value

fun function name.

parms list of parameters used in the function.

n sample size.

#### See Also

```
mdes.ird1r1, power.ird1r1
```

### **Examples**

```
## Not run:
     cosa.ird1r1(mdes=.466)
## End(Not run)
```

cosa.mod1n.cra2r2

COSA Solver for Non-randomly Varying Moderator Effect in Two-Level Cluster Random Assignment Design, Treatment at level-2 and Moderator at Level-1

# Description

cosa.mod1n.cra2r2 finds constrained optimal sample allocation (COSA) solutions for non-randomly varying moderator effect in designs with two-levels where level-2 units are randomly assigned to treatment and control groups and moderator is at level-1. COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

## Usage

42 cosa.mod1n.cra2r2

#### **Arguments**

cn marginal cost per level-1 unit.
cJ marginal cost per level-2 unit.

cost total cost or budget.

n harmonic mean of level-1 units across level-2 units (or simple average).

J level-2 sample size.

P proportion of level-2 units randomly assigned to treatment.

nJ0 vector with a length of two to specify starting values for level-1 and level-2

sample sizes.

P0 starting value for proportion of level-2 units randomly assigned to treatment.

constrain one of the followings can be constrained at a specified cost or value: "cost",

"power", or "mdes".

optimizer algorithm to find optimal sample sizes given total cost, power, or MDES. Avail-

able algorithms: "auglag\_cobyla", "auglag\_lbfgs", "auglag\_mma", or "auglag\_slsqp".

gm grid multiplier to increase the range of sample sizes for approximate integer

solutions.

ncase number of approximate integer solutions to be exported.

power statistical power (1 - type II error).

mdes minimum detectable effect size.

alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

rho2 proportion of variance in the outcome explained by level-2 units.

Q proportion of level-1 units within moderator subgroup. NULL implies continuous

moderator.

g1 number of covariates at level-1 excluding moderator.

R12 proportion of level-1 variance in the outcome explained by level-1 covariates.

#### Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

## See Also

mdes.mod1n.cra2r2, power.mod1n.cra2r2

cosa.mod1n.cra3r3 43

### **Examples**

Moderator at Level-1

#### **Description**

cosa.mod1n.cra3r3 finds constrained optimal sample allocation (COSA) solutions for non-randomly varying moderator effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups and moderator is at level-1. COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

#### Usage

cn	marginal cost per level-1 unit.
сJ	marginal cost per level-2 unit.
cK	marginal cost per level-3 unit.
cost	total cost or budget.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
Р	proportion of level-3 units randomly assigned to treatment.
nJK0	vector with a length of two to specifiy starting values for level-1, level-2 and level-3 sample sizes.
P0	starting value for proportion of level-3 units randomly assigned to treatment.
constrain	one of the followings can be constrained at a specified cost or value: "cost", "power", or "mdes".

44 cosa.mod1n.cra3r3

optimizer algorithm to find optimal sample sizes given total cost, power, or MDES. Avail-

able algorithms: "auglag\_cobyla", "auglag\_lbfgs", "auglag\_mma", or "auglag\_slsqp".

gm grid multiplier to increase the range of sample sizes for approximate integer

solutions.

ncase number of approximate integer solutions to be exported.

power statistical power (1 - type II error).

mdes minimum detectable effect size.

alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

rho2 proportion of variance in the outcome explained by level-2 units.
rho3 proportion of variance in the outcome explained by level-3 units.

Q proportion of level-1 units within moderator subgroup. NULL implies continuous

moderator.

g1 number of covariates at level-1 excluding moderator.

R12 proportion of level-1 variance in the outcome explained by level-1 covariates.

#### Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

#### See Also

```
mdes.mod1n.cra3r3, power.mod1n.cra3r3
```

#### **Examples**

cosa.mod1r.cra2r2 45

cosa.mod1r.cra2r2	COSA Solver for Randomly Varying Moderator Effect in Two-Level
	Cluster Random Assignment Design, Treatment at level-2 and Moder-
	ator at Level-1

## **Description**

cosa.mod1r.cra2r2 finds constrained optimal sample allocation (COSA) solutions for randomly varying moderator effect in designs with two-levels where level-2 units are randomly assigned to treatment and control groups and moderator is at level-1. COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

# Usage

cn	marginal cost per level-1 unit.
сJ	marginal cost per level-2 unit.
cost	total cost or budget.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	level-2 sample size.
Р	proportion of level-2 units randomly assigned to treatment.
nJ0	vector with a length of two to specifiy starting values for level-1 and level-2 sample sizes.
P0	starting value for proportion of level-2 units randomly assigned to treatment.
constrain	one of the followings can be constrained at a specified cost or value: "cost", "power", or "mdes".
optimizer	algorithm to find optimal sample sizes given total cost, power, or MDES. Available algorithms: "auglag_slsqp", "auglag_lbfgs", "auglag_mma", or "auglag_slsqp".
gm	grid multiplier to increase the range of sample sizes for approximate integer solutions.
ncase	number of approximate integer solutions to be exported.
power	statistical power (1 - type II error).
mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.

46 cosa.mod1r.cra3r3

rho2	proportion of variance in the outcome explained by level-2 units.
omega2	moderator effect heterogeneity (unconditional) across level-2 units.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g1	number of covariates at level-1 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
RT22	proportion of level-2 variance in the moderator effect explained by level-2 covariates.

#### Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

#### See Also

```
mdes.mod1r.cra2r2, power.mod1r.cra2r2
```

# Examples

cosa.mod1r.cra3r3 COSA Solver for Randomly Varying Moderator Effect in Three-Level

Cluster Random Assignment Designs, Treatment at Level-3 and Mod-

erator at Level-1

## **Description**

cosa.mod1r.cra3r3 finds constrained optimal sample allocation (COSA) solutions for randomly varying moderator effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups and moderator is at level-1. COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

cosa.mod1r.cra3r3 47

#### Usage

#### **Arguments**

cn	marginal cost per level-1 unit.
сJ	marginal cost per level-2 unit.
cK	marginal cost per level-3 unit.

cost total cost or budget.

n harmonic mean of level-1 units across level-2 units (or simple average).

J harmonic mean of level-2 units across level-3 units (or simple average).

K level-3 sample size.

P proportion of level-3 units randomly assigned to treatment.

nJK0 vector with a length of two to specify starting values for level-1, level-2 and

level-3 sample sizes.

P0 starting value for proportion of level-3 units randomly assigned to treatment.

constrain one of the followings can be constrained at a specified cost or value: "cost",

"power", or "mdes".

optimizer algorithm to find optimal sample sizes given total cost, power, or MDES. Avail-

 $able\ algorithms:\ "auglag\_cobyla",\ "auglag\_lbfgs",\ "auglag\_mma",\ or\ "auglag\_slsqp".$ 

gm grid multiplier to increase the range of sample sizes for approximate integer

solutions.

ncase number of approximate integer solutions to be exported.

power statistical power (1 - type II error).

mdes minimum detectable effect size.

alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

rho2 proportion of variance in the outcome explained by level-2 units.
rho3 proportion of variance in the outcome explained by level-3 units.
omega2 moderator effect heterogeneity (unconditional) across level-2 units.
omega3 moderator effect heterogeneity (unconditional) across level-3 units.

Q proportion of level-1 units within moderator subgroup. NULL implies continuous

moderator.

g1 number of covariates at level-1 excluding moderator.

R12 proportion of level-1 variance in the outcome explained by level-1 covariates.

RT22 proportion of level-2 variance in the moderator effect explained by level-2 co-

variates.

RT32 proportion of level-3 variance in the moderator effect explained by level-3 co-

variates.

48 cosa.mod2.cra2r2

#### Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

#### See Also

```
mdes.mod1r.cra3r3, power.mod1r.cra3r3
```

#### **Examples**

cosa.mod2.cra2r2

COSA Solver for Moderator Effect in Two-Level Cluster Random Assignment Design, Treatment and Moderator at Level-2

## **Description**

cosa.mod2.cra2r2 finds constrained optimal sample allocation (COSA) solutions for moderator effect in designs with two-levels where level-2 units are randomly assigned to treatment and control groups and moderator is at level-2. COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

# Usage

cosa.mod2.cra2r2 49

#### **Arguments**

cn marginal cost per level-1 unit.
cJ marginal cost per level-2 unit.

cost total cost or budget.

n harmonic mean of level-1 units across level-2 units (or simple average).

J level-2 sample size.

P proportion of level-2 units randomly assigned to treatment.

nJ0 vector with a length of two to specify starting values for level-1 and level-2

sample sizes.

P0 starting value for proportion of level-2 units randomly assigned to treatment.

constrain one of the followings can be constrained at a specified cost or value: "cost",

"power", or "mdes".

optimizer algorithm to find optimal sample sizes given total cost, power, or MDES. Avail-

able algorithms: "auglag\_cobyla", "auglag\_lbfgs", "auglag\_mma", or "auglag\_slsqp".

gm grid multiplier to increase the range of sample sizes for approximate integer

solutions.

ncase number of approximate integer solutions to be exported.

power statistical power (1 - type II error).
mdes minimum detectable effect size.

alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing

rho2 proportion of variance in the outcome explained by level-2 units.

Q proportion of level-1 units within moderator subgroup. NULL implies continuous

moderator.

g2 number of covariates at level-2 excluding moderator.

R12 proportion of level-1 variance in the outcome explained by level-1 covariates.
R22 proportion of level-2 variance in the outcome explained by level-2 covariates.

### Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

### See Also

mdes.mod2.cra2r2, power.mod2.cra2r2

50 cosa.mod2n.cra3r3

### **Examples**

cosa.mod2n.cra3r3

COSA Solver for Non-Randomly Varying Moderator Effect in Three-Level Cluster Random Assignment Designs, Treatment at Level-3 and Moderator at Level-2

## **Description**

cosa.mod2n.cra3r3 finds constrained optimal sample allocation (COSA) solutions for non-randomly varying moderator effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups and moderator is at level-2. COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

### Usage

marginal cost per level 1 unit

### **Arguments**

cn	marginal cost per level-1 unit.
сJ	marginal cost per level-2 unit.
cK	marginal cost per level-3 unit.
cost	total cost or budget.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
Р	proportion of level-3 units randomly assigned to treatment.
nJK0	vector with a length of two to specifiy starting values for level-1, level-2 and level-3 sample sizes.
P0	starting value for proportion of level-3 units randomly assigned to treatment.
constrain	one of the followings can be constrained at a specified cost or value: "cost", "power", or "mdes".
optimizer	algorithm to find optimal sample sizes given total cost, power, or MDES. Avail-

able algorithms: "auglag\_cobyla", "auglag\_lbfgs", "auglag\_mma", or "auglag\_slsqp".

cosa.mod2n.cra3r3 51

gm	grid multiplier to increase the range of sample sizes for approximate integer solutions.
ncase	number of approximate integer solutions to be exported.
power	statistical power (1 - type II error).
mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g2	number of covariates at level-2 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.

#### Value

R22

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

proportion of level-2 variance in the outcome explained by level-2 covariates.

### See Also

```
mdes.mod2n.cra3r3, power.mod2n.cra3r3
```

# Examples

52 cosa.mod2r.cra3r3

cosa.mod2r.cra3r3	COSA Solver for Randomly Varying Moderator Effect in Three-Level
	Cluster Random Assignment Designs, Treatment at Level-3 and Mod-
	erator at Level-2

#### **Description**

cosa.mod2r.cra3r3 finds constrained optimal sample allocation (COSA) solutions for randomly varying moderator effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups and moderator is at level-2. COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

# Usage

## **Arguments**

power mdes

cn	marginal cost per level-1 unit.
сJ	marginal cost per level-2 unit.
cK	marginal cost per level-3 unit.
cost	total cost or budget.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
Р	proportion of level-3 units randomly assigned to treatment.
nJK0	vector with a length of two to specifiy starting values for level-1, level-2 and level-3 sample sizes.
P0	starting value for proportion of level-3 units randomly assigned to treatment.
constrain	one of the followings can be constrained at a specified cost or value: "cost", "power", or "mdes".
optimizer	algorithm to find optimal sample sizes given total cost, power, or MDES. Available algorithms: "auglag_cobyla", "auglag_lbfgs", "auglag_mma", or "auglag_slsqp".
gm	grid multiplier to increase the range of sample sizes for approximate integer solutions.
ncase	number of approximate integer solutions to be exported.

statistical power (1 - type II error).

minimum detectable effect size.

cosa.mod2r.cra3r3 53

alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
omega3	moderator effect heterogeneity (unconditional) across level-3 units.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g2	number of covariates at level-2 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
RT32	proportion of level-3 variance in the moderator effect explained by level-3 covariates.

# Value

fun	function name.
parms	list of parameters used in the function.
nloptr	list of nloptr log and output.
exact.optim	exact solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).
round.optim	rounded solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

# See Also

```
mdes.mod2r.cra3r3, power.mod2r.cra3r3
```

# **Examples**

54 cosa.mod3.cra3r3

cosa.mod3.cra3r3	COSA Solver for Moderator Effect in Three-Level Cluster Random As-
	signment Designs, Treatment and Moderator at Level-3

# Description

cosa.mod3.cra3r3 finds constrained optimal sample allocation (COSA) solutions for moderator effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups and moderator is at level-3. COSA can be found in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power contraints given marginal costs per unit, (iii) under MDES contraints given marginal costs per unit, and (iv) under sample size contraints for one or more levels along with any of the i,ii, or iii options.

# Usage

cn	marginal cost per level-1 unit.
сJ	marginal cost per level-2 unit.
сК	marginal cost per level-3 unit.
cost	total cost or budget.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
Р	proportion of level-3 units randomly assigned to treatment.
nJK0	vector with a length of two to specifiy starting values for level-1, level-2 and level-3 sample sizes.
P0	starting value for proportion of level-3 units randomly assigned to treatment.
constrain	one of the followings can be constrained at a specified cost or value: "cost", "power", or "mdes".
optimizer	algorithm to find optimal sample sizes given total cost, power, or MDES. Available algorithms: "auglag_cobyla", "auglag_lbfgs", "auglag_mma", or "auglag_slsqp".
gm	grid multiplier to increase the range of sample sizes for approximate integer solutions.
ncase	number of approximate integer solutions to be exported.
power	statistical power (1 - type II error).
mdes	minimum detectable effect size.
alpha	probability of type I error.

cosa.to.mdes 55

two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g3	number of covariates at level-3 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
R32	proportion of level-3 variance in the outcome explained by level-3 covariates.

#### Value

fun function name.

parms list of parameters used in the function.

nloptr list of nloptr log and output.

exact.optim exact solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

round.optim rounded solution. MDES is calculated at the specified power (default .80), and

power is calculated at the specified MDES (default .25).

integer.optim approximate integer solutions. MDES is calculated at the specified power (de-

fault .80), and power is calculated at the specified MDES (default .25).

## See Also

```
mdes.mod3.cra3r3, power.mod3.cra3r3
```

### **Examples**

cosa.to.mdes

COSA to MDES

# Description

cosa.to.mdes converts an object returned from cosa function into an object returned from mdes function.

### Usage

```
cosa.to.mdes(x)
```

56 cosa.to.power

#### **Arguments**

Х

an object returned from one of the cosa functions.

#### **Details**

cosa.to.mdes converts an object returned from cosa function into an object returned from mdes function by passing parameters through mdes function.

#### See Also

```
cosa.to.power
```

### **Examples**

cosa.to.power

COSA to Power

# Description

cosa.to.power converts an object returned from cosa function into an object returned from power function.

## Usage

```
cosa.to.power(x)
```

## **Arguments**

Х

an object returned from one of the cosa functions.

# Details

cosa.to.power converts an object returned from cosa function into an object returned from power function by passing parameters through power function.

## See Also

```
cosa.to.mdes
```

mdes.bcra3f2

## **Examples**

mdes.bcra3f2

MDES Calculator for Three-Level Fixed Effects Blocked Cluster Random Assignment Design, Treatment at Level-2

# Description

mdes.bcra3f2 calculates minimum detectable effect size (MDES) for designs with three-levels where level-2 units are randomly assigned to treatment and control groups within level-3 units (fixed blocks).

# Usage

```
mdes.bcra3f2(power=.80, alpha=.05, two.tail=TRUE, rho2, P=.50, g2=0, R12=0, R22=0, n, J, K, ...)
```

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
P	average proportion of level-2 units randomly assigned to treatment within level-3 units.
g2	number of covariates at level-2.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

58 mdes.bcra3r2

#### Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

#### See Also

```
power.bcra3f2, cosa.bcra3f2
```

# **Examples**

```
## Not run:

mdes.bcra3f2(rho2=.10, n=20, J=44, K=5)

## End(Not run)
```

mdes.bcra3r2

MDES Calculator for Three-Level Random Effects Blocked Cluster Random Assignment Designs, Treatment at Level-2

### **Description**

mdes.bcra3r2 calculates minimum detectable effect size (MDES) for designs with three-levels where level-2 units are randomly assigned to treatment and control groups within level-3 units (random blocks).

# Usage

```
mdes.bcra3r2(power=.80, alpha=.05, two.tail=TRUE, rho2, rho3, omega3, P=.50, g3=0, R12=0, R22=0, RT32=0, n, J, K, ...)
```

# **Arguments**

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

rho2 proportion of variance in the outcome explained by level-2 units.
rho3 proportion of variance in the outcome explained by level-3 units.

omega3 treatment effect heterogeneity as ratio of treatment effect variance among level-3

units to the residual variance at level-3.

P average proportion of level-2 units randomly assigned to treatment within level-

3 units.

mdes.bcra4f3 59

g3	number of covariates at level-3.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
RT32	proportion of treatment effect variance among level-3 units explained by level-3 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
• • •	to handle extra parameters passed from other functions, do not define any additional parameters.

#### Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

## See Also

```
power.bcra3r2, cosa.bcra3r2
```

# **Examples**

mdes.bcra4f3

MDES Calculator for Four-Level Fixed Effects Blocked Cluster Random Assignment Designs, Treatment at Level-3

# **Description**

mdes.bcra4f3 calculates minimum detectable effect size (MDES) for designs with four-levels where level-3 units are randomly assigned to treatment and control groups within level-4 units (fixed blocks).

## Usage

```
mdes.bcra4f3(power=.80, alpha=.05, two.tail=TRUE,
    rho2, rho3,
    P=.50, R12=0, R22=0, R32=0, g3=0,
    n, J, K, L, ...)
```

mdes.bcra4f3

# Arguments

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
P	average proportion of level-3 units randomly assigned to treatment within level-4 units.
g3	number of covariates at level-3.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
R32	proportion of level-3 variance in the outcome explained by level-3 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	harmonic mean of level-3 units across level-4 units (or simple average).
L	number of level-4 units.
	to handle extra parameters passed from other functions, do not define any additional parameters.

# Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

## See Also

```
power.bcra4f3, cosa.bcra4f3
```

# **Examples**

mdes.bcra4r2 61

mdes.bcra4r2	MDES Calculator for Four-Level Random Effects Block Random As-
	signment Designs, Treatment at Level-2

# Description

mdes.bcra4r2 calculates minimum detectable effect size (MDES) for designs with four-levels where level-2 units are randomly assigned to treatment and control groups within level-3 units (random blocks).

# Usage

```
mdes.bcra4r2(power=.80, alpha=.05, two.tail=TRUE,
    rho2, rho3, rho4, omega3, omega4,
    P=.50, R12=0, R22=0, RT32=0, RT42=0, g4=0,
    n, J, K, L, ...)
```

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
rho4	proportion of variance in the outcome explained by level-4 units.
omega3	treatment effect heterogeneity as ratio of treatment effect variance among level-3 units to the residual variance at level-3.
omega4	treatment effect heterogeneity as ratio of treatment effect variance among level-4 units to the residual variance at level-4.
Р	average proportion of level-2 units randomly assigned to treatment within level-3 units.
g4	number of covariates at level-4.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
RT32	proportion of treatment effect variance among level-3 units explained by level-3 covariates.
RT42	proportion of treatment effect variance among level-4 units explained by level-4 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	harmonic mean of level-3 units across level-4 units (or simple average).
L	number of level-4 units.
	to handle extra parameters passed from other functions, do not define any additional parameters.

62 mdes.bcra4r3

#### Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

### See Also

```
power.bcra4r2, cosa.bcra4r2
```

# **Examples**

mdes.bcra4r3

MDES Calculator for Four-Level Random Effects Blocked Cluster Random Assignment Designs, Treatment at Level-3

## **Description**

mdes.bcra4r3 calculates minimum detectable effect size (MDES) for designs with four-levels where level-3 units are randomly assigned to treatment and control groups within level-4 units (random blocks).

## Usage

```
mdes.bcra4r3(power=.80, alpha=.05, two.tail=TRUE,
    rho2, rho3, rho4, omega4,
    P=.50, R12=0, R22=0, R32=0, RT42=0, g4=0,
    n, J, K, L, ...)
```

#### **Arguments**

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
rho4	proportion of variance in the outcome explained by level-4 units.
omega4	treatment effect heterogeneity as ratio of treatment effect variance among level-4

units to the residual variance at level-4.

mdes.bcrd3f2 63

P	average proportion of level-3 units randomly assigned to treatment within level-4 units.
g4	number of covariates at level-4.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
R32	proportion of level-3 variance in the outcome explained by level-3 covariates.
RT42	proportion of treatment effect variance among level-4 units explained by level-4 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	harmonic mean of level-3 units across level-4 units (or simple average).
L	number of level-4 units.
•••	to handle extra parameters passed from other functions, do not define any additional parameters.

## Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and 95% lower and upper confidence limits.

#### See Also

```
power.bcra4r3, cosa.bcra4r3
```

# **Examples**

mdes.bcrd3f2

MDES Calculator for Three-Level Blocked Cluster Regression Discontinuity Design, Treatment Based on Discontinuity at Level-2 (Fixed Treatment Effect)

# Description

Minimum detectable effect size calculator for three-level blocked cluster regression discontinuity design where treatment assignment is based on discontinuity at level-2 (fixed treatment effect).

mdes.bcrd3f2

## Usage

```
mdes.bcrd3f2(power=.80, alpha=.05, two.tail=TRUE, rho2, RTZ=NULL, k1=-6, k2=6, dist.Z="normal", P=.50, g2=0, R12=0, R22=0, n, J, K, ...)
```

# Arguments

power	statistical power (1 - type II error).
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
P	average proportion of level-1 units randomly assigned to treatment within level-2 units.
RTZ	correlation between treatment status and assignment variable
k1	left truncation point (in standard deviation units from full normal distribution mean).
k2	right truncation point (in standard deviation units from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g2	number of covariates at level-2.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
	to handle extra parameters passed from other functions, do not define any addi-

## Value

fun function name.

parms list of parameters used in MDES calculation.

tional parameters.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

### See Also

```
cosa.bcrd3f2, power.bcrd3f2
```

# **Examples**

mdes.bcrd3r2

mdes.bcrd3r2	MDES Calculator for Three-Level Blocked Cluster Regression Dis-
ilides. DCI d31 2	continuity Design, Treatment Based on Discontinuity at Level-2 (Random Treatment Effect)

# Description

Minimum detectable effect size calculator for three-level blocked cluster regression discontinuity design where treatment assignment is based on discontinuity at level-2 (random treatment effect).

# Usage

```
mdes.bcrd3r2(power=.80, alpha=.05, two.tail=TRUE, rho2, rho3, omega3, RTZ=NULL, k1=-6, k2=6, dist.Z="normal", P=.50, g3=0, R12=0, R22=0, RT32=0, n, J, K, ...)
```

power	statistical power (1 - type II error).
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
omega3	treatment effect heterogeneity as ratio of treatment effect variance among level-3 units to the residual variance at level-3.
P	average proportion of level-1 units randomly assigned to treatment within level-2 units.
RTZ	correlation between treatment status and assignment variable
k1	left truncation point (in standard deviation units from full normal distribution mean).
k2	right truncation point (in standard deviation units from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g3	number of covariates at level-3.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
RT32	proportion of treatment effect variance among level-3 units explained by level-3 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

66 mdes.bira2c1

#### Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

## See Also

```
cosa.bcrd3r2, power.bcrd3r2
```

## **Examples**

mdes.bira2c1

MDES Calculator for Two-Level Constant Effects Blocked Individual Random Assignment Designs, Treatment at Level-1

# Description

mdes.bira2c1 calculates minimum detectable effect size (MDES) for designs with two-levels where level-1 units are randomly assigned to treatment and control groups within level-2 units (school intercepts only).

# Usage

```
mdes.bira2c1(power=.80, alpha=.05, two.tail=TRUE, P=.50, g1=0, R12=0, n, J, ...)
```

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
P	average proportion of level-1 units randomly assigned to treatment within level-2 units.
g1	number of covariates at level-1.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	level-2 sample size.
•••	to handle extra parameters passed from other functions, do not define any additional parameters.

mdes.bira2f1 67

## Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

## See Also

```
power.bira2c1, cosa.bira2c1
```

## **Examples**

```
## Not run:
mdes.bira2c1(n=55, J=3)
## End(Not run)
```

mdes.bira2f1

MDES Calculator for Two-Level Fixed Effects Blocked Individual Random Assignment Designs, Treatment at Level-1

# Description

mdes.bira2f1 calculates minimum detectable effect size (MDES) for designs with two-levels where level-1 units are randomly assigned to treatment and control groups within level-2 units (fixed blocks).

# Usage

testing.  P average proportion of level-1 units randomly assigned to treatm 2 units.  g1 number of covariates at level-1.  R12 proportion of level-1 variance in the outcome explained by level harmonic mean of level-1 units across level-2 units (or simple a level-2 sample size.  to handle extra parameters passed from other functions, do not		
two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-testing.  P average proportion of level-1 units randomly assigned to treatm 2 units.  g1 number of covariates at level-1.  R12 proportion of level-1 variance in the outcome explained by level harmonic mean of level-1 units across level-2 units (or simple a level-2 sample size.  to handle extra parameters passed from other functions, do not	power	tistical power $(1 - \beta)$ .
testing.  P average proportion of level-1 units randomly assigned to treatm 2 units.  g1 number of covariates at level-1.  R12 proportion of level-1 variance in the outcome explained by level harmonic mean of level-1 units across level-2 units (or simple a level-2 sample size.  to handle extra parameters passed from other functions, do not	alpha	bability of type I error.
2 units.  g1 number of covariates at level-1.  R12 proportion of level-1 variance in the outcome explained by level harmonic mean of level-1 units across level-2 units (or simple a level-2 sample size.  to handle extra parameters passed from other functions, do not	two.tail	ical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis ting.
R12 proportion of level-1 variance in the outcome explained by level harmonic mean of level-1 units across level-2 units (or simple a level-2 sample size.  to handle extra parameters passed from other functions, do not	Р	erage proportion of level-1 units randomly assigned to treatment within level- nits.
n harmonic mean of level-1 units across level-2 units (or simple a level-2 sample size to handle extra parameters passed from other functions, do not	g1	mber of covariates at level-1.
J level-2 sample size to handle extra parameters passed from other functions, do not	R12	portion of level-1 variance in the outcome explained by level-1 covariates.
to handle extra parameters passed from other functions, do not	n	rmonic mean of level-1 units across level-2 units (or simple average).
	J	el-2 sample size.
tional parameters.	•••	nandle extra parameters passed from other functions, do not define any addinal parameters.

68 mdes.bira2r1

#### Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

#### See Also

```
power.bira2f1, cosa.bira2f1
```

# **Examples**

```
## Not run:

mdes.bira2f1(n=55, J=3)

## End(Not run)
```

mdes.bira2r1

MDES Calculator for Two-Level Random Effects Blocked Individual Random Assignment Designs, Individuals Randomized within Blocks

### **Description**

mdes.bira2r1 calculates minimum detectable effect size (MDES) for designs with two-levels where level-1 units are randomly assigned to treatment and control groups within level-2 units (random blocks).

# Usage

```
mdes.bira2r1(power=.80, alpha=.05, two.tail=TRUE, rho2, omega2, P=.50, g2=0, R12=0, RT22=0, n, J, ...)
```

# **Arguments**

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

rho2 proportion of variance in the outcome explained by level-2 units.

omega2 treatment effect heterogeneity as ratio of treatment effect variance among level-2

units to the residual variance at level-2.

P average proportion of level-1 units randomly assigned to treatment within level-

2 units.

g2 number of covariates at level-2.

mdes.bira3r1 69

R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
RT22	proportion of treatment effect variance among level-2 units explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	level-2 sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

## Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

## See Also

```
power.bira2r1, cosa.bira2r1
```

# **Examples**

mdes.bira3r1

MDES Calculator for Three-Level Random Effects Blocked Individual Random Assignment Design, Individuals Randomized within Blocks

# Description

mdes.bira3r1 calculates minimum detectable effect size (MDES) for designs with three-levels where level-1 units are randomly assigned to treatment and control groups within level-2 units (random blocks).

# Usage

```
mdes.bira3r1(power=.80, alpha=.05, two.tail=TRUE, rho2, rho3, omega2, omega3, P=.50, R12=0, RT22=0, RT32=0, g3=0, n, J, K, ...)
```

70 mdes.bira3r1

# Arguments

iled hypothesis
•
e among level-2
e among level-3
nt within level-
-1 covariates.
ined by level-2
ined by level-3
rerage).
rerage).
efine any addi-
e among levelent within levelent by levelented by levelenced by levelenc

# Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

# See Also

```
power.bira3r1, cosa.bira3r1
```

# **Examples**

mdes.bira4r1 71

mdes.bira4r1	MDES Calculator for Four-Level Random Effects Blocked Individual
	Random Assignment Design, Individuals Randomized within Blocks

# Description

mdes.bira4r1 calculates minimum detectable effect size (MDES) for designs with four-levels where level-1 units are randomly assigned to treatment and control groups within level-2 units (random blocks).

# Usage

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
rho4	proportion of variance in the outcome explained by level-4 units.
omega2	treatment effect heterogeneity as ratio of treatment effect variance among level-2 units to the residual variance at level-2.
omega3	treatment effect heterogeneity as ratio of treatment effect variance among level-3 units to the residual variance at level-3.
omega4	treatment effect heterogeneity as ratio of treatment effect variance among level-4 units to the residual variance at level-4.
Р	average proportion of level-1 units randomly assigned to treatment within level-2 units.
g4	number of covariates at level-4.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
RT22	proportion of treatment effect variance among level-2 units explained by level-2 covariates.
RT32	proportion of treatment effect variance among level-3 units explained by level-3 covariates.
RT42	proportion of treatment effect variance among level-4 units explained by level-4 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	harmonic mean of level-3 units across level-4 units (or simple average).
L	number of level-4 units.
• • •	to handle extra parameters passed from other functions, do not define any additional parameters.

72 mdes.bird2f1

#### Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

### See Also

```
power.bira4r1, cosa.bira4r1
```

## **Examples**

mdes.bird2f1

MDES Calculator for Two-Level Blocked Individual Regression Discontinuity Design, Treatment Based on Discontinuity at Level-1 (Fixed Treatment Effect)

# Description

Minimum detectable effect size calculator for two-level blocked individual regression discontinuity design where treatment assignment is based on discontinuity at level-1 (fixed treatment effect).

## Usage

### **Arguments**

power statistical power (1 - type II error).

alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

P average proportion of level-1 units randomly assigned to treatment within level-

2 units.

RTZ correlation between treatment status and assignment variable

k1 left truncation point (in standard deviation units from full normal distribution

mean).

mdes.bird2r1 73

k2	right truncation point (in standard deviation units from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g1	number of covariates at level-1.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	number of level-2 units.
	to handle extra parameters passed from other functions, do not define any additional parameters.

### Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

### See Also

```
cosa.bird2f1, power.bird2f1
```

## **Examples**

```
## Not run:
    mdes.bird2f1(n=10, J=100)
## End(Not run)
```

mdes.bird2r1

MDES Calculator for Two-Level Blocked Individual Regression Discontinuity Design, Treatment Based on Discontinuity at Level-1 (Random Treatment Effect)

### **Description**

Minimum detectable effect size calculator for two-level blocked individual regression discontinuity design where treatment assignment is based on discontinuity at level-1 (random treatment effect).

```
mdes.bird2r1(power=.80, alpha=.05, two.tail=TRUE, rho2, omega2, P=.50, RTZ=NULL, k1=-6, k2=6, dist.Z="normal", g2=0, R12=0, RT22=0, n, J, \dots)
```

74 mdes.bird2r1

# Arguments

power	statistical power (1 - type II error).
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
omega2	treatment effect heterogeneity as ratio of treatment effect variance among level-2 units to the residual variance at level-2.
Р	average proportion of level-1 units randomly assigned to treatment within level-2 units.
RTZ	correlation between treatment status and assignment variable
k1	left truncation point (in standard deviation units from full normal distribution mean).
k2	right truncation point (in standard deviation units from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g2	number of covariates at level-2.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
RT22	proportion of treatment effect variance among level-2 units explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	number of level-2 units.
• • •	to handle extra parameters passed from other functions, do not define any addi-

# Value

fun function name.

parms list of parameters used in MDES calculation.

tional parameters.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

# See Also

```
cosa.bird2r1, power.bird2r1
```

```
## Not run:
    mdes.bird2r1(rho2=.20, omega2=.50, n=10, J=100)
## End(Not run)
```

mdes.cra2r2 75

mdes.cra2r2	MDES Calculator for Main Effect in Two-Level Cluster Random Assignment Design, Treatment at Level-2
macs. et azi z	

# Description

mdes.cra2r2 calculates minimum detectable effect size (MDES) for main effect in designs with two-levels where level-2 units are randomly assigned to treatment and control groups.

# Usage

```
mdes.cra2r2(power=.80, alpha=.05, two.tail=TRUE, rho2, P=.50, g2=0, R12=0, R22=0, n, J, ...)
```

# Arguments

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
P	proportion of level-2 units randomly assigned to treatment.
g2	number of covariates at level-2.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	level-2 sample size.
•••	to handle extra parameters passed from other functions, do not define any additional parameters.

### Value

fun	function name.
parms	list of parameters used in MDES calculation.
ncp	noncentrality parameter.
mdes	minimum detectable effect size and $(1-\alpha)\%$ lower and upper confidence limits.

## See Also

```
power.cra2r2, cosa.cra2r2
```

76 mdes.cra3r3

### **Examples**

MDES Calculator for Main Effect in Three-Level Cluster Random Assignment Designs, Treatment at Level-3

# Description

mdes.cra3r3

mdes.cra3r3 calculates minimum detectable effect size (MDES) for main effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups.

# Usage

```
mdes.cra3r3(power=.80, alpha=.05, two.tail=TRUE, rho2, rho3, P=.50, g3=0, R12=0, R22=0, R32=0, n, J, K, ...)
```

### **Arguments**

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
P	proportion of level-3 units randomly assigned to treatment.
g3	number of covariates at level-3.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
R32	proportion of level-3 variance in the outcome explained by level-3 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
•••	to handle extra parameters passed from other functions, do not define any additional parameters.

### Value

fun	function name.
parms	list of parameters used in MDES calculation.
ncp	noncentrality parameter.
mdes	minimum detectable effect size and $(1-\alpha)\%$ lower and upper confidence limits.

mdes.cra4r4 77

### See Also

```
power.cra3r3, cosa.cra3r3
```

## **Examples**

mdes.cra4r4

MDES Calculator for Four-Level Cluster Random Assignment Designs, Treatment at Level-4

## Description

mdes.cra4r4 calculates minimum detectable effect size (MDES) for designs with four-levels where level-4 units are randomly assigned to treatment and control groups.

### Usage

```
mdes.cra4r4(power=.80, alpha=.05, two.tail=TRUE,
    rho2, rho3, rho4,
    P=.50, R12=0, R22=0, R32=0, R42=0, g4=0,
    n, J, K, L, ...)
```

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
rho4	proportion of variance in the outcome explained by level-4 units.
Р	proportion of level-4 units randomly assigned to treatment.
g4	number of covariates at level-4.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
R32	proportion of level-3 variance in the outcome explained by level-3 covariates.
R42	proportion of level-4 variance in the outcome explained by level-4 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	harmonic mean of level-3 units across level-4 units (or simple average).
L	number of level-4 units.
	to handle extra parameters passed from other functions, do not define any additional parameters.

78 mdes.crd2r2

### Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

### See Also

```
power.cra4r4, cosa.cra4r4
```

### **Examples**

mdes.crd2r2

MDES Calculator for Two-Level Cluster Regression Discontinuity Design, Treatment Based on Discontinuity at Level-2

### **Description**

Minimum detectable effect size calculator for two-level cluster regression discontinuity design where treatment assignment is based on discontinuity at level-2.

## Usage

```
mdes.crd2r2(power=.80, alpha=.05, two.tail=TRUE, rho2, P=.50, RTZ=NULL, k1=-6, k2=6, dist.Z="normal", g2=0, R12=0, R22=0, n, J, ...)
```

power	statistical power (1 - type II error).
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
P	average proportion of level-1 units randomly assigned to treatment within level-2 units.
RTZ	correlation between treatment status and assignment variable
k1	left truncation point (in standard deviation units from full normal distribution mean).
k2	right truncation point (in standard deviation units from full normal distribution mean).

mdes.crd3r3

dist.Z	distribution of assignment variable; either normal or uniform.
g2	number of covariates at level-2.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	number of level-2 units.
	to handle extra parameters passed from other functions, do not define any additional parameters.

### Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

### See Also

```
cosa.crd2r2, power.crd2r2
```

## **Examples**

```
## Not run:
    mdes.crd2r2(rho2=.20, n=10, J=100)
## End(Not run)
```

mdes.crd3r3

MDES Calculator for Three-Level Cluster Regression Discontinuity Design, Treatment Based on Discontinuity at Level-3

# Description

Minimum detectable effect size calculator for three-level cluster regression discontinuity design where treatment assignment is based on discontinuity at level-3.

```
mdes.crd3r3(power=.80, alpha=.05, two.tail=TRUE, rho2, rho3, P=.50, RTZ=NULL, k1=-6, k2=6, dist.Z="normal", g3=0, R12=0, R22=0, R32=0, n, J, K, ...)
```

mdes.crd3r3

# Arguments

power	statistical power (1 - type II error).
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
Р	average proportion of level-1 units randomly assigned to treatment within level-2 units.
RTZ	correlation between treatment status and assignment variable
k1	left truncation point (in standard deviation units from full normal distribution mean).
k2	right truncation point (in standard deviation units from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g3	number of covariates at level-3.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
R32	proportion of level-3 variance in the outcome explained by level-3 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
	to handle extra parameters passed from other functions, do not define any addi-

### Value

fun function name.

parms list of parameters used in MDES calculation.

tional parameters.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

### See Also

```
cosa.crd3r3, power.crd3r3
```

```
## Not run:

mdes.crd3r3(rho2=.20, rho3=.10, n=10, J=5, K=100)

## End(Not run)
```

mdes.ira1r1 81

mdes.ira1r1	MDES Calculator for Individual Random Assignment Designs, Completely Randomized Controlled Trials
-------------	---

# Description

mdes.ira1r1 calculates minimum detectable effect size (MDES) for completely randomized controlled trials where individuals are randomly assigned to treatment or control groups.

### Usage

```
mdes.ira1r1(power=.80, alpha=.05, two.tail=TRUE, P=.50, g1=0, R12=0, n, ...)
```

## **Arguments**

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
Р	proportion of units randomly assigned to treatment.
g1	number of covariates.
R12	proportion of variance in the outcome explained by covariates.
n	sample size.
•••	to handle extra parameters passed from other functions, do not define any additional parameters.

### Value

fun	function	name.
-----	----------	-------

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

### See Also

```
power.ira1r1, cosa.ira1r1
```

```
## Not run:
mdes.ira1r1(n=55)
## End(Not run)
```

82 mdes.ird1r1

mdes.ird1r1 MDES Calculator for Main Effect in Individual Regression Discontinuity Design	<u>-</u>
---	----------

# Description

mdes.ird1r1 calculates minimum detectable effect size for main effect in individual regression discontinuity design where treatment assignment is based on discontinuity at the individual level.

# Usage

```
mdes.ird1r1(power=.80, alpha=.05, two.tail=TRUE, P=.50, RTZ=NULL, k1=-6, k2=6, dist.Z="normal", g1=0, R12=0, n, ...)
```

# Arguments

power	statistical power (1 - type II error).
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
Р	average proportion of units randomly assigned to treatment.
RTZ	correlation between treatment status and assignment variable.
k1	left truncation point (in standard deviation units from full normal distribution mean).
k2	right truncation point (in standard deviation units from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g1	number of covariates.
R12	proportion of variance in the outcome explained by covariates.
n	sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

### Value

fun	function name.
parms	list of parameters used in MDES calculation.
ncp	noncentrality parameter.
mdes	minimum detectable effect size and $(1-\alpha)\%$ lower and upper confidence limits.

## See Also

```
cosa.ird1r1, power.ird1r1
```

mdes.mod1n.cra2r2 83

### **Examples**

```
## Not run:
    mdes.ird1r1(n=100)
## End(Not run)
```

mdes.mod1n.cra2r2

MDES Calculator for Non-Randomly Varying Moderator Effect in Two-Level Cluster Random Assignment Design, Treatment at Level-2, Moderator at Level-1

## Description

mdes.mod1n.cra2r2 calculates minimum detectable effect size (MDES) for non-randomly varying moderator effect in designs with two-levels where level-2 units are randomly assigned to treatment and control groups and moderator is at level-1.

## Usage

```
mdes.mod1n.cra2r2(power=.80, alpha=.05, two.tail=TRUE, rho2, P=.50, Q=NULL, g1=0, R12=0, n, J, ...)
```

## Arguments

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
Р	proportion of level-2 units randomly assigned to treatment.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g1	number of covariates at level-1 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	level-2 sample size.
• • •	to handle extra parameters passed from other functions, do not define any additional parameters.

### Value

fun	function name.
parms	list of parameters used in MDES calculation.
ncp	noncentrality parameter.
mdes	minimum detectable effect size and $(1-\alpha)\%$ lower and upper confidence limits.

84 mdes.mod1n.cra3r3

### See Also

```
power.mod1n.cra2r2, cosa.mod1n.cra2r2
```

### **Examples**

mdes.mod1n.cra3r3

MDES Calculator for Non-Randomly Varying Moderator Effect in Three-Level Cluster Random Assignment Design, Treatment at Level-3, Moderator at Level-1

## Description

mdes.mod1n.cra3r3 calculates minimum detectable effect size (MDES) for non-randomly varying moderator effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups and moderator is at level-1.

## Usage

```
mdes.mod1n.cra3r3(power=.80, alpha=.05, two.tail=TRUE, rho2, rho3, P=.50, Q=NULL, g1=0, R12=0, n, J, K, ...)
```

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
Р	proportion of level-3 units randomly assigned to treatment.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g1	number of covariates at level-1 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

mdes.mod1r.cra2r2 85

#### Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

### See Also

```
power.mod1n.cra3r3, cosa.mod1n.cra3r3
```

### **Examples**

mdes.mod1r.cra2r2

MDES Calculator for Randomly Varying Moderator Effect in Two-Level Cluster Random Assignment Design, Treatment at Level-2, Moderator at Level-1

### **Description**

mdes.mod1r.cra2r2 calculates minimum detectable effect size (MDES) for randomly varying moderator effect in designs with two-levels where level-2 units are randomly assigned to treatment and control groups and moderator is at level-1.

### Usage

```
mdes.mod1r.cra2r2(power=.80, alpha=.05, two.tail=TRUE, rho2, omega2, RT22=0, P=.50, Q=NULL, g1=0, R12=0, n, J, ...)
```

### **Arguments**

power statistical power  $(1 - \beta)$ . alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

rho2 proportion of variance in the outcome explained by level-2 units.
omega2 moderator effect heterogeneity (unconditional) across level-2 units.

P proportion of level-2 units randomly assigned to treatment.

Q proportion of level-1 units within moderator subgroup. NULL implies continuous

moderator.

86 mdes.mod1r.cra3r3

g1	number of covariates at level-1 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
RT22	proportion of level-2 variance in the moderator effect explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	level-2 sample size.
•••	to handle extra parameters passed from other functions, do not define any additional parameters.

## Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

### See Also

```
power.mod1r.cra2r2, cosa.mod1r.cra2r2
```

### **Examples**

```
## Not run:
mdes.mod1r.cra2r2(rho2=.2, omega2=.2, RT22=.2, n=4, J=20)
## End(Not run)
```

mdes.mod1r.cra3r3

MDES Calculator for Randomly Varying Moderator Effect in Three-Level Cluster Random Assignment Designs, Treatment at Level-3, Moderator at Level-1

## Description

mdes.mod1r.cra3r3 calculates minimum detectable effect size (MDES) for randomly varying moderator effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups and moderator is at level-1.

```
mdes.mod1r.cra3r3(power=.80, alpha=.05, two.tail=TRUE, rho2, rho3, omega2, omega3, P=.50, Q=NULL, g1=0, R12=0, RT22=0, RT32=0, n, J, K, ...)
```

mdes.mod1r.cra3r3 87

## **Arguments**

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
omega2	moderator effect heterogeneity (unconditional) across level-2 units.
omega3	moderator effect heterogeneity (unconditional) across level-3 units.
Р	proportion of level-3 units randomly assigned to treatment.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g1	number of covariates at level-1 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
RT22	proportion of level-2 variance in the moderator effect explained by level-2 covariates.
RT32	proportion of level-3 variance in the moderator effect explained by level-3 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
	to handle extra parameters passed from other functions, do not define any addi-

### Value

fun function name.

parms list of parameters used in MDES calculation.

tional parameters.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

### See Also

```
power.mod1r.cra3r3, cosa.mod1r.cra3r3
```

88 mdes.mod2.cra2r2

mdes.mod2.cra2r2	MDES Calculator for Moderator Effect in Two-Level Cluster Random
	Assignment Design, Treatment and Moderator at Level-2

# Description

mdes.mod2.cra2r2 calculates minimum detectable effect size (MDES) for moderator effect in designs with two-levels where level-2 units are randomly assigned to treatment and control groups and moderator is at level-2.

## Usage

```
mdes.mod2.cra2r2(power=.80, alpha=.05, two.tail=TRUE, rho2, P=.50, Q=NULL, g2=0, R12=0, R22=0, n, J, ...)
```

# Arguments

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
Р	proportion of level-2 units randomly assigned to treatment.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g2	number of covariates at level-2 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	level-2 sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

### Value

fun	function name.
parms	list of parameters used in MDES calculation.
ncp	noncentrality parameter.
mdes	minimum detectable effect size and $(1-\alpha)\%$ lower and upper confidence limits.

## See Also

```
power.mod2.cra2r2, cosa.mod2.cra2r2
```

mdes.mod2n.cra3r3 89

### **Examples**

```
## Not run:
mdes.mod2.cra2r2(rho2=.20, n=4, J=20, Q=.5)
## End(Not run)
```

mdes.mod2n.cra3r3

MDES Calculator for Non-Randomly Varying Moderator Effect in Three-Level Cluster Random Assignment Design, Treatment at Level-3, Moderator at Level-2

# Description

mdes.mod2n.cra3r3 calculates minimum detectable effect size (MDES) for non-randomly varying moderator effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups and moderator is at level-2.

# Usage

```
mdes.mod2n.cra3r3(power=.80, alpha=.05, two.tail=TRUE, rho2, rho3, P=.50, Q=NULL, g2=0, R12=0, R22=0, n, J, K, ...)
```

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
Р	proportion of level-3 units randomly assigned to treatment.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g2	number of covariates at level-2 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
•••	to handle extra parameters passed from other functions, do not define any additional parameters.

90 mdes.mod2r.cra3r3

#### Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

#### See Also

```
power.mod2n.cra3r3, cosa.mod2n.cra3r3
```

### **Examples**

Level Cluster Random Assignment Designs, Treatment at Level-3,

Moderator at Level-2

# Description

mdes.mod2r.cra3r3 calculates minimum detectable effect size (MDES) for randomly varying moderator effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups and moderator is at level-2.

### Usage

```
mdes.mod2r.cra3r3(power=.80, alpha=.05, two.tail=TRUE, rho2, rho3, omega3, P=.50, Q=NULL, g2=0, R12=0, R22=0, R732=0, n, J, K, ...)
```

### **Arguments**

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

rho2 proportion of variance in the outcome explained by level-2 units.
rho3 proportion of variance in the outcome explained by level-3 units.
omega3 moderator effect heterogeneity (unconditional) across level-3 units.

P proportion of level-3 units randomly assigned to treatment.

Q proportion of level-1 units within moderator subgroup. NULL implies continuous

moderator.

mdes.mod3.cra3r3

g2	number of covariates at level-2 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
RT32	proportion of level-3 variance in the moderator effect explained by level-3 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
•••	to handle extra parameters passed from other functions, do not define any additional parameters.

### Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

### See Also

```
power.mod2r.cra3r3, cosa.mod2r.cra3r3
```

### **Examples**

mdes.mod3.cra3r3

MDES Calculator for Moderator Effect in Three-Level Cluster Random Assignment Designs, Treatment and Moderator at Level-3

### **Description**

mdes.mod3.cra3r3 calculates minimum detectable effect size (MDES) for moderator effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups and moderator is at level-3.

```
mdes.mod3.cra3r3(power=.80, alpha=.05, two.tail=TRUE, rho2, rho3, P=.50, Q=NULL, g3=0, R12=0, R22=0, R32=0, n, J, K, ...)
```

92 mdes.mod3.cra3r3

# Arguments

power	statistical power $(1 - \beta)$ .
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
Р	proportion of level-3 units randomly assigned to treatment.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g3	number of covariates at level-3 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
R32	proportion of level-3 variance in the outcome explained by level-3 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

### Value

fun function name.

parms list of parameters used in MDES calculation.

ncp noncentrality parameter.

mdes minimum detectable effect size and  $(1-\alpha)\%$  lower and upper confidence limits.

## See Also

```
power.mod3.cra3r3, cosa.mod3.cra3r3
```

mdes.to.pctl 93

mdes.to.pctl

MDES to Percentiles

### **Description**

mdes.to.pctl converts MDES values returned from mdes function into percentile values.

### Usage

```
mdes.to.pctl(x)
```

### **Arguments**

Х

an object returned from mdes function or a numeric value in standard deviation units.

### **Details**

mdes.to.pctl converts MDES values returned from mdes function into percentile values. Values should be interpreted as percentile increase with reference to 50th percentile.

### See Also

```
cosa.to.mdes
```

## Examples

mdes.to.power

MDES to power

### Description

mdes.to.power converts an object returned from mdes function into an object returned from power function.

```
mdes.to.power(x)
```

94 power.bcra3f2

### **Arguments**

Χ

an object returned from one of the mdes functions.

#### **Details**

mdes.to.power converts an object returned from mdes function into an object returned from power function by passing parameters through power function.

### See Also

```
cosa.to.mdes, power.to.mdes
```

### **Examples**

```
## Not run:

# object returned from power function
  design1 <- mdes.bira2r1(rho2=.35, omega2=.10, n=83, J=10)
  # convert the object into an object returned from mdes function
  design2 <- mdes.to.power(design1)

## End(Not run)</pre>
```

power.bcra3f2

Statistical Power Calculator for Three-Level Fixed Effects Blocked Cluster Random Assignment Design, Treatment at Level-2

### **Description**

power.bcra3f2 calculates statistical power for designs with three-levels where level-2 units are randomly assigned to treatment and control groups within level-3 units (fixed blocks).

# Usage

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
Р	average proportion of level-2 units randomly assigned to treatment within level-3 units.
g2	number of covariates at level-2.

power.bcra3r2 95

R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

### Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1 - \beta)$ .

### See Also

```
mdes.bcra3f2, cosa.bcra3f2
```

## **Examples**

power.bcra3r2

Statistical Power Calculator for Three-Level Random Effects Blocked Cluster Random Assignment Designs, Treatment at Level-2

### Description

power.bcra3r2 calculates statistical power for designs with three-levels where level-2 units are randomly assigned to treatment and control groups within level-3 units (random blocks).

```
power.bcra3r2(mdes=.25, alpha=.05, two.tail=TRUE,
    rho2, rho3, omega3,
    P=.50, g3=0, R12=0, R22=0, RT32=0,
    n, J, K, ...)
```

96 power.bcra3r2

# Arguments

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
omega3	treatment effect heterogeneity as ratio of treatment effect variance among level-3 units to the residual variance at level-3.
P	average proportion of level-2 units randomly assigned to treatment within level-3 units.
g3	number of covariates at level-3.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
RT32	proportion of treatment effect variance among level-3 units explained by level-3 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

# Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1-\beta)$ .

### See Also

```
mdes.bcra3r2, cosa.bcra3r2
```

power.bcra4f3 97

power.bcra4f3	Statistical Power Calculator for Four-Level Fixed Effects Blocked
	Cluster Random Assignment Designs, Treatment at Level-3

# Description

power.bcra4f3 calculates statistical power for designs with four-levels where level-3 units are randomly assigned to treatment and control groups within level-4 units (fixed blocks).

# Usage

```
power.bcra4f3(mdes=.25, alpha=.05, two.tail=TRUE,
    rho2, rho3,
    P=.50, R12=0, R22=0, R32=0, g3=0,
    n, J, K, L, ...)
```

## Arguments

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
P	average proportion of level-3 units randomly assigned to treatment within level-4 units.
g3	number of covariates at level-3.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
R32	proportion of level-3 variance in the outcome explained by level-3 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	harmonic mean of level-3 units across level-4 units (or simple average).
L	number of level-4 units.
	to handle extra parameters passed from other functions, do not define any additional parameters.

## Value

fun	function name.
parms	list of parameters used in power calculation.
ncp	noncentrality parameter.
power	statistical power $(1 - \beta)$ .

### See Also

```
mdes.bcra4f3, cosa.bcra4f3
```

98 power.bcra4r2

### **Examples**

power.bcra4r2

Statistical Power Calculator for Four-Level Random Effects Block Random Assignment Designs, Treatment at Level-2

## Description

power.bcra4r2 calculates statistical power for designs with four-levels where level-2 units are randomly assigned to treatment and control groups within level-3 units (random blocks).

## Usage

```
power.bcra4r2(mdes=.25, alpha=.05, two.tail=TRUE,
    rho2, rho3, rho4, omega3, omega4,
    P=.50, R12=0, R22=0, RT32=0, RT42=0, g4=0,
    n, J, K, L, ...)
```

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
rho4	proportion of variance in the outcome explained by level-4 units.
omega3	treatment effect heterogeneity as ratio of treatment effect variance among level-3 units to the residual variance at level-3.
omega4	treatment effect heterogeneity as ratio of treatment effect variance among level-4 units to the residual variance at level-4.
Р	average proportion of level-2 units randomly assigned to treatment within level-3 units.
g4	number of covariates at level-4.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
RT32	proportion of treatment effect variance among level-3 units explained by level-3 covariates.
RT42	proportion of treatment effect variance among level-4 units explained by level-4 covariates.

power.bcra4r3 99

n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	harmonic mean of level-3 units across level-4 units (or simple average).
L	number of level-4 units.
	to handle extra parameters passed from other functions, do not define any additional parameters.

### Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1 - \beta)$ .

## See Also

```
mdes.bcra4r2, cosa.bcra4r2
```

### **Examples**

power.bcra4r3

Statistical Power Calculator for Four-Level Random Effects Blocked Cluster Random Assignment Designs, Treatment at Level-3

# Description

power.bcra4r3 calculates statistical power for designs with four-levels where level-3 units are randomly assigned to treatment and control groups within level-4 units (random blocks).

```
power.bcra4r3(mdes=.25, alpha=.05, two.tail=TRUE,
    rho2, rho3, rho4, omega4,
    P=.50, R12=0, R22=0, R32=0, RT42=0, g4=0,
    n, J, K, L, ...)
```

power.bcra4r3

# Arguments

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
rho4	proportion of variance in the outcome explained by level-4 units.
omega4	treatment effect heterogeneity as ratio of treatment effect variance among level-4 units to the residual variance at level-4.
P	average proportion of level-3 units randomly assigned to treatment within level-4 units.
g4	number of covariates at level-4.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
R32	proportion of level-3 variance in the outcome explained by level-3 covariates.
RT42	proportion of treatment effect variance among level-4 units explained by level-4 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	harmonic mean of level-3 units across level-4 units (or simple average).
L	number of level-4 units.
•••	to handle extra parameters passed from other functions, do not define any additional parameters.

# Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1 - \beta)$ .

# See Also

```
mdes.bcra4r3, cosa.bcra4r3
```

power.bcrd3f2

power.bcrd3f2	Statistical Power Calculator for Three-Level Blocked Cluster Regression Discontinuity Design, Treatment Based on Discontinuity at Level-2 (Fixed Treatment Effect)
	, , ,

## Description

Statistical power calculator for three-level blocked cluster regression discontinuity design where treatment assignment is based on discontinuity at level-2 (fixed treatment effect).

## Usage

```
power.bcrd3f2(mdes=.25, alpha=.05, two.tail=TRUE, rho2, RTZ=NULL, k1=-6, k2=6, dist.Z="normal", P=.50, g2=0, R12=0, R22=0, n, J, K, ...)
```

### **Arguments**

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
Р	average proportion of level-1 units randomly assigned to treatment within level-2 units.
RTZ	correlation between treatment status and assignment variable
k1	left truncation point (in standard deviation units from full normal distribution mean).
k2	right truncation point (in standard deviation units from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g2	number of covariates at level-2.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
•••	to handle extra parameters passed from other functions, do not define any additional parameters.

## Value

run	runction name.
parms	list of parameters used in power calculation.
ncp	noncentrality parameter.
power	statistical power $(1 - \beta)$

power.bcrd3r2

### See Also

```
cosa.bcrd3f2, mdes.bcrd3f2
```

### **Examples**

```
## Not run:
    mdes.bcrd3f2(rho2=.20, n=10, J=5, K=100)
## End(Not run)
```

power.bcrd3r2

Statistical Power Calculator for Three-Level Blocked Cluster Regression Discontinuity Design, Treatment Based on Discontinuity at Level-2 (Random Treatment Effect)

### **Description**

Statistical power calculator for three-level blocked cluster regression discontinuity design where treatment assignment is based on discontinuity at level-2 (random treatment effect).

## Usage

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
omega3	treatment effect heterogeneity as ratio of treatment effect variance among level-3 units to the residual variance at level-3.
Р	average proportion of level-1 units randomly assigned to treatment within level-2 units.
RTZ	correlation between treatment status and assignment variable
k1	left truncation point (in standard deviation units from full normal distribution mean).
k2	right truncation point (in standard deviation units from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.

power.bira2c1

g3	number of covariates at level-3.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
RT32	proportion of treatment effect variance among level-3 units explained by level-3 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

## Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1-\beta)$ 

### See Also

```
cosa.bcrd3r2, mdes.bcrd3r2
```

## **Examples**

power.bira2c1 Statistical Power Calculator for Two-Level Constant Effects Blocked Individual Random Assignment Designs, Treatment at Level-1

## Description

power.bira2c1 calculates statistical power for designs with two-levels where level-1 units are randomly assigned to treatment and control groups within level-2 units (school intercepts only).

104 power.bira2f1

### **Arguments**

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
P	average proportion of level-1 units randomly assigned to treatment within level-2 units.
g1	number of covariates at level-1.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	level-2 sample size.
•••	to handle extra parameters passed from other functions, do not define any additional parameters.

#### Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1 - \beta)$ .

### See Also

```
mdes.bira2c1, cosa.bira2c1
```

# **Examples**

```
## Not run:
    power.bira2c1(n=55, J=3)
## End(Not run)
```

power.bira2f1

Statistical Power Calculator for Two-Level Fixed Effects Blocked Individual Random Assignment Designs, Treatment at Level-1

### Description

power.bira2f1 calculates statistical power for designs with two-levels where level-1 units are randomly assigned to treatment and control groups within level-2 units (fixed blocks).

power.bira2r1 105

### **Arguments**

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
P	average proportion of level-1 units randomly assigned to treatment within level-2 units.
g1	number of covariates at level-1.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	level-2 sample size.
•••	to handle extra parameters passed from other functions, do not define any additional parameters. $$

### Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1 - \beta)$ .

### See Also

```
mdes.bira2f1, cosa.bira2f1
```

### **Examples**

```
## Not run:
    power.bira2f1(n=55, J=3)
## End(Not run)
```

power.bira2r1 Statistical Power Calculator for Two-Level Random Effects Blocked

Individual Random Assignment Designs, Individuals Randomized

within Blocks

### **Description**

power.bira2r1 calculates statistical power for designs with two-levels where level-1 units are randomly assigned to treatment and control groups within level-2 units (random blocks).

power.bira2r1

### **Arguments**

mdes minimum detectable effect size. alpha probability of type I error. two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing. proportion of variance in the outcome explained by level-2 units. rho2 omega2 treatment effect heterogeneity as ratio of treatment effect variance among level-2 units to the residual variance at level-2. Ρ average proportion of level-1 units randomly assigned to treatment within level-2 units. number of covariates at level-2. g2 proportion of level-1 variance in the outcome explained by level-1 covariates. R12 proportion of treatment effect variance among level-2 units explained by level-2 RT22 covariates. harmonic mean of level-1 units across level-2 units (or simple average). n J level-2 sample size.

to handle extra parameters passed from other functions, do not define any addi-

### Value

fun function name.

parms list of parameters used in power calculation.

tional parameters.

ncp noncentrality parameter. power statistical power  $(1-\beta)$ .

### See Also

```
mdes.bira2r1, cosa.bira2r1
```

power.bira3r1 107

	power.bira3r1	Statistical Power Calculator for Three-Level Random Effects Blocked Individual Random Assignment Design, Individuals Randomized within Blocks
--	---------------	---

# Description

power.bira3r1 calculates statistical power for designs with three-levels where level-1 units are randomly assigned to treatment and control groups within level-2 units (random blocks).

# Usage

# Arguments

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
omega2	treatment effect heterogeneity as ratio of treatment effect variance among level-2 units to the residual variance at level-2.
omega3	treatment effect heterogeneity as ratio of treatment effect variance among level-3 units to the residual variance at level-3.
Р	average proportion of level-1 units randomly assigned to treatment within level-2 units.
g3	number of covariates at level-3.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
RT22	proportion of treatment effect variance among level-2 units explained by level-2 covariates.
RT32	proportion of treatment effect variance among level-3 units explained by level-3 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

### Value

fun	function name.
parms	list of parameters used in power calculation.
ncp	noncentrality parameter.
power	statistical power $(1 - \beta)$ .

108 power.bira4r1

### See Also

```
mdes.bira3r1, cosa.bira3r1
```

### **Examples**

power.bira4r1

Statistical Power Calculator for Four-Level Random Effects Blocked Individual Random Assignment Design, Individuals Randomized within Blocks

## Description

power.bira4r1 calculates statistical power for designs with four-levels where level-1 units are randomly assigned to treatment and control groups within level-2 units (random blocks).

## Usage

```
power.bira4r1(mdes=.25, alpha=.05, two.tail=TRUE,
    rho2, rho3, rho4, omega2, omega3, omega4,
    P=.50, R12=0, RT22=0, RT32=0, RT42=0, g4=0,
    n, J, K, L, ...)
```

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
rho4	proportion of variance in the outcome explained by level-4 units.
omega2	treatment effect heterogeneity as ratio of treatment effect variance among level-2 units to the residual variance at level-2.
omega3	treatment effect heterogeneity as ratio of treatment effect variance among level-3 units to the residual variance at level-3.
omega4	treatment effect heterogeneity as ratio of treatment effect variance among level-4 units to the residual variance at level-4.
Р	average proportion of level-1 units randomly assigned to treatment within level-2 units.
g4	number of covariates at level-4.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.

power.bird2f1

RT22	proportion of treatment effect variance among level-2 units explained by level-2 covariates.
RT32	proportion of treatment effect variance among level-3 units explained by level-3 covariates.
RT42	proportion of treatment effect variance among level-4 units explained by level-4 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	harmonic mean of level-3 units across level-4 units (or simple average).
L	number of level-4 units.
	to handle extra parameters passed from other functions, do not define any additional parameters.

#### Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1 - \beta)$ .

#### See Also

```
mdes.bira4r1, cosa.bira4r1
```

# **Examples**

power.bird2f1

Statistical Power Calculator for Two-Level Blocked Individual Regression Discontinuity Design, Treatment Based on Discontinuity at Level-1 (Fixed Treatment Effect)

## **Description**

Statistical power calculator for two-level blocked individual regression discontinuity design where treatment assignment is based on discontinuity at level-1 (fixed treatment effect).

# Usage

```
power.bird2f1(mdes=.25, alpha=.05, two.tail=TRUE, P=.50, RTZ=NULL, k1=-6, k2=6, dist.Z="normal", g1=0, R12=0, n, J, ...)
```

power.bird2f1

# Arguments

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
P	average proportion of level-1 units randomly assigned to treatment within level-2 units.
RTZ	correlation between treatment status and assignment variable
k1	left truncation point (in standard deviation units from full normal distribution mean). $ \\$
k2	right truncation point (in standard deviation units from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g1	number of covariates at level-1.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	number of level-2 units.
•••	to handle extra parameters passed from other functions, do not define any additional parameters.

# Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter.  $\mbox{power} \qquad \mbox{statistical power} \; (1-\beta)$ 

# See Also

```
cosa.bird2f1, mdes.bird2f1
```

# **Examples**

```
## Not run:
    power.bird2f1(n=10, J=100)
## End(Not run)
```

power.bird2r1 111

power.bird2r1	Statistical Power Calculator for Two-Level Blocked Individual Regression Discontinuity Design, Treatment Based on Discontinuity at Level-1 (Random Treatment Effect)
	(

# Description

Statistical power calculator for two-level blocked individual regression discontinuity design where treatment assignment is based on discontinuity at level-1 (random treatment effect).

# Usage

```
power.bird2r1(mdes=.25, alpha=.05, two.tail=TRUE, rho2, omega2, g2=0, P=.50, RTZ=NULL, k1=-6, k2=6, dist.Z="normal", R12=0, RT22=0, n, J, \dots)
```

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
omega2	treatment effect heterogeneity as ratio of treatment effect variance among level-2 units to the residual variance at level-2.
Р	average proportion of level-1 units randomly assigned to treatment within level-2 units.
RTZ	correlation between treatment status and assignment variable
k1	left truncation point (in standard deviation units from full normal distribution mean).
k2	right truncation point (in standard deviation units from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g2	number of covariates at level-2.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
RT22	proportion of treatment effect variance among level-2 units explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	number of level-2 units.
•••	to handle extra parameters passed from other functions, do not define any additional parameters.

112 power.cra2r2

#### Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1-\beta)$ 

#### See Also

```
cosa.bird2r1, mdes.bird2r1
```

## **Examples**

```
## Not run:
    power.bird2r1(rho2=.20, omega2=.50, n=10, J=100)
## End(Not run)
```

power.cra2r2

Statistical Power Calculator for Main Effect in Two-Level Cluster Random Assignment Design, Treatment at Level-2

# Description

power.cra2r2 calculates statistical power for main effect in designs with two-levels where level-2 units are randomly assigned to treatment and control groups.

## Usage

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
Р	proportion of level-2 units randomly assigned to treatment.
g2	number of covariates at level-2.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	level-2 sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

power.cra3r3 113

#### Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1 - \beta)$ .

#### See Also

```
mdes.cra2r2, cosa.cra2r2
```

## **Examples**

```
## Not run:
    power.cra2r2(rho2=.20, n=4, J=20)
## End(Not run)
```

power.cra3r3

Statistical Power Calculator for Main Effect in Three-Level Cluster Random Assignment Designs, Treatment at Level-3

# Description

power.cra3r3 calculates statistical power for main effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups.

# Usage

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
Р	proportion of level-3 units randomly assigned to treatment.
g3	number of covariates at level-3.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
R32	proportion of level-3 variance in the outcome explained by level-3 covariates.

114 power.cra4r4

n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
17	1 12 1 :

K level-3 sample size.

... to handle extra parameters passed from other functions, do not define any addi-

tional parameters.

#### Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1 - \beta)$ .

#### See Also

```
mdes.cra3r3, cosa.cra3r3
```

### **Examples**

power.cra4r4

Statistical Power Calculator for Four-Level Cluster Random Assignment Designs, Treatment at Level-4

#### **Description**

power.cra4r4 calculates statistical power for designs with four-levels where level-4 units are randomly assigned to treatment and control groups.

## Usage

```
power.cra4r4(mdes=.25, alpha=.05, two.tail=TRUE,
    rho2, rho3, rho4,
    P=.50, R12=0, R22=0, R32=0, R42=0, g4=0,
    n, J, K, L, ...)
```

#### **Arguments**

mdes minimum detectable effect size.
alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

testing.

rho2 proportion of variance in the outcome explained by level-2 units.

power.crd2r2

rho3	proportion of variance in the outcome explained by level-3 units.
rho4	proportion of variance in the outcome explained by level-4 units.
Р	proportion of level-4 units randomly assigned to treatment.
g4	number of covariates at level-4.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
R32	proportion of level-3 variance in the outcome explained by level-3 covariates.
R42	proportion of level-4 variance in the outcome explained by level-4 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	harmonic mean of level-3 units across level-4 units (or simple average).
L	number of level-4 units.
	to handle extra parameters passed from other functions, do not define any additional parameters.

# Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1 - \beta)$ .

#### See Also

```
mdes.cra4r4, cosa.cra4r4
```

# **Examples**

power.crd2r2

Statistical Power Calculator for Two-Level Cluster Regression Discontinuity Design, Treatment Based on Discontinuity at Level-2

# Description

Statistical power calculator for two-level cluster regression discontinuity design where treatment assignment is based on discontinuity at level-2.

power.crd2r2

## Usage

# **Arguments**

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
Р	average proportion of level-1 units randomly assigned to treatment within level-2 units.
RTZ	correlation between treatment status and assignment variable
k1	left truncation point (in standard deviation units from full normal distribution mean).
k2	right truncation point (in standard deviation units from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g2	number of covariates at level-2.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	number of level-2 units.

to handle extra parameters passed from other functions, do not define any addi-

## Value

fun function name.

parms list of parameters used in power calculation.

tional parameters.

ncp noncentrality parameter. power statistical power  $(1-\beta)$ 

## See Also

```
cosa.crd2r2, mdes.crd2r2
```

# **Examples**

```
## Not run:
    power.crd2r2(rho2=.20, n=10, J=100)
## End(Not run)
```

power.crd3r3

power.crd3r3	Statistical Power Calculator for Three-Level Cluster Regression Dis-
	continuity Design, Treatment Based on Discontinuity at Level-3

# Description

Statistical power calculator for three-level cluster regression discontinuity design where treatment assignment is based on discontinuity at level-3.

# Usage

# Arguments

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
P	average proportion of level-1 units randomly assigned to treatment within level-2 units.
RTZ	correlation between treatment status and assignment variable
k1	left truncation point (in standard deviation units from full normal distribution mean).
k2	right truncation point (in standard deviation units from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g3	number of covariates at level-3.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
R32	proportion of level-3 variance in the outcome explained by level-3 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
• • •	to handle extra parameters passed from other functions, do not define any additional parameters.

# Value

fun	function name.
parms	list of parameters used in power calculation.
ncp	noncentrality parameter.
power	statistical power $(1 - \beta)$

power.ira1r1

#### See Also

```
cosa.crd3r3, mdes.crd3r3
```

#### **Examples**

```
## Not run:
    power.crd3r3(rho2=.20, rho3=.10, n=10, J=5, K=100)
## End(Not run)
```

power.ira1r1

Statistical Power Calculator for Individual Random Assignment Designs, Completely Randomized Controlled Trials

## **Description**

power.ira1r1 calculates statistical power for completely randomized controlled trials where individuals are randomly assigned to treatment or control groups.

## Usage

## **Arguments**

minimum detectable effect size.

alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.

P proportion of units randomly assigned to treatment.

g1 number of covariates.

R12 proportion of variance in the outcome explained by covariates.

n sample size.

... to handle extra parameters passed from other functions, do not define any additional parameters.

## Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1-\beta)$ .

power.ird1r1 119

#### See Also

```
mdes.ira1r1, cosa.ira1r1
```

## **Examples**

```
## Not run:
   power.ira1r1(n=55)
## End(Not run)
```

power.ird1r1

Statistical Power Calculator for Main Effect in Individual Regression Discontinuity Design

# Description

power.ird1r1 calculates statistical power for main effect in individual regression discontinuity design where treatment assignment is based on discontinuity at the individual level.

# Usage

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
Р	average proportion of units randomly assigned to treatment.
RTZ	correlation between treatment status and assignment variable.
k1	left truncation point (in standard deviation units from full normal distribution mean).
k2	right truncation point (in standard deviation units from full normal distribution mean).
dist.Z	distribution of assignment variable; either normal or uniform.
g1	number of covariates.
R12	proportion of variance in the outcome explained by covariates.
n	sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

power.mod1n.cra2r2

#### Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1-\beta)$ 

## See Also

```
cosa.ird1r1, mdes.ird1r1
```

## **Examples**

```
## Not run:
    power.ird1r1(n=100)
## End(Not run)
```

power.mod1n.cra2r2

 $Statistical\ Power\ Calculator\ for\ for\ Non-Randomly\ Varying\ Moderator\ Effect\ in\ Two-Level\ Cluster\ Random\ Assignment\ Design,\ Treatment$ 

at Level-2, Moderator at Level-1

# Description

power.mod1n.cra2r2 calculates statistical power for non-randomly varying moderator effect in designs with two-levels where level-2 units are randomly assigned to treatment and control groups and moderator is at level-1.

## Usage

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
Р	proportion of level-2 units randomly assigned to treatment.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g1	number of covariates at level-1 excluding moderator.

power.mod1n.cra3r3

R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	level-2 sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

#### Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1 - \beta)$ .

#### See Also

```
mdes.mod1n.cra2r2, cosa.mod1n.cra2r2
```

#### **Examples**

```
## Not run:
    power.mod1n.cra2r2(rho2=.20, n=4, J=20)
## End(Not run)
```

power.mod1n.cra3r3

Statistical Power Calculator for Non-Randomly Varying Moderator Effect in Three-Level Cluster Random Assignment Design, Treatment at Level-3, Moderator at Level-1

#### **Description**

power.mod1n.cra3r3 calculates statistical power for non-randomly varying moderator effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups and moderator is at level-1.

## Usage

#### **Arguments**

mdes minimum detectable effect size.
alpha probability of type I error.

two.tail logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis

esting.

rho2 proportion of variance in the outcome explained by level-2 units.

power.mod1r.cra2r2

rho3	proportion of variance in the outcome explained by level-3 units.
Р	proportion of level-3 units randomly assigned to treatment.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g1	number of covariates at level-1 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

#### Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1 - \beta)$ .

#### See Also

```
mdes.mod1n.cra3r3, cosa.mod1n.cra3r3
```

## **Examples**

power.mod1r.cra2r2

Statistical Power Calculator for Randomly Varying Moderator Effect in Two-Level Cluster Random Assignment Design, Treatment at Level-2, Moderator at Level-1

## **Description**

power.mod1r.cra2r2 calculates statistical power for randomly varying moderator effect in designs with two-levels where level-2 units are randomly assigned to treatment and control groups and moderator is at level-1.

# Usage

power.mod1r.cra2r2

# Arguments

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
omega2	moderator effect heterogeneity (unconditional) across level-2 units.
Р	proportion of level-2 units randomly assigned to treatment.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g1	number of covariates at level-1 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
RT22	proportion of level-2 variance in the moderator effect explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	level-2 sample size.
	to handle extra parameters passed from other functions, do not define any addi-

# Value

fun function name.

parms list of parameters used in power calculation.

tional parameters.

ncp noncentrality parameter.  $\mbox{power} \qquad \mbox{statistical power} \ (1-\beta).$ 

## See Also

```
mdes.mod1r.cra2r2, cosa.mod1r.cra2r2
```

# **Examples**

```
## Not run:
    power.mod1r.cra2r2(rho2=.2, omega2=.2, RT22=.2, n=4, J=20)
## End(Not run)
```

power.mod1r.cra3r3

power.mod1r.cra3r3	Statistical Power Calculator for Randomly Varying Moderator Effect in Three-Level Cluster Random Assignment Designs, Treatment at Level 3 Moderator at Level 1
	Level-3, Moderator at Level-1

# Description

power.mod1r.cra3r3 calculates statistical power for randomly varying moderator effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups and moderator is at level-1.

# Usage

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
omega2	moderator effect heterogeneity (unconditional) across level-2 units.
omega3	moderator effect heterogeneity (unconditional) across level-3 units.
P	proportion of level-3 units randomly assigned to treatment.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g1	number of covariates at level-1 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
RT22	proportion of level-2 variance in the moderator effect explained by level-2 covariates.
RT32	proportion of level-3 variance in the moderator effect explained by level-3 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
•••	to handle extra parameters passed from other functions, do not define any additional parameters.

power.mod2.cra2r2 125

#### Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1 - \beta)$ .

#### See Also

```
mdes.mod1r.cra3r3, cosa.mod1r.cra3r3
```

## **Examples**

power.mod2.cra2r2

Statistical Power Calculator for Moderator Effect in Two-Level Cluster Random Assignment Design, Treatment and Moderator at Level-2

## **Description**

power.mod2.cra2r2 calculates statistical power for moderator effect in designs with two-levels where level-2 units are randomly assigned to treatment and control groups and moderator is at level-2.

## Usage

```
power.mod2.cra2r2(mdes=.25, alpha=.05, two.tail=TRUE, rho2, P=.50, Q=NULL, g2=0, R12=0, R22=0, n, J, \dots)
```

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
P	proportion of level-2 units randomly assigned to treatment.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g2	number of covariates at level-2 excluding moderator.

power.mod2n.cra3r3

R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	level-2 sample size.
•••	to handle extra parameters passed from other functions, do not define any additional parameters.

## Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1 - \beta)$ .

# See Also

```
mdes.mod2.cra2r2, cosa.mod2.cra2r2
```

#### **Examples**

```
## Not run:
    power.mod2.cra2r2(rho2=.20, n=4, J=20, Q=.5)
## End(Not run)
```

power.mod2n.cra3r3

Statistical Power Calculator for Non-Randomly Varying Moderator Effect in Three-Level Cluster Random Assignment Design, Treatment at Level-3, Moderator at Level-2

## **Description**

power.mod2n.cra3r3 calculates statistical power for non-randomly varying moderator effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups and moderator is at level-2.

## Usage

power.mod2n.cra3r3

# Arguments

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
Р	proportion of level-3 units randomly assigned to treatment.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g2	number of covariates at level-2 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

# Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter.  $\label{eq:power} \mbox{power} \qquad \mbox{statistical power} \ (1-\beta).$ 

# See Also

```
mdes.mod2n.cra3r3, cosa.mod2n.cra3r3
```

# **Examples**

power.mod2r.cra3r3

power.mod2r.cra3r3	Statistical Power Calculator for Randomly Varying Moderator Effect
	in Three-Level Cluster Random Assignment Designs, Treatment at Level-3, Moderator at Level-2

# Description

power.mod2r.cra3r3 calculates statistical power for randomly varying moderator effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups and moderator is at level-2.

## Usage

# Arguments

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
omega3	moderator effect heterogeneity (unconditional) across level-3 units.
Р	proportion of level-3 units randomly assigned to treatment.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g2	number of covariates at level-2 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
RT32	proportion of level-3 variance in the moderator effect explained by level-3 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters.

## Value

fun	function name.
parms	list of parameters used in power calculation.
ncp	noncentrality parameter.
power	statistical power $(1 - \beta)$ .

power.mod3.cra3r3 129

#### See Also

```
mdes.mod2r.cra3r3, cosa.mod2r.cra3r3
```

#### **Examples**

power.mod3.cra3r3

Statistical Power Calculator for Moderator Effect in Three-Level Cluster Random Assignment Designs, Treatment and Moderator at Level-3

# Description

power.mod3.cra3r3 calculates statistical power for moderator effect in designs with three-levels where level-3 units are randomly assigned to treatment and control groups and moderator is at level-3.

## Usage

mdes	minimum detectable effect size.
alpha	probability of type I error.
two.tail	logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2	proportion of variance in the outcome explained by level-2 units.
rho3	proportion of variance in the outcome explained by level-3 units.
P	proportion of level-3 units randomly assigned to treatment.
Q	proportion of level-1 units within moderator subgroup. NULL implies continuous moderator.
g3	number of covariates at level-3 excluding moderator.
R12	proportion of level-1 variance in the outcome explained by level-1 covariates.
R22	proportion of level-2 variance in the outcome explained by level-2 covariates.
R32	proportion of level-3 variance in the outcome explained by level-3 covariates.
n	harmonic mean of level-1 units across level-2 units (or simple average).
J	harmonic mean of level-2 units across level-3 units (or simple average).
K	level-3 sample size.
	to handle extra parameters passed from other functions, do not define any additional parameters. $$

power.to.mdes

#### Value

fun function name.

parms list of parameters used in power calculation.

ncp noncentrality parameter. power statistical power  $(1 - \beta)$ .

#### See Also

```
mdes.mod3.cra3r3, cosa.mod3.cra3r3
```

#### **Examples**

power.to.mdes

power to MDES

## **Description**

power.to.mdes converts an object returned from power function into an object returned from mdes function.

## Usage

```
power.to.mdes(x)
```

# Arguments

Χ

an object returned from one of the power functions.

## **Details**

power.to.mdes converts an object returned from power function into an object returned from mdes function by passing parameters through mdes function.

## See Also

```
cosa.to.mdes
```

#### **Examples**

```
## Not run:

# object returned from power function
  design1 <- power.bira2r1(mdes=.15, rho2=.35, omega2=.10, n=83, J=10)
  # convert the object into an object returned from mdes function
  design2 <- power.to.mdes(design1)

## End(Not run)</pre>
```

PowerUpR-deprecated

Deprecated and Defunct functions in 'PowerUpR'

## **Description**

Deprecated functions are provided for compatibility purposes and will be defunct in the next 'PowerUpR' release. Defunct functions are no longer supported.

#### **Format**

Deprecated functions are no longer documented, please use documentation for new functions.

#### **Details**

Deprecated and defunct functions and their replacement are as follows:

- mrss.ira1r1 is deprecated, use cosa.ira1r1
- mrss.cra2r2 is deprecated, use cosa.cra2r2
- mrss.cra3r3 is deprecated, use cosa.cra3r3
- mrss.cra4r4 is deprecated, use cosa.cra4r4
- mrss.bcra3f2 is deprecated, use cosa.bcra3f2
- mrss.bcra3r2 is deprecated, use cosa.bcra3r2
- mrss.bcra4r2 is deprecated, use cosa.bcra4r2
- mrss.bcra4f3 is deprecated, use cosa.bcra4f3
- mrss.bcra4r2 is deprecated, use cosa.bcra4r2
- mrss.bira4r1 is deprecated, use cosa.bira4r1
- mrss.bira3r1 is deprecated, use cosa.bira3r1
- mrss.bira2c1 is deprecated, use cosa.bira2c1
- mrss.bira2f1 is deprecated, use cosa.bira2f1
- mrss.bira2r1 is deprecated, use cosa.bira2r1
- mrss.to.mdes is defunct, use cosa.to.mdes
- mrss.to.power is defunct, use cosa.to.power
- optimal.ira1r1 is deprecated, use cosa.ira1r1
- optimal.cra2r2 is deprecated, use cosa.cra2r2
- optimal.cra3r3 is deprecated, use cosa.cra3r3

- optimal.cra4r4 is deprecated, use cosa.cra4r4
- optimal.bcra3f2 is deprecated, use cosa.bcra3f2
- optimal.bcra3r2 is deprecated, use cosa.bcra3r2
- optimal.bcra4r2 is deprecated, use cosa.bcra4r2
- optimal.bcra4f3 is deprecated, use cosa.bcra4f3
- optimal.bcra4r2 is deprecated, use cosa.bcra4r2
- optimal.bira4r1 is deprecated, use cosa.bira4r1
- optimal.bira3r1 is deprecated, use cosa.bira3r1
- optimal.bira2c1 is deprecated, use cosa.bira2c1
- optimal.bira2f1 is deprecated, use cosa.bira2f1
- optimal.bira2r1 is deprecated, use cosa.bira2r1
- optimal.to.mdes is deprecated, use cosa.to.mdes
- optimal.to.power is deprecated, use cosa.to.power
- plot.pars is defunct, there is no replacement function
- t1t2.error is defunct, there is no replacement function

# Index

*Topic <b>PowerUpR</b>	power.bird2f1, 109
PowerUpR-package, 3	power.bird2r1, 111
*Topic block design	*Topic cluster random assignment
cosa.bcra3f2,5	cosa.bcra3f2,5
cosa.bcra3r2, 6	cosa.bcra3r2, 6
cosa.bcra4f3,8	cosa.bcra4f3,8
cosa.bcra4r2, 10	cosa.bcra4r2, 10
cosa.bcra4r3, 12	cosa.bcra4r3, 12
cosa.bcrd3f2, 14	cosa.cra2r2, 30
cosa.bcrd3r2, 16	cosa.cra3r3, 32
cosa.bira2c1, 18	cosa.cra4r4, 34
cosa.bira2f1, 19	cosa.mod1n.cra2r2,41
cosa.bira2r1, 21	cosa.mod1n.cra3r3,43
cosa.bira3r1, 23	cosa.mod1r.cra2r2,45
cosa.bira4r1, 25	cosa.mod1r.cra3r3,46
cosa.bird2f1, 27	cosa.mod2.cra2r2,48
cosa.bird2r1, 28	cosa.mod2n.cra3r3,50
mdes.bcra3f2,57	cosa.mod2r.cra3r3,52
mdes.bcra3r2,58	cosa.mod3.cra3r3,54
mdes.bcra4f3,59	mdes.bcra3f2, 57
mdes.bcra4r2,61	mdes.bcra3r2,58
mdes.bcra4r3,62	mdes.bcra4f3, 59
mdes.bcrd3f2,63	mdes.bcra4r2,61
mdes.bcrd3r2,65	mdes.bcra4r3,62
mdes.bira2c1,66	mdes.cra2r2,75
mdes.bira2f1,67	mdes.cra3r3,76
mdes.bira2r1,68	mdes.cra4r4,77
mdes.bira3r1,69	mdes.mod1n.cra2r2,83
mdes.bira4r1,71	mdes.mod1n.cra3r3,84
mdes.bird2f1,72	mdes.mod1r.cra2r2,85
mdes.bird2r1,73	mdes.mod1r.cra3r3,86
power.bcra3f2,94	mdes.mod2.cra2r2,88
power.bcra3r2,95	mdes.mod2n.cra3r3,89
power.bcra4f3,97	mdes.mod2r.cra3r3,90
power.bcra4r2,98	mdes.mod3.cra3r3,91
power.bcra4r3,99	power.bcra3f2,94
power.bcrd3f2, 101	power.bcra3r2,95
power.bcrd3r2, 102	power.bcra4f3,97
power.bira2c1, 103	power.bcra4r2,98
power.bira2f1, 104	power.bcra4r3,99
power.bira2r1, 105	power.cra2r2,112
power.bira3r1, 107	power.cra3r3,113
power.bira4r1,108	power.cra4r4,114

power.mod1n.cra2r2,120	*Topic <b>deprecated or defunct</b>
power.mod1n.cra3r3,121	PowerUpR-deprecated, 131
power.mod1r.cra2r2,122	*Topic individual random assignment
power.mod1r.cra3r3,124	cosa.bira2c1,18
power.mod2.cra2r2,125	cosa.bira2f1,19
power.mod2n.cra3r3, 126	cosa.bira2r1,21
power.mod2r.cra3r3, 128	cosa.bira3r1,23
power.mod3.cra3r3,129	cosa.bira4r1,25
*Topic cluster regression	cosa.ira1r1,39
discontinuity	mdes.bira2c1,66
cosa.bcrd3f2, 14	mdes.bira2f1,67
cosa.bcrd3r2, 16	mdes.bira2r1,68
cosa.crd2r2, <u>36</u>	mdes.bira3r1,69
cosa.crd3r3,37	mdes.bira4r1,71
mdes.bcrd3f2,63	mdes.ira1r1,81
mdes.bcrd3r2,65	power.bira2c1,103
mdes.crd2r2,78	power.bira2f1,104
mdes.crd3r3, 79	power.bira2r1, 105
power.bcrd3f2, 101	power.bira3r1,107
power.bcrd3r2, 102	power.bira4r1,108
power.crd2r2, 115	power.ira1r1,118
power.crd3r3,117	*Topic <b>individual regression</b>
*Topic <b>cosa</b>	discontinuity
cosa.bcra3f2,5	cosa.bird2f1,27
cosa.bcra3r2,6	cosa.bird2r1,28
cosa.bcra4f3,8	cosa.ird1r1,40
cosa.bcra4r2, 10	mdes.bird2f1,72
cosa.bcra4r3, 12	mdes.bird2r1,73
cosa.bcrd3f2, 14	mdes.ird1r1,82
cosa.bcrd3r2, 16	power.bird2f1, 109
cosa.bira2c1, 18	power.bird2r1,111
cosa.bira2f1, 19	power.ird1r1,119
cosa.bira2r1,21	*Topic <b>main effect</b>
cosa.bira3r1, 23	cosa.bcra3f2,5
cosa.bira4r1,25	cosa.bcra3r2,6
cosa.bird2f1, 27	cosa.bcra4f3,8
cosa.bird2r1, 28	cosa.bcra4r2, 10
cosa.cra2r2, <u>30</u>	cosa.bcra4r3, 12
cosa.cra3r3,32	cosa.bcrd3f2, 14
cosa.cra4r4,34	cosa.bcrd3r2, 16
cosa.crd2r2,36	cosa.bira2c1, 18
cosa.crd3r3,37	cosa.bira2f1, 19
cosa.ira1r1,39	cosa.bira2r1, 21
cosa.ird1r1,40	cosa.bira3r1, 23
cosa.mod1n.cra2r2,41	cosa.bira4r1,25
cosa.mod1n.cra3r3,43	cosa.bird2f1,27
cosa.mod1r.cra2r2,45	cosa.bird2r1,28
cosa.mod1r.cra3r3,46	cosa.cra2r2, 30
cosa.mod2.cra2r2,48	cosa.cra3r3, 32
cosa.mod2n.cra3r3,50	cosa.cra4r4, 34
cosa.mod2r.cra3r3,52	cosa.crd2r2, 36
cosa.mod3.cra3r3,54	cosa.crd3r3, <u>37</u>

cosa.ira1r1,39	mdes.bira2c1,66
cosa.ird1r1,40	mdes.bira2f1,67
mdes.bcra3f2,57	mdes.bira2r1,68
mdes.bcra3r2,58	mdes.bira3r1,69
mdes.bcra4f3,59	mdes.bira4r1,71
mdes.bcra4r2,61	mdes.bird2f1,72
mdes.bcra4r3,62	mdes.bird2r1, 73
mdes.bcrd3f2,63	mdes.cra2r2, <b>75</b>
mdes.bcrd3r2,65	mdes.cra3r3, 76
mdes.bira2c1,66	mdes.cra4r4,77
mdes.bira2f1,67	mdes.crd2r2, 78
mdes.bira2r1,68	mdes.crd3r3, 79
mdes.bira3r1,69	mdes.ira1r1,81
mdes.bira4r1,71	mdes.ird1r1,82
mdes.bird2f1,72	mdes.mod1n.cra2r2,83
mdes.bird2r1,73	mdes.mod1n.cra3r3,84
mdes.cra2r2,75	mdes.mod1r.cra2r2,85
mdes.cra3r3,76	mdes.mod1r.cra3r3,86
mdes.cra4r4,77	mdes.mod2.cra2r2,88
mdes.crd2r2,78	mdes.mod2n.cra3r3,89
mdes.crd3r3,79	mdes.mod2r.cra3r3,90
mdes.ira1r1,81	mdes.mod3.cra3r3,91
mdes.ird1r1,82	power.bcrd3f2, 101
power.bcra3f2,94	*Topic moderator effect
power.bcra3r2,95	cosa.mod1n.cra2r2,41
power.bcra4f3,97	cosa.mod1n.cra3r3,43
power.bcra4r2,98	cosa.mod1r.cra2r2,45
power.bcra4r3,99	cosa.mod1r.cra3r3,46
power.bcrd3f2, 101	cosa.mod2.cra2r2,48
power.bcrd3r2, 102	cosa.mod2n.cra3r3,50
power.bira2c1, 103	cosa.mod2r.cra3r3,52
power.bira2f1, 104	cosa.mod3.cra3r3,54
power.bira2r1, 105	mdes.mod1n.cra2r2,83
power.bira3r1, 107	mdes.mod1n.cra3r3,84
power.bira4r1, 108	mdes.mod1r.cra2r2,85
power.bird2f1, 109	mdes.mod1r.cra3r3,86
power.bird2r1,111	mdes.mod2.cra2r2,88
power.cra2r2, 112	mdes.mod2n.cra3r3,89
power.cra3r3,113	mdes.mod2r.cra3r3,90
power.cra4r4,114	mdes.mod3.cra3r3,91
power.crd2r2, 115	power.mod1n.cra2r2, 120
power.crd3r3, 117	power.mod1n.cra3r3,121
power.ira1r1, 118	power.mod1r.cra2r2, 122
power.ird1r1, 119	power.mod1r.cra3r3, 124
Topic <b>mdes</b>	power.mod2.cra2r2, 125
mdes.bcra3f2,57	power.mod2n.cra3r3, 126
mdes.bcra3r2,58	power.mod2r.cra3r3, 128
mdes.bcra4f3,59	power.mod3.cra3r3, 129
mdes.bcra4r2,61	*Topic <b>object conversion</b>
mdes.bcra4r3, 62	compare.cosa, 4
mdes.bcrd3f2, 63	cosa.to.mdes, 55
mdes.bcrd3r2, 65	cosa.to.power, 56
	cosa. co. power, 50

mdes.to.pctl, 93	cosa.ira1r1, 39, 81, 119, 131
mdes.to.power, 93	cosa.ird1r1, 40, 82, <i>120</i>
power.to.mdes, 130	cosa.mod1n.cra2r2,41,84,121
*Topic <b>power</b>	cosa.mod1n.cra3r3, 43, 85, 122
power.bcra3f2,94	cosa.mod1r.cra2r2, 45, 86, 123
power.bcra3r2,95	cosa.mod1r.cra3r3, 46, 87, 125
power.bcra4f3,97	cosa.mod2.cra2r2, 48, 88, 126
power.bcra4r2,98	cosa.mod2n.cra3r3, 50, 90, 127
power.bcra4r3,99	cosa.mod2r.cra3r3, 52, 91, 129
power.bcrd3r2, 102	cosa.mod3.cra3r3, 54, 92, 130
power.bira2c1, 103	cosa.to.mdes, 55, 56, 93, 94, 130–132
power.bira2f1, 104	cosa.to.power, 56, 56, 131, 132
power.bira2r1, 105	, , , , , , , , , , , , , , , , , , , ,
power.bira3r1, 107	mdes.bcra3f2, 6, 57, 95
power.bira4r1, 108	mdes.bcra3r2, 8, 58, 96
power.bird2f1, 109	mdes.bcra4f3, 10, 59, 97
power.bird2r1, 111	mdes.bcra4r2, 12, 61, 99
power.cra2r2, 112	mdes.bcra4r3, 13, 62, 100
power.cra3r3, 113	mdes.bcrd3f2, 15, 63, 102
power.cra4r4, 114	mdes.bcrd3r2, <i>17</i> , 65, <i>103</i>
power.crd2r2, 115	mdes.bira2c1, <i>19</i> , 66, <i>104</i>
power.crd3r3, 117	mdes.bira2f1, <i>21</i> , 67, <i>105</i>
power.ira1r1, 118	mdes.bira2r1, 22, 68, 106
power.ird1r1, 119	mdes.bira3r1, 24, 69, 108
power.mod1n.cra2r2, 120	mdes.bira4r1, 26, 71, 109
power.mod1n.cra3r3, 121	mdes.bird2f1, 28, 72, 110
power.mod1r.cra2r2, 122	mdes.bird2r1, 30, 73, 112
power.mod1r.cra3r3, 124	mdes.cra2r2, 31, 75, 113
power.mod1.cra3r3, 124	mdes.cra3r3, 33, 76, 114
	mdes.cra4r4, 35, 77, 115
power.mod2n.cra3r3, 126	mdes.crd2r2, <i>37</i> , 78, <i>116</i>
power.mod2r.cra3r3, 128	mdes.crd3r3, 39, 79, 118
power.mod3.cra3r3,129	mdes.ira1r1, 40, 81, 119
compare.cosa, 4	mdes.ird1r1, 40, 81, 119
cosa.bcra3f2, 5, 58, 95, 131, 132	mdes.mod1n.cra2r2, 42, 83, 121
cosa.bcra3r2, 6, 59, 96, 131, 132	mdes.mod1n.cra3r3, 44, 84, 122
cosa.bcra4f3, 8, 60, 97, 131, 132	
cosa.bcra4r3, 8, 60, 97, 131, 132	mdes.mod1r.cra2r2, 46, 85, 123
cosa.bcra4r3, 12, 63, 100	mdes.mod1r.cra3r3, 48, 86, 125
cosa.bcrd3f2, 14, 64, 102	mdes.mod2.cra2r2, 49, 88, 126
cosa.bcrd3r2, 14, 64, 102	mdes.mod2n.cra3r3, 51, 89, 127
cosa.bira2c1, 18, 67, 104, 131, 132	mdes.mod2r.cra3r3, 53, 90, 129
	mdes.mod3.cra3r3, 55, 91, 130
cosa.bira2f1, 19, 68, 105, 131, 132	mdes.to.pctl, 93
cosa.bira2r1, 21, 69, 106, 131, 132	mdes.to.power, 93
cosa.bira3r1, 23, 70, 108, 131, 132	nowen home 252 6 50 04
cosa.bira4r1, 25, 72, 109, 131, 132	power.bcra3f2, 6, 58, 94
cosa.bird2f1, 27, 73, 110	power.bcra3r2, 8, 59, 95
cosa.bird2r1, 28, 74, 112	power.bcra4f3, 10, 60, 97
cosa.cra2r2, 30, 75, 113, 131	power.bcra4r2, 12, 62, 98
cosa.cra3r3, 32, 77, 114, 131	power.bcra4r3, 13, 63, 99
cosa. cra4r4, 34, 78, 115, 131, 132	power.bcrd3f2, 15, 64, 101
cosa.crd2r2, 36, 79, 116	power.bcrd3r2, 17, 66, 102
cosa.crd3r3, 37, 80, 118	power.bira2c1, 19, 67, 103

```
power.bira2f1, 21, 68, 104
power.bira2r1, 22, 69, 105
power.bira3r1, 24, 70, 107
power.bira4r1, 26, 72, 108
power.bird2f1, 28, 73, 109
power.bird2r1, 30, 74, 111
power.cra2r2, 31, 75, 112
power.cra3r3, 33, 77, 113
power.cra4r4, 35, 78, 114
power.crd2r2, 37, 79, 115
power.crd3r3, 39, 80, 117
power.ira1r1, 40, 81, 118
power.ird1r1, 41, 82, 119
power.mod1n.cra2r2, 42, 84, 120
power.mod1n.cra3r3, 44, 85, 121
power.mod1r.cra2r2, 46, 86, 122
power.mod1r.cra3r3, 48, 87, 124
power.mod2.cra2r2, 49, 88, 125
power.mod2n.cra3r3, 51, 90, 126
power.mod2r.cra3r3, 53, 91, 128
power.mod3.cra3r3, 55, 92, 129
power.to.mdes, 94, 130
PowerUpR (PowerUpR-package), 3
PowerUpR-deprecated, 131
PowerUpR-package, 3
```