Package ‘PowerUpR’

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Description Statistical power analysis tools for designing individual or cluster randomized trials.
Includes functions to calculate statistical power (1 -
type II error), minimum detectable effect size (MDES),
minimum required sample size (MRSS), functions to solve constrained optimal sample allocation (COSA) problems,
and to visualize duo or trio relationships between statistical power, MDES, MRSS, and COSA.

URL https://github.com/metinbulus/PowerUpR

BugReports https://github.com/metinbulus/PowerUpR/issues?state=open

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`introduction` *Introduction to* `PowerUpR`

Description

`PowerUpR` is an implementation of *PowerUp!* in R environment (R Core Team, 2016). *PowerUp!* is a statistical power analysis tool to calculate minimum detectable effect size (MDES) and top level minimum required sample size (MRSS) for various experimental and quasi-experimental designs including cluster randomized trials (Dong & Maynard, 2013). `PowerUpR` package, however, solely focuses on cluster randomized trials and adds several additional features. The package bases its framework on three fundemental concepts in statistical power analysis; MDES calculation, sample size calculation, and power calculation. Congruent with this framework, `PowerUpR` additionally provides tools to calculate statistical power, MRSS for any level, and to solve constrained optimal sample allocation (COSA; Hedges & Borenstein, 2014; Raudenbush, 1997; Raudenbush & Liu, 2000) problems. COSA problems can be solved in the following forms, (i) under budgetary constraints given marginal costs per unit, (ii) under power constraints given marginal costs per unit, (iii) under MDES constraints given marginal costs per unit, and (iv) under sample size constraints for one or more levels along with any of the i, ii or iii options. Congruent with the three fundemental concepts the package also provides tools for graphing two and three dimensional relationships to investiage relative standing of design parameter under investigation.

A design parameter (one of the MDES, MRSS, power, or COSA) can be requested by using approriate function given design characteristics. Except for graphing functions, each function begins with an **output** name, following by a period, and a **design** name. There are four types of output; `mdes`, `power`, `mrss`, and `optimal`, and 14 types of design; `ira1r1`, `bira2r1`, `bira2f1`, `bira2c1`, `cra2r2`, `bira3r1`, `bcra3r2`, `bcra3f2`, `cra3r3`, `bira4r1`, `bcra4r2`, `bcra4r3`, `bcra4f3`, and `cra4r4`. The first three letters of the design stands for the type of assignment, for individual random assignment `ira`, for blocked individual random assignment `bira`, for cluster random assignment `cra`, and for blocked cluster random assignment `bcra`. It is followed by a number indicating number of levels. A single letter followed by a number indicates whether a block is considered to be `r`, random; `f`, fixed; or `c`, constant and the level at which random assingment takes place. So, to find MDES for 2-level cluster randomized blocked (random) design where random assignment is at level 1, function `mdes.cra2r1` is used.

Each function requires slightly different arguments depending on the output it produces and the design. Most of the arguments have default values to provide users a starting point. For all functions default values are

- mdes = .25
- power $(1-\beta)$ = .80
- alpha (α) = .05
- two.tail = TRUE
- P = .50

and depending on the design

- any of one of g1, g2, g3, g4 = 0
- any sequence of R12, R22, R32, R42 = 0
- any sequence of RT22, RT32, RT42 = 0

Users should be aware of default values and change them if necessary. Depending on the function minimum required arguments are

- any sequence of rho2, rho3, rho4
- any sequence of omega2, omega3, omega4
- any one of, any sequence of, or any combination of n, J, K, L

For definition of above-mentioned parameters see Dong & Maynard (2013) and Hedges & Rhoads (2009), or help files for individual functions. For reference intraclass correlation (rho2, rho3) values see Dong, Reinke, Herman, Bradshaw, and Murray (2016), Hedberg and Hedges (2014), Hedges and Hedberg (2007, 2013), Kelcey, and Phelps (2013), Schochet (2008), Spybrook, Westine, and Taylor (2016).

For reference variance (R12, R22, R32) values see Bloom, Richburg-Hayes, and Black (2007), Deke et al. (2010), Dong et al. (2016), Hedges and Hedberg (2013), Kelcey, and Phelps (2013), Spybrook, Westine,and Taylor (2016), Westine, Spybrook, and Taylor (2013). Users can also obtain design parameters for various levels using publicly available state or district data.

Click for the vignettes demonstrating how to use PowerUpR package.

Please email us any issues or suggestions.

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`mdes.bcra3f2` *Model 4.1: MDES Calculator for 3-Level Fixed Effects Blocked Cluster Random Assignment Design, Treatment at Level 2*

Description

mdes.bcra3f2 calculates minimum detectable effect size (MDES) for designs with 3-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, ...)
```

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 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.

Details

MDES formula and further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MDES calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
mdes	minimum detectable effect size and 95% lower and upper confidence limits.

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References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

power.bcra3f2, mrss.bcra3f2, optimal.bcra3f2

Examples

```
## Not run:

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


## End(Not run)
```

---

mdes.bcra3r2 *Model 4.2: MDES Calculator for 3-Level Random Effects Blocked Cluster Random Assignment Designs, Treatment at Level 2*

Description

mdes.bcra3r2 calculates minimum detectable effect size (MDES) for designs with 3-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 - 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 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.

Details

MDES formula and further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MDES calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
mdes	minimum detectable effect size and 95% lower and upper confidence limits.

Author(s)

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References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

power.bcra3r2, mrss.bcra3r2, optimal.bcra3r2

Examples

```
## Not run:

 mdes.bcra3r2(rho3=.13, rho2=.10, omega3=.40,
             n=10, J=6, K=24)


## End(Not run)
```

---

mdes.bcra4f3 — *Model 4.4: MDES Calculator for 4-Level Fixed Effects Blocked Cluster Random Assignment Designs, Treatment at Level 3*

Description

`mdes.bcra4f3` calculates minimum detectable effect size (MDES) for designs with 4-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, ...)
```

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.
`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 3 units (or simple average).
`L`	number of level 4 units.
`...`	to handle extra parameters passed from other functions, do not define any additional parameters.

Details

MDES formula and further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MDES calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
mdes	minimum detectable effect size and 95% lower and upper confidence limits.

Author(s)

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References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

power.bcra4f3, mrss.bcra4f3, optimal.bcra4f3

Examples

```
## Not run:

  mdes.bcra4f3(rho3=.15, rho2=.15,
              n=10, J=4, K=4, L=15)

## End(Not run)
```

---

mdes.bcra4r2 — *Model 4.3: MDES Calculator for 4-Level Random Effects Block Random Assignment Designs, Treatment at Level 2*

Description

mdes.bcra4r2 calculates minimum detectable effect size (MDES) for designs with 4-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, ...)
```

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.
`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.
`P`	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 3 units (or simple average).
`L`	number of level 4 units.
`...`	to handle extra parameters passed from other functions, do not define any additional parameters.

Details

MDES formula and further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MDES calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
mdes	minimum detectable effect size and 95% lower and upper confidence limits.

Author(s)

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References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

power.bcra4r2, mrss.bcra4r2, optimal.bcra4r2

Examples

```
## Not run:

  mdes.bcra4r2(rho4=.05, rho3=.15, rho2=.15,
               omega4=.50, omega3=.50,
               n=10, J=4, L=27, K=4)

## End(Not run)
```

---

mdes.bcra4r3 *Model 4.5: MDES Calculator for 4-Level Random Effects Blocked Cluster Random Assignment Designs, Treatment at Level 3*

Description

mdes.bcra4r3 calculates minimum detectable effect size (MDES) for designs with 4-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 - 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.
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 3 units (or simple average).
L	number of level 4 units.
...	to handle extra parameters passed from other functions, do not define any additional parameters.

Details

MDES formula and further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MDES calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
mdes	minimum detectable effect size and 95% lower and upper confidence limits.

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References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

power.bcra4r3, mrss.bcra4r3, optimal.bcra4r3

Examples

```
## Not run:

  mdes.bcra4r3(rho4=.05, rho3=.15, rho2=.15,
               omega4=.50,
               n=10, J=4, L=27, K=4)

## End(Not run)
```

---

mdes.bira2c1 *Model 2.1: MDES Calculator for 2-Level Constant Effects Blocked Individual Random Assignment Designs, Treatment at Level 1*

Description

mdes.bira2c1 calculates minimum detectable effect size (MDES) for designs with 2-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, ...)
```

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.
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.

Details

MDES formula and further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MDES calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
mdes	minimum detectable effect size and 95% lower and upper confidence limits.

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References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

power.bira2c1, mrss.bira2c1, optimal.bira2c1

Examples

```
## Not run:

 mdes.bira2c1(n=55, J=3)


## End(Not run)
```

`mdes.bira2f1` *Model 2.2: MDES Calculator for 2-Level Fixed Effects Blocked Individual Random Assignment Designs, Treatment at Level 1*

Description

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

Usage

```
mdes.bira2f1(power=.80, alpha=.05, two.tail=TRUE,
             P=.50, g1=0, R12=0,
             n, J, ...)
```

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.
`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.

Details

MDES formula and further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in MDES calculation.
`df`	model degrees of freedom
`M`	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
`mdes`	minimum detectable effect size and 95% lower and upper confidence limits.

Author(s)

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References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

power.bira2f1, mrss.bira2f1, optimal.bira2f1

Examples

```
## Not run:

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


## End(Not run)
```

---

mdes.bira2r1 *Model 2.3: MDES Calculator for 2-Level Random Effects Blocked Individual Random Assignment Designs, Individuals Randomized within Blocks*

Description

mdes.bira2r1 calculates minimum detectable effect size (MDES) for designs with 2-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 - 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.
P	average proportion of level 1 units randomly assigned to treatment within level 2 units.
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	level 2 sample size.
...	to handle extra parameters passed from other functions, do not define any additional parameters.

Details

MDES formula and further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MDES calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
mdes	minimum detectable effect size and 95% lower and upper confidence limits.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

power.bira2r1, mrss.bira2r1, optimal.bira2r1

Examples

```
## Not run:

 mdes.bira2r1(rho2=.35, omega2=.10,
             n=83, J=480)


## End(Not run)
```

---

mdes.bira3r1 *Model 2.4: MDES Calculator for 3-Level Random Effects Blocked Individual Random Assignment Design, Individuals Randomized within Blocks*

Description

mdes.bira3r1 calculates minimum detectable effect size (MDES) for designs with 3-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, ...)
```

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.
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.
P	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.

Details

MDES formula and further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MDES calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
mdes	minimum detectable effect size and 95% lower and upper confidence limits.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

power.bira3r1, mrss.bira3r1, optimal.bira3r1

Examples

```
## Not run:

 mdes.bira3r1(rho3=.20, rho2=.15, omega3=.10, omega2=.10,
             n=69, J=10, K=100)

## End(Not run)
```

`mdes.bira4r1` *Model 2.5: MDES Calculator for 4-Level Random Effects Blocked Individual Random Assignment Design, Individuals Randomized within Blocks*

Description

`mdes.bira4r1` calculates minimum detectable effect size (MDES) for designs with 4-levels where level 1 units are randomly assigned to treatment and control groups within level 2 units (random blocks).

Usage

```
mdes.bira4r1(power=.80, 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, ...)
```

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.
`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.
`P`	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 3 units (or simple average).
L	number of level 4 units.
...	to handle extra parameters passed from other functions, do not define any additional parameters.

Details

MDES formula and further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MDES calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
mdes	minimum detectable effect size and 95% lower and upper confidence limits.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

power.bira4r1, mrss.bira4r1, optimal.bira4r1

Examples

```
## Not run:

  mdes.bira4r1(rho4=.05, rho3=.15, rho2=.15,
               omega4=.50, omega3=.50, omega2=.50,
               n=10, J=4, L=27, K=4)

## End(Not run)
```

`mdes.cra2r2` *Model 3.1: MDES Calculator for 2-Level Cluster Random Assignment Design, Treatment at Level 2*

Description

`mdes.cra2r2` calculates minimum detectable effect size (MDES) for designs with 2-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 - 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`	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.

Details

MDES formula and further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in MDES calculation.
`df`	model degrees of freedom
`M`	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
`mdes`	minimum detectable effect size and 95% lower and upper confidence limits.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

power.cra2r2, mrss.cra2r2, optimal.cra2r2

Examples

```
## Not run:

 mdes.cra2r2(rho2=.20,
             n=4, J=20)


## End(Not run)
```

---

mdes.cra3r3 — *Model 3.2: MDES Calculator for 3-Level Cluster Random Assignment Designs, Treatment at Level 3*

Description

mdes.cra3r3 calculates minimum detectable effect size (MDES) for designs with 3-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 - 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.

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.

Details

MDES formula and further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MDES calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
mdes	minimum detectable effect size and 95% lower and upper confidence limits.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

power.cra3r3, mrss.cra3r3, optimal.cra3r3

Examples

```
## Not run:

 mdes.cra3r3(rho3=.13, rho2=.10, omega3=.40,
             n=10, J=6, K=24)


## End(Not run)
```

mdes.cra4r4 *Model 3.3: MDES Calculator for 4-Level Cluster Random Assignment Designs, Treatment at Level 4*

Description

mdes.cra4r4 calculates minimum detectable effect size (MDES) for designs with 4-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, ...)
```

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.
rho4	proportion of variance in the outcome explained by level 4 units.
P	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 3 units (or simple average).
L	number of level 4 units.
...	to handle extra parameters passed from other functions, do not define any additional parameters.

Details

MDES formula and further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MDES calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
mdes	minimum detectable effect size and 95% lower and upper confidence limits.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

power.cra4r4, mrss.cra4r4, optimal.cra4r4

Examples

```
## Not run:

  mdes.cra4r4(rho4=.05, rho3=.05, rho2=.10,
              n=10, J=2, K=3, L=20)

## End(Not run)
```

---

mdes.ira1r1 — *Model 1.0: 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 and control groups.

Usage

```
mdes.ira1r1(power=.80, alpha=.05, two.tail=TRUE,
            P=.50, 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.
`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.

Details

MDES formula and further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in MDES calculation.
`df`	model degrees of freedom
`M`	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
`mdes`	minimum detectable effect size and 95% lower and upper confidence limits.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

`power.ira1r1`, `mrss.ira1r1`, `optimal.ira1r1`

Examples

```
## Not run:

 mdes.ira1r1(n=55)


## End(Not run)
```

mrss.bcra3f2	*Model 4.1: MRSS Calculator for 3-Level Fixed Effects Blocked Cluster Random Assignment Designs, Treatment at Level 2*

Description

mrss.bcra3f2 calculates minimum required sample size (MRSS) for designs with 3-levels where level 2 units are randomly assigned to treatment and control groups within level 3 units (fixed blocks).

Usage

```
mrss.bcra3f2(mdes=.25, power=.80, alpha=.05, two.tail=TRUE,
             gm=2, ncase=10, constrain="power",
             n=NULL, J=NULL, K=NULL, K0=10, J0=10, tol=.10,
             rho2,
             P=.50, g2=0, R12=0, R22=0)
```

Arguments

mdes	minimum detectable effect size.
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.
gm	grid multiplier to increase the range of sample size search for each level.
ncase	number of cases to show in the output.
constrain	parameter to contrain; "cost", "power", or "mdes".
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.
J0	starting value for estimating number of level 2 units.
K0	starting value for estimating number of level 3 units.
tol	tolerance to stop the search algorithm.
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.

Details

Level 2 and level 3 sample sizes (J and K) are calculated using an iterative procedure described in Dong & Maynard (2013) due to model degrees of freedom dependency on J and K. For other levels (n) MRSS calculation is simply solving for the unknown. MRSS calculator returns values that are not integer. Rounding may produce MDES and power values different from what was specified, therefore an integer solution is approximated using brute force (See Value section). Integer solution to MRSS for an omitted level assumes that specified sample sizes for remaining levels may subject to some changes.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MRSS calculation.
round.mrss	solution after rounding.
integer.mrss	best integer solutions around round.mrss solution.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

mdes.bcra3f2, power.bcra3f2, optimal.bcra3f2

Examples

```
## Not run:

     mrss.bcra3f2(rho3=.06, rho2=.17,
                  n=15, J=3)


## End(Not run)
```

`mrss.bcra3r2` *Model 4.2: MRSS Calculator for 3-Level Random Effects Blocked Cluster Random Assignment Designs, Treatment at Level 2*

Description

`mrss.bcra3r2` calculates minimum required sample size (MRSS) for designs with 3-levels where level 2 units are randomly assigned to treatment and control groups within level 3 units (random blocks).

Usage

```
mrss.bcra3r2(mdes=.25, power=.80, alpha=.05, two.tail=TRUE,
             gm=2, ncase=10, constrain="power",
             n=NULL, J=NULL, K=NULL, K0=10, tol=.10,
             rho2, rho3, omega3,
             P=.50, g3=0, R12=0, R22=0, RT32=0)
```

Arguments

`mdes`	minimum detectable effect size.
`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.
`gm`	grid multiplier to increase the range of sample size search for each level.
`ncase`	number of cases to show in the output.
`constrain`	parameter to contrain; `"cost"`, `"power"`, or `"mdes"`.
`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.
`K0`	starting value for estimating number of level 3 units.
`tol`	tolerance to stop the search algorithm.
`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.

Details

Level 3 sample size (K) is calculated using an iterative procedure described in Dong & Maynard (2013) due to model degrees of freedom dependency on K. For other levels (n and J) MRSS calculation is simply solving for the unknown. MRSS calculator returns values that are not integer. Rounding may produce MDES and power values different from what was specified, therefore an integer solution is approximated using brute force (See Value section). Integer solution to MRSS for an omitted level assumes that specified sample sizes for remaining levels may subject to some changes.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in MRSS calculation.
`round.mrss`	solution after rounding.
`integer.mrss`	best integer solutions around `round.mrss` solution.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

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

Examples

```
## Not run:

     mrss.bcra3r2(rho3=.13, rho2=.10, omega3=.40,
                  n=10, J=6)


## End(Not run)
```

mrss.bcra4f3 — *Model 4.4: MRSS Calculator for 4-Level Fixed Effects Blocked Cluster Random Assignment Designs, Treatment at Level 3*

Description

mrss.bcra4f3 calculates minimum required sample size (MRSS) for designs with 4-levels where level 3 units are randomly assigned to treatment and control groups within level 4 units (fixed blocks).

Usage

```
mrss.bcra4f3(mdes=.25, power=.80, alpha=.05, two.tail=TRUE,
             gm=2, ncase=10, constrain="power",
             n=NULL, J=NULL, K=NULL, L=NULL, L0=10, K0=10, tol=.10,
             rho2, rho3,
             P=.50, g3=0, R12=0, R22=0, R32=0)
```

Arguments

mdes	minimum detectable effect size.
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.
gm	grid multiplier to increase the range of sample size search for each level.
ncase	number of cases to show in the output.
constrain	parameter to contrain; "cost", "power", or "mdes".
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 3 units (or simple average).
L	number of level 4 units.
K0	starting value for estimating number of level 3 units.
L0	starting value for estimating number of level 4 units.
tol	tolerance to stop the search algorithm.
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.

Details

Level 3 and level 4 sample sizes (K and L) are calculated using an iterative procedure described in Dong & Maynard (2013) due to model degrees of freedom dependency on K and L. For other levels (n and J) MRSS calculation is simply solving for the unknown. MRSS calculator returns values that are not integer. Rounding may produce MDES and power values different from what was specified, therefore an integer solution is approximated using brute force (See Value section). Integer solution to MRSS for an omitted level assumes that specified sample sizes for remaining levels may subject to some changes.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MRSS calculation.
round.mrss	solution after rounding.
integer.mrss	best integer solutions around round.mrss solution.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

mdes.bcra4f3, power.bcra4f3, optimal.bcra4f3

Examples

```
## Not run:

    mrss.bcra4f3(rho3=.15, rho2=.15,
                 n=10, J=4, K=4)


## End(Not run)
```

---

mrss.bcra4r2 — *Model 4.3: MRSS Calculator for 4-Level Random Effects Block Random Assignment Designs, Treatment at Level 2*

Description

mrss.bcra4r2 calculates minimum required sample size (MRSS) for designs with 4-levels where level 2 units are randomly assigned to treatment and control groups within level 3 units (random blocks).

Usage

```
mrss.bcra4r2(mdes=.25, power=.80, alpha=.05, two.tail=TRUE,
             gm=2, ncase=10, constrain="power",
             n=NULL, J=NULL, K=NULL, L=NULL, L0=10, tol=.10,
             rho2, rho3, rho4, omega3, omega4,
             P=.50, R12=0, R22=0, RT32=0, RT42=0, g4=0)
```

Arguments

mdes	minimum detectable effect size.
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.
gm	grid multiplier to increase the range of sample size search for each level.
ncase	number of cases to show in the output.
constrain	parameter to contrain; "cost", "power", or "mdes".
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 3 units (or simple average).
L	number of level 4 units.
L0	starting value for estimating number of level 4 units.
tol	tolerance to stop the search algorithm.
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.

P	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.

Details

Level 4 sample size (L) is calculated using an iterative procedure described in Dong & Maynard (2013) due to model degrees of freedom dependency on L. For other levels (n, J and K) MRSS calculation is simply solving for the unknown. MRSS calculator returns values that are not integer. Rounding may produce MDES and power values different from what was specified, therefore an integer solution is approximated using brute force (See Value section). Integer solution to MRSS for an omitted level assumes that specified sample sizes for remaining levels may subject to some changes.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MRSS calculation.
round.mrss	solution after rounding.
integer.mrss	best integer solutions around round.mrss solution.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

mdes.bcra4r2, power.bcra4r2, optimal.bcra4r2

Examples

```
## Not run:

     mrss.bcra4r2(rho4=.05, rho3=.15, rho2=.15,
                  omega4=.50, omega3=.50, omega2=.50,
                  n=10, J=2, K=10)


## End(Not run)
```

---

mrss.bcra4r3 — *Model 4.5: MRSS Calculator for 4-Level Random Effects Blocked Cluster Random Assignment Designs, Treatment at Level 3*

Description

`mrss.bcra4r3` calculates minimum required sample size (MRSS) for designs with 4-levels where level 3 units are randomly assigned to treatment and control groups within level 4 units (random blocks).

Usage

```
mrss.bcra4r3(mdes=.25, power=.80, alpha=.05, two.tail=TRUE,
             gm=2, ncase=10, constrain="power",
             n=NULL, J=NULL, K=NULL, L=NULL, L0=10, tol=.10,
             rho2, rho3, rho4, omega4,
             P=.50, R12=0, R22=0, R32=0, RT42=0, g4=0)
```

Arguments

`mdes`	minimum detectable effect size.
`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.
`gm`	grid multiplier to increase the range of sample size search for each level.
`ncase`	number of cases to show in the output.
`constrain`	parameter to constrain; `"cost"`, `"power"`, or `"mdes"`.
`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 3 units (or simple average).
`L`	number of level 4 units.
`L0`	starting value for estimating number of level 4 units.
`tol`	tolerance to stop the search algorithm.

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.

Details

Level 4 sample size (L) is calculated using an iterative procedure described in Dong & Maynard (2013) due to model degrees of freedom dependency on L. For other levels (n, J and K) MRSS calculation is simply solving for the unknown. MRSS calculator returns values that are not integer. Rounding may produce MDES and power values different from what was specified, therefore an integer solution is approximated using brute force (See Value section). Integer solution to MRSS for an omitted level assumes that specified sample sizes for remaining levels may subject to some changes.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MRSS calculation.
round.mrss	solution after rounding.
integer.mrss	best integer solutions around round.mrss solution.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

mdes.bcra4r3, power.bcra4r3, optimal.bcra4r3

Examples

```
## Not run:

     mrss.bcra4r3(rho4=.05, rho3=.15, rho2=.15,
                  omega4=.50,
                  n=10, J=2, K=10)


## End(Not run)
```

---

mrss.bira2c1 *Model 2.1: MRSS Calculator for 2-Level Constant Effects Blocked Individual Random Assignment Designs, Treatment at Level 1*

Description

mrss.bira2c1 calculates minimum required sample size (MRSS) for designs with 2-levels where level 1 units are randomly assigned to treatment and control groups within level 2 units (school intercepts only).

Usage

```
mrss.bira2c1(mdes=.25, power=.80, alpha=.05, two.tail=TRUE,
             gm=2, ncase=10, constrain="power",
             n=NULL, J=NULL, J0=10, n0=10, tol=.10,
             P=.50, g1=0, R12=0)
```

Arguments

mdes	minimum detectable effect size.
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.
gm	grid multiplier to increase the range of sample size search for each level.
ncase	number of cases to show in the output.
constrain	parameter to constrain; "cost", "power", or "mdes".
n	harmonic mean of level 1 units across level 2 units (or simple average).
J	level 2 sample size.
n0	starting value for estimating number of level 1 units.
J0	starting value for estimating number of level 2 units.
tol	tolerance to stop the search algorithm.
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.

Details

Level 2 and level 1 sample sizes (`J` and `n`) are calculated using an iterative procedure described in Dong & Maynard (2013) due to model degrees of freedom dependency on `J` and `n`. MRSS calculator returns values that are not integer. Rounding may produce MDES and power values different from what was specified, therefore an integer solution is approximated using brute force (See Value section). Integer solution to MRSS for an omitted level assumes that specified sample sizes for remaining levels may subject to some changes.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in MRSS calculation.
`round.mrss`	solution after rounding.
`integer.mrss`	best integer solutions around `round.mrss` solution.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

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

Examples

```
## Not run:

    mrss.bira2c1(n=83)


## End(Not run)
```

`mrss.bira2f1` *Model 2.2: MRSS Calculator for 2-Level Fixed Effects Blocked Individual Random Assignment Designs, Treatment at Level 1*

Description

`mrss.bira2f1` calculates minimum required sample size (MRSS) for designs with 2-levels where level 1 units are randomly assigned to treatment and control groups within level 2 units (fixed blocks).

Usage

```
mrss.bira2f1(mdes=.25, power=.80, alpha=.05, two.tail=TRUE,
            gm=2, ncase=10, constrain="power",
            n=NULL, J=NULL, J0=10, n0=10, tol=.10,
            P=.50, g1=0, R12=0)
```

Arguments

`mdes`	minimum detectable effect size.
`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.
`gm`	grid multiplier to increase the range of sample size search for each level.
`ncase`	number of cases to show in the output.
`constrain`	parameter to constrain; `"cost"`, `"power"`, or `"mdes"`.
`n`	harmonic mean of level 1 units across level 2 units (or simple average).
`J`	level 2 sample size.
`n0`	starting value for estimating number of level 1 units.
`J0`	starting value for estimating number of level 2 units.
`tol`	tolerance to stop the search algorithm.
`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.

Details

Level 2 and level 1 sample sizes (`J` and `n`) are calculated using an iterative procedure described in Dong & Maynard (2013) due to model degrees of freedom dependency on `J` and `n`. MRSS calculator returns values that are not integer. Rounding may produce MDES and power values different from what was specified, therefore an integer solution is approximated using brute force (See Value section). Integer solution to MRSS for an omitted level assumes that specified sample sizes for remaining levels may subject to some changes.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in MRSS calculation.
`round.mrss`	solution after rounding.
`integer.mrss`	best integer solutions around `round.mrss` solution.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

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

Examples

```
## Not run:

     mrss.ira2f1(n=83)


## End(Not run)
```

mrss.bira2r1 — *Model 2.3: MRSS Calculator for 2-Level Random Effects Blocked Individual Random Assignment Designs, Individuals Randomized within Blocks*

Description

mrss.bira2r1 calculates minimum required sample size (MRSS) for designs with 2-levels where level 1 units are randomly assigned to treatment and control groups within level 2 units (random blocks).

Usage

```
mrss.bira2r1(mdes=.25, power=.80, alpha=.05, two.tail=TRUE,
             gm=2, ncase=10, constrain="power",
             n=NULL, J=NULL, J0=10, tol=.10,
             rho2, omega2,
             g2=0, P=.50, R12=0, RT22=0)
```

Arguments

mdes	minimum detectable effect size.
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.
gm	grid multiplier to increase the range of sample size search for each level.
ncase	number of cases to show in the output.
constrain	parameter to constrain; "cost", "power", or "mdes".
n	harmonic mean of level 1 units across level 2 units (or simple average).
J	level 2 sample size.
J0	starting value for estimating number of level 2 units.
tol	tolerance to stop the search algorithm.
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.
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.

Details

Level 2 sample size (J) is calculated using an iterative procedure described in Dong & Maynard (2013) due to model degrees of freedom dependency on J. For other level (n) MRSS calculation is simply solving for the unknown. MRSS calculator returns values that are not integer. Rounding may produce MDES and power values different from what was specified, therefore an integer solution is approximated using brute force (See Value section). Integer solution to MRSS for an omitted level assumes that specified sample sizes for remaining levels may subject to some changes.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in MRSS calculation.
`round.mrss`	solution after rounding.
`integer.mrss`	best integer solutions around `round.mrss` solution.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

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

Examples

```
## Not run:

     mrss.bira2r1(rho2=.35, omega2=.10,
                  n=83)


## End(Not run)
```

mrss.bira3r1 — *Model 2.4: MRSS Calculator for 3-Level Random Effects Blocked Individual Random Assignment Design, Individuals Randomized within Blocks*

Description

mrss.bira3r1 calculates minimum required sample size for designs with 3-levels where level 1 units are randomly assigned to treatment and control groups within level 2 units (random blocks).

Usage

```
mrss.bira3r1(mdes=.25, power=.80, alpha=.05, two.tail=TRUE,
            gm=2, ncase=10, constrain="power",
            n=NULL, J=NULL, K=NULL, K0=10, tol=.10,
            rho2, rho3, omega2, omega3,
            P=.50, R12=0, RT22=0, RT32=0, g3=0)
```

Arguments

mdes	minimum detectable effect size.
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.
gm	grid multiplier to increase the range of sample size search for each level.
ncase	number of cases to show in the output.
constrain	parameter to constrain; "cost", "power", or "mdes".
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.
K0	starting value for estimating number of level 3 units.
tol	tolerance to stop the search algorithm.
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.
P	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.

Details

Level 3 sample size (K) is calculated using an iterative procedure described in Dong & Maynard (2013) due to model degrees of freedom dependency on K. For other levels (n, and J) MRSS calculation is simply solving for the unknown. MRSS calculator returns values that are not integer. Rounding may produce MDES and power values different from what was specified, therefore an integer solution is approximated using brute force (See Value section). Integer solution to MRSS for an omitted level assumes that specified sample sizes for remaining levels may subject to some changes.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MRSS calculation.
round.mrss	solution after rounding.
integer.mrss	best integer solutions around round.mrss solution.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

mdes.bira3r1, power.bira3r1, optimal.bira3r1

Examples

```
## Not run:

    mrss.bira3r1(rho3=.20, rho2=.15, omega3=.10, omega2=.10,
                 n=69, J=10)


## End(Not run)
```

`mrss.bira4r1` *Model 2.5: MRSS Calculator for 4-Level Random Effects Blocked Individual Random Assignment Design, Individuals Randomized within Blocks*

Description

`mrss.bira4r1` calculates minimum required sample size (MRSS) for designs with 4-levels where level 1 units are randomly assigned to treatment and control groups within level 2 units (random blocks).

Usage

```
mrss.bira4r1(mdes=.25, power=.80, alpha=.05, two.tail=TRUE,
             gm=2, ncase=10, constrain="power",
             n=NULL, J=NULL, K=NULL, L=NULL, L0=10, tol=.10,
             rho2, rho3, rho4, omega2, omega3, omega4,
             P=.50, R12=0, RT22=0, RT32=0, RT42=0, g4=0)
```

Arguments

`mdes`	minimum detectable effect size.
`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.
`gm`	grid multiplier to increase the range of sample size search for each level.
`ncase`	number of cases to show in the output.
`constrain`	parameter to constrain; `"cost"`, `"power"`, or `"mdes"`.
`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 3 units (or simple average).
`L`	number of level 4 units.
`L0`	starting value for estimating number of level 4 units.
`tol`	tolerance to stop the search algorithm.
`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.
P	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.

Details

Level 4 sample size (L) is calculated using an iterative procedure described in Dong & Maynard (2013) due to model degrees of freedom dependency on L. For other levels (n, J and K) MRSS calculation is simply solving for the unknown. MRSS calculator returns values that are not integer. Rounding may produce MDES and power values different from what was specified, therefore an integer solution is approximated using brute force (See Value section). Integer solution to MRSS for an omitted level assumes that specified sample sizes for remaining levels may subject to some changes.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MRSS calculation.
round.mrss	solution after rounding.
integer.mrss	best integer solutions around round.mrss solution.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

mdes.bira4r1, power.bira4r1, optimal.bira4r1

Examples

```
## Not run:

     mrss.bira4r1(rho4=.05, rho3=.15, rho2=.15,
                  omega4=.50, omega3=.50, omega2=.50,
                  n=10, J=2, K=10)


## End(Not run)
```

`mrss.cra2r2` *Model 3.1: MRSS Calculator for 2-Level Cluster Random Assignment Design, Treatment at Level 2*

Description

`mrss.cra2r2` calculates minimum required sample size (MRSS) for designs with 2-levels where level 2 units are randomly assigned to treatment and control groups.

Usage

```
mrss.cra2r2(mdes=.25, power=.80, alpha=.05, two.tail=TRUE,
            gm=2, ncase=10, constrain="power",
            n=NULL, J=NULL, J0=10, tol=.10,
            rho2,
            g2=0, P=.50, R12=0, R22=0)
```

Arguments

`mdes`	minimum detectable effect size.
`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.
`gm`	grid multiplier to increase the range of sample size search for each level.
`ncase`	number of cases to show in the output.
`constrain`	parameter to contrain; `"cost"`, `"power"`, or `"mdes"`.
`n`	harmonic mean of level 1 units across level 2 units (or simple average).
`J`	level 2 sample size.
`J0`	starting value for estimating number of level 2 units.
`tol`	tolerance to stop the search algorithm.
`rho2`	proportion of variance in the outcome explained by level 2 units.
`P`	average 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.

Details

Level 2 sample size (J) is calculated using an iterative procedure described in Dong & Maynard (2013) due to model degrees of freedom dependency on J. For other level (n) MRSS calculation is simply solving for the unknown. MRSS calculator returns values that are not integer. Rounding may produce MDES and power values different from what was specified, therefore an integer solution is approximated using brute force (See Value section). Integer solution to MRSS for an omitted level assumes that specified sample sizes for remaining levels may subject to some changes.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in MRSS calculation.
`round.mrss`	solution after rounding.
`integer.mrss`	best integer solutions around `round.mrss` solution.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

`mdes.cra2r2`, `power.cra2r2`, `optimal.cra2r2`

Examples

```
## Not run:

     mrss.cra2r2(rho2=.35,
                 n=83)


## End(Not run)
```

`mrss.cra3r3` *Model 3.2: MRSS Calculator for 3-Level Cluster Random Assignment Designs, Treatment at Level 3*

Description

`mrss.cra3r3` calculates minimum required sample size for designs with 3-levels where level 3 units are randomly assigned to treatment and control groups.

Usage

```
mrss.cra3r3(mdes=.25, power=.80, alpha=.05, two.tail=TRUE,
            gm=2, ncase=10, constrain="power",
            n=NULL, J=NULL, K=NULL, K0=10, tol=.10,
            rho2, rho3,
            P=.50, g3=0, R12=0, R22=0, R32=0)
```

Arguments

`mdes`	minimum detectable effect size.
`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.
`gm`	grid multiplier to increase the range of sample size search for each level.
`ncase`	number of cases to show in the output.
`constrain`	parameter to contrain; `"cost"`, `"power"`, or `"mdes"`.
`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.
`K0`	starting value for estimating number of level 3 units.
`tol`	tolerance to stop the search algorithm.
`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.

Details

Level 3 sample size (K) is calculated using an iterative procedure described in Dong & Maynard (2013) due to model degrees of freedom dependency on K. For other levels (n, and J) MRSS calculation is simply solving for the unknown. MRSS calculator returns values that are not integer. Rounding may produce MDES and power values different from what was specified, therefore an integer solution is approximated using brute force (See Value section). Integer solution to MRSS for an omitted level assumes that specified sample sizes for remaining levels may subject to some changes.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in MRSS calculation.
`round.mrss`	solution after rounding.
`integer.mrss`	best integer solutions around `round.mrss` solution.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

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

Examples

```
## Not run:

     mrss.cra3r3(rho3=.06, rho2=.17,
                 n=15, J=3)


## End(Not run)
```

mrss.cra4r4 *Model 3.3: MRSS Calculator for 4-Level Cluster Random Assignment Designs, Treatment at Level 4*

Description

mrss.cra4r4 calculates minimum required sample size (MRSS) for designs with 4-levels where level 4 units are randomly assigned to treatment and control groups.

Usage

```
mrss.cra4r4(mdes=.25, power=.80, alpha=.05, two.tail=TRUE,
            gm=2, ncase=10, constrain="power",
            n=NULL, J=NULL, K=NULL, L=NULL, L0=10, tol=.10,
            rho2, rho3, rho4,
            P=.50, R12=0, R22=0, R32=0, R42=0, g4=0)
```

Arguments

mdes	minimum detectable effect size.
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.
gm	grid multiplier to increase the range of sample size search for each level.
ncase	number of cases to show in the output.
constrain	parameter to constrain; "cost", "power", or "mdes".
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 3 units (or simple average).
L	number of level 4 units.
L0	starting value for estimating number of level 4 units.
tol	tolerance to stop the search algorithm.
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.
P	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.

Details

Level 4 sample size (L) is calculated using an iterative procedure described in Dong & Maynard (2013) due to model degrees of freedom dependency on L. For other levels (n, J and K) MRSS calculation is simply solving for the unknown. MRSS calculator returns values that are not integer. Rounding may produce MDES and power values different from what was specified, therefore an integer solution is approximated using brute force (See Value section). Integer solution to MRSS for an omitted level assumes that specified sample sizes for remaining levels may subject to some changes.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in MRSS calculation.
`round.mrss`	solution after rounding.
`integer.mrss`	best integer solutions around `round.mrss` solution.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

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

Examples

```
## Not run:

    mrss.cra4r4(rho4=.05, rho3=.05, rho2=.10,
                n=10, J=2, K=3)


## End(Not run)
```

mrss.ira1r1 *Model 1.0: MRSS Calculator for Individual Random Assignment Designs, Completely Randomized Controlled Trials*

Description

mrss.ira1r1 calculates minimum required sample size (MRSS) for completely randomized controlled trials where individuals are randomly assigned to treatment and control groups.

Usage

```
mrss.ira1r1(mdes=.25, power=.80, alpha=.05, two.tail=TRUE,
            gm=10, ncase=10, constrain="power", n=NULL, n0=10, tol=.10,
            P=.50, g1=0, R12=0)
```

Arguments

mdes	minimum detectable effect size.
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.
gm	grid multiplier to increase the range of sample size search.
ncase	number of cases to show in the output.
constrain	parameter to constrain; "cost", "power", or "mdes".
n	included for consistency, it should remain NULL.
n0	starting value for n
tol	tolerance to stop the search algorithm.
P	proportion of units randomly assigned to treatment.
g1	number of covariates.
R12	proportion of variance in the outcome explained by covariates.

Details

Sample size n) is calculated using an iterative procedure described in Dong & Maynard (2013) due to model degrees of freedom dependency on n.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in MRSS calculation.
round.mrss	solution after rounding.
integer.mrss	best integer solutions around round.mrss solution.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

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

Examples

```
## Not run:

    mrss.ira1r1(n=83)


## End(Not run)
```

`mrss.to.mdes` *MRSS to MDES*

Description

`mrss.to.mdes` converts an object returned from `mrss` function into an object returned from `mdes` function.

Usage

```
mrss.to.mdes(design)
```

Arguments

`design`	an object returned from one of the `mrss` functions.

Details

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

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

See Also

mrss.to.power, optimal.to.mdes, optimal.to.power

Examples

```
## Not run:

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


## End(Not run)
```

`mrss.to.power` *MRSS to Power*

Description

`mrss.to.power` converts an object returned from `mrss` function into an object returned from `power` function.

Usage

```
mrss.to.power(design)
```

Arguments

`design`	an object returned from one of the `mrss` functions.

Details

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

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

See Also

mrss.to.mdes, optimal.to.mdes, optimal.to.power

Examples

```
## Not run:

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


## End(Not run)
```

---

optimal.bcra3f2 — *Model 4.1: COSA Solver for 3-Level Fixed Effects Blocked Cluster Random Assignment Designs, Treatment at Level 2*

Description

`optimal.bcra3f2` finds constrained optimal sample allocation (COSA) solutions for designs with 3-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

```
optimal.bcra3f2(cn, cJ, cK, cost=NULL, n=NULL, J=NULL, K=NULL,
                power=.80, mdes=.25, alpha=.05, two.tail=TRUE,
                nJK0=c(10,10,10), ncase=10, gm=2,
                constrain="cost", optimizer="auglag_cobyla",
                rho2,
                P=.50, g2=0,  R12=0, R22=0)
```

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.
`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.
nJK0	vector with a length of three to specifiy starting values for level 1, level 2, and level 3 sample sizes.
ncase	number of cases to show in the output.
gm	grid multiplier to increase the range of sample size search for each level.
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".
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.

Details

Constrained optimal sample allocation (COSA; Hedges & Borenstein, 2014; Raudenbush, 1997; Raudenbush & Liu, 2000) problems are solved using nloptr (Ypma, 2014) package, an implementation of NLopt (Johnson, n.d.) in R (R Core Team, 2016). More specifically, Augmented Lagrangian method is used for global optimization (AUGLAG, Birgin & Martines, 2008; Conn, Gould, & Toint, 1991) in conjuction with one of the following local optimization algorithms: Constrained Optimization by Linear Approximations (COBYLA, Powell, 1994), Low Storage BFGS (LBFGS, Liu & Nocedal, 1989), Method of Moving Asymptotes (MMA, Svanberg, 2002), or Sequental Least-Squares Quadratic Programming (SLSQP, Kraft, 1988). See NLopt website for a brief summary.

nloptr returns values that are not integer. Rounding may produce cost, power or MDES values different from what was specified. A better solution is approximated using brute force. If the constrained value (cost, power or MDES) in the output deviates from what was specified, increasing grid multiplier (gm) often solves the problem. More cases can be printed by increasing ncase.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in the function.
nloptr	list of nloptr log and output.
round.optim	solution after rounding. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).
integer.optim	best integer solutions around round.optim solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

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See Also

mdes.bcra3f2, power.bcra3f2, mrss.bcra3f2

Examples

```
## Not run:

     optimal.bcra3f2(cn=1, cJ=10, cK=100, cost=5600,
                     constrain="cost",
                     rho2=.10)


## End(Not run)
```

`optimal.bcra3r2` *Model 4.2: COSA Solver for 3-Level Random Effects Blocked Cluster Random Assignment Designs, Treatment at Level 2*

Description

`optimal.bcra3r2` finds constrained optimal sample allocation (COSA) solutions for designs with 3-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

```
optimal.bcra3r2(cn, cJ, cK, cost=NULL, n=NULL, J=NULL, K=NULL,
                power=.80, mdes=.25, alpha=.05, two.tail=TRUE,
                nJK0=c(10,10,10), ncase=10, gm=2,
                constrain="cost", optimizer="auglag_cobyla",
                rho2, rho3, omega3,
                P=.50, g3=0, R12=0, R22=0, RT32=0)
```

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.
`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.
nJK0	vector with a length of three to specifiy starting values for level 1, level 2, and level 3 sample sizes.
ncase	number of cases to show in the output.
gm	grid multiplier to increase the range of sample size search for each level.
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".
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.

Details

Constrained optimal sample allocation (COSA; Hedges & Borenstein, 2014; Raudenbush, 1997; Raudenbush & Liu, 2000) problems are solved using nloptr (Ypma, 2014) package, an implementation of NLopt (Johnson, n.d.) in R (R Core Team, 2016). More specifically, Augmented Lagrangian method is used for global optimization (AUGLAG, Birgin & Martines, 2008; Conn, Gould, & Toint, 1991) in conjuction with one of the following local optimization algorithms: Constrained Optimization by Linear Approximations (COBYLA, Powell, 1994), Low Storage BFGS (LBFGS, Liu & Nocedal, 1989), Method of Moving Asymptotes (MMA, Svanberg, 2002), or Sequental Least-Squares Quadratic Programming (SLSQP, Kraft, 1988). See NLopt website for a brief summary.

nloptr returns values that are not integer. Rounding may produce cost, power or MDES values different from what was specified. A better solution is approximated using brute force. If the constrained value (cost, power or MDES) in the output deviates from what was specified, increasing grid multiplier (gm) often solves the problem. More cases can be printed by increasing ncase.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in the function.
nloptr	list of nloptr log and output.

`round.optim` solution after rounding. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

`integer.optim` best integer solutions around `round.optim` solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

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Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. V., & Borenstein, M. (2014). Conditional Optimal Design in Three- and Four-Level Experiments. *Journal of Educational and Behavioral Statistics, 39(4)*, 257-281

Hedges, L. & Rhoads, C.(2009). Statistical Power Analysis in Education Research (NCSER 2010-3006). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at http://ies.ed.gov/ncser/.

Johnson, S. G. (n.d.). The NLopt nonlinear-optimization package. Package available at http://ab-initio.mit.edu/nlopt.

Kraft, D. (1988). A software package for sequential quadratic programming. Obersfaffeuhofen, Germany: DFVLR.

Liu, D. C., & Nocedal, J. (1989). On the limited memory BFGS method for large scale optimization. *Mathematical programming, 45(1-3)*, 503-528.

Powell, M. J. (1994). A direct search optimization method that models the objective and constraint functions by linear interpolation. In Advances in optimization and numerical analysis (pp. 51-67). Springer Netherlands.

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Raudenbush, S. W. (1997). Statistical analysis and optimal design for cluster randomized trials. *Psychological Methods, 2*, 173-185.

Raudenbush, S. W., & Liu, X. (2000). Statistical power and optimal design for multisite trials. *Psychological Methods, 5*, 199-213.

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Ypma, J. (2014). `nloptr`: R interface to NLopt. R package version 1.0.4. Package available at https://cran.r-project.org/package=nloptr

See Also

mdes.bcra3r2, power.bcra3r2, mrss.bcra3r2

Examples

```
## Not run:

     optimal.bcra3r2(cn=1, cJ=10, cK=100, cost=5600,
                     constrain="cost",
                     rho3=.13, rho2=.10, omega3=.40)


## End(Not run)
```

---

optimal.bcra4f3 *Model 4.4: COSA Solver for 4-Level Fixed Effects Blocked Cluster Random Assignment Designs, Treatment at Level 3*

Description

optimal.bcra4f3 finds constrained optimal sample allocation (COSA) solutions for designs with 4-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 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

```
optimal.bcra4f3(cn, cJ, cK, cL, cost=NULL, n=NULL, J=NULL, K=NULL, L=NULL,
                power=.80, mdes=.25, alpha=.05, two.tail=TRUE,
                nJKL0=c(10,10,10,10), ncase=10, gm=2,
                constrain="cost", optimizer="auglag_cobyla",
                rho3, rho2,
                P=.50, g3=0, R32=0, R22=0, R12=0)
```

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.
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 3 units (or simple average).
L	number of 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.
nJKL0	vector with a length of four to specifiy starting values for level 1, level 2, level 3, and level 4 sample sizes.
ncase	number of cases to show in the output.
gm	grid multiplier to increase the range of sample size search for each level.
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".
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.

Details

Constrained optimal sample allocation (COSA; Hedges & Borenstein, 2014; Raudenbush, 1997; Raudenbush & Liu, 2000) problems are solved using nloptr (Ypma, 2014) package, an implementation of NLopt (Johnson, n.d.) in R (R Core Team, 2016). More specifically, Augmented Lagrangian method is used for global optimization (AUGLAG, Birgin & Martines, 2008; Conn, Gould, & Toint, 1991) in conjuction with one of the following local optimization algorithms: Constrained Optimization by Linear Approximations (COBYLA, Powell, 1994), Low Storage BFGS (LBFGS, Liu & Nocedal, 1989), Method of Moving Asymptotes (MMA, Svanberg, 2002), or Sequental Least-Squares Quadratic Programming (SLSQP, Kraft, 1988). See NLopt website for a brief summary.

nloptr returns values that are not integer. Rounding may produce cost, power or MDES values different from what was specified. A better solution is approximated using brute force. If the constrained value (cost, power or MDES) in the output deviates from what was specified, increasing grid multiplier (gm) often solves the problem. More cases can be printed by increasing ncase.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in the function.
nloptr	list of nloptr log and output.
round.optim	solution after rounding. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).
integer.optim	best integer solutions around round.optim solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

Author(s)

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References

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Conn, A. R., Gould, N. I. M., & Toint, P.L. (1991). A globally convergent augmented Lagrangian algorithm for optimization with general constraints and simple bounds. *SIAM J. Numer. Anal. 28(2)*, 545-572.

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. V., & Borenstein, M. (2014). Conditional Optimal Design in Three- and Four-Level Experiments. *Journal of Educational and Behavioral Statistics, 39(4)*, 257-281

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Liu, D. C., & Nocedal, J. (1989). On the limited memory BFGS method for large scale optimization. *Mathematical programming, 45(1-3)*, 503-528.

Powell, M. J. (1994). A direct search optimization method that models the objective and constraint functions by linear interpolation. In Advances in optimization and numerical analysis (pp. 51-67). Springer Netherlands.

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See Also

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

Examples

```
## Not run:

     optimal.bcra4f3(cn=1, cJ=10, cK=100, cL=1000, cost=75600,
                     constrain="cost",
                     rho3=.15, rho2=.20)


## End(Not run)
```

`optimal.bcra4r2` *Model 4.3: COSA Solver for 4-Level Random Effects Block Random Assignment Designs, Treatment at Level 2*

Description

`optimal.bcra4r2` finds constrained optimal sample allocation (COSA) solutions for designs with 4-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

```
optimal.bcra4r2(cn, cJ, cK, cL, cost=NULL, n=NULL, J=NULL, K=NULL, L=NULL,
                power=.80, mdes=.25, alpha=.05, two.tail=TRUE,
                nJKL0=c(10,10,10,10), ncase=10, gm=2,
                constrain="cost", optimizer="auglag_cobyla",
                rho4, rho3, rho2, omega4, omega3,
                P=.50, g4=0, RT42=0, RT32=0, R22=0, R12=0)
```

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.
`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 3 units (or simple average).
`L`	number of 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.
`nJKL0`	vector with a length of four to specifiy starting values for level 1, level 2, level 3, and level 4 sample sizes.
`ncase`	number of cases to show in the output.
`gm`	grid multiplier to increase the range of sample size search for each level.
`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"`.
`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.
`P`	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.

Details

Constrained optimal sample allocation (COSA; Hedges & Borenstein, 2014; Raudenbush, 1997; Raudenbush & Liu, 2000) problems are solved using `nloptr` (Ypma, 2014) package, an implementation of NLopt (Johnson, n.d.) in R (R Core Team, 2016). More specifically, Augmented Lagrangian method is used for global optimization (AUGLAG, Birgin & Martines, 2008; Conn, Gould, & Toint, 1991) in conjuction with one of the following local optimization algorithms: Constrained Optimization by Linear Approximations (COBYLA, Powell, 1994), Low Storage BFGS (LBFGS, Liu & Nocedal, 1989), Method of Moving Asymptotes (MMA, Svanberg, 2002), or Sequental Least-Squares Quadratic Programming (SLSQP, Kraft, 1988). See NLopt website for a brief summary.

`nloptr` returns values that are not integer. Rounding may produce cost, power or MDES values different from what was specified. A better solution is approximated using brute force. If the constrained value (cost, power or MDES) in the output deviates from what was specified, increasing grid multiplier (`gm`) often solves the problem. More cases can be printed by increasing `ncase`.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in the function.
`nloptr`	list of `nloptr` log and output.
`round.optim`	solution after rounding. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).
`integer.optim`	best integer solutions around `round.optim` solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

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See Also

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

Examples

```
## Not run:

    optimal.bcra4r2(cn=1, cJ=10, cK=100, cL=1000, cost=75600,
                    constrain="cost",
                    rho4=.10, rho3=.15, rho2=.20,
                    omega4=.50, omega3=.50)


## End(Not run)
```

`optimal.bcra4r3` *Model 4.5: COSA Solver for 4-Level Random Effects Blocked Cluster Random Assignment Designs, Treatment at Level 3*

Description

optimal.bcra4r3 finds constrained optimal sample allocation (COSA) solutions for designs with 4-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

```
optimal.bcra4r3(cn, cJ, cK, cL, cost=NULL, n=NULL, J=NULL, K=NULL, L=NULL,
                power=.80, mdes=.25, alpha=.05, two.tail=TRUE,
                nJKL0=c(10,10,10,10), ncase=10, gm=2,
                constrain="cost", optimizer="auglag_cobyla",
                rho4, rho3, rho2, omega4,
                P=.50, g4=0, RT42=0, R32=0, R22=0, R12=0)
```

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.
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 3 units (or simple average).
L	number of 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.
nJKL0	vector with a length of four to specifiy starting values for level 1, level 2, level 3, and level 4 sample sizes.
ncase	number of cases to show in the output.
gm	grid multiplier to increase the range of sample size search for each level.
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".
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.

Details

Constrained optimal sample allocation (COSA; Hedges & Borenstein, 2014; Raudenbush, 1997; Raudenbush & Liu, 2000) problems are solved using nloptr (Ypma, 2014) package, an implementation of NLopt (Johnson, n.d.) in R (R Core Team, 2016). More specifically, Augmented Lagrangian method is used for global optimization (AUGLAG, Birgin & Martines, 2008; Conn, Gould, & Toint, 1991) in conjuction with one of the following local optimization algorithms: Constrained Optimization by Linear Approximations (COBYLA, Powell, 1994), Low Storage BFGS (LBFGS, Liu & Nocedal, 1989), Method of Moving Asymptotes (MMA, Svanberg, 2002), or Sequental Least-Squares Quadratic Programming (SLSQP, Kraft, 1988). See NLopt website for a brief summary.

nloptr returns values that are not integer. Rounding may produce cost, power or MDES values different from what was specified. A better solution is approximated using brute force. If the constrained value (cost, power or MDES) in the output deviates from what was specified, increasing grid multiplier (gm) often solves the problem. More cases can be printed by increasing ncase.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in the function.
nloptr	list of nloptr log and output.
round.optim	solution after rounding. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).
integer.optim	best integer solutions around round.optim solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

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See Also

`mdes.bcra4r3`, `power.bcra4r3`, `mrss.bcra4r3`

Examples

```
## Not run:

    optimal.bcra4r3(cn=1, cJ=10, cK=100, cL=1000, cost=75600,
                    constrain="cost",
```

```
                    rho4=.10, rho3=.15, rho2=.20,
                    omega4=.50)

## End(Not run)
```

---

optimal.bira2c1 *Model 2.1: COSA Solver for 2-Level Constant Effects Blocked Individual Random Assignment Designs, Treatment at Level 1*

Description

`optimal.bira2c1` finds constrained optimal sample allocation (COSA) solutions for designs with 2-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

```
optimal.bira2c1(cn, cJ, cost=NULL, n=NULL, J=NULL,
                power=.80, mdes=.25, alpha=.05, two.tail=TRUE,
                nJ0=c(10,10), ncase=10, gm=2,
                constrain="cost", optimizer="auglag_cobyla",
                P=.50, g1=0, R12=0)
```

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.
`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.
`nJ0`	vector with a length of two to specifiy starting values for level 1 and level 2 sample sizes.
`ncase`	number of cases to show in the output.
`gm`	grid multiplier to increase the range of sample size search for each level.

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".
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.

Details

Constrained optimal sample allocation (COSA; Hedges & Borenstein, 2014; Raudenbush, 1997; Raudenbush & Liu, 2000) problems are solved using nloptr (Ypma, 2014) package, an implementation of NLopt (Johnson, n.d.) in R (R Core Team, 2016). More specifically, Augmented Lagrangian method is used for global optimization (AUGLAG, Birgin & Martines, 2008; Conn, Gould, & Toint, 1991) in conjuction with one of the following local optimization algorithms: Constrained Optimization by Linear Approximations (COBYLA, Powell, 1994), Low Storage BFGS (LBFGS, Liu & Nocedal, 1989), Method of Moving Asymptotes (MMA, Svanberg, 2002), or Sequental Least-Squares Quadratic Programming (SLSQP, Kraft, 1988). See NLopt website for a brief summary.

nloptr returns values that are not integer. Rounding may produce cost, power or MDES values different from what was specified. A better solution is approximated using brute force. If the constrained value (cost, power or MDES) in the output deviates from what was specified, increasing grid multiplier (gm) often solves the problem. More cases can be printed by increasing ncase.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in the function.
nloptr	list of nloptr log and output.
round.optim	solution after rounding. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).
integer.optim	best integer solutions around round.optim solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

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Ypma, J. (2014). `nloptr`: R interface to NLopt. R package version 1.0.4. Package available at https://cran.r-project.org/package=nloptr

See Also

mdes.bira2c1, power.bira2c1, mrss.bira2c1

Examples

```
## Not run:

     optimal.bira2c1(cn=1, cJ=10, cost=560,
                     constrain="cost")


## End(Not run)
```

optimal.bira2f1 *Model 2.2: COSA Solver for 2-Level Fixed Effects Blocked Individual Random Assignment Designs, Treatment at Level 1*

Description

`optimal.bira2f1` finds constrained optimal sample allocation (COSA) solutions for designs with 2-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.

Usage

```
optimal.bira2f1(cn, cJ, cost=NULL, n=NULL, J=NULL,
                power=.80, mdes=.25, alpha=.05, two.tail=TRUE,
                nJ0=c(10,10), ncase=10, gm=2,
                constrain="cost", optimizer="auglag_cobyla",
                P=.50, g1=0, R12=0)
```

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.
`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.
`nJ0`	vector with a length of four to specifiy starting values for level 1 and level 2 sample sizes.
`ncase`	number of cases to show in the output.
`gm`	grid multiplier to increase the range of sample size search for each level.
`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"`.
`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.

Details

Constrained optimal sample allocation (COSA; Hedges & Borenstein, 2014; Raudenbush, 1997; Raudenbush & Liu, 2000) problems are solved using `nloptr` (Ypma, 2014) package, an implementation of NLopt (Johnson, n.d.) in R (R Core Team, 2016). More specifically, Augmented Lagrangian method is used for global optimization (AUGLAG, Birgin & Martines, 2008; Conn, Gould, & Toint, 1991) in conjuction with one of the following local optimization algorithms: Constrained Optimization by Linear Approximations (COBYLA, Powell, 1994), Low Storage BFGS (LBFGS, Liu & Nocedal, 1989), Method of Moving Asymptotes (MMA, Svanberg, 2002), or Sequental Least-Squares Quadratic Programming (SLSQP, Kraft, 1988). See NLopt website for a brief summary.

`nloptr` returns values that are not integer. Rounding may produce cost, power or MDES values different from what was specified. A better solution is approximated using brute force. If the constrained value (cost, power or MDES) in the output deviates from what was specified, increasing grid multiplier (`gm`) often solves the problem. More cases can be printed by increasing `ncase`.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in the function.
`nloptr`	list of `nloptr` log and output.
`round.optim`	solution after rounding. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).
`integer.optim`	best integer solutions around `round.optim` solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

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See Also

mdes.bira2f1, power.bira2f1, mrss.bira2f1

Examples

```
## Not run:

     optimal.bira2f1(cn=1, cJ=10, cost=560,
                     constrain="cost")


## End(Not run)
```

---

optimal.bira2r1 — *Model 2.3: COSA Solver for 2-Level Random Effects Blocked Individual Random Assignment Designs, Individuals Randomized within Blocks*

Description

`optimal.bira2r1` finds constrained optimal sample allocation (COSA) solutions for designs with 2-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

```
optimal.bira2r1(cn, cJ, cost=NULL, n=NULL, J=NULL,
                power=.80, mdes=.25, alpha=.05, two.tail=TRUE,
                nJ0=c(10,10), ncase=10, gm=2,
                constrain="cost", optimizer="auglag_cobyla",
                rho2, omega2,
                P=.50, g2=0, R12=0, RT22=0)
```

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.
`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.
`nJ0`	vector with a length of two to specifiy starting values for level 1 and level 2 sample sizes.
`ncase`	number of cases to show in the output.
`gm`	grid multiplier to increase the range of sample size search for each level.
`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"`.
`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.

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.

Details

Constrained optimal sample allocation (COSA; Hedges & Borenstein, 2014; Raudenbush, 1997; Raudenbush & Liu, 2000) problems are solved using nloptr (Ypma, 2014) package, an implementation of NLopt (Johnson, n.d.) in R (R Core Team, 2016). More specifically, Augmented Lagrangian method is used for global optimization (AUGLAG, Birgin & Martines, 2008; Conn, Gould, & Toint, 1991) in conjuction with one of the following local optimization algorithms: Constrained Optimization by Linear Approximations (COBYLA, Powell, 1994), Low Storage BFGS (LBFGS, Liu & Nocedal, 1989), Method of Moving Asymptotes (MMA, Svanberg, 2002), or Sequental Least-Squares Quadratic Programming (SLSQP, Kraft, 1988). See NLopt website for a brief summary.

nloptr returns values that are not integer. Rounding may produce cost, power or MDES values different from what was specified. A better solution is approximated using brute force. If the constrained value (cost, power or MDES) in the output deviates from what was specified, increasing grid multiplier (gm) often solves the problem. More cases can be printed by increasing ncase.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in the function.
nloptr	list of nloptr log and output.
round.optim	solution after rounding. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).
integer.optim	best integer solutions around round.optim solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

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See Also

mdes.bira2r1, power.bira2r1, mrss.bira2r1

Examples

```
## Not run:

    optimal.bira2r1(cn=1, cJ=10, cost=560,
                    constrain="cost", rho2=.20, omega2=.50)


## End(Not run)
```

optimal.bira3r1 — *Model 2.4: COSA Solver for 3-Level Random Effects Blocked Individual Random Assignment Design, Individuals Randomized within Blocks*

Description

`optimal.bira3r1` finds constrained optimal sample allocation (COSA) solutions for designs with 3-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

```
optimal.bira3r1(cn, cJ, cK, cost=NULL, n=NULL, J=NULL, K=NULL,
                power=.80, mdes=.25, alpha=.05, two.tail=TRUE,
                nJK0=c(10,10,10), ncase=10, gm=2,
                constrain="cost", optimizer="auglag_cobyla",
                rho2, rho3, omega2, omega3,
                P=.50, g3=0, R12=0, RT22=0, RT32=0)
```

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.
`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.
`nJK0`	vector with a length of three to specifiy starting values for level 1, level 2, and level 3 sample sizes.
`ncase`	number of cases to show in the output.
`gm`	grid multiplier to increase the range of sample size search for each level.
`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".
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.
P	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.

Details

Constrained optimal sample allocation (COSA; Hedges & Borenstein, 2014; Raudenbush, 1997; Raudenbush & Liu, 2000) problems are solved using nloptr (Ypma, 2014) package, an implementation of NLopt (Johnson, n.d.) in R (R Core Team, 2016). More specifically, Augmented Lagrangian method is used for global optimization (AUGLAG, Birgin & Martines, 2008; Conn, Gould, & Toint, 1991) in conjuction with one of the following local optimization algorithms: Constrained Optimization by Linear Approximations (COBYLA, Powell, 1994), Low Storage BFGS (LBFGS, Liu & Nocedal, 1989), Method of Moving Asymptotes (MMA, Svanberg, 2002), or Sequental Least-Squares Quadratic Programming (SLSQP, Kraft, 1988). See NLopt website for a brief summary.

nloptr returns values that are not integer. Rounding may produce cost, power or MDES values different from what was specified. A better solution is approximated using brute force. If the constrained value (cost, power or MDES) in the output deviates from what was specified, increasing grid multiplier (gm) often solves the problem. More cases can be printed by increasing ncase.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in the function.
nloptr	list of nloptr log and output.
round.optim	solution after rounding. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).
integer.optim	best integer solutions around round.optim solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

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See Also

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

Examples

```
## Not run:

    optimal.bira3r1(cn=1, cJ=10, cK=100, cost=5600,
                    constrain="cost",
                    rho3=.20, rho2=.15, omega3=.10, omega2=.10)


## End(Not run)
```

---

optimal.bira4r1 *Model 2.5: COSA Solver for 4-Level Random Effects Blocked Individual Random Assignment Design, Individuals Randomized within Blocks*

Description

optimal.bira4r1 finds constrained optimal sample allocation (COSA) solutions for designs with 4-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

```
optimal.bira4r1(cn, cJ, cK, cL, cost=NULL, n=NULL, J=NULL, K=NULL, L=NULL,
                power=.80, mdes=.25, alpha=.05, two.tail=TRUE,
                nJKL0=c(10,10,10,10), ncase=10, gm=2,
                constrain="cost", optimizer="auglag_cobyla",
                rho4, rho3, rho2, omega4, omega3, omega2,
                P=.50, g4=0, RT42=0, RT32=0, RT22=0, R12=0)
```

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.
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 3 units (or simple average).
L	number of 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.
nJKL0	vector with a length of four to specifiy starting values for level 1, level 2, level 3, and level 4 sample sizes.
ncase	number of cases to show in the output.
gm	grid multiplier to increase the range of sample size search for each level.
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".
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.
P	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.

Details

Constrained optimal sample allocation (COSA; Hedges & Borenstein, 2014; Raudenbush, 1997; Raudenbush & Liu, 2000) problems are solved using nloptr (Ypma, 2014) package, an implementation of NLopt (Johnson, n.d.) in R (R Core Team, 2016). More specifically, Augmented Lagrangian method is used for global optimization (AUGLAG, Birgin & Martines, 2008; Conn, Gould, & Toint, 1991) in conjuction with one of the following local optimization algorithms: Constrained Optimization by Linear Approximations (COBYLA, Powell, 1994), Low Storage BFGS (LBFGS, Liu & Nocedal, 1989), Method of Moving Asymptotes (MMA, Svanberg, 2002), or Sequental Least-Squares Quadratic Programming (SLSQP, Kraft, 1988). See NLopt website for a brief summary.

nloptr returns values that are not integer. Rounding may produce cost, power or MDES values different from what was specified. A better solution is approximated using brute force. If the constrained value (cost, power or MDES) in the output deviates from what was specified, increasing grid multiplier (gm) often solves the problem. More cases can be printed by increasing ncase.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in the function.
nloptr	list of nloptr log and output.
round.optim	solution after rounding. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).
integer.optim	best integer solutions around round.optim solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

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Ypma, J. (2014). nloptr: R interface to NLopt. R package version 1.0.4. Package available at https://cran.r-project.org/package=nloptr

See Also

mdes.bira4r1, power.bira4r1, mrss.bira4r1

Examples

```
## Not run:

    optimal.bira4r1(cn=1, cJ=10, cK=100, cL=1000, cost=75600,
                    constrain="cost",
                    rho4=.10, rho3=.15, rho2=.20,
                    omega4=.50, omega3=.50, omega2=.50)


## End(Not run)
```

---

optimal.cra2r2 — *Model 3.1: COSA Solver for 2-Level Cluster Random Assignment Design, Treatment at Level 2*

Description

optimal.cra2r2 finds constrained optimal sample allocation (COSA) solutions for designs with 2-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

```
optimal.cra2r2(cn, cJ, cost=NULL, n=NULL, J=NULL,
               power=.80, mdes=.25, alpha=.05, two.tail=TRUE,
               nJ0=c(10,10), ncase=10, gm=2,
               constrain="cost", optimizer="auglag_cobyla",
               rho2,
               P=.50, g2=0, R12=0, R22=0)
```

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.
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.
nJ0	vector with a length of two to specifiy starting values for level 1 and level 2 sample sizes.
ncase	number of cases to show in the output.
gm	grid multiplier to increase the range of sample size search for each level.
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".
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.

Details

Constrained optimal sample allocation (COSA; Hedges & Borenstein, 2014; Raudenbush, 1997; Raudenbush & Liu, 2000) problems are solved using nloptr (Ypma, 2014) package, an implementation of NLopt (Johnson, n.d.) in R (R Core Team, 2016). More specifically, Augmented Lagrangian method is used for global optimization (AUGLAG, Birgin & Martines, 2008; Conn, Gould, & Toint, 1991) in conjuction with one of the following local optimization algorithms: Constrained Optimization by Linear Approximations (COBYLA, Powell, 1994), Low Storage BFGS (LBFGS, Liu & Nocedal, 1989), Method of Moving Asymptotes (MMA, Svanberg, 2002), or Sequental Least-Squares Quadratic Programming (SLSQP, Kraft, 1988). See NLopt website for a brief summary.

nloptr returns values that are not integer. Rounding may produce cost, power or MDES values different from what was specified. A better solution is approximated using brute force. If the constrained value (cost, power or MDES) in the output deviates from what was specified, increasing grid multiplier (gm) often solves the problem. More cases can be printed by increasing ncase.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in the function.
nloptr	list of `nloptr` log and output.
round.optim	solution after rounding. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).
integer.optim	best integer solutions around `round.optim` solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

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Ypma, J. (2014). nloptr: R interface to NLopt. R package version 1.0.4. Package available at https://cran.r-project.org/package=nloptr

See Also

mdes.cra2r2, power.cra2r2, mrss.cra2r2

Examples

```
## Not run:

    optimal.cra2r2(cn=1, cJ=10, cost=560,
                   constrain="cost", rho2=.20)


## End(Not run)
```

---

optimal.cra3r3 *Model 3.2: COSA Solver for 3-Level Cluster Random Assignment Designs, Treatment at Level 3*

Description

optimal.cra3r3 finds constrained optimal sample allocation (COSA) solutions for designs with 3-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

```
optimal.cra3r3(cn, cJ, cK, cost=NULL, n=NULL, J=NULL, K=NULL,
               power=.80, mdes=.25, alpha=.05, two.tail=TRUE,
               nJK0=c(10,10,10), ncase=10, gm=2,
               constrain="cost", optimizer="auglag_cobyla",
               rho2, rho3,
               P=.50, g3=0, R12=0, R22=0, R32=0)
```

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.
`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.
`nJK0`	vector with a length of three to specify starting values for level 1, level 2, and level 3 sample sizes.
`ncase`	number of cases to show in the output.
`gm`	grid multiplier to increase the range of sample size search for each level.
`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"`.
`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.

Details

Constrained optimal sample allocation (COSA; Hedges & Borenstein, 2014; Raudenbush, 1997; Raudenbush & Liu, 2000) problems are solved using `nloptr` (Ypma, 2014) package, an implementation of NLopt (Johnson, n.d.) in R (R Core Team, 2016). More specifically, Augmented Lagrangian method is used for global optimization (AUGLAG, Birgin & Martines, 2008; Conn, Gould, & Toint, 1991) in conjuction with one of the following local optimization algorithms: Constrained Optimization by Linear Approximations (COBYLA, Powell, 1994), Low Storage BFGS (LBFGS, Liu & Nocedal, 1989), Method of Moving Asymptotes (MMA, Svanberg, 2002), or Sequental Least-Squares Quadratic Programming (SLSQP, Kraft, 1988). See NLopt website for a brief summary.

nloptr returns values that are not integer. Rounding may produce cost, power or MDES values different from what was specified. A better solution is approximated using brute force. If the constrained value (cost, power or MDES) in the output deviates from what was specified, increasing grid multiplier (gm) often solves the problem. More cases can be printed by increasing ncase.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in the function.
nloptr	list of nloptr log and output.
round.optim	solution after rounding. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).
integer.optim	best integer solutions around round.optim solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

Author(s)

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Raudenbush, S. W., & Liu, X. (2000). Statistical power and optimal design for multisite trials. *Psychological Methods, 5*, 199-213.

Svanberg, K. (2002). A class of globally convergent optimization methods based on conservative convex separable approximations. *SIAM journal on optimization, 12(2)*, 555-573.

Ypma, J. (2014). nloptr: R interface to NLopt. R package version 1.0.4. Package available at https://cran.r-project.org/package=nloptr

See Also

mdes.cra3r3, power.cra3r3, mrss.cra3r3

Examples

```
## Not run:

    optimal.cra3r3(cn=1, cJ=10, cK=100, cost=5600,
                   constrain="cost",
                   rho3=.06, rho2=.17)


## End(Not run)
```

---

optimal.cra4r4 *Model 3.3: COSA Solver for 4-Level Cluster Random Assignment Designs, Treatment at Level 4*

Description

optimal.cra4r4 finds constrained optimal sample allocation (COSA) solutions for designs with 4-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

```
optimal.cra4r4(cn, cJ, cK, cL, cost=NULL, n=NULL, J=NULL, K=NULL, L=NULL,
               power=.80, mdes=.25, alpha=.05, two.tail=TRUE,
               nJKL0=c(10,10,10,10), ncase=10, gm=2,
               constrain="cost", optimizer="auglag_cobyla",
               rho4, rho3, rho2,
               P=.50, g4=0, R42=0, R32=0, R22=0, R12=0)
```

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.
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 3 units (or simple average).
L	number of 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.
nJKL0	vector with a length of four to specifiy starting values for level 1, level 2, level 3, and level 4 sample sizes.
ncase	number of cases to show in the output.
gm	grid multiplier to increase the range of sample size search for each level.
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"`.
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.
P	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.

Details

Constrained optimal sample allocation (COSA; Hedges & Borenstein, 2014; Raudenbush, 1997; Raudenbush & Liu, 2000) problems are solved using `nloptr` (Ypma, 2014) package, an implementation of NLopt (Johnson, n.d.) in R (R Core Team, 2016). More specifically, Augmented Lagrangian method is used for global optimization (AUGLAG, Birgin & Martines, 2008; Conn, Gould, & Toint, 1991) in conjuction with one of the following local optimization algorithms: Constrained Optimization by Linear Approximations (COBYLA, Powell, 1994), Low Storage BFGS (LBFGS, Liu & Nocedal, 1989), Method of Moving Asymptotes (MMA, Svanberg, 2002), or Sequental Least-Squares Quadratic Programming (SLSQP, Kraft, 1988). See NLopt website for a brief summary.

`nloptr` returns values that are not integer. Rounding may produce cost, power or MDES values different from what was specified. A better solution is approximated using brute force. If the constrained value (cost, power or MDES) in the output deviates from what was specified, increasing grid multiplier (`gm`) often solves the problem. More cases can be printed by increasing `ncase`.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in the function.
`nloptr`	list of `nloptr` log and output.
`round.optim`	solution after rounding. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).
`integer.optim`	best integer solutions around `round.optim` solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

Author(s)

Metin Bulus <`bulus.metin@gmail.com`> Nianbo Dong <`dong.nianbo@gmail.com`>

References

Birgin, E. G., Martinez, J. M. (2008) Improving ultimate convergence of an augmented Lagrangian method. *Optimization Methods and Software 23(2)*, 177-195.

Conn, A. R., Gould, N. I. M., & Toint, P.L. (1991). A globally convergent augmented Lagrangian algorithm for optimization with general constraints and simple bounds. *SIAM J. Numer. Anal. 28(2)*, 545-572.

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. V., & Borenstein, M. (2014). Conditional Optimal Design in Three- and Four-Level Experiments. *Journal of Educational and Behavioral Statistics, 39(4)*, 257-281

Hedges, L. & Rhoads, C.(2009). Statistical Power Analysis in Education Research (NCSER 2010-3006). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at `http://ies.ed.gov/ncser/`.

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Liu, D. C., & Nocedal, J. (1989). On the limited memory BFGS method for large scale optimization. *Mathematical programming, 45(1-3)*, 503-528.

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Raudenbush, S. W. (1997). Statistical analysis and optimal design for cluster randomized trials. *Psychological Methods, 2*, 173-185.

Raudenbush, S. W., & Liu, X. (2000). Statistical power and optimal design for multisite trials. *Psychological Methods, 5*, 199-213.

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Ypma, J. (2014). nloptr: R interface to NLopt. R package version 1.0.4. Package available at https://cran.r-project.org/package=nloptr

See Also

mdes.cra4r4, power.cra4r4, mrss.cra4r4

Examples

```
## Not run:

     optimal.cra4r4(cn=1, cJ=10, cK=100, cL=1000, cost=75600,
                    constrain="cost",
                    rho4=.05, rho3=.05, rho2=.10)


## End(Not run)
```

---

optimal.ira1r1 *Model 1.0: COSA Solver for Individual Random Assignment Designs, Completely Randomized Controlled Trials*

Description

optimal.ira1r1 finds constrained optimal sample allocation (COSA) solutions for completely randomized controlled trials where individuals 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

```
optimal.ira1r1(cn, cost=NULL, n=NULL,
               power=.80, mdes=.25, alpha=.05, two.tail=TRUE,
               N0=c(10), ncase=10, gm=10,
               constrain="cost", optimizer="auglag_cobyla",
               P=.50, g1=0, R12=0)
```

Arguments

`cn`	marginal cost per unit.
`cost`	total cost or budget.
`n`	included for consistency, it should remain `NULL`.
`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 values for n.
`ncase`	number of cases to show in the output.
`gm`	grid multiplier to increase the range of sample size search.
`constrain`	one of the followings can be constrained at a specified cost or value: `"cost"`, `"power"`, or `"mdes"`.
`optimizer`	algorithm to find optimal sample size given total cost, power, or MDES. Available algorithms: `"auglag_cobyla"`, `"auglag_lbfgs"`, `"auglag_mma"`, or `"auglag_slsqp"`.
`P`	proportion of units randomly assigned to treatment.
`g1`	number of covariates.
`R12`	proportion of variance in the outcome explained by covariates.

Details

An optimization is not necessary because the relationship between contraints and optimal sample is straight forward multiplication or division. Therefore use of this function is not recommended. Nonetheless, this function is provided for consistency and convenience.

Further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in the function.
`nloptr`	list of `nloptr` log and output.
`round.optim`	solution after rounding. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).
`integer.optim`	best integer solutions around `round.optim` solution. MDES is calculated at the specified power (default .80), and power is calculated at the specified MDES (default .25).

Author(s)

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References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

See Also

mdes.ira1r1, power.ira1r1, mrss.ira1r1

Examples

```
## Not run:

     optimal.ira1r1(cn=1, cost=560,
                    constrain="cost")


## End(Not run)
```

---

optimal.to.mdes *Optimal to MDES*

Description

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

Usage

```
optimal.to.mdes(design)
```

Arguments

design	an object returned from one of the optimal functions.

Details

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

Author(s)

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See Also

optimal.to.power, mrss.to.mdes, mrss.to.power

Examples

```
## Not run:

     # object returned from optimal function
     design1 <- optimal.bira2r1(cn=1, cJ=10, cost=560,
                                constrain="cost", rho2=.20, omega2=.50)
     # convert the object into an object returned from mdes function
     design2 <- optimal.to.mdes(design1)


## End(Not run)
```

---

optimal.to.power *Optimal to Power*

Description

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

Usage

```
optimal.to.power(design)
```

Arguments

design	an object returned from one of the optimal functions.

Details

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

Author(s)

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See Also

optimal.to.mdes, mrss.to.power, mrss.to.power

Examples

```
## Not run:

     # object returned from optimal function
     design1 <- optimal.bira2r1(cn=1, cJ=10, cost=560,
                                constrain="cost", rho2=.20, omega2=.50)
     # convert the object into an object returned from power function
     design2 <- optimal.to.power(design1)


## End(Not run)
```

`plot.pars` *Plots Duo or Trio Relationships between Statistical Power, MDES, MRSS, and COSA*

Description

`plot` produces two or three dimensional plots (including contour plots) that delineate relationships between statisitcal power, MDES, MRSS and COSA for objects returned from one of the `PowerUpR` functions.

Usage

```
  ## S3 method for class 'pars'
plot(x, pars=c("power","mdes",NA), type="p",
       left.right.angle=30, up.down.angle=30, nlevels=10,
       mdes.seq=NULL, power.seq=NULL, mrss.seq=NULL,...)
```

Arguments

`x`	an object returned from one of the `PowerUpR` functions.
`pars`	character vector; valid values are `"mdes"`, `"power"`, and depending on the design, any one of the `"n"`, `"J"`, `"K"`, or `"L"`. Default vector `c("power","mdes",NA)` produces a three dimensional plot where `NA` is replaced by top level sample size. To override the default user should replace `NA` with any one of the `"n"`, `"J"`, `"K"`, or `"L"`. Including only two parameters produces two dimensional plot. One of the parameters must be either `"mdes"`, or `"power"`.
`type`	character value; `"p"` for plot, `"c"` for contour.
`left.right.angle`	numeric value; rotates 3D graph from left to right.
`up.down.angle`	numeric value; rotates 3D graph from up to down.
`nlevels`	number of contour levels.
`mdes.seq`	sequence for MDES.
`power.seq`	sequence for power.
`mrss.seq`	sequence for MRSS.
`...`	other graphical parameters.

Details

`plot.pars` produces plots for MDES, power, MRSS, and COSA using objects returned from `PowerUpR` functions. User can plot 2D, 3D or contour plots by specifying `pars` and `type` arguments. By default object returned from `mdes` functions produces plots where MDES is on top axis (either y or z), similarly, object returned from `power` functions produces plots where power is on top axis (either y or z). However user can switch between `mdes` and `power` functions to obtain an alternative plot. For objects returned from `mrss` or `optimal` functions by default MDES is on top axis (either y or z). User can change this by specifying `pars` arguments where its first argument matches with parameter to be plotted on top axis (either y or z).

Author(s)

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See Also

`t1t2.error`, `contour`, `persp`, `plot`

Examples

```
## Not run:

     design1 <- mdes.bira2r1(rho2=.35, omega2=.10,
                            n=83, J=480)
     # MDES against power & J (3D plot)
     plot(design1)
     # MDES against power & J (contour plot)
     plot(design1, type="c")
     # MDES against J (2D plot)
     plot(design1, pars=c("mdes","J"))


## End(Not run)
```

`power.bcra3f2` *Model 4.1: Statistical Power Calculator for 3-Level Fixed Effects Blocked Cluster Random Assignment Design, Treatment at Level 2*

Description

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

Usage

```
power.bcra3f2(mdes=.25, alpha=.05, two.tail=TRUE,
     rho2,
     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.
`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.

Details

Power formula was derived within power analysis framework descibed by Hedges & Rhoads (2009). Further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in power calculation.
`df`	model degrees of freedom
`M`	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
`power`	statistical power (1 - type II error).

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. & Rhoads, C.(2009). Statistical Power Analysis in Education Research (NCSER 2010-3006). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at http://ies.ed.gov/ncser/.

See Also

mdes.bcra3f2, mrss.bcra3f2, optimal.bcra3f2

Examples

```
## Not run:

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


## End(Not run)
```

---

power.bcra3r2 *Model 4.2: Statistical Power Calculator for 3-Level Random Effects Blocked Cluster Random Assignment Designs, Treatment at Level 2*

Description

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

Usage

```
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, ...)
```

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.

Details

Power formula was derived within power analysis framework descibed by Hedges & Rhoads (2009). Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in power calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
power	statistical power (1 - type II error).

Author(s)

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References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. & Rhoads, C.(2009). Statistical Power Analysis in Education Research (NCSER 2010-3006). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at http://ies.ed.gov/ncser/.

See Also

mdes.bcra3r2, mrss.bcra3r2, optimal.bcra3r2

Examples

```
## Not run:

    power.bcra3r2(rho3=.13, rho2=.10, omega3=.40,
                  n=10, J=6, K=24)


## End(Not run)
```

`power.bcra4f3` *Model 4.4: Statistical Power Calculator for 4-Level Fixed Effects Blocked Cluster Random Assignment Designs, Treatment at Level 3*

Description

`power.bcra4f3` calculates statistical power for designs with 4-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 3 units (or simple average).
`L`	number of level 4 units.
`...`	to handle extra parameters passed from other functions, do not define any additional parameters.

Details

Power formula was derived within power analysis framework descibed by Hedges & Rhoads (2009). Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in power calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
power	statistical power (1 - type II error).

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. & Rhoads, C.(2009). Statistical Power Analysis in Education Research (NCSER 2010-3006). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at http://ies.ed.gov/ncser/.

See Also

mdes.bcra4f3, mrss.bcra4f3, optimal.bcra4f3

Examples

```
## Not run:

    power.bcra4f3(rho3=.15, rho2=.15,
                  n=10, J=4, K=4, L=15)

## End(Not run)
```

---

power.bcra4r2 *Model 4.3: Statistical Power Calculator for 4-Level Random Effects Block Random Assignment Designs, Treatment at Level 2*

Description

power.bcra4r2 calculates statistical power for designs with 4-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, ...)
```

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.
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.
P	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 3 units (or simple average).
L	number of level 4 units.
...	to handle extra parameters passed from other functions, do not define any additional parameters.

Details

Power formula was derived within power analysis framework descibed by Hedges & Rhoads (2009). Further definition of design parameters can be found in Dong & Maynard (2013) and Hedges & Rhoads (2009).

Value

fun	function name.
par	list of parameters used in power calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
power	statistical power (1 - type II error).

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. & Rhoads, C.(2009). Statistical Power Analysis in Education Research (NCSER 2010-3006). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at http://ies.ed.gov/ncser/.

See Also

mdes.bcra4r2, mrss.bcra4r2, optimal.bcra4r2

Examples

```
## Not run:

    power.bcra4r2(rho4=.05, rho3=.15, rho2=.15,
                  omega4=.50, omega3=.50,
                  n=10, J=4, L=27, K=4)

## End(Not run)
```

---

power.bcra4r3 — *Model 4.5: Statistical Power Calculator for 4-Level Random Effects Blocked Cluster Random Assignment Designs, Treatment at Level 3*

Description

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

Usage

```
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, ...)
```

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 3 units (or simple average).
`L`	number of level 4 units.
`...`	to handle extra parameters passed from other functions, do not define any additional parameters.

Details

Power formula was derived within power analysis framework descibed by Hedges & Rhoads (2009). Further definition of design parameters can be found in Dong & Maynard (2013) and Hedges & Rhoads (2009).

Value

`fun`	function name.
`par`	list of parameters used in power calculation.
`df`	model degrees of freedom

M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
power	statistical power (1 - type II error).

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. & Rhoads, C.(2009). Statistical Power Analysis in Education Research (NCSER 2010-3006). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at http://ies.ed.gov/ncser/.

See Also

mdes.bcra4r3, mrss.bcra4r3, optimal.bcra4r3

Examples

```
## Not run:

    power.bcra4r3(rho4=.05, rho3=.15, rho2=.15,
                  omega4=.50,
                  n=10, J=4, L=27, K=4)

## End(Not run)
```

---

power.bira2c1 *Model 2.1: Statistical Power Calculator for 2-Level Constant Effects Blocked Individual Random Assignment Designs, Treatment at Level 1*

Description

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

Usage

```
power.bira2c1(mdes=.25, alpha=.05, two.tail=TRUE,
              P=.50, g1=0, R12=0,
              n, J, ...)
```

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.

Details

Power formula was derived within power analysis framework descibed by Hedges & Rhoads (2009). Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in power calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
power	statistical power (1 - type II error).

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. & Rhoads, C.(2009). Statistical Power Analysis in Education Research (NCSER 2010-3006). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at http://ies.ed.gov/ncser/.

See Also

mdes.bira2c1, mrss.bira2c1, optimal.bira2c1

Examples

```
## Not run:

   power.bira2c1(n=55, J=3)


## End(Not run)
```

---

power.bira2f1 *Model 2.2: Statistical Power Calculator for 2-Level Fixed Effects Blocked Individual Random Assignment Designs, Treatment at Level 1*

Description

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

Usage

```
power.bira2f1(mdes=.25, alpha=.05, two.tail=TRUE,
              P=.50, g1=0, R12=0,
              n, J, ...)
```

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.

Details

Power formula was derived within power analysis framework descibed by Hedges & Rhoads (2009). Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in power calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
power	statistical power (1 - type II error).

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. & Rhoads, C.(2009). Statistical Power Analysis in Education Research (NCSER 2010-3006). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at http://ies.ed.gov/ncser/.

See Also

mdes.bira2f1, mrss.bira2f1, optimal.bira2f1

Examples

```
## Not run:

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


## End(Not run)
```

---

power.bira2r1 — *Model 2.3: Statistical Power Calculator for 2-Level Random Effects Blocked Individual Random Assignment Designs, Individuals Randomized within Blocks*

Description

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

Usage

```
power.bira2r1(mdes=.25, alpha=.05, two.tail=TRUE,
              rho2, omega2,
              g2=0, P=.50, R12=0, RT22=0,
              n, J, ...)
```

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	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.
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.

Details

Power formula was derived within power analysis framework descibed by Hedges & Rhoads (2009). Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in power calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
power	statistical power (1 - type II error).

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. & Rhoads, C.(2009). Statistical Power Analysis in Education Research (NCSER 2010-3006). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at http://ies.ed.gov/ncser/.

See Also

mdes.bira2r1, mrss.bira2r1, optimal.bira2r1

Examples

```
## Not run:

   power.bira2r1(rho2=.35, omega2=.10,
                 n=83, J=480)


## End(Not run)
```

---

power.bira3r1 *Model 2.4: Statistical Power Calculator for 3-Level Random Effects Blocked Individual Random Assignment Design, Individuals Randomized within Blocks*

Description

power.bira3r1 calculates statistical power for designs with 3-levels where level 1 units are randomly assigned to treatment and control groups within level 2 units (random blocks).

Usage

```
power.bira3r1(mdes=.25, alpha=.05, two.tail=TRUE,
              rho2, rho3, omega2, omega3,
              P=.50, R12=0, RT22=0, RT32=0, g3=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.
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.
P	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.

Details

Power formula was derived within power analysis framework descibed by Hedges & Rhoads (2009). Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in power calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
power	statistical power (1 - type II error).

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. & Rhoads, C.(2009). Statistical Power Analysis in Education Research (NCSER 2010-3006). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at http://ies.ed.gov/ncser/.

See Also

mdes.bira3r1, mrss.bira3r1, optimal.bira3r1

Examples

```
## Not run:

    power.bira3r1(rho3=.20, rho2=.15, omega3=.10, omega2=.10,
                  n=69, J=10, K=100)

## End(Not run)
```

---

power.bira4r1 *Model 2.5: Statistical Power Calculator for 4-Level Random Effects Blocked Individual Random Assignment Design, Individuals Randomized within Blocks*

Description

power.bira4r1 calculates statistical power for designs with 4-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, ...)
```

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.
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.
P	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 3 units (or simple average).
L	number of level 4 units.
...	to handle extra parameters passed from other functions, do not define any additional parameters.

Details

Power formula was derived within power analysis framework descibed by Hedges & Rhoads (2009). Further definition of design parameters can be found in Dong & Maynard (2013) and Hedges & Rhoads (2009).

Value

fun	function name.
par	list of parameters used in power calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
power	statistical power (1 - type II error).

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. & Rhoads, C.(2009). Statistical Power Analysis in Education Research (NCSER 2010-3006). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at http://ies.ed.gov/ncser/.

See Also

`mdes.bira4r1`, `mrss.bira4r1`, `optimal.bira4r1`

Examples

```
## Not run:

    power.bira4r1(rho4=.05, rho3=.15, rho2=.15,
                  omega4=.50, omega3=.50, omega2=.50,
                  n=10, J=4, L=27, K=4)

## End(Not run)
```

`power.cra2r2` *Model 3.1: Statistical Power Calculator for 2-Level Cluster Random Assignment Design, Treatment at Level 2*

Description

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

Usage

```
power.cra2r2(mdes=.25, alpha=.05, two.tail=TRUE,
             rho2,
             g2=0, P=.50, R12=0, R22=0,
             n, J, ...)
```

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.

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.

Details

Power formula was derived within power analysis framework descibed by Hedges & Rhoads (2009). Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in power calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
power	statistical power (1 - type II error).

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. & Rhoads, C.(2009). Statistical Power Analysis in Education Research (NCSER 2010-3006). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at http://ies.ed.gov/ncser/.

See Also

mdes.cra2r2, mrss.cra2r2, optimal.cra2r2

Examples

```
## Not run:

   power.cra2r2(rho2=.20,
                n=4, J=20)


## End(Not run)
```

`power.cra3r3` *Model 3.2: Statistical Power Calculator for 3-Level Cluster Random Assignment Designs, Treatment at Level 3*

Description

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

Usage

```
power.cra3r3(mdes=.25, alpha=.05, two.tail=TRUE,
             rho2, rho3,
             P=.50, g3=0, R12=0, R22=0, R32=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.
`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.

Details

Power formula was derived within power analysis framework descibed by Hedges & Rhoads (2009). Further definition of design parameters can be found in Dong & Maynard (2013).

Value

fun	function name.
par	list of parameters used in power calculation.
df	model degrees of freedom
M	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
power	statistical power (1 - type II error).

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. & Rhoads, C.(2009). Statistical Power Analysis in Education Research (NCSER 2010-3006). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at http://ies.ed.gov/ncser/.

See Also

mdes.cra3r3, mrss.cra3r3, optimal.cra3r3

Examples

```
## Not run:

    power.cra3r3(rho3=.06, rho2=.17,
                 n=15, J=3, K=60)


## End(Not run)
```

power.cra4r4 *Model 3.3: Statistical Power Calculator for 4-Level Cluster Random Assignment Designs, Treatment at Level 4*

Description

power.cra4r4 calculates statistical power for designs with 4-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.
rho3	proportion of variance in the outcome explained by level 3 units.
rho4	proportion of variance in the outcome explained by level 4 units.
P	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 3 units (or simple average).
L	number of level 4 units.
...	to handle extra parameters passed from other functions, do not define any additional parameters.

Details

Power formula was derived within power analysis framework descibed by Hedges & Rhoads (2009). Further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in power calculation.
`df`	model degrees of freedom
`M`	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
`power`	statistical power (1 - type II error).

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. & Rhoads, C.(2009). Statistical Power Analysis in Education Research (NCSER 2010-3006). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at http://ies.ed.gov/ncser/.

See Also

`mdes.cra4r4`, `mrss.cra4r4`, `optimal.cra4r4`

Examples

```
## Not run:

    power.cra4r4(rho4=.05, rho3=.05, rho2=.10,
                 n=10, J=2, K=3, L=20)

## End(Not run)
```

`power.ira1r1` *Model 1.0: 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 and control groups.

Usage

```
power.ira1r1(mdes=.25, alpha=.05, two.tail=TRUE,
             P=.50, g1=0, R12=0,
             n, ...)
```

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`	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.

Details

Power formula was derived within power analysis framework descibed by Hedges & Rhoads (2009). Further definition of design parameters can be found in Dong & Maynard (2013).

Value

`fun`	function name.
`par`	list of parameters used in power calculation.
`df`	model degrees of freedom
`M`	multiplier for MDES calcuation given model degrees of freedom, α and β (1-power).
`power`	statistical power (1 - type II error).

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

References

Dong & Maynard (2013). PowerUp!: A Tool for Calculating Minum Detectable Effect Sizes and Minimum Required Sample Sizes for Experimental and Quasi-Experimental Design Studies,*Journal of Research on Educational Effectiveness, 6(1)*, 24-6.

Hedges, L. & Rhoads, C.(2009). Statistical Power Analysis in Education Research (NCSER 2010-3006). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. This report is available on the IES website at http://ies.ed.gov/ncser/.

See Also

mdes.ira1r1, mrss.ira1r1, optimal.ira1r1

Examples

```
## Not run:

   power.ira1r1(n=55)


## End(Not run)
```

`t1t2.error` *Plots Type I and Type II Error Rates*

Description

`t1t2.error` plots Type I (α) and Type II (β) error rates using central and noncentral `t` distributions for any objects returned from one of the `PowerUpR` functions.

Usage

```
t1t2.error(x)
```

Arguments

x	an object returned from one of the `PowerUpR` functions.

Details

`t1t2.error` plots Type I (α) and Type II (β) error rates using central and noncentral `t` distributions for any objects returned from one of the `PowerUpR` functions. It is provided for didactic purpose.

Author(s)

Metin Bulus <bulus.metin@gmail.com> Nianbo Dong <dong.nianbo@gmail.com>

See Also

plot.pars

Examples

```
## Not run:

     design1 <- mdes.bira2r1(rho2=.35, omega2=.10,
                             n=83, J=480)
     t1t2.error(design1)


## End(Not run)
```

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