Package 'MSRDT'

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Type Package

Title Multi-State Reliability Demonstration Tests (MSRDT)

Version 0.1.0

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Description This is a implementation of design methods for multi-
state reliability demonstration tests (MSRDT) with failure count data,
which is associated with the work from the published paper ``Multi-state Reliability Demonstration Tests" by Suiyao Chen et al. (2017) <doi:10.1080/08982112.2017.1314493>.
It implements two types of MSRDT, multiple periods (MP) and multiple failure modes (MFM).
For MP, two different scenarios with criteria on cumulative periods (Cum) or separate periods (Sep) are implemented respectively.
It also provides the implementation of conventional design method, namely binomial tests for failure count data.

Depends R (>= 3.3.0)

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Imports gtools, stats, reshape2, dplyr, utils

Suggests tidyverse, knitr, rmarkdown

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BugReports https://github.com/ericchen12377/MSRDT/issues

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`bconsumerrisk` *Consumer's Risk for Binomial RDT*

Description

Define the consumer's risk function which gets the probability of passing the test when the lower level reliability requirement is not satisfied (for binomial RDT).

Usage

```
bconsumerrisk(n, c, pi, R)
```

Arguments

`n`	RDT sample size.
`c`	Maximum allowable failures.
`pi`	Failure probability.
`R`	Lower level reliability requirement.

Value

Probability of consumer's risk

See Also

bcore for getting the core probability of passting the test; boptimal_n for getting the optimal test sample size; bIndicator for getting the binary indicator;

Other Binomial RDT functions: bIndicator(), bcore(), boptimal_n()

Examples

```
pi <- pi_MCSim_beta(M = 1000, seed = 10, a = 1, b = 1)
bconsumerrisk(n = 10, c = 2, pi = pi, R = 0.8);
```

---

bcore *Probability Core for Binomial RDT*

Description

Define the summed core function inside of the integration which gets the probability of passing the test given specific failure probabilities (for binomial RDT).

Usage

```
bcore(n, c, pi)
```

Arguments

n	RDT sample size.
c	Maximum allowable failures.
pi	Failure probability.

Value

Core probability of passing the test given specific failure probabilities.

See Also

boptimal_n for getting the optimal test sample size; bconsumerrisk for getting the consumer's risk; bIndicator for getting the binary indicator;

Other Binomial RDT functions: bIndicator(), bconsumerrisk(), boptimal_n()

Examples

```
bcore(n = 10, c = 2, pi = 0.2)
```

bIndicator *Binary Indicator for Binomial RDT*

Description

Define the binary indicator function to check whether the failure probability satisfies the lower level reliability requirement (for binomial RDT).

Usage

```
bIndicator(pi, R)
```

Arguments

pi	Failure probability.
R	Lower Level reliability requirement.

Value

0 – No; 1 – Yes.

See Also

bcore for getting the core probability of passting the test; boptimal_n for getting the optimal test sample size; bconsumerrisk for getting the consumer's risk;

Other Binomial RDT functions: bconsumerrisk(), bcore(), boptimal_n()

Examples

```
bIndicator(pi = 0.05, R = 0.9)
bIndicator(pi = 0.2, R = 0.9)
```

boptimal_n *Optimal Test Sample Size for Binomial RDT*

Description

Define the optimal function to find the optimal test plan with minimum test sample size given an acceptable level of consumer's risk (for binomial RDT).

Usage

```
boptimal_n(c, pi, R, thres_CR)
```

Arguments

c	Maximum allowable failures
pi	Failure probability
R	Lower level reliability requirement
thres_CR	Threshold (acceptable level) of consumer's risk

Value

Minimum test sample size

See Also

bcore for getting the core probability of passting the test; bconsumerrisk for getting the consumer's risk; bIndicator for getting the binary indicator;

Other Binomial RDT functions: bIndicator(), bconsumerrisk(), bcore()

Examples

```
pi <- pi_MCSim_beta(M = 5000, seed = 10, a = 1, b = 1)
boptimal_n(c = 2, pi = pi, R = 0.8, thres_CR = 0.05)
```

MFM_consumerrisk *Consumer's Risk for Multi-state RDT with Multiple Failure Modes (MFM)*

Description

Define the consumer risk function which gets the probability of passing the test when the lower level reliability requirements are not satisfied under different failure modes (for Multi-state RDT, Multiple Failure Modes).

Usage

```
MFM_consumerrisk(n, cvec, pivec, Rvec)
```

Arguments

n	RDT sample size
cvec	Maximum allowable failures for each separate period
pivec	Failure probability for each seperate period
Rvec	Lower level reliability requirements for each cumulative period from the beginning of the test.

Value

Probability for consumer's risk

See Also

MFM_core for getting the core probability of passting the test; MFM_Indicator for getting the binary indicator; MFM_optimal_n for getting the optimal test sample size;

Other MSRDT for MFM functions: MFM_Indicator(), MFM_core(), MFM_optimal_n()

Examples

```
pi1 <- pi_MCSim_beta(M = 1000, seed = 10, a = 1, b = 1)
pi2 <- pi_MCSim_beta(M = 1000, seed = 10, a = 2, b = 18)
MFM_consumerrisk(n = 10, cvec = c(1, 1), pivec = cbind(pi1, pi2), Rvec = c(0.8, 0.7))
```

MFM_core *Probability Core for Multi-state RDT with Multiple Failure Modes (MFM)*

Description

Define the summed core function inside of the integration which gets the probability of passing the test given specific failure probabilities under different failure modes (for Multi-state RDT, Multiple Failure Modes).

Usage

```
MFM_core(n, cvec, pivec)
```

Arguments

n	RDT sample size
cvec	Maximum allowable failures for each separate period
pivec	Failure probability for each seperate period

Value

Core probability of passing the test given specific failure probabilities

See Also

MFM_consumerrisk for getting the consumer's risk; MFM_Indicator for getting the binary indicator; MFM_optimal_n for getting the optimal test sample size;

Other MSRDT for MFM functions: MFM_Indicator(), MFM_consumerrisk(), MFM_optimal_n()

Examples

```
#' #Example for two failure modes
pi1 <- pi_MCSim_beta(M = 1000, seed = 10, a = 1, b = 1)
pi2 <- pi_MCSim_beta(M = 1000, seed = 10, a = 2, b = 18)
MFM_core(n = 10, cvec = c(1, 1), pivec = c(pi1[1], pi2[1]));
#The function also works for more than two failure modes.
#However, the computation cost may increase.
#Example for three failure modes
MFM_core(n = 10, cvec = c(1, 1, 1), pivec = c(0.8, 0.9, 0.8));
```

MFM_Indicator *Binary Indicator for Multi-state RDT with Multiple Failure Modes (MFM)*

Description

Define the binary indicator function to check whether the failure probability satisfies the lower level reliability requirements for each failure mode (for Multi-state RDT, Multiple Failure Models)

Usage

```
MFM_Indicator(pivec, Rvec)
```

Arguments

pivec	Failure probability for each separate period.
Rvec	Lower level reliability requirements for each cumulative period from the beginning of the test.

Value

0 – No; 1 – Yes.

See Also

MFM_core for getting the core probability of passting the test; MFM_consumerrisk for getting the consumer's risk; MFM_optimal_n for getting the optimal test sample size;

Other MSRDT for MFM functions: MFM_consumerrisk(), MFM_core(), MFM_optimal_n()

Examples

```
MFM_Indicator(pivec = c(0.1, 0.2), Rvec = c(0.8, 0.6))
MFM_Indicator(pivec = c(0.1, 0.2, 0.1), Rvec = c(0.8, 0.6, 0.4))
MFM_Indicator(pivec = c(0.1, 0.4), Rvec = c(0.8, 0.7))
```

MFM_optimal_n *Optimal Test Sample Size for Multi-state RDT with Multiple Failure Modes (MFM)*

Description

Define the optimal function to find the optimal test plan with minimum test sample size given an acceptable level of consumer's risk (for Multi-state RDT, Multiple Failure Modes).

Usage

```
MFM_optimal_n(cvec, pivec, Rvec, thres_CR)
```

Arguments

cvec	Maximum allowable failures for each separate period
pivec	Failure probability for each seperate period
Rvec	Lower level reliability requirements for each cumulative period from the beginning of the test.
thres_CR	Threshold (acceptable level) of consumer's risk

Value

Minimum test sample size

See Also

MFM_core for getting the core probability of passting the test; MFM_consumerrisk for getting the consumer's risk; MFM_Indicator for getting the binary indicator;

Other MSRDT for MFM functions: MFM_Indicator(), MFM_consumerrisk(), MFM_core()

Examples

```
pi1 <- pi_MCSim_beta(M = 5000, seed = 10, a = 1, b = 1)
pi2 <- pi_MCSim_beta(M = 5000, seed = 10, a = 2, b = 18)
MFM_optimal_n(cvec = c(1, 1), pivec = cbind(pi1, pi2), Rvec = c(0.8, 0.7), thres_CR = 0.05)
```

MPCum_consumerrisk — *Consumer's Risk for Multi-state RDT with Multiple Periods and Criteria for Cumulative Periods*

Description

Define the consumer risk function which gets the probability of passing the test when the lower level reliability requirements are not satisfied for any cumulative periods. The maximum allowable failures for each cumulative period need to be satisfied to pass the test (for Multi-state RDT, Multiple Periods, Scenario I)

Usage

```
MPCum_consumerrisk(n, cvec, pivec, Rvec)
```

Arguments

n	RDT sample size
cvec	Maximum allowable failures for each separate period
pivec	Failure probability for each seperate period
Rvec	Lower level reliability requirements for each cumulative period from the beginning of the test.

Value

Probability for consumer's risk

Examples

```
pi <- pi_MCSim_dirichlet(M = 1000, seed = 10, par = c(1, 1, 1))
MPCum_consumerrisk(n = 10, cvec = c(1, 1), pivec = pi, Rvec = c(0.8, 0.7))
```

MPCum_core — *Probability Core for Multi-state RDT with Multiple Periods and Criteria for Cumulative Periods*

Description

Define the summed core function inside of the integration which gets the probability of passing the test given specific failure probabilities. The maximum allowable failures for each cumulative period need to be satisfied to pass the test (for Multi-state RDT, Multiple Periods, Scenario I).

Usage

```
MPCum_core(n, cvec, pivec)
```

Arguments

n	RDT sample size
cvec	Maximum allowable failures for each separate period
pivec	Failure probability for each seperate period

Value

Core probability of passing the test given specific failure probabilities

Examples

```
#Example for two periods
pi <- pi_MCSim_dirichlet(M = 1000, seed = 10, par = c(1, 1, 1))
MPCum_core(n = 10, cvec = c(1, 1), pivec = pi[1, ]);
#The function also works for more than two periods, however, may increase the computation cost.
#Example for three periods
pi <- pi_MCSim_dirichlet(M = 1000, seed = 10, par = c(1, 1, 1, 1))
MPCum_core(n = 10, cvec = c(1, 1, 1), pivec = pi[1, ]);
```

MPCum_optimal_n *Optimal Test Sample Size for Multi-state RDT with Multiple Periods and Criteria for Cumulative Periods*

Description

Define the optimal function to find the optimal test plan with minimum test sample size given an acceptable level of consumer's risk. The maximum allowable failures for each cumulative period need to be satisfied to pass the test (for Multi-state RDT, Multiple Periods, Scenario I)

Usage

```
MPCum_optimal_n(cvec, pivec, Rvec, thres_CR)
```

Arguments

cvec	Maximum allowable failures for each separate period
pivec	Failure probability for each seperate period
Rvec	Lower level reliability requirements for each cumulative period from the beginning of the test.
thres_CR	Threshold (acceptable level) of consumer's risk

Value

Minimum test sample size

Examples

```
pi <- pi_MCSim_dirichlet(M = 5000, seed = 10, par = c(1, 1, 1))
MPCum_optimal_n(cvec = c(1,1), pivec = pi, Rvec = c(0.8, 0.7), thres_CR = 0.05)
```

`MPSep_consumerrisk` *Consumer's Risk for Multi-state RDT with Multiple Periods and Criteria for Separate Periods*

Description

Define the consumer risk function hich gets the probability of passing the test when the lower level reliability requirements are not satisfied for any cumulative periods. The maximum allowable failures for each separate period need to be satisfied to pass the test (for Multi-state RDT, Multiple Periods, Scenario I)

Usage

```
MPSep_consumerrisk(n, cvec, pivec, Rvec)
```

Arguments

`n`	RDT sample size
`cvec`	Maximum allowable failures for each separate period
`pivec`	Failure probability for each seperate period
`Rvec`	Lower level reliability requirements for each cumulative period from the beginning of the test.

Value

Probability for consumer's risk

Examples

```
pi <- pi_MCSim_dirichlet(M = 1000, seed = 10, par = c(1, 1, 1))
MPSep_consumerrisk(n = 10, cvec = c(1, 1), pi = pi, Rvec = c(0.8, 0.7))
```

MPSep_core — *Probability Core for Multi-state RDT with Multiple Periods and Criteria for Separate Periods*

Description

Define the summed core function inside of the integration which gets the probability of passing the test given specific failure probabilities. The maximum allowable failures for each separate period need to be satisfied to pass the test (for Multi-state RDT, Multiple Periods, Scenario II).

Usage

```
MPSep_core(n, cvec, pivec)
```

Arguments

n	RDT sample size
cvec	Maximum allowable failures for each separate period
pivec	Failure probability for each seperate period

Value

Core probability of passing the test given specific failure probabilities

Examples

```
#Example for two periods
pi <- pi_MCSim_dirichlet(M = 1000, seed = 10, par = c(1, 1, 1))
MPSep_core(n = 10, cvec = c(1, 1), pivec = pi[1, ]);
#The function also works for more than two periods, however, may increase the computation cost.
#Example for three periods
pi <- pi_MCSim_dirichlet(M = 1000, seed = 10, par = c(1, 1, 1, 1))
MPSep_core(n = 10, cvec = c(1, 1, 1), pivec = pi[1, ]);
```

MPSep_optimal_n — *Optimal Test Sample Size for Multi-state RDT with Multiple Periods and Criteria for Separate Periods*

Description

Define the optimal function to find the optimal test plan with minimum test sample size given an acceptable level of consumer's risk. The maximum allowable failures for each separate period need to be satisfied to pass the test (for Multi-state RDT, Multiple Periods, Scenario I)

Usage

```
MPSep_optimal_n(cvec, pivec, Rvec, thres_CR)
```

Arguments

cvec	Maximum allowable failures for each separate period
pivec	Failure probability for each seperate period
Rvec	Lower level reliability requirements for each cumulative period from the beginning of the test.
thres_CR	Threshold (acceptable level) of consumer's risk

Value

Minimum test sample size

Examples

```
pi <- pi_MCSim_dirichlet(M = 5000, seed = 10, par = c(1, 1, 1))
MPSep_optimal_n(cvec = c(1, 1), pivec = pi, Rvec = c(0.8, 0.7), thres_CR = 0.05)
```

MP_Indicator *Binary Indicator for Multi-state RDT with Multiple Periods*

Description

Define the binary indicator function to check whether the failure probability satisfies the lower level reliability requirements for each cumulative period (for Multi-state RDT, Multiple Periods)

Usage

```
MP_Indicator(pivec, Rvec)
```

Arguments

pivec	Failure probability for each separate period.
Rvec	Lower level reliability requirements for each cumulative period from the beginning of the test.

Value

0 – No; 1 – Yes.

Examples

```
MP_Indicator(pivec = c(0.1, 0.2), Rvec = c(0.8, 0.6))
MP_Indicator(pivec = c(0.1, 0.2, 0.1), Rvec = c(0.8, 0.6, 0.4))
MP_Indicator(pivec = c(0.1, 0.3), Rvec = c(0.8, 0.7))
```

pi_MCSim_beta *Beta Prior Simulation for Binomial RDT*

Description

Define the simulation function to generate failure probability with Beta prior distributions as conjugate prior to binomial distributions (for binomial RDT).

Usage

```
pi_MCSim_beta(M, seed, a, b)
```

Arguments

M	Simulation sample size
seed	Random seed for random sample
a	Shape parameter 1 for beta distribution
b	Shape parameter 2 for beta distribution

Value

Vector of failure probability sample values

See Also

pi_MCSim_dirichlet

Other Prior distribution generation functions: pi_MCSim_dirichlet()

Examples

```
pi <- pi_MCSim_beta(M = 1000, seed = 10, a = 1, b = 1)
```

pi_MCSim_dirichlet *Dirichlet Prior Simulation for Multi-state RDT*

Description

Define the simulation function to generate failure probability with Dirichlet prior distributions as conjugate prior to multinomial distributions (for multi-state RDT).

Usage

```
pi_MCSim_dirichlet(M, seed, par)
```

Arguments

M	Simulation sample size
seed	Random seed for random sample
par	Parameters for dirichlet distribution

Value

Vector of failure probability sample

See Also

pi_MCSim_beta

Other Prior distribution generation functions: pi_MCSim_beta()

Examples

```
pi <- pi_MCSim_dirichlet(M = 1000, seed = 10, par = c(1, 1, 1))
```

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