

# Package ‘modcmfitr’

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**Title** Fit a Modified Connor-Mosimann Distribution to Elicited  
Quantiles in Multinomial Problems

**Version** 0.1.0

**Date** 2017-10-20

**Description** Fits a modified version of the Connor-Mosimann distribution (Connor & Mosimann (1969)<doi:10.2307/2283728>), a Connor-Mosimann distribution or Dirichlet distribution (e.g. Gelman, Carlin, Stern & Rubin Chapter 3.5 (2004, <ISBN:1-58488-388-X>) to elicited quantiles of a multinomial distribution. Code is also provided to sample from the distributions, generating inputs suitable for a probabilistic sensitivity analysis / Monte Carlo simulation in a decision model.

**Depends** R (>= 3.4.2)

**Imports** gtools (>= 3.5.0), nloptr (>= 1.0.4)

**License** GPL-2

**Encoding** UTF-8

**LazyData** true

**RoxygenNote** 6.0.1

**Suggests** cowplot, ggplot2, tidyr, knitr, rmarkdown

**VignetteBuilder** knitr

**NeedsCompilation** no

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fitDirichlet	<i>Fit Dirichlet distribution</i>
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## Description

This function fits a Dirichlet distribution to an elicited set of quantiles from, e.g. an expert elicitation workshop. The function uses the `crs2lm()` function from the `nloptr` package to search for the set of hyperparameters that generates quantiles that match the elicited data as closely as possible. `crs2lm()` repeatedly calls `TestFitDirichlet()` until it finds the best fitting set of inputs. The function returns a data frame containing the best fit set of hyperparameters of the Dirichlet, the Target quantiles and the modelled quantiles.

## Usage

```
fitDirichlet(Outcomes, RawData, SearchParams, Quantiles)
```

## Arguments

Outcomes	A vector of names of outcomes
RawData	matrix of lower, middle and upper quantiles for each dimension elicited from experts
SearchParams	A vector of number of iterations and max number of searches. Number of iterations is the number of draws from the mCM distribution used to estimate the quantiles. Try 10,000 first. Max number of searches is the maximum number of searches the search algorithm conducts. The higher the better the solution, but also the longer it takes. Try 1000 first.
Quantiles	Sets the quantiles to be fit. If median and 95% Credibility Intervals, then set to <code>c(0.025,0.5,0.975)</code> . If median and tertiles then <code>c(0.33,0.5,0.66)</code> . If median and quartiles then <code>c(0.25,0.5,0.75)</code> and so on.

## Value

Returns a matrix, each row representing one of the Outcomes. Column 'Dirichlet' is the parameters of the Dirichlet distribution. The next three columns (`Tgt_LL`, `Tgt_MED`, `Tgt_UL`) are the target quantiles input to the function as 'RawData' in the example above. The final three (`Mdl_LL`, `Mdl_MED`, `Mdl_UL`) are the quantiles resulting from the model fitting. If the mCM is a good fit, the Mdl columns will be identical to the Tgt columns.

**Examples**

```

Outcomes <- c("Remission","Progression","Dead")
RawData <- matrix(data = c(0.43, 0.55, 0.65,
                          0.16, 0.27, 0.46,
                          0.03, 0.18, 0.23
                          ),ncol=3,byrow=TRUE)

SearchParams <- c(10000,100) #number of iterations, max number of searches

Quantiles <- c(0.025,0.5,0.975) # example here is 95% credibility limits and median.

fitDirichlet(Outcomes, RawData, SearchParams, Quantiles)

```

fitModCM

*Fit modified Connor-Mosimann or Connor-Mosimann distribution***Description**

This function fits a modified CM distribution to an elicited set of quantiles from, e.g. an expert elicitation workshop. The function uses the `crs2lm()` function from the `nloptr` package to search for the set of hyperparameters that that generates quantiles that match the elicited data as closely as possible. `crs2lm()` repeatedly calls `TestFitModCM()` until it finds the best fitting set of inputs. The function returns a data frame containing the best fit set of hyperparameters for the Zeds, the Target quantiles and the modelled quantiles.

**Usage**

```
fitModCM(Outcomes, RawData, SearchParams, ModCMorCM, Quantiles)
```

**Arguments**

Outcomes	A vector of names of outcomes
RawData	matrix of lower, middle and upper quantiles for each dimension elicited from experts
SearchParams	A vector of number of iterations and max number of searches. Number of iterations is the number of draws from the mCM distribution used to estimate the quantiles. Try 10,000 first. Max number of searches is the maximum number of searches the search algorithm conducts. The higher the better the fit, but also the longer it takes to find it.
ModCMorCM	If =1, then will fit a modified CM. If =0 then will fit a CM (i.e. forces lower and upper limits of each marginal scaled beta to 0 and 1 respectively)
Quantiles	Sets the quantiles to be fit. If median and 95% Credibility Interval, then set to <code>c(0.025,0.5,0.975)</code> . If median and tertiles then <code>(0.33,0.5,0.66)</code> . If median and quartiles then <code>c(0.25,0.5,0.75)</code> and so on.

**Value**

Returns a matrix, each row representing one of the Outcomes. Columns a, b, LL and UL are the parameters of the mCM distribution. Note that the final row will always be zeroes as the number of rows of the mCM distribution is k-1 where k is the number of outcomes. The next three columns (Tgt\_LL, Tgt\_MED, Tgt\_UL) are the target quantiles input to the function as 'RawData' in the example above. The final three (Mdl\_LL, Mdl\_MED, Mdl\_UL) are the quantiles resulting from the model fitting. If the mCM is a good fit, the Mdl columns will be identical to the Tgt columns.

**Examples**

```
Outcomes <- c("Remission", "Progression", "Dead")
RawData <- matrix(data = c(0.43, 0.55, 0.65,
                          0.16, 0.27, 0.46,
                          0.03, 0.18, 0.23
                          ), ncol=3, byrow=TRUE)

SearchParams <- c(10000, 100) #number of iterations, max number of searches

ModCMorCM <- 1

Quantiles <- c(0.025, 0.5, 0.975) # example here is 95% credibility limits and median.

fitModCM(Outcomes, RawData, SearchParams, ModCMorCM, Quantiles)
```

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fitMultiplemCM	<i>Fit modified Connor-Mosimann distributions to multiple experts' opinions</i>
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**Description**

This function fits a modified CM distribution to an elicited set of quantiles from multiple experts. It saves time by calculating the results for several experts at once, rather than having to call fitModCM() for each expert. It takes a raw datafile with the elicited quantiles from each expert, divides it up expert by expert, and calls fitModCM() once for each expert, returning a data frame with Zed parameters of the modCM distribution for each, along with the target and modelled quantiles.

**Usage**

```
fitMultiplemCM(Quantiles, SearchParams, RawData)
```

**Arguments**

**Quantiles** Sets the quantiles to be fit. If median and 95% Credibility Intervals, then set to c(0.025,0.5,0.975). If median and tertiles then c(0.33,0.5,0.66). If median and quartiles then c(0.25,0.5,0.75) and so on.

SearchParams	A vector of number of iterations and max number of searches. Number of iterations is the number of draws from the mCM distribution used to estimate the quantiles. 10,000 is a good number to try first. Max number of searches is the maximum number of searches the search algorithm conducts. The higher the better the fit, but also the longer it takes to find it.
RawData	Data frame of data elicited from experts. Must have five columns: expert, outcome, lower quantile, median, upper quantile.

## Value

Returns a matrix, each row representing one of the Outcomes for each expert. Columns a, b, LL and UL are the parameters of the mCM distribution. Note that the final row will always be zeroes as the number of rows of the mCM distribution is  $k-1$  where  $k$  is the number of outcomes. The next three columns (Tgt\_LL, Tgt\_MED, Tgt\_UL) are the target quantiles input to the function as 'RawData' in the example above. The final three (Mdl\_LL, Mdl\_MED, Mdl\_UL) are the quantiles resulting from the model fitting. If the mCM is a good fit, the Mdl columns will be identical to the Tgt columns.

## Examples

```
Quantiles <- c(0.025,0.5,0.975) # to fit median and 95% Credibility Intervals
SearchParams <- c(10000,100) # number of iterations, max number of searches
RawData <- data.frame(expert = as.character(c(1,1,1,2,2,2)),
  Outcome = as.factor(c("Remission","Progression","Dead",
    "Remission","Progression","Dead")),
  LL = as.numeric(c(0.43, 0.16, 0.03, 0.35, 0.15, 0.00)),
  MED = as.numeric(c(0.55, 0.27, 0.18, 0.60, 0.30, 0.10)),
  UL = as.numeric(c(0.65, 0.46, 0.23, 0.70, 0.45, 0.20)))

fitMultiplemCM(Quantiles, SearchParams, RawData)
```

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mergeMultiplemCM

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*Merge multiple modified Connor-Mosimann distributions together*


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## Description

This function merges the results of multiple experts' distributions using a numeric linear pool approach. It samples from the distributions of all experts individually many times (e.g. 100,000), then calculates the overall quantiles and medians from the samples. The function returns a matrix representing the lower, median and upper limits of the pooled distribution. This can then be fed into fitModCM() to generate a modified Connor-Mosimann distribution representing the overall spread of the experts' beliefs.

## Usage

```
mergeMultiplemCM(NrSamples, RawData)
```

**Arguments**

NrSamples	Vector of length 1. Sets the number of samples to draw from each expert's mCM distribution
RawData	Data frame of mCM parameters. Must have six columns: expert, outcome, a, b, L, U of modified Connor-Mosimann distribution. Note last row of parameters will always be zero. Columns 1:6 of the output from function fitMultipleCM() are in the correct format for this.

**Examples**

```
NrSamples <- 100000
RawData <- data.frame(expert = as.character(c(1,1,1,2,2,2)),
  Outcome = as.factor(c("Remission", "Progression", "Dead",
    "Remission", "Progression", "Dead")),
  a = as.numeric(c(6.0786, 0.2245, 0, 6.9214, 4.5259, 0)),
  b = as.numeric(c(7.5900, 0.5866, 0, 1.7187, 3.1892, 0)),
  L = as.numeric(c(0.3400, 0.4839, 0, 0.0152, 0.2390, 0)),
  U = as.numeric(c(0.7917, 0.9213, 0, 0.7106, 0.9970, 0)))
mergeMultipleCM(NrSamples, RawData)
```

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 modcmfitr

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*modcmfitr: A package to fit and sample from a modified Connor-Mosimann distribution*


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**Description**

This package fits a modified Connor-Mosimann (mCM) distribution to quantiles of a multinomial distribution elicited from experts using a process such as the Sheffield Elicitation Framework (SHELF, O'Hagan & Oakley).

**Details**

More details and worked examples are provided in the help files and accompanying vignette. Functions are also provided to fit Connor-Mosimann (CM) and Dirichlet (D) distributions, and to sample from mCM and CM distributions. A function to sample from the Dirichlet distribution is available in the gtools package (Warnes, Bolker & Lumley).

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`rModCM`*Sample from modified Connor-Mosimann distribution*

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**Description**

This function returns n samples from a modified CM distribution

**Usage**

```
rModCM(n, Z)
```

**Arguments**

n	Number of samples
Z	vector of (k-1) scaled beta parameters. Where k=number of dimensions to problem. Columns = (a,b,lower limit, upper limit) of scaled beta distribution

**Examples**

```
n <- 1000
Z <- matrix(data = c(1.098, 3.070, 0.66, 0.85,
                    9.021, 7.990, 0.62, 1,
                    10, 0.01, 0.14, 0.58,
                    10, 10, 0.57, 1), ncol=4, byrow=TRUE)

rModCM(n,Z)
```

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