

Package ‘mixl’

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Type Package

Title Simulated Maximum Likelihood Estimation of Mixed Logit Models for Large Datasets

Version 1.3.5

Description Specification and estimation of multinomial logit models. Large datasets and complex models are supported, with an intuitive syntax. Multinomial Logit Models, Mixed models, random coefficients and Hybrid Choice are all supported. For more information, see Molloy et al. (2021) <<https://www.research-collection.ethz.ch/handle/20.500.11850/477416>>.

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URL <https://github.com/joemolloy/fast-mixed-mnl>

BugReports <https://github.com/joemolloy/fast-mixed-mnl/issues>

Imports maxLik, numDeriv, randtoolbox, Rcpp (>= 0.12.19), readr, sandwich, stats, stringr (>= 1.3.1)

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Contents

mixl-package	2
av_matrix	3
check_draw_inputs	4
check_inputs	4
compileUtilityFunction	5
create_halton_draws	6
estimate	6
extract_av_cols	8
extract_indiv_data	9
generate_default_availabilities	9
posteriors	10
print.mixl	11
print.summary.mixl	12
probabilities	13
specify_model	14
summary.mixl	15
summary_tex	16
utilities	17
vcov.mixl	18
Index	20

mixl-package	<i>Estimate mixed multinomial logit models</i>
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Description

Estimate mixed multinomial logit models using (simulated) maximum likelihood estimation. The package supports standard mnl, mixed-logit and hybrid choice. Using compilation to C++, model estimation is significantly faster than in native R code.

Details

This section should provide a more detailed overview of how to use the package, including the most important functions.

Author(s)

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References

Molloy, J., Becker, F., Schmid, B., & Axhausen, K. W. (2021). mixl: An open-source R package for estimating complex choice models on large datasets. *Journal of choice modelling*, 39, 100284.

Examples

```

data("Train", package="mlogit")
head(Train, 3)
Train$ID <- Train$id
Train$CHOICE <- as.numeric(Train$choice)

mnl_test <- "
  ASC_B_RND = @ASC_B + draw_2 * @SIGMA_B;

  U_A =          @B_price * $price_A / 1000 + @B_time * $time_A / 60 + @B_change * $change_A;
  U_B = ASC_B_RND + @B_price * $price_B / 1000 + @B_timeB * $time_B / 60;
"

model_spec <- mixl::specify_model(mnl_test, Train)

#only take starting values that are needed
est <- stats::setNames(c(0,0,0,0,0,0), c("B_price", "B_time", "B_timeB",
"B_change", "ASC_B", "SIGMA_B"))

availabilities <- mixl::generate_default_availabilities(Train, model_spec$num_utility_functions)

model <- mixl::estimate(model_spec, est, Train, availabilities = availabilities, nDraws = 20)

summary(model)

```

av_matrix

Extract the availabilites matrix from the dataset, using column indicies

Description

Extract the availabilites matrix from the dataset, using column indicies

Usage

```
av_matrix(data, av_cols)
```

Arguments

data The dataset used in the model
av_cols A vector of the the column indicies of the availabilities for each alternative

Value

Matrix of availabilities for alternatives and the number of choice observations

Examples

```

data("Train", package="mlogit")
Train$ID <- Train$id
Train$CHOICE <- as.numeric(Train$choice)
Train$avail_A <- sample(2, replace=TRUE, size=nrow(Train))-1
Train$avail_B <- sample(2, replace=TRUE, size=nrow(Train))-1
av_matrix(Train, c('avail_A', 'avail_B'))

```

check_draw_inputs *Check the inputs to the draw function*

Description

Check the inputs to the draw function

Usage

```
check_draw_inputs(draws, nDraws, draw_dimensions, Nindividuals)
```

Arguments

draws	The specified Model
nDraws	Named vector of proposed start values for the model
draw_dimensions	the dataset on which to estimate
Nindividuals	The availabilities for the alternatives in the model specification

Value

A list consisting of the checked draws and Ndraws, both computed if required)

check_inputs *Check the inputs to the estimate function*

Description

This function checks the start_vlaues, data, availabilities, draws and fixedparams for validity. If this function runs without error, then the inputs are valid for the maxLikelihood function. These checks are important, because an error in the internal C++ code will cause the Rstudio session to crash. Incidentally, if there is concern of this happening, it is recommended to run the script from the command line, using Rscript.

Usage

```
check_inputs(  
  model_spec,  
  start_values,  
  data,  
  availabilities,  
  draws,  
  fixedparam,  
  weights  
)
```

Arguments

model_spec	The specified Model
start_values	Named vector of proposed start values for the model
data	the dataset on which to estimate
availabilities	The availabilities for the alternatives in the model specification
draws	The matrix of random draws
fixedparam	Named vector of parameters to be fixed
weights	The weights vector

Value

Nothing

compileUtilityFunction

compileUtilityFunction *Deprecated, please see [specify_model\(\)](#)*

Description

compileUtilityFunction *Deprecated, please see [specify_model\(\)](#)*

Usage

```
compileUtilityFunction(...)
```

Arguments

... Parameters to `specify_model`

`create_halton_draws` *Create a standard set of Halton draws to use in estimation*

Description

Create a standard set of Halton draws to use in estimation

Usage

```
create_halton_draws(Nindividuals, nDraws, draw_dimensions)
```

Arguments

<code>Nindividuals</code>	The number individuals in the dataset
<code>nDraws</code>	The number of draws needed
<code>draw_dimensions</code>	the number of draw dimensions needed

Value

Matrix of availabilities for alternatives and the number of choice observations

Examples

```
create_halton_draws(100, 10, 5)
create_halton_draws(100, 100, 20)
```

`estimate` *Runs a maximum likelihood estimation on a mixl choice model*

Description

This function performs a maximum likelihood estimation for choice models specified using this package.

Usage

```
estimate(
  model_spec,
  start_values,
  data,
  availabilities,
  draws,
  nDraws,
  fixedparam = c(),
```

```

    num_threads = 1,
    weights = NULL,
    ...
)

```

Arguments

<code>model_spec</code>	The object that contains the loglikelihood function and other variables that help return better error messages. This function is best generated using the specify_model() function.
<code>start_values</code>	A named vector of start values for the estimation. A warning and error will be given respectively if too many values are included or some are missing.
<code>data</code>	A dataframe of the observations. It must include the columns CHOICE and ID, as well as columns for the variables specified in the utility function. The CHOICE variable must be from 1..k, where k is the number of utility functions
<code>availabilities</code>	A 1/0 matrix of availabilities. The dimensions must be <code>nrows(data) * k</code> , where there are k utility functions.
<code>draws</code>	A numeric matrix of draws for calculating mixed effects. If there are no mixed effects, this should be left null. If the model specification included mixed effects, either this or <code>nDraws</code> need to be specified.
<code>nDraws</code>	The number of draws to use in estimating a mixed model. Only needed if <code>draws</code> is left null. Then a matrix of normal halton draws will be generated.
<code>fixedparam</code>	(optional) Coefficients which should be fixed to their starting values during estimation.
<code>num_threads</code>	The maximum number of parallel cores to use in estimation. The default is 1. This should only be specified on machines with an openMP compiler (linux and some OSXs).
<code>weights</code>	(optional) A vector of weights (vector length must equal the number of observations).
<code>...</code>	further arguments. such as <code>control</code> are passed to the maximisation routine in <code>maxLik</code> . See maxLik::maxLik() for more details

Details

It is a wrapper for the `maxLik` function in the `maxLik` package. And additional arguments can be passed through to this function if required.

Value

a `mixl` object that contains the results of the estimation

Examples

```

data("Train", package="mlogit")
Train$ID <- Train$id
Train$CHOICE <- as.numeric(Train$choice)

```

```

mnl_test <- "
U_A = @B_price * $price_A / 1000 + @B_time * $time_A / 60;
U_B = @asc + @B_price * $price_B / 1000 + @B_timeB * $time_B / 60;
"

model_spec <- mixl::specify_model(mnl_test, Train, disable_multicore=T)

#only take starting values that are needed
est <- stats::setNames(c(1, 1,1,1), c("asc", "B_price", "B_time", "B_timeB"))
availabilities <- mixl::generate_default_availabilities(
  Train, model_spec$num_utility_functions)

model <- mixl::estimate(model_spec, est, Train, availabilities = availabilities)
print(model)

```

extract_av_cols	<i>Extract the availabilites matrix from the dataset using a column name prefix</i>
-----------------	---

Description

Extract the availabilites matrix from the dataset using a column name prefix

Usage

```
extract_av_cols(data, prefix)
```

Arguments

data	The dataset used in the model
prefix	The prefix of the availability columns, i.e. avail_

Value

Matrix of availabilities for alternatives and the number of choice observations

Examples

```

data("Train", package="mlogit")
Train$ID <- Train$id
Train$CHOICE <- as.numeric(Train$choice)
Train$avail_A <- sample(2, replace=TRUE, size=nrow(Train))-1
Train$avail_B <- sample(2, replace=TRUE, size=nrow(Train))-1
extract_av_cols(Train, 'avail_')

```

extract_indiv_data	<i>Extract the individual level data from the dataset for use in posterior analysis</i>
--------------------	---

Description

Extract the individual level data from the dataset for use in posterior analysis

Usage

```
extract_indiv_data(data, data_cols = NULL)
```

Arguments

data	The dataset
data_cols	The individual level columns of attributes - Can be null to take aggregate for each column

Value

dataframe of all individual level data for each ID

Examples

```
data("Train", package="mlogit")
Train$ID <- Train$id
Train$CHOICE <- as.numeric(Train$choice)
#in this case not actually individual data columns
#an ID column is required here
extract_indiv_data(Train, c('comfort_A', 'comfort_B'))
```

generate_default_availabilities	<i>Generate a ones-matrix of availabilities</i>
---------------------------------	---

Description

Generate a ones-matrix of availabilities

Usage

```
generate_default_availabilities(data, num_utility_functions)
```

Arguments

`data` The dataset used in the model
`num_utility_functions`
 the number of alternatives in the model

Value

Ones-matrix of availabilities for alternatives and the number of choice observations

Examples

```
data("Train", package="mlogit")
Train$ID <- Train$id
Train$CHOICE <- as.numeric(Train$choice)
generate_default_availabilities(Train, 5)
```

posteriors

Calculate the posteriors for a specified and estimated model

Description

Calculate the posteriors for a specified and estimated model

Usage

```
posteriors(model, indiv_data, code_output_file = NULL)
```

Arguments

`model` The estimated Model
`indiv_data` Alternative individual data to use instead of that in the dataset
`code_output_file`
 An (optional) location where the compiled code should be saved (useful for debugging)

Value

Dataframe of individual-level posteriors

Examples

```
data("Train", package="mlogit")
Train$ID <- Train$id
Train$CHOICE <- as.numeric(Train$choice)
mnl_test <- "
  ASC_A_RND = @ASC_A + draw_1 * @SIGMA_A1 + draw_7 * @SIGMA_A2;
  ASC_B_RND = @ASC_B + draw_2 * @SIGMA_B;
```

```

    U_A = ASC_A_RND + @B_price * $price_A / 1000
      + @B_time * $time_A / 60 + @B_change * $change_A;
    U_B = ASC_B_RND + @B_price * $price_B / 1000 + @B_timeB * $time_B / 60;
  "

#only take starting values that are needed
est <- stats::setNames(c(-1059.69729, -181.27796, -251.78909,
-241.18878, -86.77386, -173.09451,
291.02618, 142.71793, 332.60909)
, c("B_price", "B_time", "B_timeB", "B_change",
"ASC_A", "ASC_B", "SIGMA_A1", "SIGMA_A2", "SIGMA_B"))

availabilities <- generate_default_availabilities(Train, 2)

model_specification <- specify_model(mnl_test, Train, disable_multicore=T)
model <- estimate(model_specification, est, Train,
availabilities = availabilities, nDraws = 1)

posteriors(model)

```

print.mixl

Prints the output of a model

Description

`print()` is an S3 method for the `mixl` class. It creates a model summary and then prints the result

Usage

```
## S3 method for class 'mixl'
print(x, ...)
```

Arguments

<code>x</code>	The model to print
<code>...</code>	Options to pass to print

Examples

```

data("Train", package="mlogit")
Train$ID <- Train$id
Train$CHOICE <- as.numeric(Train$choice)

mnl_test <- "
U_A = @B_price * $price_A / 1000 + @B_time * $time_A / 60;
U_B = @asc + @B_price * $price_B / 1000 + @B_timeB * $time_B / 60;
"

```

```

model_spec <- mixl::specify_model(mnl_test, Train, disable_multicore=T)

#only take starting values that are needed
est <- stats::setNames(c(1, 1,1,1), c("asc", "B_price", "B_time", "B_timeB"))
availabilities <- mixl::generate_default_availabilities(
  Train, model_spec$num_utility_functions
)

model2 <- mixl::estimate(model_spec, est, Train, availabilities = availabilities)
print(model2)

```

print.summary.mixl *Print a model summary*

Description

`print()` is an S3 method for the `summary.mixl` class, the output of a model plus goodness of fit metrics

Usage

```

## S3 method for class 'summary.mixl'
print(x, digits = max(3L, getOption("digits") - 3L), ...)

```

Arguments

<code>x</code>	The summary to print.
<code>digits</code>	minimum number of significant digits to be used for most numbers.
<code>...</code>	Options to pass to print.

Examples

```

data("Train", package="mlogit")
Train$ID <- Train$id
Train$CHOICE <- as.numeric(Train$choice)

mnl_test <- "
U_A = @B_price * $price_A / 1000 + @B_time * $time_A / 60;
U_B = @asc + @B_price * $price_B / 1000 + @B_timeB * $time_B / 60;
"

model_spec <- mixl::specify_model(mnl_test, Train, disable_multicore=T)

#only take starting values that are needed
est <- stats::setNames(c(1, 1,1,1), c("asc", "B_price", "B_time", "B_timeB"))
availabilities <- mixl::generate_default_availabilities(
  Train, model_spec$num_utility_functions
)

```

```
model2 <- mixl::estimate(model_spec, est, Train, availabilities = availabilities)
print(model2)
```

probabilities	<i>Calculate the probabilities for a specified and estimated model. Note that if new data or draws are provided, the model will not be re-estimated</i>
---------------	---

Description

Calculate the probabilities for a specified and estimated model. Note that if new data or draws are provided, the model will not be re-estimated

Usage

```
probabilities(
  model,
  data = NULL,
  availabilities = NULL,
  draws = NULL,
  nDraws = NULL,
  num_threads = 1
)
```

Arguments

model	The estimated Model
data	(Optional) New data to use instead of that in the dataset
availabilities	(Optional) New availabilites to use
draws	(Optional) Optional new set of random draws to use
nDraws	(Optional) Optional new number of random draws to use
num_threads	Enable parallel computing where available using this many cores

Value

Dataframe of individual-level posteriors

Examples

```
data("Train", package="mlogit")
Train$ID <- Train$id
Train$CHOICE <- as.numeric(Train$choice)

mnl_test <- "
U_A = @B_price * $price_A / 1000 + @B_time * $time_A / 60;
```

```

U_B = @asc + @B_price * $price_B / 1000 + @B_timeB * $time_B / 60;
"

model_spec <- mixl::specify_model(mnl_test, Train, disable_multicore=T)

#only take starting values that are needed
est <- stats::setNames(c(1, 1,1,1), c("asc", "B_price", "B_time", "B_timeB"))
availabilities <- mixl::generate_default_availabilities(
  Train, model_spec$num_utility_functions
)

model <- mixl::estimate(model_spec, est, Train, availabilities = availabilities)
probabilities(model)

#hypothetical scenario where the travel time of option A doubles
Train$time_A = Train$time_A * 2
probabilities(model, Train)

```

specify_model	<i>Validate the utility functions against the dataset and generate the optimised loglikelihood function</i>
---------------	---

Description

This function takes a utility function description, and generates a optimised C++ version of the utility function which can be called from R. If the data_names are provided, then the variables in the function are checked against those provided. If an output_file is provided, the C++ code is saved there. See the user guide vignette for how to write valid utility scripts. There is some minimal specific syntax required.

Usage

```

specify_model(
  utility_script,
  dataset = NULL,
  output_file = NULL,
  compile = TRUE,
  model_name = "mixl_model",
  disable_multicore = T,
  ...
)

```

Arguments

`utility_script` The utility script to be compiled

`dataset` An (optional) dataframe to check if the all the variables are present

output_file	An (optional) location where the compiled code should be saved (useful for debugging)
compile	If compile is false, then the code will not be compiled, but just validated and saved if an output_file is specified. Default is true.
model_name	A name for the model, which will be used for saving. Defaults to <i>mixl_model</i>
disable_multicore	Deprecated and not used. Mutlicore is now autodetected
...	Further parameters to pass to sourceCpp

Value

An object which contains the loglikelihood function, and information from the compile process

See Also

`browseVignettes("mixl")`

Examples

```
data("Train", package="mlogit")
Train$ID <- Train$id
Train$CHOICE <- as.numeric(Train$choice)

mnl_test <- "
U_A = @B_price * $price_A / 1000 + @B_time * $time_A / 60;
U_B = @asc + @B_price * $price_B / 1000 + @B_timeB * $time_B / 60;
"

model_spec <- mixl::specify_model(mnl_test, Train, disable_multicore=T)

#only take starting values that are needed
est <- stats::setNames(c(1, 1,1,1), c("asc", "B_price", "B_time", "B_timeB"))
availabilities <- mixl::generate_default_availabilities(
  Train, model_spec$num_utility_functions)

model <- mixl::estimate(model_spec, est, Train, availabilities = availabilities)
print(model)
```

summary.mixl

Create a model summary

Description

`summary()` is an S3 method for the class `mixl`, which adds metrics of goodness of fit

Usage

```
## S3 method for class 'mixl'
summary(object, ...)
```

Arguments

```
object          The mixl output to summarize.
...             Options to pass to summarize (currently).
```

Value

A summary object for a mixl model

Examples

```
data("Train", package="mlogit")
Train$ID <- Train$id
Train$CHOICE <- as.numeric(Train$choice)

mnl_test <- "
U_A = @B_price * $price_A / 1000 + @B_time * $time_A / 60;
U_B = @asc + @B_price * $price_B / 1000 + @B_timeB * $time_B / 60;
"

model_spec <- mixl::specify_model(mnl_test, Train, disable_multicore=T)

#only take starting values that are needed
est <- stats::setNames(c(1, 1,1,1), c("asc", "B_price", "B_time", "B_timeB"))
availabilities <- mixl::generate_default_availabilities(
  Train, model_spec$num_utility_functions
)

model2 <- mixl::estimate(model_spec, est, Train, availabilities = availabilities)
print(model2)
```

summary_tex

Return tex formatted output of a model summary. If an output_file parameter is provided, save the object to that location

Description

The returned object can be passed to texreg's formatting functions (see 'Examples').

Usage

```
summary_tex(model_summary, output_file)
```


Arguments

model_summary A summary of an estimated Model
 output_file Where to save the tex representation

Value

Formatted texreg object containing the latex table suitable for a research paper. See [createTexreg](#)

Examples

```
data("Train", package="mlogit")
Train$ID <- Train$id
Train$CHOICE <- as.numeric(Train$choice)

mnl_test <- "
U_A = @B_price * $price_A / 1000 + @B_time * $time_A / 60;
U_B = @asc + @B_price * $price_B / 1000 + @B_timeB * $time_B / 60;
"

model_spec <- mixl::specify_model(mnl_test, Train, disable_multicore=T)

#only take starting values that are needed
est <- stats::setNames(c(1, 1,1,1), c("asc", "B_price", "B_time", "B_timeB"))
availabilities <- mixl::generate_default_availabilities(
  Train, model_spec$num_utility_functions
)

model2 <- mixl::estimate(model_spec, est, Train, availabilities = availabilities)
print(model2)

tex <- summary_tex(model2)
texreg::screenreg(tex, digits = 5)
```

 utilities

Return the the utilities for a set of coefficients

Description

Return the the utilities for a set of coefficients

Usage

```
utilities(model_spec, beta, data, availabilities, draws, nDraws)
```

Arguments

model_spec	The generated model_spec.
beta	The coefficients to use in the model when estimating the utilities.
data	The dataframe of observations.
availabilities	The availabilities of each alternative.
draws	For mixed models, a matrix of draws. If none is provided, one is created.
nDraws	The number of draws to use or generated.

Value

Dataframe of utilities for each observation

Examples

```

data("Train", package="mlogit")
Train$ID <- Train$id
Train$CHOICE <- as.numeric(Train$choice)

est <- stats::setNames(c(1,1,1,1), c("B_price", "B_time", "B_timeB", "B_change"))

availabilities <- mixl::generate_default_availabilities(Train, 2)

Nindividuals <- length(unique(Train$ID))

utility_script <- "
  U_A = @B_price * $price_A / 1000 + @B_time * $time_A / 60 + @B_change * $change_A;
  U_B = @B_price * $price_B / 1000 + @B_timeB * $time_B / 60 ;
"

model_spec <- mixl::specify_model(utility_script, Train)

utilities_matrix = mixl::utilities(model_spec, est, Train, availabilities, NULL)

utilities_matrix

```

vcov.mixl

Calculates the Variance-Covariance Matrix of the mixl summary

Description

`vcov()` is an S3 method for the `summary.mixl` class, giving the Variance-Covariance Matrix

Usage

```

## S3 method for class 'mixl'
vcov(object, eigentol = 1e-12, ...)

```

Arguments

object	The summary to print.
eigentol	The tolerance value.
...	Options to pass to print.

Examples

```
data("Train", package="mlogit")
Train$ID <- Train$id
Train$CHOICE <- as.numeric(Train$choice)

mnl_test <- "
U_A = @B_price * $price_A / 1000 + @B_time * $time_A / 60;
U_B = @asc + @B_price * $price_B / 1000 + @B_timeB * $time_B / 60;
"

model_spec <- mixl::specify_model(mnl_test, Train, disable_multicore=T)

#only take starting values that are needed
est <- stats::setNames(c(1, 1,1,1), c("asc", "B_price", "B_time", "B_timeB"))
availabilities <- mixl::generate_default_availabilities(
  Train, model_spec$num_utility_functions
)

model2 <- mixl::estimate(model_spec, est, Train, availabilities = availabilities)
print(model2)
```

Index

* Multinomial logit MNL GPU

 mixl-package, 2

av_matrix, 3

check_draw_inputs, 4

check_inputs, 4

compileUtilityFunction, 5

create_halton_draws, 6

createTexreg, 17

estimate, 6

extract_av_cols, 8

extract_indiv_data, 9

generate_default_availabilities, 9

maxLik::maxLik(), 7

mixl (mixl-package), 2

mixl-package, 2

posteriors, 10

print(), 11, 12

print.mixl, 11

print.summary.mixl, 12

probabilities, 13

sourceCpp, 15

specify_model, 14

specify_model(), 5, 7

summary(), 15

summary.mixl, 15

summary_tex, 16

utilities, 17

vcov(), 18

vcov.mixl, 18