Package 'choicer'

May 20, 2026

Title Discrete Choice Models for Economic Applications

Version 0.1.0

Description Fast estimation of discrete-choice models for applied economics.
Likelihoods, analytical gradients and Hessians are implemented in C++ with 'OpenMP' parallelism, scaling efficiently to specifications with many alternative-specific constants. Post-estimation routines return predicted shares, own- and cross-price elasticities, and diversion ratios.
Supports multinomial logit ('MNL'), mixed logit ('MXL'), and nested logit ('NL').

License LGPL (>= 3)

URL https://github.com/fpcordeiro/choicer

BugReports https://github.com/fpcordeiro/choicer/issues

Encoding UTF-8

Depends R (>= 4.1.0)

LinkingTo Rcpp, RcppArmadillo

Imports data.table, nloptr, randtoolbox, Rcpp, stats

Suggests testthat (>= 3.0.0), numDeriv, future.apply, goftest

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Author Fernando Cordeiro [aut, cre, cph]

Maintainer Fernando Cordeiro <fernandolpcordeiro@gmail.com>

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Contents

`blp` *BLP contraction mapping*

Description

Finds the ASC (delta) parameters such that predicted market shares match target shares, using the contraction mapping of Berry, Levinsohn, and Pakes (1995) doi:10.2307/2171802.

Usage

```
blp(object, target_shares, ...)
```

Arguments

`object`	A fitted model object.
`target_shares`	Numeric vector of target market shares (length J).
`...`	Additional arguments passed to methods.

Value

Converged delta (ASC) vector.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
blp(fit, target_shares = rep(1/J, J))
```

`blp.choicer_mnl` *BLP contraction mapping for multinomial logit model*

Description

BLP contraction mapping for multinomial logit model

Usage

```
## S3 method for class 'choicer_mnl'
blp(
  object,
  target_shares,
  delta_init = NULL,
  tol = 1e-08,
  max_iter = 1000,
  ...
)
```

Arguments

`object`	A `choicer_mnl` object fitted with `keep_data = TRUE`.
`target_shares`	Numeric vector of target market shares. Length `J_inside` when no outside option, or `J_inside + 1` (with the outside option's share at index 1) when `include_outside_option = TRUE`.
`delta_init`	Initial guess for delta (ASC) values. If `NULL`, uses the estimated ASCs from the fitted model.
`tol`	Convergence tolerance (default 1e-8).
`max_iter`	Maximum iterations (default 1000).
`...`	Additional arguments (ignored).

Value

Converged delta (ASC) vector.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
blp(fit, target_shares = rep(1/J, J))
```

`blp.choicer_mxl` *BLP contraction mapping for mixed logit model*

Description

BLP contraction mapping for mixed logit model

Usage

```
## S3 method for class 'choicer_mxl'
blp(
  object,
  target_shares,
  delta_init = NULL,
  tol = 1e-08,
  max_iter = 1000,
  ...
)
```

Arguments

`object`	A `choicer_mxl` object fitted with `keep_data = TRUE`.
`target_shares`	Numeric vector of target market shares. Length `J_inside` when no outside option, or `J_inside + 1` (with the outside option's share at index 1) when `include_outside_option = TRUE`.
`delta_init`	Initial guess for delta (ASC) values. If `NULL`, uses the estimated ASCs from the fitted model.
`tol`	Convergence tolerance (default 1e-8).
`max_iter`	Maximum iterations (default 1000).
`...`	Additional arguments (ignored).

Value

Converged delta (ASC) vector.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), w1 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mxlogit(
  data = dt, id_col = "id", alt_col = "alt", choice_col = "choice",
  covariate_cols = "x1", random_var_cols = "w1", S = 50L
```

```
)
blp(fit, target_shares = rep(1/J, J))
```

`blp_contraction` *BLP95 contraction mapping to find delta given target shares*

Description

BLP95 contraction mapping to find delta given target shares

Usage

```
blp_contraction(
  delta,
  target_shares,
  X,
  beta,
  alt_idx,
  M,
  weights,
  include_outside_option = FALSE,
  tol = 1e-08,
  max_iter = 1000L
)
```

Arguments

`delta`	J x 1 vector with initial guess for deltas (ASCs)
`target_shares`	J x 1 vector with target shares for each alternative
`X`	sum(M) x K design matrix with covariates. M[i] x K matrix for individual i
`beta`	K x 1 vector with model parameters
`alt_idx`	sum(M) x 1 vector with indices of alternatives within each choice set; 1-based indexing
`M`	N x 1 vector with number of alternatives for each individual
`weights`	N x 1 vector with weights for each observation
`include_outside_option`	whether to include outside option normalized to 0 (if so, the outside option is not included in the data)
`tol`	convergence tolerance
`max_iter`	maximum number of iterations

Value

vector with contraction's delta (ASCs) output

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
beta <- coef(fit)[fit$param_map$beta]
delta <- blp_contraction(rep(0, J), rep(1/J, J), fit$data$X,
  beta, fit$data$alt_idx, fit$data$M, fit$data$weights)
delta
```

`build_var_mat` *Reconstruct variance matrix L from L_params*

Description

Reconstruct variance matrix L from L_params

Usage

```
build_var_mat(L_params, K_w, rc_correlation)
```

Arguments

`L_params`	flattened choleski decomposition version of the random coefficient parameters matrix
`K_w`	dimension of the random coefficient parameter (symmetric) matrix
`rc_correlation`	whether random coefficients are correlated

Value

matrix equal to LL', where L is the choleski decomposition of random coefficient matrix

Examples

```
L_params <- c(log(1.0), 0.3, log(0.5))
Sigma <- build_var_mat(L_params, K_w = 2, rc_correlation = TRUE)
Sigma  # 2x2 covariance matrix
```

coef.choicer_fit *Extract coefficients from a choicer_fit object*

Description

Extract coefficients from a choicer_fit object

Usage

```
## S3 method for class 'choicer_fit'
coef(object, ...)
```

Arguments

object	A choicer_fit object.
...	Additional arguments (ignored).

Value

Named numeric vector of estimated coefficients.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
coef(fit)
```

diversion_ratios *Compute aggregate diversion ratios*

Description

Computes a J x J matrix of diversion ratios. Entry (i, j) is the fraction of demand lost by alternative j that is captured by alternative i when alternative j becomes less attractive.

Usage

```
diversion_ratios(object, ...)
```

Arguments

object	A fitted model object.
...	Additional arguments passed to methods.

Value

A J x J diversion ratio matrix with alternative labels.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
diversion_ratios(fit)
```

---

diversion_ratios.choicer_mnl

Diversion ratios for multinomial logit model

Description

Diversion ratios for multinomial logit model

Usage

```
## S3 method for class 'choicer_mnl'
diversion_ratios(object, ...)
```

Arguments

object	A `choicer_mnl` object fitted with `keep_data = TRUE`.
...	Additional arguments (ignored).

Value

A J x J diversion ratio matrix with alternative labels.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
diversion_ratios(fit)
```

`diversion_ratios.choicer_mxl` *Diversion ratios for mixed logit model*

Description

Computes the attribute-based diversion ratio matrix. Entry (k, j) is the fraction of demand lost by alternative j that is captured by alternative k when a marginal change in alternative j's `wrt_var` attribute reduces s_j.

Usage

```
## S3 method for class 'choicer_mxl'
diversion_ratios(object, wrt_var, is_random_coef = FALSE, ...)
```

Arguments

`object`	A `choicer_mxl` object fitted with `keep_data = TRUE`.
`wrt_var`	Variable used to perturb alternative j's utility: a column name (character) or 1-based index. Indexes into X columns for fixed coefficients, or W columns for random coefficients (when `is_random_coef = TRUE`).
`is_random_coef`	Logical. `TRUE` if the variable has a random coefficient (is in W), `FALSE` if fixed (in X). Default `FALSE`.
`...`	Additional arguments (ignored).

Details

Unlike MNL, the MXL diversion ratio depends on which variable is perturbed: the realised coefficient β_{ik}^s varies across individuals and draws and does not cancel in the ratio. For a variable with a fixed coefficient the result is independent of the variable (β cancels); for a random-coefficient variable it is not.

Value

A J x J diversion ratio matrix with alternative labels. Cross-products are averaged across simulation draws inside the integration to avoid Jensen-style bias.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), w1 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mxlogit(
  data = dt, id_col = "id", alt_col = "alt", choice_col = "choice",
  covariate_cols = "x1", random_var_cols = "w1", S = 50L
)
diversion_ratios(fit, "x1")
diversion_ratios(fit, "w1", is_random_coef = TRUE)
```

---

elasticities *Compute aggregate elasticities*

Description

Computes a J x J matrix of aggregate elasticities. Entry (i, j) is the percentage change in the probability of choosing alternative i when the attribute of alternative j changes by 1\

Usage

```
elasticities(object, ...)
```

Arguments

object	A fitted model object.
...	Additional arguments passed to methods.

Value

A J x J elasticity matrix with alternative labels.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
elasticities(fit, "x1")
```

elasticities.choicer_mnl

Elasticities for multinomial logit model

Description

Elasticities for multinomial logit model

Usage

```
## S3 method for class 'choicer_mnl'
elasticities(object, elast_var, ...)
```

Arguments

object	A choicer_mnl object fitted with keep_data = TRUE.
elast_var	Variable for elasticity computation: a column name (character) or 1-based index into the design matrix X.
...	Additional arguments (ignored).

Value

A J x J elasticity matrix with alternative labels.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
elasticities(fit, "x1")
```

elasticities.choicer_mxl

Elasticities for mixed logit model

Description

Elasticities for mixed logit model

Usage

```
## S3 method for class 'choicer_mxl'
elasticities(object, elast_var, is_random_coef = FALSE, ...)
```

Arguments

object	A choicer_mxl object fitted with keep_data = TRUE.
elast_var	Variable for elasticity computation: a column name (character) or 1-based index. Indexes into X columns for fixed coefficients, or W columns for random coefficients (when is_random_coef = TRUE).
is_random_coef	Logical. TRUE if the variable has a random coefficient (is in W), FALSE if fixed (in X). Default FALSE.
...	Additional arguments (ignored).

Value

A J x J elasticity matrix with alternative labels.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), w1 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mxlogit(
  data = dt, id_col = "id", alt_col = "alt", choice_col = "choice",
  covariate_cols = "x1", random_var_cols = "w1", S = 50L
)
elasticities(fit, "x1")
elasticities(fit, "w1", is_random_coef = TRUE)
```

---

get_halton_normals *Halton draws for mixed logit*

Description

Create halton normal draws in appropriate format for mixed logit estimation

Usage

```
get_halton_normals(S, N, K_w)
```

Arguments

S	Number of draws for each choice situation
N	number of choice situations
K_w	dimension of random coefficients (number of columns in W matrix)

Value

K_w x S x N array with halton standard normal draws

Examples

```
draws <- get_halton_normals(S = 50, N = 10, K_w = 2)
dim(draws)  # 2 x 50 x 10
```

---

jacobian_vech_Sigma *Utility to compute analytical Jacobian of random coefficient matrix transformed by vech (dVech(Sigma) / dTheta)*

Description

Utility to compute analytical Jacobian of random coefficient matrix transformed by vech (dVech(Sigma) / dTheta)

Usage

```
jacobian_vech_Sigma(L_params, K_w, rc_correlation = TRUE)
```

Arguments

L_params	flattened choleski decomposition version of the random coefficient parameters matrix
K_w	dimension of the random coefficient parameter (symmetric) matrix
rc_correlation	whether random coefficients are correlated

Value

Jacobian (dVech(Sigma) / dTheta)

Examples

```
L_params <- c(log(0.8), 0.2, log(0.6))
J_mat <- jacobian_vech_Sigma(L_params, K_w = 2, rc_correlation = TRUE)
dim(J_mat)  # 3 x 3 for K_w=2 correlated
```

logLik.choicer_fit *Extract log-likelihood from a choicer_fit object*

Description

Returns a logLik object, which enables AIC() and BIC() automatically.

Usage

```
## S3 method for class 'choicer_fit'
logLik(object, ...)
```

Arguments

object	A choicer_fit object.
...	Additional arguments (ignored).

Value

A logLik object with df and nobs attributes.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
logLik(fit)
AIC(fit)
BIC(fit)
```

mc_asymptotics *Asymptotic diagnostics for a Monte Carlo study*

Description

Consumes a choicer_mc object and returns per-parameter asymptotic diagnostics: Monte Carlo bias (with MC standard error), empirical SD of the estimates, mean of the reported standard errors, SE-to-SD ratio (information-matrix-equality check), Wald coverage at nominal 90 / 95 / 99 percent with Wilson confidence bands, moments of the studentized statistic z = (theta_hat - theta_0) / se, and four normality tests on z (Shapiro-Wilk, Anderson-Darling via goftest::ad.test, a hand-coded Jarque-Bera statistic, and a one-sample Kolmogorov-Smirnov test against N(0, 1)).

Usage

```
mc_asymptotics(
  mc,
  level = 0.95,
  se_col = "se",
  conv_threshold = 0.99,
  se_ratio_threshold_floor = 0.1
)
```

Arguments

mc	A choicer_mc object returned by monte_carlo().
level	Confidence level for the Wilson bands on coverage rates. Defaults to 0.95.
se_col	Name of the column in mc$replications to use as the standard-error source. Defaults to "se" (the Hessian-based SE stored by monte_carlo()). Callers that augment replications with an alternative SE flavor (e.g., "se_bhhh" for a BHHH/OPG comparison) can pass that column name to recompute every SE-dependent diagnostic (mean_se, se_ratio, mean_se_w, cov90/95/99, z-moments, normality tests, pass flags) against that flavor. Useful for the information-matrix-equality check in Claim 4 of the MXL validation suite.
conv_threshold	Numeric in [0, 1]. Minimum fraction of replications that must converge for the per-parameter pass_convergence flag to be TRUE. The flag compares R_used / R_total (per parameter) against this threshold. Defaults to 0.99.
se_ratio_threshold_floor	Numeric scalar. Minimum half-width for the pass_se_ratio band. The actual band used is max(se_ratio_threshold_floor, 3 * 1.4 / sqrt(R_used)), where the 1.4 / sqrt(R) term approximates the large-sample SD of mean_se / sd_emp. The floor guarantees the band is never tighter than the historical hard cutoff. Defaults to 0.10.

Details

Six logical pass / fail flags are attached to every parameter row: pass_bias requires |bias_mc_se| < 3; pass_se_ratio requires |se_ratio - 1| to lie within max(se_ratio_threshold_floor, 3 * 1.4 / sqrt(R_used)) (a noise-aware band that widens at small R_used and tightens to the floor at large R_used); pass_cov95 requires the nominal 95 percent level to lie in the Wilson band for empirical coverage; pass_skew requires |skew_z| < 0.3; pass_kurt requires excess kurtosis of z in [-0.5, 1.0]; pass_convergence requires the per-parameter convergence rate (R_used / R_total) to meet conv_threshold.

Non-converged replications are excluded per parameter (reported in R_excluded). Winsorized (5 percent / 95 percent) versions of bias, sd_emp, and mean_se are reported in parallel columns (bias_w, sd_emp_w, mean_se_w) so silent outlier exclusion is transparent to the reader. Two robust SE-to-SD ratios accompany the Hessian-mean-based se_ratio: se_ratio_med (median SE divided by the empirical SD) and se_ratio_w (winsorized mean SE divided by the winsorized empirical SD); both stay near 1 when 1-2 replications produce near-singular Hessians that inflate mean_se. The companion se_med column reports the median per-replication SE used by se_ratio_med. Neither robust ratio drives a pass_* flag — they are purely informational.

Winsorized z-moment counterparts (mean_z_w, sd_z_w, skew_z_w, kurt_excess_z_w) are reported alongside the raw z-moments and feed an additional pass_z_w flag (Winsorized skew within the same band as pass_skew AND Winsorized excess kurtosis within the same band as pass_kurt). A companion pass_cov95_w flag is TRUE when either pass_cov95 is TRUE OR the per-rep Winsorized z-CI (the empirical 2.5 / 97.5 percentiles of the Winsorized z) covers truth-zero. These two flags are designed for boundary scenarios (e.g., near-zero variance components) where a small number of reps with vanishing SE inflate the raw z-moments without indicating an estimator defect.

Value

An object of class choicer_mc_asymptotics — a data.table with one row per unique parameter and columns documented above — with meta attached as an attribute (attr(x, "meta")).

Examples

```
sim_fun <- function(seed) simulate_mnl_data(N = 1000, J = 3, seed = seed)
fit_fun <- function(sim) run_mnlogit(
  data = sim$data, id_col = "id", alt_col = "alt", choice_col = "choice",
  covariate_cols = c("x1", "x2"), outside_opt_label = 0L,
  include_outside_option = FALSE, use_asc = TRUE,
  control = list(print_level = 0L)
)
mc <- monte_carlo(sim_fun, fit_fun, R = 50L, seed = 1L, progress = FALSE)
mc_asymptotics(mc)
```

---

mnl_diversion_ratios_parallel

Compute MNL diversion ratios (parallelized over individuals)

Description

Computes the diversion ratio matrix DR(j->k), which measures the fraction of demand lost by alternative j that is captured by alternative k. For MNL: DR(j->k) = sum_n(w_n * P_nj * P_nk) / sum_n(w_n * P_nj * (1 - P_nj))

Usage

```
mnl_diversion_ratios_parallel(
  theta,
  X,
  alt_idx,
  M,
  weights,
  use_asc = TRUE,
  include_outside_option = FALSE
)
```

Arguments

theta	K + J - 1 or K + J vector with model parameters
X	sum(M) x K design matrix with covariates.
alt_idx	sum(M) x 1 vector with indices of alternatives; 1-based indexing
M	N x 1 vector with number of alternatives for each individual
weights	N x 1 vector with weights for each observation
use_asc	whether to use alternative-specific constants
include_outside_option	whether to include outside option

Value

J x J matrix where entry (k, j) = DR(j->k). Diagonal is 0.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
dr <- mnl_diversion_ratios_parallel(coef(fit), fit$data$X, fit$data$alt_idx,
  fit$data$M, fit$data$weights)
dr
```

---

mnl_elasticities_parallel

Compute aggregate elasticities for MNL model

Description

Computes the aggregate elasticity matrix (weighted average of individual elasticities) for the Multinomial Logit model.

Usage

```
mnl_elasticities_parallel(
  theta,
  X,
  alt_idx,
  choice_idx,
  M,
```

```
  weights,
  elast_var_idx,
  use_asc = TRUE,
  include_outside_option = FALSE
)
```

Arguments

theta	K + J - 1 or K + J vector with model parameters
X	sum(M) x K design matrix with covariates.
alt_idx	sum(M) x 1 vector with indices of alternatives; 1-based indexing
choice_idx	N x 1 vector (kept for API consistency, but not used)
M	N x 1 vector with number of alternatives for each individual
weights	N x 1 vector with weights for each observation
elast_var_idx	1-based index of the column in X for which to compute the elasticity
use_asc	whether to use alternative-specific constants
include_outside_option	whether to include outside option

Value

J x J matrix of aggregate elasticities

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
elas <- mnl_elasticities_parallel(coef(fit), fit$data$X, fit$data$alt_idx,
  fit$data$choice_idx, fit$data$M, fit$data$weights, elast_var_idx = 1L)
elas
```

---

mnl_loglik_gradient_parallel

Log-likelihood and gradient for multinomial logit model

Description

Computes the log-likelihood and its gradient for the Multinomial Logit model using OpenMP for parallelization. Allows for inclusion of alternative-specific constants, outside option, and observation weights.

Usage

```
mnl_loglik_gradient_parallel(
  theta,
  X,
  alt_idx,
  choice_idx,
  M,
  weights,
  use_asc = TRUE,
  include_outside_option = FALSE
)
```

Arguments

theta	K + J - 1 or K + J vector with model parameters
X	sum(M) x K design matrix with covariates. Stacks M[i] x K matrices for individual i.
alt_idx	sum(M) x 1 vector with indices of alternatives within each choice set; 1-based indexing
choice_idx	N x 1 vector with indices of chosen alternatives; 1-based indexing relative to X; 0 is used if include_outside_option=True
M	N x 1 vector with number of alternatives for each individual
weights	N x 1 vector with weights for each observation
use_asc	whether to use alternative-specific constants
include_outside_option	whether to include outside option normalized to 0 (if so, the outside option is not included in the data)

Value

List with loglikelihood and gradient evaluated at input arguments

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
d <- prepare_mnl_data(dt, "id", "alt", "choice", c("x1", "x2"))
theta <- rep(0, ncol(d$X) + nrow(d$alt_mapping) - 1)
result <- mnl_loglik_gradient_parallel(theta, d$X, d$alt_idx,
  d$choice_idx, d$M, d$weights)
result$objective  # negative log-likelihood
```

`mnl_loglik_hessian_parallel` *Hessian matrix for multinomial logit model*

Description

Hessian matrix for multinomial logit model

Usage

```
mnl_loglik_hessian_parallel(
  theta,
  X,
  alt_idx,
  choice_idx,
  M,
  weights,
  use_asc = TRUE,
  include_outside_option = FALSE
)
```

Arguments

`theta`	K + J - 1 or K + J vector with model parameters
`X`	sum(M) x K design matrix with covariates. Stacks M[i] x K matrices for individual i.
`alt_idx`	sum(M) x 1 vector with indices of alternatives within each choice set; 1-based indexing
`choice_idx`	N x 1 vector with indices of chosen alternatives; 1-based indexing relative to X; 0 is used if include_outside_option=True
`M`	N x 1 vector with number of alternatives for each individual
`weights`	N x 1 vector with weights for each observation
`use_asc`	whether to use alternative-specific constants
`include_outside_option`	whether to include outside option normalized to 0 (if so, the outside option is not included in the data)

Value

Hessian matrix of the negative log-likelihood

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
H <- mnl_loglik_hessian_parallel(coef(fit), fit$data$X, fit$data$alt_idx,
  fit$data$choice_idx, fit$data$M, fit$data$weights)
dim(H)
```

---

mnl_predict *Prediction of choice probabilities and utilities based on fitted model*

Description

Prediction of choice probabilities and utilities based on fitted model

Usage

```
mnl_predict(
  theta,
  X,
  alt_idx,
  M,
  use_asc = TRUE,
  include_outside_option = FALSE
)
```

Arguments

theta	K + J - 1 or K + J vector with model parameters
X	sum(M) x K design matrix with covariates. Stacks M[i] x K matrices for individual i.
alt_idx	sum(M) x 1 vector with indices of alternatives within each choice set; 1-based indexing
M	N x 1 vector with number of alternatives for each individual
use_asc	whether to use alternative-specific constants
include_outside_option	whether to include outside option normalized to 0 (if so, the outside option is not included in the data)

Value

List with choice probability and utility for each choice situation evaluated at input arguments

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
pred <- mnl_predict(coef(fit), fit$data$X, fit$data$alt_idx,
  fit$data$M, use_asc = TRUE)
head(pred$choice_prob)
```

---

mnl_predict_shares *Prediction of market shares based on fitted model*

Description

Prediction of market shares based on fitted model

Usage

```
mnl_predict_shares(
  theta,
  X,
  alt_idx,
  M,
  weights,
  use_asc = TRUE,
  include_outside_option = FALSE
)
```

Arguments

theta	K + J - 1 or K + J vector with model parameters
X	sum(M) x K design matrix with covariates. Stacks M[i] x K matrices for individual i.
alt_idx	sum(M) x 1 vector with indices of alternatives within each choice set; 1-based indexing
M	N x 1 vector with number of alternatives for each individual
weights	N x 1 vector with weights for each observation

use_asc whether to use alternative-specific constants

include_outside_option
whether to include outside option normalized to 0 (if so, the outside option is not included in the data)

Value

vector with predicted market shares for each alternative

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
shares <- mnl_predict_shares(coef(fit), fit$data$X, fit$data$alt_idx,
  fit$data$M, fit$data$weights, use_asc = TRUE)
shares
```

---

monte_carlo *Monte Carlo parameter recovery*

Description

Replicates a (DGP -> fit) cycle R times with independent seeds and collects per-parameter estimates, standard errors, bias, and coverage. Returns a choicer_mc object; call summary() for aggregated statistics (mean estimate, bias, RMSE, coverage rate, convergence rate).

Usage

```
monte_carlo(
  sim_fun,
  fit_fun,
  R = 100,
  seed = 1L,
  parallel = FALSE,
  progress = TRUE,
  ...
)
```

Arguments

sim_fun	Function of seed returning a choicer_sim.
fit_fun	Function of a choicer_sim returning a choicer_fit.
R	Number of replications.
seed	Base integer seed. Replication r uses seed + r - 1L.
parallel	Logical; if TRUE and future.apply is available, run replications in parallel using the user's active future::plan().
progress	Logical; print a one-line progress update per iteration in serial mode. Ignored when parallel = TRUE.
...	Unused.

Details

Each iteration calls sim_fun(seed = seed + r - 1L), then fit_fun(sim). Write sim_fun as a closure that captures N, J, and other DGP settings and forwards seed. Write fit_fun as a closure that takes a choicer_sim and returns a fitted choicer_fit object, wrapping any data-preparation, draws, or optimizer-control setup.

Value

A choicer_mc object: a list with elements replications (a long data.table with one row per estimated parameter per replication) and meta (run metadata).

Examples

```
sim_fun <- function(seed) simulate_mnl_data(N = 1000, J = 4, seed = seed)
fit_fun <- function(sim) run_mnlogit(
  data = sim$data, id_col = "id", alt_col = "alt", choice_col = "choice",
  covariate_cols = c("x1", "x2"), outside_opt_label = 0L,
  include_outside_option = FALSE, use_asc = TRUE,
  control = list(print_level = 0L)
)
mc <- monte_carlo(sim_fun, fit_fun, R = 5, seed = 1L, progress = FALSE)
summary(mc)
```

---

mxl_bhhh_parallel *BHHH (outer product of gradients) information matrix for Mixed Logit*

Description

Computes the BHHH approximation to the observed information matrix for the Mixed Logit model: $H_{BHHH} = \sum_i w_i \cdot s_i s_i^\top$, where s_i is the per-individual score (gradient of $\log \bar{P}_i$). This outer product of gradients (OPG) estimator provides an alternative to the analytical Hessian for standard error computation that scales to large problems where the analytical Hessian is infeasible (e.g., many alternatives or simulation draws).

Usage

```
mxl_bhhh_parallel(
  theta,
  X,
  W,
  alt_idx,
  choice_idx,
  M,
  weights,
  eta_draws,
  rc_dist,
  rc_correlation = TRUE,
  rc_mean = FALSE,
  use_asc = TRUE,
  include_outside_option = FALSE
)
```

Arguments

theta	vector collecting model parameters (beta, mu, L, delta (ASCs))
X	design matrix for covariates with fixed coefficients; sum(M_i) x K_x
W	design matrix for covariates with random coefficients; sum(M_i) x K_w or J x K_w
alt_idx	sum(M) x 1 vector with indices of alternatives within each choice set; 1-based indexing
choice_idx	N x 1 vector with indices of chosen alternatives; 1-based indexing relative to X; 0 is used if include_outside_option=True
M	N x 1 vector with number of alternatives for each individual
weights	N x 1 vector with weights for each observation
eta_draws	Array with choice situation draws; K_w x S x N
rc_dist	K_w x 1 integer vector indicating distribution of random coefficients: 0 = normal, 1 = log-normal
rc_correlation	whether random coefficients should be correlated
rc_mean	whether to estimate means for random coefficients.
use_asc	whether to use alternative-specific constants.
include_outside_option	whether to include outside option normalized to 0 (if so, the outside option is not included in the data)

Value

n_params x n_params PSD matrix representing the observed information matrix estimated by the outer product of gradients (same sign convention as the negated Hessian returned by `mxl_hessian_parallel`, so it can be inverted directly to obtain vcov).

Note

The BHHH/OPG estimator is only asymptotically equivalent to the Hessian-based information matrix at the true MLE. In finite samples it can underestimate standard errors, particularly when the model is mis-specified or away from the optimum.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), w1 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
d <- prepare_mxl_data(dt, "id", "alt", "choice", "x1", "w1")
eta <- get_halton_normals(50, d$N, ncol(d$W))
theta <- rep(0, ncol(d$X) + ncol(d$W) + nrow(d$alt_mapping) - 1)
H <- mxl_bhhh_parallel(theta, d$X, d$W, d$alt_idx, d$choice_idx,
  d$M, d$weights, eta, rc_dist = rep(0L, ncol(d$W)),
  rc_correlation = FALSE, rc_mean = FALSE)
dim(H)
```

---

mxl_blp_contraction *BLP contraction mapping for mixed logit*

Description

Finds the ASC (delta) parameters such that predicted market shares match target shares, using the contraction mapping of Berry, Levinsohn, and Pakes (1995).

Usage

```
mxl_blp_contraction(
  delta,
  target_shares,
  X,
  W,
  beta,
  mu,
  L_params,
  alt_idx,
  M,
  weights,
  eta_draws,
  rc_dist,
  rc_correlation = TRUE,
  rc_mean = FALSE,
```

```
  include_outside_option = FALSE,
  tol = 1e-08,
  max_iter = 1000L
)
```

Arguments

delta	J-1 or J vector with initial guess for deltas (ASCs)
target_shares	J vector with target market shares
X	design matrix for fixed coefficients; sum(M_i) x K_x
W	design matrix for random coefficients; sum(M_i) x K_w or J x K_w
beta	K_x vector with fixed coefficients
mu	K_w vector with mean parameters (raw, will be transformed if log-normal)
L_params	Cholesky parameters vector
alt_idx	sum(M) x 1 vector with indices of alternatives; 1-based indexing
M	N x 1 vector with number of alternatives for each individual
weights	N x 1 vector with weights for each observation
eta_draws	Array with draws; K_w x S x N
rc_dist	K_w vector indicating distribution (0=normal, 1=log-normal)
rc_correlation	whether random coefficients are correlated
rc_mean	whether mu parameters represent means (TRUE) or are zero (FALSE)
include_outside_option	whether outside option is included
tol	convergence tolerance (default 1e-8)
max_iter	maximum iterations (default 1000)

Value

vector with converged delta (ASC) values

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), w1 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
d <- prepare_mxl_data(dt, "id", "alt", "choice", "x1", "w1")
eta <- get_halton_normals(50, d$N, ncol(d$W))
fit <- run_mxlogit(input_data = d, eta_draws = eta)
pm <- fit$param_map
delta <- mxl_blp_contraction(rep(0, J), rep(1/J, J), d$X, d$W,
  coef(fit)[pm$beta], rep(0, ncol(d$W)), coef(fit)[pm$sigma],
```

```
  d$alt_idx, d$M, d$weights, eta, rc_dist = rep(0L, ncol(d$W)),
  rc_correlation = FALSE, rc_mean = FALSE)
delta
```

`mxl_diversion_ratios_parallel` *Diversion ratios for Mixed Logit (simulated, derivative-based)*

Description

Computes the matrix of attribute-based diversion ratios for a fitted Mixed Logit model. DR(k, j) is the fraction of demand lost by alternative `j` that is captured by alternative `k` when a marginal change in alternative j's `elast_var` attribute reduces s_j.

Usage

```
mxl_diversion_ratios_parallel(
  theta,
  X,
  W,
  alt_idx,
  M,
  weights,
  eta_draws,
  rc_dist,
  elast_var_idx,
  is_random_coef,
  rc_correlation = TRUE,
  rc_mean = FALSE,
  use_asc = TRUE,
  include_outside_option = FALSE
)
```

Arguments

`theta`	parameter vector (beta, [mu], L, delta)
`X`	design matrix for fixed coefficients; sum(M_i) x K_x
`W`	design matrix for random coefficients; sum(M_i) x K_w or J x K_w
`alt_idx`	sum(M) x 1 vector with indices of alternatives; 1-based indexing
`M`	N x 1 vector with number of alternatives for each individual
`weights`	N x 1 vector with weights for each observation
`eta_draws`	Array with draws; K_w x S x N
`rc_dist`	K_w vector indicating distribution (0=normal, 1=log-normal)
`elast_var_idx`	1-based index of the perturbed variable

`is_random_coef`	TRUE if the variable is in W (random coef), FALSE if in X (fixed)
`rc_correlation`	whether random coefficients are correlated
`rc_mean`	whether mu parameters are estimated
`use_asc`	whether ASCs are included
`include_outside_option`	whether outside option is included

Details

In MNL the per-draw realized coefficient is a constant, so it cancels in the ratio and the result is independent of the variable chosen. In MXL, the realized coefficient β_{ik}^s varies across individuals and draws, so the diversion ratio depends on which attribute is perturbed. For a variable with a fixed coefficient the dependence again vanishes (the constant cancels); for a random-coefficient variable it does not.

Value

J x J (or (J+1) x (J+1)) matrix of diversion ratios with zero diagonal.

`mxl_elasticities_parallel` *Compute aggregate elasticities for mixed logit model*

Description

Computes the aggregate elasticity matrix (weighted average of individual elasticities) for the Mixed Logit model. The elasticity E(i,j) represents the percentage change in the probability of choosing alternative i when the attribute of alternative j changes by 1%.

Usage

```
mxl_elasticities_parallel(
  theta,
  X,
  W,
  alt_idx,
  choice_idx,
  M,
  weights,
  eta_draws,
  rc_dist,
  elast_var_idx,
  is_random_coef,
  rc_correlation = TRUE,
  rc_mean = FALSE,
  use_asc = TRUE,
  include_outside_option = FALSE
)
```

Arguments

theta	parameter vector (beta, [mu], L, delta)
X	design matrix for fixed coefficients; sum(M_i) x K_x
W	design matrix for random coefficients; sum(M_i) x K_w or J x K_w
alt_idx	sum(M) x 1 vector with indices of alternatives; 1-based indexing
choice_idx	N x 1 vector (kept for API consistency, not used)
M	N x 1 vector with number of alternatives for each individual
weights	N x 1 vector with weights for each observation
eta_draws	Array with draws; K_w x S x N
rc_dist	K_w vector indicating distribution (0=normal, 1=log-normal)
elast_var_idx	1-based index of the variable for elasticity computation
is_random_coef	TRUE if variable is in W (random coef), FALSE if in X (fixed coef)
rc_correlation	whether random coefficients are correlated
rc_mean	whether mu parameters are estimated
use_asc	whether ASCs are included
include_outside_option	whether outside option is included

Value

J x J matrix of aggregate elasticities

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), w1 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
d <- prepare_mxl_data(dt, "id", "alt", "choice", "x1", "w1")
eta <- get_halton_normals(50, d$N, ncol(d$W))
fit <- run_mxlogit(input_data = d, eta_draws = eta)
elas <- mxl_elasticities_parallel(coef(fit), d$X, d$W, d$alt_idx,
  d$choice_idx, d$M, d$weights, eta, rc_dist = rep(0L, ncol(d$W)),
  elast_var_idx = 1L, is_random_coef = FALSE,
  rc_correlation = FALSE, rc_mean = FALSE)
elas
```

`mxl_hessian_parallel` *Analytical Hessian of the log-likelihood v2*

Description

Computes the Hessian of the log-likelihood for the Mixed Logit model using OpenMP for parallelization. Mirrors the parameters of mxl_loglik_gradient_parallel.

Usage

```
mxl_hessian_parallel(
  theta,
  X,
  W,
  alt_idx,
  choice_idx,
  M,
  weights,
  eta_draws,
  rc_dist,
  rc_correlation = TRUE,
  rc_mean = FALSE,
  use_asc = TRUE,
  include_outside_option = FALSE
)
```

Arguments

`theta`	vector collecting model parameters (beta, mu, L, delta (ASCs))
`X`	design matrix for covariates with fixed coefficients; sum(M_i) x K_x
`W`	design matrix for covariates with random coefficients; sum(M_i) x K_w or J x K_w
`alt_idx`	sum(M) x 1 vector with indices of alternatives within each choice set; 1-based indexing
`choice_idx`	N x 1 vector with indices of chosen alternatives; 1-based indexing relative to X; 0 is used if include_outside_option=True
`M`	N x 1 vector with number of alternatives for each individual
`weights`	N x 1 vector with weights for each observation
`eta_draws`	Array with choice situation draws; K_w x S x N
`rc_dist`	K_w x 1 integer vector indicating distribution of random coefficients: 0 = normal, 1 = log-normal
`rc_correlation`	whether random coefficients should be correlated
`rc_mean`	whether to estimate means for random coefficients.
`use_asc`	whether to use alternative-specific constants.

include_outside_option
: whether to include outside option normalized to 0 (if so, the outside option is not included in the data)

Value

Hessian evaluated at input arguments

Note

For log-normal random coefficients (rc_dist=1) with rc_mean=TRUE, the distribution is a shifted log-normal: beta_k = exp(mu_k) + exp(L_k * eta), where exp(mu_k) shifts the location and exp(L_k * eta) ~ LogNormal(0, sigma_k^2). This differs from the textbook parameterization exp(mu_k + L_k * eta).

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), w1 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
d <- prepare_mxl_data(dt, "id", "alt", "choice", "x1", "w1")
eta <- get_halton_normals(50, d$N, ncol(d$W))
theta <- rep(0, ncol(d$X) + ncol(d$W) + nrow(d$alt_mapping) - 1)
H <- mxl_hessian_parallel(theta, d$X, d$W, d$alt_idx, d$choice_idx,
  d$M, d$weights, eta, rc_dist = rep(0L, ncol(d$W)),
  rc_correlation = FALSE, rc_mean = FALSE)
dim(H)
```

---

mxl_loglik_gradient_parallel

Log-likelihood and gradient for Mixed Logit

Description

Computes the log-likelihood and its gradient for the Mixed Logit model using OpenMP for parallelization. Allows for inclusion of alternative-specific constants, outside option, observation weights, correlated random coefficients.

Usage

```
mxl_loglik_gradient_parallel(
  theta,
  X,
  W,
```

```
  alt_idx,
  choice_idx,
  M,
  weights,
  eta_draws,
  rc_dist,
  rc_correlation = TRUE,
  rc_mean = FALSE,
  use_asc = TRUE,
  include_outside_option = FALSE
)
```

Arguments

theta	vector collecting model parameters (beta, mu, L, delta (ASCs))
X	design matrix for covariates with fixed coefficients; sum(M_i) x K_x
W	design matrix for covariates with random coefficients; sum(M_i) x K_w or J x K_w
alt_idx	sum(M) x 1 vector with indices of alternatives within each choice set; 1-based indexing
choice_idx	N x 1 vector with indices of chosen alternatives; 1-based indexing relative to X; 0 is used if include_outside_option=True
M	N x 1 vector with number of alternatives for each individual
weights	N x 1 vector with weights for each observation
eta_draws	Array with choice situation draws; K_w x S x N
rc_dist	K_w x 1 integer vector indicating distribution of random coefficients: 0 = normal, 1 = log-normal
rc_correlation	whether random coefficients should be correlated
rc_mean	whether to estimate means for random coefficients. If so, mean parameters (mu) should be included in theta after beta parameters.
use_asc	whether to use alternative-specific constants. If so, parameters should be included in theta after beta and L (and mu, if applicable).
include_outside_option	whether to include outside option normalized to 0 (if so, the outside option is not included in the data)

Value

List with loglikelihood and gradient evaluated at input arguments

Note

For log-normal random coefficients (rc_dist=1) with rc_mean=TRUE, the distribution is a shifted log-normal: beta_k = exp(mu_k) + exp(L_k * eta), where exp(mu_k) shifts the location and exp(L_k * eta) ~ LogNormal(0, sigma_k^2). This differs from the textbook parameterization exp(mu_k + L_k * eta).

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), w1 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
d <- prepare_mxl_data(dt, "id", "alt", "choice", "x1", "w1")
eta <- get_halton_normals(50, d$N, ncol(d$W))
K_x <- ncol(d$X); K_w <- ncol(d$W); J <- nrow(d$alt_mapping)
theta <- rep(0, K_x + K_w + J - 1)
result <- mxl_loglik_gradient_parallel(theta, d$X, d$W, d$alt_idx,
  d$choice_idx, d$M, d$weights, eta, rc_dist = rep(0L, K_w),
  rc_correlation = FALSE, rc_mean = FALSE)
result$objective
```

---

mxl_predict *Per-observation simulated choice probabilities for Mixed Logit*

Description

Returns the simulated choice probability for each (individual, alternative) row of `X`, averaged over the supplied Halton draws. Mirrors `mnl_predict`.

Usage

```
mxl_predict(
  theta,
  X,
  W,
  alt_idx,
  M,
  eta_draws,
  rc_dist,
  rc_correlation = TRUE,
  rc_mean = FALSE,
  use_asc = TRUE,
  include_outside_option = FALSE
)
```

Arguments

`theta`	parameter vector (beta, [mu], L, delta)
`X`	design matrix for fixed coefficients; sum(M_i) x K_x
`W`	design matrix for random coefficients; sum(M_i) x K_w or J x K_w

alt_idx	sum(M) x 1 vector with indices of alternatives; 1-based indexing
M	N x 1 vector with number of alternatives for each individual
eta_draws	Array with draws; K_w x S x N
rc_dist	K_w vector indicating distribution (0=normal, 1=log-normal)
rc_correlation	whether random coefficients are correlated
rc_mean	whether mu parameters are estimated
use_asc	whether ASCs are included
include_outside_option	whether the outside option is present

Value

List with choice_prob (length sum(M)), utility (length sum(M), simulated mean of the deterministic + W*gamma component), and, when include_outside_option = TRUE, choice_prob_outside (length N).

---

mxl_predict_shares *Predicted aggregate market shares for Mixed Logit*

Description

Exported wrapper around the internal mxl_predict_shares_internal. Parses theta using the standard parameter ordering and returns the simulated weighted-average market shares.

Usage

```
mxl_predict_shares(
  theta,
  X,
  W,
  alt_idx,
  M,
  weights,
  eta_draws,
  rc_dist,
  rc_correlation = TRUE,
  rc_mean = FALSE,
  use_asc = TRUE,
  include_outside_option = FALSE
)
```

Arguments

theta	parameter vector (beta, [mu], L, delta)
X	design matrix for fixed coefficients; sum(M_i) x K_x
W	design matrix for random coefficients; sum(M_i) x K_w or J x K_w
alt_idx	sum(M) x 1 vector with indices of alternatives; 1-based indexing
M	N x 1 vector with number of alternatives for each individual
weights	N x 1 vector with weights for each observation
eta_draws	Array with draws; K_w x S x N
rc_dist	K_w vector indicating distribution (0=normal, 1=log-normal)
rc_correlation	whether random coefficients are correlated
rc_mean	whether mu parameters are estimated
use_asc	whether ASCs are included
include_outside_option	whether outside option is included

Value

Vector of length J (or J+1 with outside option) of predicted shares.

---

new_choicer_sim *Construct a* choicer_sim *object*

Description

Wraps simulated data, true parameter values, and DGP settings into a classed list. Returned by simulate_mnl_data(), simulate_mxl_data(), and simulate_nl_data(), and consumed by recovery_table().

Usage

```
new_choicer_sim(data, true_params, settings, model)
```

Arguments

data	A data.table of simulated choice observations.
true_params	Named list of true DGP parameters (e.g. beta, delta, Sigma, mu, lambdas).
settings	Named list of DGP settings (e.g. N, J, K_x).
model	Character scalar: "mnl", "mxl", or "nl".

Value

A list of class choicer_sim.

`nl_loglik_gradient_parallel` *Log-likelihood and gradient for Nested Logit model*

Description

Computes the log-likelihood and its gradient for the Nested Logit model using OpenMP for parallelization. Especially handles singleton nests by fixing their lambda parameters to 1. Only non-singleton nests have a inclusive value coefficient estimated in theta.

Usage

```
nl_loglik_gradient_parallel(
  theta,
  X,
  alt_idx,
  choice_idx,
  nest_idx,
  M,
  weights,
  use_asc = TRUE,
  include_outside_option = FALSE
)
```

Arguments

`theta`	(K + n_non_singleton_nests + n_delta) vector with model parameters. Order: `[beta (K), lambda (n_non_singleton_nests), delta (n_delta)]`
`X`	sum(M) x K design matrix with covariates.
`alt_idx`	sum(M) x 1 vector with indices of alternatives; 1-based indexing.
`choice_idx`	N x 1 vector with indices of chosen alternatives; 0 for outside option, 1-based index relative to rows in X_i otherwise.
`nest_idx`	J x 1 vector with indices of nests for each alternative; 1-based indexing (1 to n_nests).
`M`	N x 1 vector with number of alternatives for each individual.
`weights`	N x 1 vector with weights for each observation.
`use_asc`	whether to use alternative-specific constants.
`include_outside_option`	whether to include outside option normalized to V=0, lambda=1.

Value

List with loglikelihood and gradient evaluated at input arguments

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 4
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, nest := ifelse(alt <= 2, "A", "B")]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
d <- prepare_nl_data(dt, "id", "alt", "choice", c("x1", "x2"), "nest")
K_x <- ncol(d$X); K_l <- length(unique(d$nest_idx))
theta <- c(rep(0, K_x), rep(0.5, K_l), rep(0, J - 1))
result <- nl_loglik_gradient_parallel(theta, d$X, d$alt_idx,
  d$choice_idx, d$nest_idx, d$M, d$weights)
result$objective
```

---

nl_loglik_numeric_hessian

Numerical Hessian of the log-likelihood via finite differences

---

Description

Numerical Hessian of the log-likelihood via finite differences

Usage

```
nl_loglik_numeric_hessian(
  theta,
  X,
  alt_idx,
  choice_idx,
  nest_idx,
  M,
  weights,
  use_asc = TRUE,
  include_outside_option = FALSE,
  eps = 1e-06
)
```

Arguments

theta	(K + n_delta + n_nests) vector with model parameters. Order: [beta (K), delta (n_delta), lambda (
X	sum(M) x K design matrix with covariates.
alt_idx	sum(M) x 1 vector with indices of alternatives; 1-based indexing.
choice_idx	N x 1 vector with indices of chosen alternatives; 0 for outside option, 1-based index relative to rows in X_i otherwise.

nest_idx	J x 1 vector with indices of nests for each alternative; 1-based indexing (1 to n_nests).
M	N x 1 vector with number of alternatives for each individual.
weights	N x 1 vector with weights for each observation.
use_asc	whether to use alternative-specific constants.
include_outside_option	whether to include outside option normalized to V=0, lambda=1.
eps	finite difference step size

Value

Hessian evaluated at input arguments

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 4
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, nest := ifelse(alt <= 2, "A", "B")]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
d <- prepare_nl_data(dt, "id", "alt", "choice", c("x1", "x2"), "nest")
K_x <- ncol(d$X); K_l <- length(unique(d$nest_idx))
theta <- c(rep(0, K_x), rep(0.5, K_l), rep(0, J - 1))
H <- nl_loglik_numeric_hessian(theta, d$X, d$alt_idx, d$choice_idx,
  d$nest_idx, d$M, d$weights)
dim(H)
```

---

nobs.choicer_fit *Extract number of observations from a choicer_fit object*

Description

Extract number of observations from a choicer_fit object

Usage

```
## S3 method for class 'choicer_fit'
nobs(object, ...)
```

Arguments

object	A choicer_fit object.
...	Additional arguments (ignored).

Value

Integer number of choice situations.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
nobs(fit)
```

---

predict.choicer_mnl *Predict from a multinomial logit model*

Description

Computes choice probabilities or aggregate market shares.

Usage

```
## S3 method for class 'choicer_mnl'
predict(object, type = c("probabilities", "shares"), ...)
```

Arguments

object	A choicer_mnl object.
type	One of "probabilities" (individual-level choice probabilities) or "shares" (aggregate market shares).
...	Additional arguments (ignored).

Value

For "probabilities": a list with `choice_prob` and `utility` vectors. For "shares": a named numeric vector of market shares per alternative.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
```

```
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
predict(fit, type = "shares")
predict(fit, type = "probabilities")
```

`predict.choicer_mxl` *Predict from a mixed logit model*

Description

Computes simulated choice probabilities or aggregate market shares using stored Halton draws.

Usage

```
## S3 method for class 'choicer_mxl'
predict(object, type = c("probabilities", "shares"), ...)
```

Arguments

`object`	A choicer_mxl object.
`type`	Either "probabilities" (per-observation simulated choice probabilities) or "shares" (aggregate simulated market shares).
`...`	Additional arguments (ignored).

Value

For "probabilities": a list with `choice_prob` and `utility` vectors averaged across simulation draws. For "shares": a named numeric vector of simulated market shares per alternative.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), w1 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mxlogit(
  data = dt, id_col = "id", alt_col = "alt", choice_col = "choice",
  covariate_cols = "x1", random_var_cols = "w1", S = 50L
)
predict(fit, type = "shares")
predict(fit, type = "probabilities")
```

prepare_mnl_data *Prepare inputs for* mnl_loglik_gradient_parallel()

Description

Prepares and validates inputs for multinomial logit estimation routine.

Usage

```
prepare_mnl_data(
  data,
  id_col,
  alt_col,
  choice_col,
  covariate_cols,
  weights = NULL,
  outside_opt_label = NULL,
  include_outside_option = FALSE
)
```

Arguments

data	Data frame containing choice data.
id_col	Name of the column identifying choice situations (individuals).
alt_col	Name of the column identifying alternatives.
choice_col	Name of the column indicating chosen alternative (1 = chosen, 0 = not chosen).
covariate_cols	Vector of names of columns to be used as covariates.
weights	Optional vector of weights for each choice situation. If NULL, equal weights are used.
outside_opt_label	Label for the outside option (if any). If NULL, no outside option is assumed.
include_outside_option	Logical indicating whether to include an outside option in the model.

Value

A list containing:

- X: Design matrix (sum(M) x K).
- alt_idx: Integer vector of alternative indices.
- choice_idx: Integer vector of chosen alternative indices.
- M: Integer vector with number of alternatives per choice situation.
- N: Number of choice situations.
- weights: Vector of weights.

- include_outside_option: Logical flag.
- alt_mapping: Data.table mapping alternatives to summary statistics.
- dropped_cols: Names of columns dropped due to collinearity, if any.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
input <- prepare_mnl_data(dt, "id", "alt", "choice", c("x1", "x2"))
str(input$X)
input$alt_mapping
```

---

prepare_mxl_data *Prepare inputs for* mxl_loglik_gradient_parallel()

Description

Prepares and validates inputs for mixed logit estimation routine.

Usage

```
prepare_mxl_data(
  data,
  id_col,
  alt_col,
  choice_col,
  covariate_cols,
  random_var_cols,
  weights = NULL,
  outside_opt_label = NULL,
  include_outside_option = FALSE,
  rc_correlation = FALSE
)
```

Arguments

data	Data frame containing choice data
id_col	Name of the column identifying choice situations (individuals)
alt_col	Name of the column identifying alternatives
choice_col	Name of the column indicating chosen alternative (1 = chosen, 0 = not chosen)
covariate_cols	Vector of names of columns to be used as covariates

`random_var_cols`
: Vector of names of columns to be used as random variables

`weights`
: Optional vector of weights for each choice situation. If NULL, equal weights are used.

`outside_opt_label`
: Label for the outside option (if any). If NULL, no outside option is assumed.

`include_outside_option`
: Logical indicating whether to include an outside option in the model.

`rc_correlation`
: Logical indicating whether random coefficients are correlated. Default is FALSE.

Value

A `choicer_data_mxl` object (list) containing:

- `X`: Fixed-coefficient design matrix (sum(M) x K_x).
- `W`: Random-coefficient design matrix (sum(M) x K_w).
- `alt_idx`: Integer vector of alternative indices.
- `choice_idx`: Integer vector of chosen alternative indices.
- `M`: Integer vector with number of alternatives per choice situation.
- `N`: Number of choice situations.
- `weights`: Vector of weights.
- `include_outside_option`: Logical flag.
- `rc_correlation`: Logical flag.
- `alt_mapping`: data.table mapping alternatives to summary statistics.
- `dropped_cols`: Names of columns dropped due to collinearity, if any.
- `data_spec`: List with column-name metadata.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), w1 = rnorm(.N), w2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
input <- prepare_mxl_data(dt, "id", "alt", "choice", "x1", c("w1", "w2"))
str(input$X)
str(input$W)
```

prepare_nl_data *Prepare inputs for nested logit estimation*

Description

Validates inputs, builds design matrices, and constructs nest structure for nested logit estimation. Calls prepare_mnl_data internally for base data preparation, then adds nest-specific fields.

Usage

```
prepare_nl_data(
  data,
  id_col,
  alt_col,
  choice_col,
  covariate_cols,
  nest_col,
  weights = NULL,
  outside_opt_label = NULL,
  include_outside_option = FALSE
)
```

Arguments

data	Data frame containing choice data.
id_col	Name of the column identifying choice situations (individuals).
alt_col	Name of the column identifying alternatives.
choice_col	Name of the column indicating chosen alternative (1 = chosen, 0 = not chosen).
covariate_cols	Vector of names of columns to be used as covariates.
nest_col	Name of the column mapping each alternative to its nest. Every alternative must belong to exactly one nest.
weights	Optional vector of weights for each choice situation. If NULL, equal weights are used.
outside_opt_label	Label for the outside option (if any). If NULL, no outside option is assumed.
include_outside_option	Logical indicating whether to include an outside option in the model.

Value

A choicer_data_nl object (list) containing:

- All fields from prepare_mnl_data (X, alt_idx, choice_idx, M, N, weights, include_outside_option, alt_mapping, dropped_cols).
- nest_idx: Integer vector of length J mapping each alternative (in alt_mapping row order) to its nest.
- data_spec: List with column name metadata including nest_col.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 4
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, nest := ifelse(alt <= 2, "A", "B")]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
input <- prepare_nl_data(dt, "id", "alt", "choice", c("x1", "x2"), "nest")
input$nest_idx
input$alt_mapping
```

---

print.choicer_fit *Print a choicer_fit object*

Description

Prints a brief summary of the fitted model.

Usage

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

Arguments

x	A choicer_fit object.
...	Additional arguments (ignored).

Value

The object invisibly.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
print(fit)
```

print.summary.choicer_mnl

Print summary for multinomial logit model

Description

Print summary for multinomial logit model

Usage

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

Arguments

x	A summary.choicer_mnl object.
...	Additional arguments (ignored).

Value

The object invisibly.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
print(summary(fit))
```

print.summary.choicer_mxl

Print summary for mixed logit model

Description

Print summary for mixed logit model

Usage

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

Arguments

x	A summary.choicer_mxl object.
...	Additional arguments (ignored).

Value

The object invisibly.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), w1 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mxlogit(
  data = dt, id_col = "id", alt_col = "alt", choice_col = "choice",
  covariate_cols = "x1", random_var_cols = "w1", S = 50L
)
print(summary(fit))
```

---

print.summary.choicer_nl

Print summary for nested logit model

Description

Print summary for nested logit model

Usage

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

Arguments

x	A summary.choicer_nl object.
...	Additional arguments (ignored).

Value

The object invisibly.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 4
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, nest := ifelse(alt <= 2, "A", "B")]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_nestlogit(
  data = dt, id_col = "id", alt_col = "alt", choice_col = "choice",
  covariate_cols = c("x1", "x2"), nest_col = "nest"
)
print(summary(fit))
```

---

recovery_table *Parameter recovery table*

Description

Compares fitted coefficients to a set of true parameter values on the same scale as the estimator's internal parameterization. Returns one row per estimated parameter with true value, estimate, standard error, bias, relative bias (%), z-score against the truth, Wald CI, and a coverage indicator.

Usage

```
recovery_table(object, truth = NULL, level = 0.95, ...)

## S3 method for class 'choicer_fit'
recovery_table(object, truth = NULL, level = 0.95, ...)

## S3 method for class 'choicer_mc'
recovery_table(object, truth = NULL, level = 0.95, ...)
```

Arguments

`object`	A `choicer_fit` object (MNL, MXL, or NL) or a `choicer_mc` result.
`truth`	Either a `choicer_sim` object (whose `$true_params` will be used) or a named list of true parameter values.
`level`	Confidence level for the Wald CI and coverage indicator. Default `0.95`.
`...`	Unused.

Details

For MXL fits the `sigma` block compares the raw Cholesky parameters (`L_params`), not the reconstructed covariance matrix. For log-normal random-coefficient means the raw `mu` estimate is compared directly; callers who want recovery on the DGP scale (`exp(mu)`) should transform both sides before calling.

When the estimator has normalized the first inside alternative's ASC to zero (which happens for MNL/MXL with `include_outside_option = FALSE` and no outside option baked into the fit), the first entry of `truth$delta` is dropped before the comparison so lengths match.

Value

See class-specific methods.

Methods (by class)

- `recovery_table(choicer_fit)`: Returns a `choicer_recovery` object (a `data.table`) with columns `parameter`, `group`, `true`, `estimate`, `se`, `bias`, `rel_bias_pct`, `z_vs_true`, `lower_ci`, `upper_ci`, `covers`.
- `recovery_table(choicer_mc)`: For a `choicer_mc` object, delegates to `summary(object, level)` and returns a `choicer_mc_summary`. Inspect `object$replications` directly for per-rep detail.

Examples

```
sim <- simulate_mnl_data(N = 2000, J = 4, seed = 123)
fit <- run_mnlogit(
  data = sim$data, id_col = "id", alt_col = "alt", choice_col = "choice",
  covariate_cols = c("x1", "x2"),
  outside_opt_label = 0L, include_outside_option = FALSE, use_asc = TRUE
)
recovery_table(fit, sim)
```

---

run_mnlogit *Runs multinomial logit estimation*

Description

Estimates a multinomial logit model via maximum likelihood.

Usage

```
run_mnlogit(
  data = NULL,
  id_col = NULL,
  alt_col = NULL,
  choice_col = NULL,
```

```
  covariate_cols = NULL,
  input_data = NULL,
  optimizer = NULL,
  control = list(),
  weights = NULL,
  outside_opt_label = NULL,
  include_outside_option = FALSE,
  use_asc = TRUE,
  keep_data = TRUE,
  nloptr_opts = NULL
)
```

Arguments

`data`	Data frame containing choice data (convenience workflow). Mutually exclusive with `input_data`.
`id_col`	Name of the column identifying choice situations (individuals).
`alt_col`	Name of the column identifying alternatives.
`choice_col`	Name of the column indicating chosen alternative (1 = chosen, 0 = not chosen).
`covariate_cols`	Vector of names of columns to be used as covariates.
`input_data`	List output from `prepare_mnl_data` (advanced workflow). Mutually exclusive with `data`.
`optimizer`	Optimizer to use: `"nloptr"` (default), `"optim"`, or a custom function with signature `f(theta_init, eval_f, lower, upper, control)` where `eval_f(theta)` returns `list(objective, gradient)`. Must return a list with `par`/`value` (or `solution`/`objective`). If the custom function accepts `control` or `...`, the `control` argument is forwarded; otherwise it is silently ignored.
`control`	List of optimizer-specific control parameters passed to the chosen optimizer (e.g., `list(maxeval = 2000)` for nloptr).
`weights`	Optional vector of weights for each choice situation. If `NULL`, equal weights are used.
`outside_opt_label`	Label for the outside option (if any). If `NULL`, no outside option is assumed.
`include_outside_option`	Logical indicating whether to include an outside option in the model.
`use_asc`	Logical indicating whether to include alternative-specific constants (ASCs) in the model.
`keep_data`	Logical. If `TRUE` (default), stores prepared data in the returned object for `predict()` and post-estimation functions.
`nloptr_opts`	Deprecated. Use `optimizer` and `control` instead.

Details

Two workflows are supported:

Convenience (default) Supply `data` and column names. Data preparation (`prepare_mnl_data`) is handled automatically.

Advanced Call `prepare_mnl_data` yourself and pass the result via `input_data`.

Value

A `choicer_mnl` object (inherits from `choicer_fit`). Standard S3 methods available: `summary()`, `coef()`, `vcov()`, `logLik()`, `AIC()`, `BIC()`, `nobs()`, `predict()`.

Examples

```
library(data.table)
set.seed(42)
N <- 100; J <- 3; beta_true <- c(1.0, -0.5)
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, V := drop(as.matrix(.SD) %*% beta_true), .SDcols = c("x1","x2")]
dt[, prob := exp(V) / sum(exp(V)), by = id]
dt[, choice := as.integer(alt == sample(alt, 1, prob = prob)), by = id]

fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
summary(fit)
coef(fit)
AIC(fit)
predict(fit, type = "shares")
```

`run_mxlogit` *Runs mixed logit estimation*

Description

Estimates a mixed logit model via simulated maximum likelihood.

Usage

```
run_mxlogit(
  data = NULL,
  id_col = NULL,
  alt_col = NULL,
  choice_col = NULL,
  covariate_cols = NULL,
  random_var_cols = NULL,
  input_data = NULL,
  eta_draws = NULL,
  S = 100L,
  rc_dist = NULL,
  rc_mean = FALSE,
```

```
  rc_correlation = FALSE,
  use_asc = TRUE,
  theta_init = NULL,
  lower = NULL,
  upper = NULL,
  optimizer = NULL,
  control = list(),
  se_method = c("hessian", "bhhh"),
  scale_vars = c("none", "sd", "mad", "iqr"),
  weights = NULL,
  outside_opt_label = NULL,
  include_outside_option = FALSE,
  keep_data = TRUE,
  nloptr_opts = NULL
)
```

Arguments

`data`	Data frame containing choice data (convenience workflow). Mutually exclusive with `input_data`.
`id_col`	Name of the column identifying choice situations.
`alt_col`	Name of the column identifying alternatives.
`choice_col`	Name of the column indicating chosen alternative (1/0).
`covariate_cols`	Vector of column names for fixed covariates.
`random_var_cols`	Vector of column names for random coefficients.
`input_data`	List output from `prepare_mxl_data` (advanced workflow). Mutually exclusive with `data`.
`eta_draws`	Array of shape K_w x S x N with standard normal draws. Required for the advanced workflow; auto-generated from `S` in the convenience workflow.
`S`	Integer number of Halton draws per individual (convenience workflow only). Default 100.
`rc_dist`	Integer vector indicating distribution of random coefficients (0 = normal, 1 = log-normal). Default: all normal.
`rc_mean`	Logical indicating whether to estimate means for random coefficients.
`rc_correlation`	Logical indicating whether random coefficients are correlated (convenience workflow). Ignored when `input_data` is used (taken from the prepared data).
`use_asc`	Logical indicating whether to include alternative-specific constants.
`theta_init`	Initial parameter vector in natural-scale units. If `NULL`, defaults to zeros for the β, μ, and ASC blocks, and `log(0.5)` on the Cholesky diagonal (so each diagonal factor $L_{pp} = 0.5$, i.e. a moderate random-coefficient variance of `0.25`). The zero-on-diagonal alternative corresponds to $L_{pp} = 1$ (unit RC variance), which often lets the first L-BFGS step overshoot.
`lower, upper`	Optional parameter bounds for the optimizer, in natural-scale units (forward-transformed internally to scaled space when `scale_vars != "none"`). Each accepts three forms:

NULL (default) Unbounded (-Inf/Inf).

Unnamed numeric vector of length n_params Full-length vector ordered exactly like theta_init (the nloptr-native form).

Named numeric vector Names must be a subset of the parameter names (β block: column names of X; μ block: Mu_<col> (if rc_mean = TRUE); Cholesky block: L_<i><j> for $i \geq j$; ASC block: ASC_<level>). Unlisted parameters default to $\pm\infty$. This is the recommended form for typical use, e.g. lower = c(L_11 = -5, L_22 = -5) to clip Cholesky diagonals.

optimizer Optimizer to use: "nloptr" (default), "optim", or a custom function. See run_mnlogit for details.

control List of optimizer-specific control parameters.

se_method Method for computing standard errors. Either "hessian" (default) for the analytical Hessian of the simulated log-likelihood, or "bhhh" for the BHHH/outer-product-of-gradients (OPG) estimator. BHHH scales better to large problems (many alternatives or simulation draws) but may underestimate standard errors in finite samples or away from the optimum.

scale_vars Pre-estimation column scaling for design matrices. One of "none" (default), "sd" (sample standard deviation), "mad" (stats::mad, i.e. 1.4826 $\times$ median absolute deviation; SD-equivalent under normality), or "iqr" (stats::IQR(x) / 1.349; also SD-equivalent under normality). When not "none", every column of X and W is divided by the chosen scale before optimization to improve Hessian conditioning. Robust scales ("mad"/"iqr") better capture the bulk for heavy-tailed columns where SD is dominated by outliers, but stats::mad can return zero when more than half of a column's entries are identical (e.g., a sparse 0/1 dummy) and will then trigger the same near-constant-column error as "sd". Coefficients and standard errors are back-transformed to the user's natural units via the delta method, so reported quantities are invariant to this choice. Columns of W associated with log-normal random coefficients (rc_dist == 1) are passed through unchanged, since the shifted log-normal parameterization does not admit a closed-form back-transform under multiplicative scaling.

weights Optional weight vector (convenience workflow). If NULL, equal weights are used.

outside_opt_label Label for the outside option (convenience workflow).

include_outside_option Logical whether to include an outside option (convenience workflow).

keep_data Logical. If TRUE (default), stores prepared data in the returned object for post-estimation functions.

nloptr_opts Deprecated. Use optimizer and control instead.

Details

Two workflows are supported:

Convenience Supply data and column names. Data preparation (prepare_mxl_data) and Halton draw generation (get_halton_normals) are handled automatically.

Advanced Call prepare_mxl_data and get_halton_normals yourself, then pass the results via input_data and eta_draws.

Value

A `choicer_mxl` object (inherits from `choicer_fit`). Standard S3 methods available: `summary()`, `coef()`, `vcov()`, `logLik()`, `AIC()`, `BIC()`, `nobs()`.

Examples

```
library(data.table)
set.seed(42)
N <- 100; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), w1 = rnorm(.N), w2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]

fit <- run_mxlogit(
  data = dt, id_col = "id", alt_col = "alt", choice_col = "choice",
  covariate_cols = "x1", random_var_cols = c("w1", "w2"), S = 50L
)
summary(fit)
```

---

run_nestlogit *Runs nested logit estimation*

Description

Estimates a nested logit model via maximum likelihood.

Usage

```
run_nestlogit(
  data = NULL,
  id_col = NULL,
  alt_col = NULL,
  choice_col = NULL,
  covariate_cols = NULL,
  nest_col = NULL,
  input_data = NULL,
  use_asc = TRUE,
  theta_init = NULL,
  param_names = NULL,
  optimizer = NULL,
  control = list(),
  weights = NULL,
  outside_opt_label = NULL,
  include_outside_option = FALSE,
  keep_data = TRUE,
  nloptr_opts = NULL
)
```

Arguments

data	Data frame containing choice data (convenience workflow). Mutually exclusive with input_data.
id_col	Name of the column identifying choice situations.
alt_col	Name of the column identifying alternatives.
choice_col	Name of the column indicating chosen alternative (1/0).
covariate_cols	Vector of column names for covariates.
nest_col	Name of the column mapping each alternative to its nest (convenience workflow).
input_data	List containing prepared input data for estimation (advanced workflow). Mutually exclusive with data.
use_asc	Logical indicating whether to include alternative specific constants (ASCs).
theta_init	Optional initial parameter vector. If NULL, a default vector is used.
param_names	Optional vector of parameter names. If NULL, default names are generated.
optimizer	Optimizer to use: "nloptr" (default), "optim", or a custom function. See run_mnlogit for details.
control	List of optimizer-specific control parameters.
weights	Optional weight vector (convenience workflow). If NULL, equal weights are used.
outside_opt_label	Label for the outside option (convenience workflow).
include_outside_option	Logical whether to include an outside option (convenience workflow).
keep_data	Logical. If TRUE (default), stores prepared data in the returned object for post-estimation functions.
nloptr_opts	Deprecated. Use optimizer and control instead.

Details

Two workflows are supported:

Convenience Supply data and column names (including nest_col). Data preparation (prepare_nl_data) is handled automatically.

Advanced Call prepare_nl_data (or build the input list manually) and pass it via input_data.

Value

A choicer_nl object (inherits from choicer_fit). Standard S3 methods available: summary(), coef(), vcov(), logLik(), AIC(), BIC(), nobs().

Examples

```
library(data.table)
set.seed(42)
N <- 100; J <- 4
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, nest := ifelse(alt <= 2, "A", "B")]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]

fit <- run_nestlogit(
  data = dt, id_col = "id", alt_col = "alt", choice_col = "choice",
  covariate_cols = c("x1", "x2"), nest_col = "nest"
)
summary(fit)
```

`simulate_mnl_data` *Simulate multinomial logit data*

Description

Generates synthetic choice data with i.i.d. Gumbel errors, optionally with varying choice-set sizes and an outside option (alt = 0). Choices are determined by argmax of utility; covariates are drawn as Uniform(-1, 1).

Usage

```
simulate_mnl_data(
  N = 5000,
  J = 5,
  beta = c(0.8, -0.6),
  delta = NULL,
  seed = 123,
  outside_option = TRUE,
  vary_choice_set = TRUE
)
```

Arguments

`N`	Number of choice situations.
`J`	Number of inside alternatives.
`beta`	Fixed coefficients for `x1..x{K_x}` (length `K_x = length(beta)`).
`delta`	Alternative-specific constants for inside alternatives (length `J`). Defaults to an alternating pattern of `c(0.5, -0.5)`.
`seed`	Random seed. Pass `NULL` to skip `set.seed()` (useful inside `monte_carlo()` where the caller manages RNG).

`outside_option` Logical; if `TRUE` (default) an outside option with `alt = 0` and zero covariates is added to every choice set.

`vary_choice_set` Logical; if `TRUE` (default) choice set size is sampled uniformly from `2:J`; if `FALSE` every individual faces all `J` inside alternatives.

Value

A `choicer_sim` object.

Examples

```
sim <- simulate_mnl_data(N = 1000, J = 5, seed = 123)
print(sim)
```

---

simulate_mxl_data *Simulate mixed logit data*

Description

Generates synthetic choice data with random coefficients drawn from a multivariate normal (optionally log-normal per dimension) and an additional mean shifter `mu`. Random coefficients are parameterized via the lower Cholesky factor of `Sigma`. Covariates are Uniform(-1, 1) by default; columns named in `price_cols` are drawn as `-Uniform(0.1, 3)` to mimic strictly-negative price variables.

Usage

```
simulate_mxl_data(
  N = 5000,
  J = 4,
  beta = c(0.8, -0.6),
  delta = NULL,
  mu = NULL,
  Sigma = matrix(c(1, 0.5, 0.5, 1.5), nrow = 2),
  rc_dist = NULL,
  rc_correlation = NULL,
  price_cols = NULL,
  seed = 123,
  outside_option = TRUE,
  vary_choice_set = TRUE
)
```

Arguments

N	Number of choice situations.
J	Number of inside alternatives.
beta	Fixed coefficients for x1..x{K_x} (length K_x = length(beta)).
delta	ASCs for inside alternatives (length J). Defaults to an alternating pattern of c(0.5, -0.5).
mu	Mean shifter for random coefficients (length K_w = ncol(Sigma)). Defaults to a zero vector.
Sigma	Covariance matrix of random coefficients (square, K_w x K_w).
rc_dist	Integer vector (length K_w): 0L for normal, 1L for log-normal. Default NULL is treated as all-normal.
rc_correlation	Logical; if NULL (default) it is auto-detected from the off-diagonal entries of Sigma.
price_cols	Character vector of w* column names to draw as -Uniform(0.1, 3) instead of Uniform(-1, 1). Default NULL.
seed	Random seed (NULL skips set.seed()).
outside_option	Logical; include outside option with alt = 0.
vary_choice_set	Logical; if TRUE (default) choice set size is sampled uniformly from 2:J.

Details

Random coefficients are constructed to match the estimator's parameterization in src/mxlogit.cpp. For every dimension the raw draw is L %*% eta where eta ~ N(0, I). A normal random coefficient (rc_dist = 0) is then gamma_k = mu_k + (L %*% eta)_k. A log-normal random coefficient (rc_dist = 1) follows the shifted log-normal beta_k = exp(mu_k) + exp((L %*% eta)_k) – not the textbook exp(mu_k + sigma_k * eta) – so mu_k in true_params$mu is on the same scale the estimator recovers and recovery_table() can compare like-for-like.

Value

A choicer_sim object. true_params includes beta, delta, Sigma, L_params (packed Cholesky parameters), mu, rc_dist, rc_correlation.

Examples

```
sim <- simulate_mxl_data(N = 1000, J = 4, seed = 123)
print(sim)
```

simulate_nl_data *Simulate nested logit data*

Description

Generates synthetic choice data with nested logit probabilities computed analytically (log-sum-exp over inclusive values), then samples choices from the implied multinomial. The outside option (`j = 0`) sits in a singleton nest with `lambda = 1`.

Usage

```
simulate_nl_data(
  N = 10000,
  beta = c(1.5, -0.8),
  delta = c(`1` = 0.5, `2` = 0.3, `3` = -0.2, `4` = -0.5, `5` = 0.4),
  nests = list(c(1, 2), c(3, 4, 5)),
  lambdas = c(0.8, 0.2),
  seed = 123
)
```

Arguments

`N`	Number of choice situations.
`beta`	Fixed coefficients for covariates `X, W` (length 2 by default).
`delta`	Named numeric vector of ASCs for inside alternatives.
`nests`	List of integer vectors defining nest membership for inside alternatives.
`lambdas`	Numeric vector of dissimilarity parameters, one per nest.
`seed`	Random seed (`NULL` skips `set.seed()`).

Value

A `choicer_sim` object. `true_params` includes `beta`, `delta`, `lambdas`; `settings` includes the `nest_structure`. The returned `data` retains a `nest` column (integer, with `0L` for the outside option) for convenient use with `run_nestlogit()`.

Note

Unlike `simulate_mnl_data()` and `simulate_mxl_data()`, this function does not expose `outside_option` or `vary_choice_set` flags. The outside option (`j = 0`) is always present as a singleton nest with `lambda = 1`, and every individual faces the full set of inside alternatives. Add these flags if downstream use cases need them.

Examples

```
sim <- simulate_nl_data(N = 2000, seed = 123)
print(sim)
```

summary.choicer_mnl *Summary for multinomial logit model*

Description

Computes and returns a coefficient summary table with standard errors, z-values, p-values, and significance codes. Triggers lazy Hessian computation if standard errors have not been computed yet.

Usage

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

Arguments

object	A choicer_mnl object.
...	Additional arguments (ignored).

Value

A summary.choicer_mnl object (list with coefficients table and metadata).

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
summary(fit)
```

summary.choicer_mxl *Summary for mixed logit model*

Description

Computes coefficient summary with delta-method transformation for variance parameters (Cholesky to covariance scale) and log-normal mean parameters. Triggers lazy Hessian computation if standard errors have not been computed yet.

Usage

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

Arguments

object	A choicer_mxl object.
...	Additional arguments (ignored).

Value

A summary.choicer_mxl object.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), w1 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mxlogit(
  data = dt, id_col = "id", alt_col = "alt", choice_col = "choice",
  covariate_cols = "x1", random_var_cols = "w1", S = 50L
)
summary(fit)
```

---

summary.choicer_nl *Summary for nested logit model*

Description

Triggers lazy Hessian computation if standard errors have not been computed yet.

Usage

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

Arguments

object	A choicer_nl object.
...	Additional arguments (ignored).

Value

A summary.choicer_nl object.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 4
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, nest := ifelse(alt <= 2, "A", "B")]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_nestlogit(
  data = dt, id_col = "id", alt_col = "alt", choice_col = "choice",
  covariate_cols = c("x1", "x2"), nest_col = "nest"
)
summary(fit)
```

---

vcov.choicer_fit *Extract variance-covariance matrix from a choicer_fit object*

Description

Triggers lazy Hessian computation if vcov has not been computed yet.

Usage

```
## S3 method for class 'choicer_fit'
vcov(object, ...)
```

Arguments

object	A choicer_fit object.
...	Additional arguments (ignored).

Value

Named variance-covariance matrix, or NULL if unavailable.

Examples

```
library(data.table)
set.seed(42)
N <- 50; J <- 3
dt <- data.table(id = rep(1:N, each = J), alt = rep(1:J, N))
dt[, `:=`(x1 = rnorm(.N), x2 = rnorm(.N))]
dt[, choice := 0L]
dt[, choice := sample(c(1L, rep(0L, J - 1))), by = id]
fit <- run_mnlogit(dt, "id", "alt", "choice", c("x1", "x2"))
vcov(fit)
```

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