Package: bqmm (via r-universe)

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Title Bayesian Multilevel Quantile Regression

Version 0.1.0

Description Fits Bayesian mixed-effects (multilevel) quantile regression models using the asymmetric Laplace working likelihood and Stan. Supports an 'lme4'-style formula interface with nested and crossed random effects, fitting one or several quantiles, post-hoc non-crossing rearrangement of fitted quantiles, and the Yang, Wang and He (2016) posterior-variance correction for valid frequentist inference from the (misspecified) asymmetric Laplace posterior.

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ald *The asymmetric Laplace family for quantile regression*

Description

A lightweight family object describing the asymmetric Laplace distribution (ALD) working likelihood used by `bqmm()`. It mirrors the role of a stats::family object but is intentionally minimal in this release.

Usage

```
ald(link = "identity")
```

Arguments

`link`	Name of the link for the location (quantile) parameter. Only `"identity"` is supported in v0.1.

Value

An object of class `"bqmm_family"`.

Examples

```
ald()
```

as.matrix.bqmm *Coerce a bqmm fit to a matrix of posterior draws*

Description

Coerce a bqmm fit to a matrix of posterior draws

Usage

```
## S3 method for class 'bqmm'
as.matrix(x, ...)
```

Arguments

`x`	A bqmm fit.
`...`	Unused.

Value

A matrix of posterior draws (draws in rows, parameters in columns), using the raw Stan parameter names.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
dim(as.matrix(fit))
```

---

as_draws.bqmm *Convert a bqmm fit to a posterior draws object*

Description

Convert a bqmm fit to a posterior draws object

Usage

```
## S3 method for class 'bqmm'
as_draws(x, ...)
```

Arguments

x	A bqmm fit.
...	Unused.

Value

A draws_array (from the posterior package) with tidy variable names: b_<name> for fixed effects, sd_<component> for random-effect SDs, and sigma.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
as_draws(fit)
```

---

bqmm *Bayesian multilevel quantile regression*

Description

Fits a Bayesian mixed-effects quantile regression model using the asymmetric Laplace working likelihood and Stan. The interface follows lme4: random effects are written inline in the formula, e.g. y ~ x + (1 + x | group), and nested or crossed grouping factors are both supported.

Usage

```
bqmm(
  formula,
  data,
  tau = 0.5,
  family = ald(),
  prior = NULL,
  cov = c("diagonal", "unstructured"),
  adjust = TRUE,
  prior_only = FALSE,
  chains = 4,
  iter = 2000,
  warmup = floor(iter/2),
  cores = getOption("mc.cores", 1L),
  seed = NULL,
  control = list(adapt_delta = 0.95),
  ...
)
```

Arguments

formula	An lme4-style model formula.
data	A data frame containing the variables in formula.
tau	Quantile level(s) in (0, 1). Scalar or vector.
family	A bqmm_family object; currently only ald().
prior	A bqmm_prior() object, or NULL for data-scaled defaults.
cov	Random-effect covariance structure. "diagonal" (default) models independent random effects and supports any number of nested or crossed terms. "unstructured" adds an LKJ-correlated covariance but currently requires exactly one random-effects term (e.g. y ~ x + (1 + x | g)).
adjust	Logical; compute the Yang-Wang-He (2016) variance correction so that vcov(fit, adjusted = TRUE) returns valid fixed-effect uncertainty. Default TRUE.
prior_only	Logical; sample from the prior predictive distribution.
chains, iter, warmup, cores, seed	Passed to rstan::sampling().
control	A list of sampler control parameters (e.g. adapt_delta). Defaults raise adapt_delta to 0.95 because ALD posteriors are sharp.
...	Additional arguments forwarded to rstan::sampling().

Details

One or several quantiles may be requested through tau. A scalar returns a single bqmm fit; a vector fits each quantile independently and returns a bqmm_multi container.

Value

A bqmm object (single tau) or a bqmm_multi object (vector tau).

Examples

```
# A minimal fit; raise chains/iter for real analyses.
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
summary(fit)
```

---

bqmm_prior *Priors for a Bayesian quantile mixed model*

Description

Builds the list of prior hyperparameters passed to Stan. Defaults are weakly informative and scaled to the data (see bqmm_default_priors()); any element supplied here overrides the default.

Usage

```
bqmm_prior(
  beta_mean = 0,
  beta_sd = NULL,
  sigma_scale = NULL,
  re_scale = NULL,
  lkj = 2
)
```

Arguments

beta_mean	Numeric scalar or vector: prior mean(s) for the fixed-effect coefficients. Recycled to the number of columns of the design matrix. Default 0.
beta_sd	Positive scalar or vector: prior SD(s) for the fixed-effect coefficients. NULL (default) uses a data-scaled value.
sigma_scale	Positive scalar: half-normal scale for the ALD scale sigma. NULL (default) uses a data-scaled value.
re_scale	Positive scalar: half-normal scale for the random-effect standard deviations. NULL (default) uses a data-scaled value.
lkj	Positive scalar: LKJ shape parameter for the random-effect correlation matrix (used only when cov = "unstructured"). 2 favours weak correlations; 1 is uniform over correlation matrices.

Value

An object of class "bqmm_prior".

Examples

```
bqmm_prior(beta_sd = 5)
```

coef.bqmm *Extract model coefficients*

Description

Alias for `fixef()`; returns the posterior-median fixed effects.

Usage

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

Arguments

`object`	A bqmm fit.
`...`	Unused.

Value

A named numeric vector of posterior-median fixed-effect coefficients.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
coef(fit)
```

coef.bqmm_multi *Coefficient-versus-tau matrix for a bqmm_multi fit*

Description

Coefficient-versus-tau matrix for a bqmm_multi fit

Usage

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

Arguments

`object`	A bqmm_multi fit.
`...`	Unused.

Value

A tau-by-coefficient matrix of posterior-median fixed effects, with one row per quantile.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = c(0.25, 0.75), chains = 1, iter = 250,
            refresh = 0, seed = 1)
coef(fit)
```

`confint.bqmm` *Confidence (credible) intervals for the fixed effects*

Description

Wald-type intervals built from the posterior-median estimates and the (optionally misspecification-corrected) fixed-effect covariance.

Usage

```
## S3 method for class 'bqmm'
confint(
  object,
  parm,
  level = 0.95,
  adjusted = TRUE,
  method = c("ywh", "ij"),
  cluster = TRUE,
  ...
)
```

Arguments

`object`	A `bqmm` fit.
`parm`	Optional subset of coefficients (names or indices) to return.
`level`	Interval coverage (default `0.95`).
`adjusted`	Logical; if `TRUE` (default) use the corrected covariance from `vcov.bqmm()`, otherwise the naive posterior covariance.
`method`	Correction to use when `adjusted = TRUE`; see `vcov.bqmm()`.
`cluster`	Logical; use the cluster-robust form (default `TRUE`).
`...`	Unused.

Value

A matrix with one row per coefficient and lower/upper interval columns.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
confint(fit)
```

`fitted.bqmm` *Linear predictor (conditional tau-quantile) at the posterior median*

Description

Linear predictor (conditional tau-quantile) at the posterior median

Usage

```
## S3 method for class 'bqmm'
fitted(object, ...)
```

Arguments

`object`	A bqmm fit.
`...`	Unused.

Value

Numeric vector of fitted conditional quantiles.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
head(fitted(fit))
```

`fixef.bqmm` *Posterior-median fixed effects*

Description

Posterior-median fixed effects

Usage

```
## S3 method for class 'bqmm'
fixef(object, ...)
```

Arguments

object	A bqmm fit.
...	Unused.

Value

A named numeric vector of posterior-median fixed-effect coefficients.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
fixef(fit)
```

---

log_lik.bqmm *Pointwise log-likelihood draws*

Description

Pointwise log-likelihood draws

Usage

```
## S3 method for class 'bqmm'
log_lik(object, ...)
```

Arguments

object	A bqmm fit.
...	Unused.

Value

An S x N matrix of pointwise log-likelihood values, suitable for use with the loo package.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
dim(log_lik(fit))
```

nobs.bqmm *Number of observations used in the fit*

Description

Number of observations used in the fit

Usage

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

Arguments

object	A bqmm fit.
...	Unused.

Value

An integer, the number of observations.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
nobs(fit)
```

plot.bqmm *Plot a bqmm fit*

Description

Default plot shows fixed-effect posterior intervals. With bayesplot installed, richer MCMC plots are available via as_draws().

Usage

```
## S3 method for class 'bqmm'
plot(x, ...)
```

Arguments

x	A bqmm fit.
...	Unused.

Value

Invisibly, x.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
plot(fit)
```

---

plot.bqmm_multi *Plot coefficient-versus-tau paths for a bqmm_multi fit*

Description

Plot coefficient-versus-tau paths for a bqmm_multi fit

Usage

```
## S3 method for class 'bqmm_multi'
plot(x, ...)
```

Arguments

x	A bqmm_multi fit.
...	Unused.

Value

Invisibly, x.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = c(0.25, 0.75), chains = 1, iter = 250,
            refresh = 0, seed = 1)
plot(fit)
```

posterior_epred.bqmm *Draws of the expected response (conditional tau-quantile)*

Description

Draws of the expected response (conditional tau-quantile)

Usage

```
## S3 method for class 'bqmm'
posterior_epred(object, ...)
```

Arguments

object	A bqmm fit.
...	Unused.

Value

An S x N matrix of posterior draws of the linear predictor, where S is the number of posterior draws and N the number of observations.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
dim(posterior_epred(fit))
```

posterior_predict.bqmm *Draws from the posterior predictive distribution*

Description

Draws from the posterior predictive distribution

Usage

```
## S3 method for class 'bqmm'
posterior_predict(object, ...)
```

Arguments

object	A bqmm fit.
...	Unused.

Value

An S x N matrix of posterior predictive draws of the response, where S is the number of posterior draws and N the number of observations.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
dim(posterior_predict(fit))
```

---

predict.bqmm *Predictions from a bqmm fit*

Description

Predictions from a bqmm fit

Usage

```
## S3 method for class 'bqmm'
predict(
  object,
  newdata = NULL,
  re.form = NULL,
  noncrossing = c("none", "rearrange"),
  ...
)
```

Arguments

object	A bqmm fit.
newdata	Optional data frame; if omitted, training data are used.
re.form	NULL includes random effects (training data only); NA gives population-level predictions.
noncrossing	One of "none" or "rearrange". Rearrangement only has an effect for bqmm_multi objects (multiple quantiles).
...	Unused.

Value

Numeric vector of predicted conditional quantiles.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
head(predict(fit, re.form = NA))
```

---

ranef.bqmm *Posterior-median random effects*

Description

Posterior-median random effects

Usage

```
## S3 method for class 'bqmm'
ranef(object, ...)
```

Arguments

object	A bqmm fit.
...	Unused.

Value

A numeric vector of posterior-median random effects aligned with the columns of the random-effects design matrix Z, or NULL if the model has no random effects.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
ranef(fit)
```

---

rearrange_quantiles *Rearrange fitted quantiles to remove crossing*

Description

Post-hoc monotonisation of estimated quantile curves (Chernozhukov, Fernandez-Val and Galichon, 2010): at any covariate point, sorting the fitted values across quantile levels into increasing order yields a valid, non-crossing set of quantiles and never increases estimation error. This is the v0.1 non-crossing strategy; joint constrained estimation is deferred.

Usage

```
rearrange_quantiles(preds)
```

Arguments

preds	A numeric matrix of fitted quantiles with one column per quantile level, ordered by increasing tau (rows = observations).

Value

A matrix of the same shape with each row sorted increasingly.

Examples

```
m <- rbind(c(1, 0.5, 2), c(0, 1, 0.8))   # some crossings
rearrange_quantiles(m)
```

---

residuals.bqmm *Residuals from a bqmm fit*

Description

Residuals from a bqmm fit

Usage

```
## S3 method for class 'bqmm'
residuals(object, ...)
```

Arguments

object	A bqmm fit.
...	Unused.

Value

Numeric vector of response-minus-fitted residuals.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
head(residuals(fit))
```

`summary.bqmm` *Summarize a bqmm fit*

Description

Produces a fixed-effect coefficient table (estimate, standard error and interval) together with random-effect standard deviations.

Usage

```
## S3 method for class 'bqmm'
summary(
  object,
  level = 0.95,
  adjusted = TRUE,
  method = c("ywh", "ij"),
  cluster = TRUE,
  ...
)
```

Arguments

`object`	A `bqmm` fit.
`level`	Interval coverage (default `0.95`).
`adjusted`	Logical; if `TRUE` (default) use the corrected covariance from `vcov.bqmm()` for the standard errors and intervals.
`method`	Correction to use when `adjusted = TRUE`; see `vcov.bqmm()`.
`cluster`	Logical; use the cluster-robust form (default `TRUE`).
`...`	Unused.

Value

An object of class `summary.bqmm`.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
summary(fit)
```

summary.bqmm_multi *Summarize a bqmm_multi fit*

Description

Summarize a bqmm_multi fit

Usage

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

Arguments

object	A bqmm_multi fit.
...	Passed to the per-quantile summary() method for each fit.

Value

A list of summary.bqmm objects, one per quantile.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = c(0.25, 0.75), chains = 1, iter = 250,
            refresh = 0, seed = 1)
summary(fit)
```

VarCorr.bqmm *Random-effect standard deviations and correlations*

Description

Random-effect standard deviations and correlations

Usage

```
## S3 method for class 'bqmm'
VarCorr(x, sigma = 1, ...)
```

Arguments

x	A bqmm fit.
sigma	Ignored; present for compatibility with the generic.
...	Unused.

Value

A named numeric vector of posterior-median random-effect standard deviations (with a posterior-median correlation matrix attached as the `"correlation"` attribute for unstructured models), or `NULL` if the model has no random effects.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
VarCorr(fit)
```

`vcov.bqmm` *Variance-covariance of the fixed effects*

Description

Variance-covariance of the fixed effects

Usage

```
## S3 method for class 'bqmm'
vcov(object, adjusted = TRUE, method = c("ywh", "ij"), cluster = TRUE, ...)
```

Arguments

`object`	A `bqmm` fit.
`adjusted`	Logical; if `TRUE` (default) return a misspecification- corrected covariance (chosen by `method`), otherwise the naive posterior covariance.
`method`	Correction to use when `adjusted = TRUE`: `"ywh"` (default) is the Yang-Wang-He posterior-covariance sandwich (`compute_ywh_multiplicative()`); `"ij"` is the Infinitesimal Jackknife (`ij_vcov()`). Both are cluster-robust by default for a mixed model.
`cluster`	Logical; use the cluster-robust form (default `TRUE`).
`...`	Unused.

Value

A K x K covariance matrix for the fixed effects.

Examples

```
fit <- bqmm(distance ~ age + (1 | Subject), data = nlme::Orthodont,
            tau = 0.5, chains = 1, iter = 300, refresh = 0, seed = 1)
vcov(fit)
```

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