

Package ‘lillardhaz’

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Type Package

Title Simultaneous-Equations Hazard/Probit Models with a
Gaussian-Copula Correlation

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Description Fits two-equation simultaneous models in the style of Lillard (1993) <[doi:10.1016/0304-4076\(93\)90106-F](https://doi.org/10.1016/0304-4076(93)90106-F)>: a pair of processes, each either a binary probit outcome or a continuous-time hazard duration, linked through a single correlation parameter between their underlying error terms and estimated jointly by maximum likelihood via a Gaussian copula. Equation 1 may be a probit, a log-normal accelerated-failure-time hazard, or a piecewise (linear-log-hazard) Gompertz hazard with an arbitrary, user-specified number of segments; equation 2 is always a hazard, log-normal or piecewise Gompertz. Models can also be fit under independence (correlation fixed at zero), which reduces exactly to two separate univariate fits. See the package vignette/manual for the full likelihood derivation and a simulation-based verification.

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Encoding UTF-8

Depends R (>= 3.5)

Imports maxLik, pbivnorm, stats

Suggests testthat (>= 3.0.0)

Config/testthat/edition 3

URL <https://github.com/nobifukuda/lillardhaz>

BugReports <https://github.com/nobifukuda/lillardhaz/issues>

Config/roxygen2/version 8.0.0

NeedsCompilation no

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lillardhaz-package	<i>lillardhaz: Simultaneous-Equations Hazard/Probit Models</i>
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Description

Fits two-equation simultaneous models in the style of Lillard (1993): a pair of processes – each a binary probit outcome or a continuous-time hazard duration – linked through a single correlation parameter between their underlying error terms, estimated jointly by maximum likelihood via a Gaussian copula. See [fit_lillardhaz](#).

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See Also

Useful links:

- <https://github.com/nobifukuda/lillardhaz>
- Report bugs at <https://github.com/nobifukuda/lillardhaz/issues>

fit_lillardhaz	<i>Fit a Lillard-style simultaneous-equations hazard/probit model</i>
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Description

Fits a two-equation simultaneous model in the style of Lillard (1993): a pair of processes, each either a binary probit outcome or a continuous- time hazard duration, linked through a single correlation parameter between their underlying error terms and estimated jointly by maximum likelihood via a Gaussian copula.

Usage

```
fit_lillardhaz(
  eq1,
  eq2,
  data,
  y1,
  d1 = NULL,
  y2,
  d2,
  x1 = character(0),
  x2 = character(0),
  nodes1 = NULL,
  nodes2 = NULL,
  corr = TRUE,
  start = NULL,
  method = "BFGS"
)
```

Arguments

eq1	one of "probit", "lognormal", "pgompertz".
eq2	one of "lognormal", "pgompertz".
data	a data frame.
y1	name of equation 1's outcome: the binary 0/1 variable if eq1="probit", otherwise the duration variable.
d1	name of equation 1's failure indicator (ignored if eq1="probit").
y2	name of equation 2's duration variable.
d2	name of equation 2's failure indicator.
x1	character vector of covariate names for equation 1's location index (may be empty for an intercept-only equation).
x2	character vector of covariate names for equation 2's location index.
nodes1, nodes2	interior nodes (ascending numeric vectors) for a piecewise-Gompertz equation 1/equation 2; required exactly when that equation is "pgompertz".
corr	logical; if FALSE, fixes the copula correlation at 0 and fits the two equations independently (see the manual for why this reduces exactly to two separate univariate fits).
start	optional named numeric vector of starting values.
method	optimization method passed to <code>maxLik::maxLik</code> .

Value

An object of class "lillardhaz": a list with components

`coefficients` named numeric vector of maximum-likelihood estimates (equation 1 and 2 location coefficients, ancillary parameters such as `ln_sigma` or piecewise-Gompertz slopes, and `atanh_rho` if `corr = TRUE`).

se standard errors from the inverse negative Hessian (NA if the Hessian is singular).
 loglik maximized log-likelihood.
 rho, rho_se estimated copula correlation between the two equations' error terms and its delta-method standard error (0 and NA when corr = FALSE).
 fit the underlying maxLik object.
 eq1type, eq2type, nodes1, nodes2, corr, x1, x2, y1name, y2name the model specification.
 n number of observations.
 call the matched call.
 Methods for print, summary and predict are available.

Examples

```
set.seed(1)
n <- 2000
x1 <- rnorm(n); x2 <- rbinom(n, 1, 0.5)
t1 <- exp(1 - 0.3 * x1 + 0.5 * rnorm(n))
c1 <- -log(runif(n)) / 0.05
t2 <- exp(0.6 + 0.4 * x2 + 0.6 * rnorm(n))
c2 <- -log(runif(n)) / 0.05
d <- data.frame(
  time1 = pmin(t1, c1), event1 = as.integer(t1 <= c1),
  time2 = pmin(t2, c2), event2 = as.integer(t2 <= c2),
  x1 = x1, x2 = x2
)
fit <- fit_lillardhaz("lognormal", "lognormal", d,
  y1 = "time1", d1 = "event1", y2 = "time2", d2 = "event2",
  x1 = "x1", x2 = "x2")
summary(fit)
head(predict(fit, type = "surv2"))
```

predict.lillardhaz	<i>Predicted survival/density/index from a fitted lillardhaz model</i>
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Description

Predicted survival/density/index from a fitted lillardhaz model

Usage

```
## S3 method for class 'lillardhaz'
predict(object, newdata, type = "surv2", ...)
```

Arguments

object	a fitted "lillardhaz" object.
newdata	optional data frame; defaults to the estimation sample via object\$call.
type	one of "surv2" (default), "surv1", "dens1", "dens2", "pr1", "xb1", "xb2".
...	unused.

Value

A numeric vector with one element per row of `newdata`, evaluated at the estimated coefficients. Its meaning depends on type:

"xb1", "xb2" the linear location index $x'\beta$ of equation 1 or 2 (for a log-normal equation, the mean of log duration; for a piecewise-Gompertz equation, the log of the proportional hazard shift).

"pr1" the predicted probability that the binary outcome of equation 1 equals 1, $\Phi(x'\beta)$; only available when `eq1 = "probit"`.

"surv1", "surv2" the marginal survival probability $S(t)$, a value in $[0, 1]$, of equation 1 or 2 evaluated at the observed duration in `newdata` (variable `y1` or `y2` used in the fit).

"dens1", "dens2" the marginal density $f(t)$ of equation 1 or 2 evaluated at that duration.

The survival and density predictions are marginal (per equation) and do not condition on the other equation's outcome.

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