Package 'CoxPhLb'

April 4, 2019

Type Package

Title Analyzing Right-Censored Length-Biased Data

Date 2019-04-3

Version 1.2.0

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Description Performs analysis of right-censored length-biased data using Cox model. It contains model fitting and checking, and the stationarity assumption test. The model fitting and checking methods are described in Qin and Shen (2010) <doi:10.1111/j.1541-0420.2009.01287.x> and Lee, Ning, and Shen (2018) <doi:10.1007/s10985-018-9422-y>.

License GPL-2

Depends survival

Encoding UTF-8

LazyData true

RoxygenNote 6.1.1

NeedsCompilation no

Repository CRAN

Date/Publication 2019-04-04 13:30:02 UTC

R topics documented:

coxphlb *Fit Cox Model to Right-Censored Length-Biased Data*

Description

Fits a Cox model to right-censored length-biased data.

Usage

```
coxphlb(formula, data, method = c("Bootstrap","EE"),
boot.iter = 500, seed.n = round(runif(1,1,1e09)), digits = 3L)
```

Arguments

formula	A formula object with the form `response ~ predictors`. For `response`, use `Surv` object.
data	A data frame containing the variables in the model.
method	A character string specifying the method for variance estimation. The bootstrap resampling method ("Bootstrap") is used as the default. The estimating equation method ("EE") uses the asymptotic variance estimation.
boot.iter	The number of bootstrap iterations. Default is 500.
seed.n	An integer specifying seed number.
digits	An integer controlling the number of digits to print.

Details

This function uses the weighted estimating equation proposed by Qin and Shen (2010). It returns coefficient estimates and the corresponding variance estimates based on either the asymptotic variance or the bootstrap resampling method. It also tests the null hypothesis that the coefficients are equal to 0.

Value

A list containing the following components:

coefficients	The vector of coefficients.
var	The variance matrix of the coefficients.
std.err	The standard error of the coefficients.
z.score	z scores for the coefficients.
p.value	p-values for the coefficients.
lower.95	Lower 95% confidence intervals of the coefficients.
upper.95	Upper 95% confidence intervals of the coefficients.
method	The approach used to obtain the standard error of the coefficients.

The list is returned as an object of the coxphlb class to represent a fitted proportional hazards model. Objects of this class have methods for the functions coef, print, summary, and vcov. The object also contains the following: formula; varnames, the variables used in the model; result, the table output.

References

Qin J. and Shen Y. (2010). Statistical Methods for Analyzing Right-Censored Length-Biased Data under Cox Model. *Biometrics* 66(2), 382-392.

See Also

coxphlb.ftest, coxphlb.phtest, station.test, station.test.plot

Examples

```
## Not run:
# Fit a Cox model using model based variance estimation
fit.ee <- coxphlb(Surv(a, y, delta) ~ x1 + x2, data = ExampleData1,
                  method = "EE")
summary(fit.ee) # display the results

# Fit a Cox model using bootstrap resampling method
fit.bs <- coxphlb(Surv(a, y, delta) ~ x1 + x2, data = ExampleData1,
                  method = "Bootstrap", seed.n = 1234)
summary(fit.bs) # display the results

## End(Not run)
```

---

coxphlb.ftest *Test the Functional Form of Covariates in Cox Model with Right-Censored Length-Biased Data*

Description

Tests the functional form of covariates assumed for a Cox model fit (coxphlb).

Usage

```
coxphlb.ftest(fit, data, spec.p = 1, n.sim = 1000, z0 = NULL,
seed.n = round(runif(1,1,1e09)), digits = 3L)
```

Arguments

fit	The result of fitting a Cox model, using the coxphlb function.
data	A data frame containing the variables in the model.
spec.p	An integer specifying which covariate to be tested. Default is 1. If set to 1, the first column of the covariate matrix is tested.

n.sim	The number of resampling. Default is 1000.
z0	A vector of grid points to use for the specified covariate. The default is a vector of 100 equally distributed numeric values within the range of the specified covariate.
seed.n	An integer specifying seed number.
digits	An integer controlling the number of digits to print.

Details

The functional form of a continuous covariate is checked by constructing test statistics based on asymptotically mean-zero processes. The asymptotic distribution of the test statistics is approximated via resampling. This function computes the p-value by comparing the test statistics with n.sim number of resamples. If the p-value is small (e.g., <0.05), it is likely that the assumption is violated. The test should be done per variable for continuous covariates.

Value

A list containing the following components:

p.value	A p-value.
	The list is returned as an object of the coxphlb.ftest class. Objects of this class have methods for the function print. The object also contains the following: n.sim; z0; stat.mat.z, the test statistic; sim.mat.z, samples from the null distribution; varnames, the variable that is tested; result, the table output.

References

Lee, C.H., Ning, J., and Shen, Y. Model diagnostics for proportional hazards model with length-biased data. *Lifetime Data Analysis* 25(1), 79-96.

See Also

coxphlb, coxphlb.phtest, coxphlb.ftest.plot

Examples

```
## Not run:
# Fit a Cox model
fit.ee <- coxphlb(Surv(a, y, delta) ~ x1 + x2, data = ExampleData1,
                  method = "EE")

# Check the Functional Form of the Cox Model
ftest <- coxphlb.ftest(fit.ee, data = ExampleData1, spec.p = 2,
                       seed.n = 1234)
print(ftest) # display the results

## End(Not run)
```

`coxphlb.ftest.plot` *Graphical Test of the Functional Form of Covariates in Cox Model with Right-Censored Length-Biased Data*

Description

Returns a plot of the cumulative sums of mean zero stochastic processes.

Usage

```
coxphlb.ftest.plot(x, n.plot = 20, seed.n = round(runif(1,1,1e09)))
```

Arguments

`x`	The result of the `coxphlb.ftest` function.
`n.plot`	The number of randomly selected realizations. Default is 20.
`seed.n`	An integer specifying seed number.

Details

The function returns a plot with the test statistics in a black line and 20 processes randomly sampled from the pool of resamples in grey lines. When the test statistics lie within the randomly sampled lines, it suggests that the model assumption is valid.

References

Lee, C.H., Ning, J., and Shen, Y. Model diagnostics for proportional hazards model with length-biased data. *Lifetime Data Analysis* 25(1), 79-96.

See Also

`coxphlb`, `coxphlb.ftest`

Examples

```
## Not run:
# Fit a Cox model
fit.ee <- coxphlb(Surv(a, y, delta) ~ x1 + x2, data = ExampleData1,
                  method = "EE")

# Check the Functional Form of the Cox Model
ftest <- coxphlb.ftest(fit.ee, data = ExampleData1, spec.p = 2,
                       seed.n = 1234)
coxphlb.ftest.plot(ftest, n.plot = 50, seed.n = 1234) # display the plot

## End(Not run)
```

`coxphlb.phtest` *Test the Proportional Hazards Assumption of Cox Model with Right-Censored Length-Biased Data*

Description

Tests the proportional hazards assumption for a Cox model fit (coxphlb).

Usage

```
coxphlb.phtest(fit, data, spec.p = NULL, n.sim = 1000,
seed.n = round(runif(1,1,1e09)), digits = 3L)
```

Arguments

`fit`	The result of fitting a Cox model, using the `coxphlb` function.
`data`	A data frame containing the variables in the model.
`spec.p`	An integer specifying which covariate to be tested. Default is NULL. If NULL, global test is conducted. If specified, the per-variable test is conducted.
`n.sim`	The number of resampling. Default is 1000.
`seed.n`	An integer specifying seed number.
`digits`	An integer controlling the number of digits to print.

Details

The proportional hazards assumption is checked by constructing test statistics based on asymptotically mean-zero processes. The asymptotic distribution of the test statistics is approximated via resampling. This function computes the p-value by comparing the test statistics with n.sim number of resamples. If the p-value is small (e.g., <0.05), it is likely that the assumption is violated. The test can be done either per variable or globally. The global test checks if the proportional hazards assumption is valid for the overall covariates.

Value

A list containing the following components:

`p.value` A p-value.

The list is returned as an object of the `coxphlb.phtest` class. Objects of this class have methods for the function `print`. The object also contains the following: `spec.p`; `n.sim`; `stat.mat.t`, the test statistic; `sim.mat.t`, samples from the null distribution; `yy`, the observed ordered failure times; `varnames`, the variable that is tested; `result`, the table output.

References

Lee, C.H., Ning, J., and Shen, Y. Model diagnostics for proportional hazards model with length-biased data. *Lifetime Data Analysis* 25(1), 79-96.

See Also

coxphlb, coxphlb.ftest, coxphlb.phtest.plot

Examples

```
## Not run:
# Fit a Cox model
fit.ee <- coxphlb(Surv(a, y, delta) ~ x1 + x2, data = ExampleData1,
                  method = "EE")

# Check the Proportional Hazards Assumption
ptest1 <- coxphlb.phtest(fit.ee, data = ExampleData1, spec.p = 2,
                         seed.n = 1234)
print(ptest1) # display the results

# Run a Global Test
ptest2 <- coxphlb.phtest(fit.ee, data = ExampleData1, spec.p = NULL,
                         seed.n=1234)
print(ptest2) # display the results

## End(Not run)
```

---

coxphlb.phtest.plot *Graphical Test of the Proportional Hazards Assumption of Covariates in Cox Model with Right-Censored Length-Biased Data*

Description

Returns a plot of the cumulative sums of mean zero stochastic processes.

Usage

```
coxphlb.phtest.plot(x, n.plot = 20, seed.n = round(runif(1,1,1e09)))
```

Arguments

x	The result of the coxphlb.phtest function.
n.plot	The number of randomly selected realizations. Default is 20.
seed.n	An integer specifying seed number.

Details

The function returns a plot with the test statistics in a black line and 20 processes randomly sampled from the pool of resamples in grey lines. When the test statistics lie within the randomly sampled lines, it suggests that the model assumption is valid. A plot cannot be generated for the global test.

References

Lee, C.H., Ning, J., and Shen, Y. Model diagnostics for proportional hazards model with length-biased data. *Lifetime Data Analysis* 25(1), 79-96.

See Also

coxphlb, coxphlb.phtest

Examples

```
## Not run:
# Fit a Cox model
fit.ee <- coxphlb(Surv(a, y, delta) ~ x1 + x2, data = ExampleData1,
                  method = "EE")

# Check the Proportional Hazards Assumption
ptest1 <- coxphlb.phtest(fit.ee, data = ExampleData1, spec.p = 2,
                         seed.n = 1234)
coxphlb.phtest.plot(ptest1, n.plot = 50, seed.n = 1234) # display the plot

## End(Not run)
```

ExampleData1 *Example Data 1*

Description

A simulated right-censored length-biased data set. The example data set contains failure time, left-truncation time, censoring indicator, and the covariates.

Usage

```
ExampleData1
```

Format

A data frame with 200 observations.

y failure time

a left-truncation time

delta censoring status (0=censored, 1=uncensored)

x1 first covariate (binary variable, 0 or 1)

x2 second covariate (continuous variable, range from 0.0 to 1.0)

Note

This example data satisfy the stationarity assumption.

ExampleData2 *Example Data 2*

Description

A simulated right-censored left-truncated data set. The example data set contains failure time, left-truncation time, censoring indicator, and the covariates.

Usage

```
ExampleData2
```

Format

A data frame with 200 observations.

y failure time

a left-truncation time

delta censoring status (0=censored, 1=uncensored)

x1 first covariate (binary variable, 0 or 1)

x2 second covariate (continuous variable, range from 0.0 to 1.0)

Note

The stationarity assumption is violated for this example data.

station.test *Test the Stationarity Assumption*

Description

Tests the null hypothesis that the incidence process is stationary.

Usage

```
station.test(a, v, delta, digits = 3L)
```

Arguments

a	A vector of backward recurrence time (i.e., left-truncation time).
v	A vector of forward recurrence time (i.e., failure time minus left-truncation time).
delta	A vector of censoring indicator, 0=censored, 1=uncensored.
digits	An integer controlling the number of digits to print.

Details

The stationarity assumption is checked by computing the test statistic and the corresponding p-value. A large p-value suggests strong evidence of stationarity. When the p-value is small (e.g., <0.05), it is likely that the stationarity assumption is violated.

Value

A list containing the following components:

`test.statistic` A test statistic.

`p.value` A p-value based on two-sided test.

The list is returned as an object of the `station.test` class. Objects of this class have methods for the function `print`. The object also contains the following: `result`, the table output.

References

Addona, V. and Wolfson, D. B. (2006). A formal test for the stationarity of the incidence rate using data from a prevalent cohort study with follow-up. *Lifetime data analysis*, 12(3), 267-284.

See Also

`coxphlb`, `coxphlb.ftest`, `coxphlb.phtest`, `station.test.plot`

Examples

```
# Check the Stationarity Assumption
stest1 <- station.test(ExampleData1$a, ExampleData1$y-ExampleData1$a,
                       ExampleData1$delta)
print(stest1)  # display the results

stest2 <- station.test(ExampleData2$a, ExampleData2$y-ExampleData2$a,
                       ExampleData2$delta)
print(stest2)    # display the results
```

---

station.test.plot *Graphical Test of the Stationarity Assumption*

Description

Returns a plot of two Kaplan-Meier curves for forward recurrence time and backward recurrence time.

Usage

```
station.test.plot(a, v, delta)
```

Arguments

a	A vector of backward recurrence time (i.e., left-truncation time).
v	A vector of forward recurrence time (i.e., failure time minus left-truncation time).
delta	A vector of censoring indicator, 0=censored, 1=uncensored.

Details

The stationarity assumption can be checked by comparing the Kaplan-Meier curves. More overlap of the two survival curves suggests stronger evidence of stationarity.

References

Asgharian, M., Wolfson, D. B., and Zhang, X. (2006). Checking stationarity of the incidence rate using prevalent cohort survival data. *Statistics in medicine*, 25(10), 1751-1767.

See Also

coxphlb, coxphlb.ftest, coxphlb.phtest, station.test

Examples

```
# Check the Stationarity Assumption Graphically
station.test.plot(ExampleData1$a, ExampleData1$y-ExampleData1$a,
                  ExampleData1$delta) # plot curves

station.test.plot(ExampleData2$a, ExampleData2$y-ExampleData2$a,
                  ExampleData2$delta) # plot curves
```

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