Package ‘emplik’

August 23, 2015

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Version 1.0-2
Depends R (>= 3.0), quantreg
Suggests KMsurv, boot
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Description Empirical likelihood ratio tests for means/quantiles/hazards
from possibly censored and/or truncated data. Now does regression too.
This version contains some C code.
Title Empirical Likelihood Ratio for Censored/Truncated Data
License GPL (>= 2)
URL http://www.ms.uky.edu/~mai/EmpLik.html
NeedsCompilation yes
Repository CRAN
Date/Publication 2015-08-23 10:27:17

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The Buckley-James censored regression estimator

Description

Compute the Buckley-James estimator in the regression model

\[ y_i = \beta x_i + \epsilon_i \]

with right censored \( y_i \). Iteration method.

Usage

\[
\text{BJnoint}(x, y, \text{delta}, \text{beta0} = \text{NA}, \text{maxiter}=30, \text{error} = 0.00001)
\]

Arguments

- \( x \) a matrix or vector containing the covariate, one row per observation.
- \( y \) a numeric vector of length \( N \), censored responses.
- \( \text{delta} \) a vector of length \( N \), delta=0/1 for censored/uncensored.
- \( \text{beta0} \) an optional vector for starting value of iteration.
- \( \text{maxiter} \) an optional integer to control iterations.
- \( \text{error} \) an optional positive value to control iterations.

Details

This function compute the Buckley-James estimator when your model do not have an intercept term. Of course, if you include a column of 1’s in the \( x \) matrix, it is also OK with this function and it is equivalent to having an intercept term. If your model do have an intercept term, then you could also (probably should) use the function \( \text{bj}() \) in the Design library. It should be more refined than \( \text{BJnoint} \) in the stopping rule for the iterations.

This function is included here mainly to produce the estimator value that may provide some useful information with the function \( \text{bjtest}() \). For example you may want to test a beta value near the Buckley-James estimator.
bjtest

Value

A list with the following components:

- beta: the Buckley-James estimator.
- iteration: number of iterations performed.

Author(s)

Mai Zhou.

References


Examples

```r
x <- matrix(c(rnorm(50, mean=1), rnorm(50, mean=2)), ncol=2, nrow=50)
## Suppose now we wish to test Ho: 2mu(1)-mu(2)=0, then
y <- 2*x[,1]-x[,2]
x <- c(28, -44, 29, 30, 26, 27, 22, 23, 33, 16, 24, 29, 24, 40, 21, 31, 34, -2, 25, 19)
```

bjtest

Test the Buckley-James estimator by Empirical Likelihood

Description

Use the empirical likelihood ratio and Wilks theorem to test if the regression coefficient is equal to beta.

The log empirical likelihood been maximized is

\[
\sum_{d=1} \log \Delta F(e_i) + \sum_{d=0} \log [1 - F(e_i)];
\]

where \( e_i \) are the residuals.

Usage

`bjtest(y, d, x, beta)`

Arguments

- `y`: a vector of length N, containing the censored responses.
- `d`: a vector (length N) of either 1’s or 0’s. d=1 means y is uncensored; d=0 means y is right censored.
- `x`: a matrix of size N by q.
- `beta`: a vector of length q. The value of the regression coefficient to be tested in the model \( y_i = \beta x_i + e_i \)
Details

The above likelihood should be understood as the likelihood of the error term, so in the regression model the error epsilon should be iid.

This version can handle the model where beta is a vector (of length q).

The estimation equations used when maximize the empirical likelihood is

\[ 0 = \sum d_i \Delta F(e_i)(x \cdot m[i])/(nw_i) \]

which was described in detail in the reference below.

Value

A list with the following components:

-2LLR
the -2 loglikelihood ratio; have approximate chisq distribution under \( H_o \).

logelR
the log empirical likelihood, under estimating equation.

logel1
the log empirical likelihood of the Kaplan-Meier of e’s.

prob
the probabilities that max the empirical likelihood under estimating equation.

Author(s)

Mai Zhou.

References


Examples

```r
xx <- c(28, -44, 29, 30, 26, 27, 22, 23, 33, 16, 24, 29, 24, 40, 21, 31, 34, -2, 25, 19)
```

bjtest1d

**Test the Buckley-James estimator by Empirical Likelihood, 1-dim only**

Description

Use the empirical likelihood ratio and Wilks theorem to test if the regression coefficient is equal to beta. For 1-dim beta only.

The log empirical likelihood been maximized is

\[ \sum_{d=1} \log \Delta F(e_i) + \sum_{d=0} \log[1 - F(e_i)]. \]
Usage

bjtest1d(y, d, x, beta)

Arguments

y a vector of length N, containing the censored responses.
d a vector of either 1’s or 0’s. d=1 means y is uncensored. d=0 means y is right censored.
x a vector of length N, covariate.
beta a number. the regression coefficient to be tested in the model y = x beta + epsilon

Details

In the above likelihood, $e_i = y_i - x \cdot \text{beta}$ is the residuals.
Similar to bjtest(), but only for 1-dim beta.

Value

A list with the following components:

"-2LLR" the -2 loglikelihood ratio; have approximate chi square distribution under $H_0$.
logel2 the log empirical likelihood, under estimating equation.
logel1 the log empirical likelihood of the Kaplan-Meier of e’s.
prob the probabilities that max the empirical likelihood under estimating equation constraint.

Author(s)

Mai Zhou.

References


Examples

xx <- c(28, -44, 29, 30, 26, 27, 22, 23, 33, 16, 24, 29, 24, 40, 21, 31, 34, -12, 25, 19)
bjtestII

Alternative test of the Buckley-James estimator by Empirical Likelihood

Description

Use the empirical likelihood ratio (alternative form) and Wilks theorem to test if the regression coefficient is equal to beta, based on the estimating equations.

The log empirical likelihood been maximized is

\[ \sum_{j=1}^{n} \log p_j; \sum p_j = 1 \]

where the probability \( p_j \) is for the jth martingale differences of the estimating equations.

Usage

\[ \text{bjtestII}(y, d, x, \beta) \]

Arguments

- \( y \): a vector of length \( N \), containing the censored responses.
- \( d \): a vector of length \( N \). Either 1’s or 0’s. \( d=1 \) means \( y \) is uncensored; \( d=0 \) means \( y \) is right censored.
- \( x \): a matrix of size \( N \) by \( q \).
- \( \beta \): a vector of length \( q \). The value of the regression coefficient to be tested in the model \( Y_i = \beta x_i + \epsilon_i \)

Details

The above likelihood should be understood as the likelihood of the martingale difference terms. For the definition of the Buckley-James martingale or estimating equation, please see the (2015) book in the reference list.

The estimation equations used when maximize the empirical likelihood is

\[ 0 = \sum d_i \Delta F(e_i)(x \cdot m[i, i])/(nw_i) \]

where \( e_i \) is the residuals, other details are described in the reference book of 2015 below.

The final test is carried out by \( \text{el.test} \). So the output is similar to the output of \( \text{el.test} \).

Value

A list with the following components:

- "-2LLR" the -2 loglikelihood ratio; have approximate chisq distribution under \( H_0 \).
- logel2 the log empirical likelihood, under estimating equation.
- logel the log empirical likelihood of the Kaplan-Meier of \( e \)'s.
- prob the probabilities that max the empirical likelihood under estimating equation.
Author(s)

Mai Zhou.

References


Examples

data(myeloma)

bjtestII(y=myeloma[,1], d=myeloma[,2], x=cbind(1, myeloma[,3]), beta=c(37, -3.4))

el.cen.EM

Empirical likelihood ratio for mean with right, left or doubly censored data, by EM algorithm

Description

This program uses EM algorithm to compute the maximized (wrt $p_i$) empirical log likelihood function for right, left or doubly censored data with the MEAN constraint:

$$\sum_{d_i=1} p_i f(x_i) = \int f(t) dF(t) = \mu.$$  

Where $p_i = \Delta F(x_i)$ is a probability, $d_i$ is the censoring indicator, 1(uncensored), 0(right censored), 2(left censored). It also returns those $p_i$.

The empirical log likelihood been maximized is

$$\sum_{d_i=1} \log \Delta F(x_i) + \sum_{d_i=0} \log[1 - F(x_i)] + \sum_{d_i=2} \log F(x_i).$$

Usage

el.cen.EM(x,d,fun=function(t){t},mu,maxit=25,error=1e-9,...)
Arguments

- `x`: a vector containing the observed survival times.
- `d`: a vector containing the censoring indicators, 1-uncensored; 0-right censored; 2-left censored.
- `fun`: a continuous (weight) function used to calculate the mean as in $H_0$. `fun(t)` must be able to take a vector input `t`. Default to the identity function $f(t) = t$.
- `mu`: a real number used in the constraint, mean value of $f(X)$.
- `maxit`: an optional integer, used to control maximum number of iterations.
- `error`: an optional positive real number specifying the tolerance of iteration error. This is the bound of the $L_1$ norm of the difference of two successive weights.
- `...`: additional arguments, if any, to pass to `fun`.

Details

This implementation is all in R and have several for-loops in it. A faster version would use C to do the for-loop part. But this version seems faster enough and is easier to port to Splus.

We return the log likelihood all the time. Sometimes, (for right censored and no censor case) we also return the -2 log likelihood ratio. In other cases, you have to plot a curve with many values of the parameter, mu, to find out where is the place the log likelihood becomes maximum. And from there you can get -2 log likelihood ratio between the maximum location and your current parameter in $H_0$.

In order to get a proper distribution as NPMLE, we automatically change the d for the largest observation to 1 (even if it is right censored), similar for the left censored, smallest observation. $\mu$ is a given constant. When the given constants $\mu$ is too far away from the NPMLE, there will be no distribution satisfy the constraint. In this case the computation will stop. The -2 Log empirical likelihood ratio should be infinite.

The constant $\mu$ must be inside $(\min f(x_i), \max f(x_i))$ for the computation to continue. It is always true that the NPMLE values are feasible. So when the computation stops, try move the $\mu$ closer to the NPMLE —

$$\sum_{d_i=1} p_i^0 f(x_i)$$

$p_i^0$ taken to be the jumps of the NPMLE of CDF. Or use a different `fun`.

Difference to the function `e1.cen.EM2`: here duplicate (input) observations are collapsed (with weight 2, 3, ... etc.) but those will stay separate by default in the `e1.cen.EM2`. This will lead to a different `loglik` value. But the `–2LLR` value should be same in either version.

Value

A list with the following components:

- `loglik`: the maximized empirical log likelihood under the constraint.
- `times`: locations of CDF that have positive mass.
- `prob`: the jump size of CDF at those locations.
- `–2LLR`: If available, it is Minus two times the Empirical Log Likelihood Ratio. Should be approximately chi-square distributed under $H_0$. 

Author(s)
Mai Zhou

References


Examples
```r
## example with tied observations
x <- c(1, 1.5, 2, 3, 4, 5, 6, 5, 4, 1, 2, 4.5)
d <- c(1, 1, 0, 1, 0, 1, 1, 1, 0, 0, 1)
el.cen.EM2(x, d, mu=3.5)
```

```
# we should get "-2LLR" = 1.2466....
myfun5 <- function(x, theta, eps) {
  u <- (x-theta)*sqrt(5)/eps
  INDE <- (u < sqrt(5)) & (u > -sqrt(5))
  u[u >= sqrt(5)] <- 0
  u[u <= -sqrt(5)] <- 1
  y <- 0.5 - (u - (u)^3/15)*3/(4*sqrt(5))
  u[ INDE ] <- y[ INDE ]
  return(u)
}
el.cen.EM2(x, d, fun=myfun5, mu=0.5, theta=3.5, eps=0.1)
```

---

**el.cen.EM2**

**Empirical likelihood ratio test for a vector of means with right, left or doubly censored data, by EM algorithm**

Description

This function is similar to `el.cen.EM()`, but for multiple constraints. In the input there is a vector of observations \( x = (x_1, \ldots, x_n) \) and a function `fun`. The function `fun` should return the \( n \times k \) matrix

\[
(f_1(x), f_2(x), \ldots, f_k(x)).
\]

Also, the ordering of the observations, when consider censoring or redistributing-to-the-right, is according to the value of \( x \), not \( \text{fun}(x) \). So the probability distribution is for values \( x \). This program uses EM algorithm to maximize (wrt \( \mu_i \)) empirical log likelihood function for right, left or doubly censored data with the MEAN constraint:

\[
j = 1, 2, \ldots, k \quad \sum_{d_i=1} p_if_j(x_i) = \int f_j(t)dF(t) = \mu_j^{-}.
\]
Where \( p_i = \Delta F(x_i) \) is a probability, \( d_i \) is the censoring indicator, 1 (uncensored), 0 (right censored), 2 (left censored). It also returns those \( p_i \). The log likelihood function is defined as

\[
\sum_{d_i=1} \log \Delta F(x_i) + \sum_{d_i=2} \log F(x_i) + \sum_{d_i=0} \log[1 - F(x_i)].
\]

**Usage**

\[
el.cen.EM2(x,d,xc=1:length(x),fun,mu,maxit=25,error=1e-9,...)
\]

**Arguments**

- **x**
  - a vector containing the observed survival times.

- **d**
  - a vector containing the censoring indicators, 1-uncensored; 0-right censored; 2-left censored.

- **xc**
  - an optional vector of collapsing control values. If \( xc[i] \neq xc[j] \) have different values then \((x[i],d[i]),(x[j], d[j])\) will not merge into one observation with weight two even if they are identical. Default is not to merge.

- **fun**
  - a left continuous (weight) function that returns a matrix. The columns (=k) of the matrix is used to calculate the means and will be tested in \( H_0 \). \( \text{fun}(t) \) must be able to take a vector input \( t \).

- **mu**
  - a vector of length \( k \). Used in the constraint, as the mean of \( f(X) \).

- **maxit**
  - an optional integer, used to control maximum number of iterations.

- **error**
  - an optional positive real number specifying the tolerance of iteration error. This is the bound of the \( L_1 \) norm of the difference of two successive weights.

- ... additional inputs to pass to \( \text{fun}() \).

**Details**

This implementation is all in R and have several for-loops in it. A faster version would use C to do the for-loop part. (but this version is easier to port to Splus, and seems faster enough).

We return the log likelihood all the time. Sometimes, (for right censored and no censor case) we also return the -2 log likelihood ratio. In other cases, you have to plot a curve with many values of the parameter, \( \mu \), to find out where the log likelihood becomes maximum. And from there you can get -2 log likelihood ratio between the maximum location and your current parameter in \( H_0 \).

In order to get a proper distribution as NPMLE, we automatically change the \( d \) for the largest observation to 1 (even if it is right censored), similar for the left censored, smallest observation. \( \mu \) is a given constant vector. When the given constants \( \mu \) is too far away from the NPMLE, there will be no distribution satisfy the constraint. In this case the computation will stop. The -2 Log empirical likelihood ratio should be infinite.

The constant vector \( \mu \) must be inside \((\min f(x_i), \max f(x_i))\) for the computation to continue. It is always true that the NPMLE values are feasible. So when the computation stops, try move the \( \mu \) closer to the NPMLE —

\[
\hat{\mu}_j = \sum_{d_i=1} p_i^0 f_j(x_i)
\]

where \( p_i^0 \) taken to be the jumps of the NPMLE of CDF. Or use a different \( \text{fun} \).
Difference to the function el.cen.EM: due to the introduction of input xc here in this function, the output loglik may be different compared to the function el.cen.EM due to not collapsing of duplicated input survival values. The -2LLR should be the same from both functions.

Value
A list with the following components:

loglik the maximized empirical log likelihood under the constraints.
times locations of CDF that have positive mass.
prob the jump size of CDF at those locations.
"-2LLR" If available, it is Minus two times the Empirical Log Likelihood Ratio. Should be approx. chi-square distributed under Ho.
Pval If available, the P-value of the test, using chi-square approximation.
lam the Lagrange multiplier in the final EM step (the M-step)

Author(s)
Mai Zhou

References

Examples
```r
### censored regression with one right censored observation.
## we check the estimation equation, with the MLE inside myfun7.
y <- c(3, 5.3, 6.4, 9.1, 14.1, 15.4, 18.1, 15.3, 14, 5.8, 7.3, 14.4)
x <- c(1, 1.5, 2, 3, 4, 5, 6, 5, 4, 1, 2, 4.5)
d <- c(1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1)
## first we estimate beta, the MLE
lm.wfit(x=cbind(rep(1,12),x), y=y, w=KMM(x=x, d=d)$jump[rank(y)])$coef
## you should get 1.392885 and 2.845658
## then define myfun7 with the MLE value
myfun7 <- function(y, xmat) {
  temp1 <- y - (1.392885 + 2.845658 * xmat)
  return(cbind(temp1, xmat*temp1))
}
## now test
el.cen.EM2(y,d, fun=myfun7, mu=c(0,0), xmat=x)
## we should get, Pval = 1, as the MLE should.
## for other values of (a, b) inside myfun7, you get other Pval
##
## rqfun1 <- function(y, xmat, beta, tau = 0.5) {
##  temp1 <- tau - (1-rf(y-betaxmat))
##  return(xmat * temp1)
```
el.cen.test

Empirical likelihood ratio for mean with right censored data, by QP.

Description

This program computes the maximized (wrt \( p_i \)) empirical log likelihood function for right censored data with the MEAN constraint:

\[
\sum_i [d_i p_i g(x_i)] = \int g(t) dF(t) = \mu
\]

where \( p_i = \Delta F(x_i) \) is a probability, \( d_i \) is the censoring indicator. The \( d \) for the largest observation is always taken to be 1. It then computes the -2 log empirical likelihood ratio which should be approximately chi-square distributed if the constraint is true. Here \( F(t) \) is the (unknown) CDF; \( g(t) \) can be any given left continuous function in \( t \). \( \mu \) is a given constant. The data must contain some right censored observations. If there is no censoring or the only censoring is the largest observation, the code will stop and we should use \[ \text{el.test( )} \] which is for uncensored data.
The log empirical likelihood been maximized is

\[
\sum_{d_i=1} \log \Delta F(x_i) + \sum_{d_i=0} \log [1 - F(x_i)].
\]

Usage

```
el.cen.test(x, d, fun=function(x){x}, mu, error=1e-8, maxit=15)
```

Arguments

- **x**: a vector containing the observed survival times.
- **d**: a vector containing the censoring indicators, 1-uncensor; 0-censor.
- **fun**: a left continuous (weight) function used to calculate the mean as in \( H_0 \). \( \text{fun}(t) \) must be able to take a vector input \( t \). Default to the identity function \( f(t) = t \).
- **mu**: a real number used in the constraint, sum to this value.
- **error**: an optional positive real number specifying the tolerance of iteration error in the QP. This is the bound of the \( L_1 \) norm of the difference of two successive weights.
- **maxit**: an optional integer, used to control maximum number of iterations.

Details

When the given constants \( \mu \) is too far away from the NPMLE, there will be no distribution satisfy the constraint. In this case the computation will stop. The -2 Log empirical likelihood ratio should be infinite.

The constant \( \mu \) must be inside \((\min f(x_i), \max f(x_i))\) for the computation to continue. It is always true that the NPMLE values are feasible. So when the computation cannot continue, try move the \( \mu \) closer to the NPMLE, or use a different \( \text{fun} \).

This function depends on \( \text{Wdataclean2()} \), \( \text{WKM()} \) and \( \text{solve3.QP()} \)

This function uses sequential Quadratic Programming to find the maximum. Unlike other functions in this package, it can be slow for larger sample sizes. It took about one minute for a sample of size 2000 with 20\% censoring on a 1GHz, 256MB PC, about 19 seconds on a 3 GHz 512MB PC.

Value

A list with the following components:

- **"-2LLR"**: The -2Log Likelihood ratio.
- **xtimes**: the location of the CDF jumps.
- **weights**: the jump size of CDF at those locations.
- **pval**: P-value
- **error**: the \( L_1 \) norm between the last two wts.
- **iteration**: number of iterations carried out
Author(s)
Mai Zhou, Kun Chen

References


Examples
```
# el.cen.test(rexp(100), c(rep(0,25),rep(1,75)), mu=1.5)
# second example with tied observations
x <- c(1, 1.5, 2, 3, 4, 5, 6, 5, 4, 1, 2, 4.5)
d <- c(1, 1, 0, 1, 0, 1, 1, 1, 1, 0, 0, 1)
el.cen.test(x,d,mu=3.5)
# we should get "-2LLR" = 1.246634 etc.
```

---

**el.ltrc.EM**  
*Empirical likelihood ratio for mean with left truncated and right censored data, by EM algorithm*

Description
This program uses EM algorithm to compute the maximized (wrt \(p_i\)) empirical log likelihood function for left truncated and right censored data with the MEAN constraint:

\[
\sum_{d_i=1} p_i f(x_i) = \int f(t)dF(t) = \mu^*.
\]

Where \(p_i = \Delta F(x_i)\) is a probability, \(d_i\) is the censoring indicator, 1 (uncensored), 0 (right censored). The \(d\) for the largest observation \(x\), is always (automatically) changed to 1. \(\mu\) is a given constant. This function also returns those \(p_i\).

The log empirical likelihood function been maximized is

\[
\sum_{d_i=1} \log \frac{\Delta F(x_i)}{1 - F(y_i)} + \sum_{d_i=0} \log \frac{1 - F(x_i)}{1 - F(y_i)}.
\]

Usage
```
el.ltrc.EM(y,x,d,fun=function(t){t},mu,maxit=30,error=1e-9)
```
**el.ltrc.EM**

**Arguments**

- `y`: an optional vector containing the observed left truncation times.
- `x`: a vector containing the censored survival times.
- `d`: a vector containing the censoring indicators, 1-uncensored; 0-right censored.
- `fun`: a continuous (weight) function used to calculate the mean as in \( H_0 \). `fun(t)` must be able to take a vector input `t`. Default to the identity function \( f(t) = t \).
- `mu`: a real number used in the constraint, mean value of \( f(X) \).
- `error`: an optional positive real number specifying the tolerance of iteration error. This is the bound of the \( L_1 \) norm of the difference of two successive weights.
- `maxit`: an optional integer, used to control maximum number of iterations.

**Details**

We return the -2 log likelihood ratio, and the constrained NPMLE of CDF. The un-constrained NPMLE should be WJT or Lynden-Bell estimator.

When the given constants \( \mu \) is too far away from the NPMLE, there will be no distribution satisfy the constraint. In this case the computation will stop. The -2 Log empirical likelihood ratio should be infinite.

The constant `mu` must be inside \( (\min f(x_i), \max f(x_i)) \) for the computation to continue. It is always true that the NPMLE values are feasible. So when the computation stops, try move the `mu` closer to the NPMLE —

\[
\sum_{d_i=1}^n p_i^0 f(x_i)
\]

\( p_i^0 \) taken to be the jumps of the NPMLE of CDF. Or use a different `fun`.

This implementation is all in R and have several for-loops in it. A faster version would use C to do the for-loop part. (but this version is easier to port to Splus, and seems faster enough).

**Value**

A list with the following components:

- `times`: locations of CDF that have positive mass.
- `prob`: the probability of the constrained NPMLE of CDF at those locations.
- "-2LLR": It is Minus two times the Empirical Log Likelihood Ratio. Should be approximate chi-square distributed under Ho.

**Author(s)**

Mai Zhou
References


Examples

```r
## example with tied observations
y <- c(0, 0, 0.5, 0, 1, 2, 2, 0, 0, 0, 0, 0)
x <- c(1, 1.5, 2, 3, 4, 5, 6, 5, 4, 1, 2, 4.5)
d <- c(1, 1, 0, 1, 0, 1, 1, 1, 0, 0, 1)
el.test(y, x, d, mu=3.5)

ypsy <- c(51, 58, 55, 28, 25, 48, 47, 25, 31, 30, 33, 43, 45, 35, 36)
xpsy <- c(52, 59, 57, 50, 57, 59, 61, 61, 62, 67, 68, 69, 69, 65, 76)
dpsy <- c(1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 1, 0, 1)
el.test(ypsy, xpsy, dpsy, mu=64)
```

---

**el.test**

Empirical likelihood ratio test for the means, uncensored data

**Description**

Compute the empirical likelihood ratio with the mean vector fixed at mu.

The log empirical likelihood been maximized is

\[ \sum_{i=1}^{n} \log \Delta F(x_i). \]

**Usage**

```r
el.test(x, mu, lam, maxit=25, gradtol=1e-7, 
svdtol = 1e-9, itertrace=FALSE)
```

**Arguments**

- **x**: a matrix or vector containing the data, one row per observation.
- **mu**: a numeric vector (of length = ncol(x)) to be tested as the mean vector of x above, as \( H_0 \).
- **lam**: an optional vector of length = length(mu), the starting value of Lagrange multipliers, will use 0 if missing.
maxit an optional integer to control iteration when solve constrained maximization.
gradtol an optional real value for convergence test.
svdtol an optional real value to detect singularity while solve equations.
itertrace a logical value. If the iteration history needs to be printed out.

Details

If \( \mu \) is in the interior of the convex hull of the observations \( x \), then \( wts \) should sum to \( n \). If \( \mu \) is outside the convex hull then \( wts \) should sum to nearly zero, and \(-2LLR\) will be a large positive number. It should be infinity, but for inferential purposes a very large number is essentially equivalent. If \( \mu \) is on the boundary of the convex hull then \( wts \) should sum to nearly \( k \) where \( k \) is the number of observations within that face of the convex hull which contains \( \mu \).

When \( \mu \) is interior to the convex hull, it is typical for the algorithm to converge quadratically to the solution, perhaps after a few iterations of searching to get near the solution. When \( \mu \) is outside or near the boundary of the convex hull, then the solution involves a \( \lambda \) of infinite norm.

The algorithm tends to nearly double \( \lambda \) at each iteration and the gradient size then decreases roughly by half at each iteration.

The goal in writing the algorithm was to have it “fail gracefully” when \( \mu \) is not inside the convex hull. The user can either leave \(-2LLR\) “large and positive” or can replace it by infinity when the weights do not sum to nearly \( n \).

Value

A list with the following components:

\(-2LLR\) the -2 loglikelihood ratio; approximate chisq distribution under \( H_0 \).

\( pval \) the observed P-value by chi-square approximation.

\( \lambda \) the final value of Lagrange multiplier.

grad the gradient at the maximum.

hess the Hessian matrix.

wts weights on the observations

nits number of iteration performed

Author(s)

Original Splus code by Art Owen. Adapted to R by Mai Zhou.

References

Examples

```r
x <- matrix(c(rnorm(50,mean=1), rnorm(50,mean=2)), ncol=2,nrow=50)
el.test(x, mu=c(1,2))
## Suppose now we wish to test Ho: 2mu(1)-mu(2)=0, then
y <- 2*x[,1]-x[,2]
el.test(y, mu=0)
xx <- c(28,-44,29,30,26,27,22,23,33,16,24,29,24,40,21,31,34,-2,25,19)
el.test(xx, mu=15) #### -2LLR = 1.805702
```

el.test.wt  
*Weighted Empirical Likelihood ratio for mean, uncensored data*

Description

This program is similar to `el.test()` except it takes weights, and is for one dimensional `mu`. The mean constraint considered is:

\[ \sum_{i=1}^{n} p_i x_i = \mu. \]

where \( p_i = \Delta F(x_i) \) is a probability. Plus the probability constraint: \( \sum p_i = 1 \).

The weighted log empirical likelihood been maximized is

\[ \sum_{i=1}^{n} w_i \log p_i. \]

Usage

`el.test.wt(x, wt, mu, usingC=TRUE)`

Arguments

- `x` a vector containing the observations.
- `wt` a vector containing the weights.
- `mu` a real number used in the constraint, weighted mean value of \( f(X) \).
- `usingC` TRUE: use C function, which may be benifit when sample size is large; FALSE: use pure R function.

Details

This function used to be an internal function. It becomes external because others may find it useful elsewhere.

The constant `mu` must be inside \( (\min x_i, \max x_i) \) for the computation to continue.
Value

A list with the following components:

- **x** the observations.
- **wt** the vector of weights.
- **prob** The probabilities that maximized the weighted empirical likelihood under mean constraint.

Author(s)

Mai Zhou, Y.F. Yang for C part.

References


Examples

```r
## example with tied observations
x <- c(1, 1.5, 2, 3, 4, 5, 6, 5, 4, 1, 2, 4.5)
d <- c(1, 1, 0, 1, 0, 1, 1, 1, 0, 0, 1)
el.cen.EM(x, d, mu=3.5)
## we should get "-zLLR" = 1.2466....
myfun5 <- function(x, theta, eps) {
  u <- (x-theta)*sqrt(5)/eps
  INDE <- (u < sqrt(5)) & (u > -sqrt(5))
  u[u >= sqrt(5)] <- 0
  u[u <= -sqrt(5)] <- 1
  y <- 0.5 - (u - (u)^3/15)*3/(4*sqrt(5))
  u[ INDE ] <- y[ INDE ]
  return(u)
}
el.cen.EM(x, d, fun=myfun5, mu=0.5, theta=3.5, eps=0.1)
```

Description

This program is similar to `el.test()` except it takes weights.

The mean constraints are:

\[ \sum_{i=1}^{n} p_i x_i = \mu. \]

Where \( p_i = \Delta F(x_i) \) is a probability. Plus the probability constraint: \( \sum p_i = 1. \)
The weighted log empirical likelihood been maximized is
\[ \sum_{i=1}^{n} w_i \log p_i. \]

**Usage**

el.test.wt2(x, wt, mu, maxit = 25, gradtol = 1e-07, Hessian = FALSE, svdtol = 1e-09, itertrace = FALSE)

**Arguments**

- **x**: a matrix (of size n x p) or vector containing the observations.
- **wt**: a vector of length n, containing the weights. If weights are all 1, this is very similar to el.test. wt have to be positive.
- **mu**: a vector of length p, used in the constraint. weighted mean value of \( f(X) \).
- **maxit**: an integer, the maximum number of iteration.
- **gradtol**: a positive real number, the tolerance for a solution
- **Hessian**: logical. if the Hessian needs to be computed?
- **svdtol**: tolerance in perform SVD of the Hessian matrix.
- **itertrace**: TRUE/FALSE, if the intermediate steps needs to be printed.

**Details**

This function used to be an internal function. It becomes external because others may find it useful.

It is similar to the function el.test( ) with the following differences:

1. The output lambda in el.test.wts, when divided by n (the sample size or sum of all the weights) should be equal to the output lambda in el.test.
2. The Newton step of iteration in el.test.wts is different from those in el.test. (even when all the weights are one).

**Value**

A list with the following components:
- **lambda**: the Lagrange multiplier. Solution.
- **wt**: the vector of weights.
- **grad**: The gradian at the final solution.
- **nits**: number of iterations performed.
- **prob**: The probabilities that maximized the weighted empirical likelihood under mean constraint.

**Author(s)**

Mai Zhou
el.trun.test

References


Examples

```r
# example with tied observations
x <- c(1, 1.5, 2, 3, 4, 5, 6, 5, 4, 1, 2, 4.5)
d <- c(1, 1, 1, 0, 1, 1, 1, 1, 0, 0, 1)
el.cen.EM(x, d, mu=3.5)
# we should get "-2LLR" = 1.2466....
myfun5 <- function(x, theta, eps) {
  u <- (x-theta)*sqrt(5)/eps
  INDE <- (u < sqrt(5)) & (u > -sqrt(5))
  u[u >= sqrt(5)] <- 0
  u[u <= -sqrt(5)] <- 1
  y <- 0.5 - (u - (u^3/15)*3/(4*sqrt(5)))
  u[ INDE ] <- y[ INDE ]
  return(u)
}
el.cen.EM(x, d, fun=myfun5, mu=0.5, theta=3.5, eps=0.1)
```

---

el.trun.test  

*Empirical likelihood ratio for mean with left truncated data*

Description

This program uses EM algorithm to compute the maximized (wrt $p_i$) empirical log likelihood function for left truncated data with the MEAN constraint:

$$
\sum p_i f(x_i) = \int f(t) dF(t) = \mu^*.
$$

Where $p_i = \Delta F(x_i)$ is a probability. $\mu$ is a given constant. It also returns those $p_i$ and the $p_i$ without constraint, the Lynden-Bell estimator.

The log likelihood been maximized is

$$
\sum_{i=1}^{n} \log \frac{\Delta F(x_i)}{1 - F(y_i)}.
$$

Usage

```
el.trun.test(y, x, fun=function(t){t}, mu, maxit=20, error=1e-9)
```
Arguments

- **y**: a vector containing the left truncation times.
- **x**: a vector containing the survival times. truncation means x>y.
- **fun**: a continuous (weight) function used to calculate the mean as in $H_0$. fun(t) must be able to take a vector input t. Default to the identity function $f(t) = t$.
- **mu**: a real number used in the constraint, mean value of $f(X)$.
- **error**: an optional positive real number specifying the tolerance of iteration error. This is the bound of the $L_1$ norm of the difference of two successive weights.
- **maxit**: an optional integer, used to control maximum number of iterations.

Details

This implementation is all in R and have several for-loops in it. A faster version would use C to do the for-loop part. But it seems faster enough and is easier to port to Splus.

When the given constants $\mu$ is too far away from the NPMLE, there will be no distribution satisfy the constraint. In this case the computation will stop. The -2 Log empirical likelihood ratio should be infinite.

The constant mu must be inside $(\min f(x_i), \max f(x_i))$ for the computation to continue. It is always true that the NPMLE values are feasible. So when the computation stops, try move the mu closer to the NPMLE —

$$\sum_{d_i = 1} p_0^i f(x_i)$$

$p_0^i$ taken to be the jumps of the NPMLE of CDF. Or use a different fun.

Value

A list with the following components:

- **"-2LLR"**: the maximized empirical log likelihood ratio under the constraint.
- **NPMLE**: jumps of NPMLE of CDF at ordered x.
- **NPMLEmu**: same jumps but for constrained NPMLE.

Author(s)

Mai Zhou

References


Examples

## example with tied observations
vet <- c(30, 384, 4, 54, 13, 123, 97, 153, 59, 117, 16, 151, 22, 56, 21, 18, 139, 20, 31, 52, 287, 18, 51, 122, 27, 54, 7, 63, 392, 10)
vetstart <- c(0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0)
el.trun.test(vetstart, vet, mu=80, maxit=15)

emplikh disc  Empirical likelihood ratio for discrete hazard with right censored, left truncated data

Description

Use empirical likelihood ratio and Wilks theorem to test the null hypothesis that

$$\sum_i [f(x_i, \theta) \log(1 - dH(x_i))] = K$$

where $H(t)$ is the (unknown) discrete cumulative hazard function; $f(t, \theta)$ can be any predictable function of $t$. $\theta$ is the parameter of the function and $K$ is a given constant. The data can be right censored and left truncated.

When the given constants $\theta$ and/or $K$ are too far away from the NPMLE, there will be no hazard function satisfy this constraint and the minus 2Log empirical likelihood ratio will be infinite. In this case the computation will stop.

Usage

emplikh disc(x, d, y= -Inf, K, fun, tola=.Machine$double.eps^+.25, theta)

Arguments

x  a vector, the observed survival times.
d  a vector, the censoring indicators, 1-uncensor; 0-censor.
y  optional vector, the left truncation times.
K  a real number used in the constraint, sum to this value.
fun  a left continuous (weight) function used to calculate the weighted discrete hazard in $H_0$. $\text{fun}(x, \theta)$ must be able to take a vector input $x$, and a parameter $\theta$.
tola  an optional positive real number specifying the tolerance of iteration error in solve the non-linear equation needed in constrained maximization.
theta  a given real number used as the parameter of the function $f$. 
Details

The log likelihood been maximized is the ‘binomial’ empirical likelihood:

\[
\sum D_i \log w_i + (R_i - D_i) \log[1 - w_i]
\]

where \( w_i = \Delta H(t_i) \) is the jump of the cumulative hazard function, \( D_i \) is the number of failures observed at \( t_i \), \( R_i \) is the number of subjects at risk at time \( t_i \).

For discrete distributions, the jump size of the cumulative hazard at the last jump is always 1. We have to exclude this jump from the summation since \( \log(1 - dH(\cdot)) \) do not make sense.

The constants \theta and \( \kappa \) must be inside the so called feasible region for the computation to continue. This is similar to the requirement that in testing the value of the mean, the value must be inside the convex hull of the observations. It is always true that the NPMLE values are feasible. So when the computation stops, try move the \theta and \( \kappa \) closer to the NPMLE. When the computation stops, the -2LLR should have value infinite.

In case you do not need the \theta in the definition of the function \( f \), you still need to formally define your \text{fun} function with a \theta input, just to match the arguments.

Value

A list with the following components:

- \text{times} the location of the hazard jumps.
- \text{wts} the jump size of hazard function at those locations.
- \text{lambda} the final value of the Lagrange multiplier.
- "-2LLR" The discrete -2Log Likelihood ratio.
- \text{Pval} P-value
- \text{niters} number of iterations used

Author(s)

Mai Zhou

References


Examples

```r
fun4 <- function(x, theta) { as.numeric(x <= theta) }
x <- c(1, 2, 3, 4, 5, 6, 5, 4, 3, 4, 1, 2.4, 4.5)
d <- c(1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 1)
# test if -H(4) = -0.7
emplikh.disc2(x=x,d=d,K=0.7,fun=fun4,theta=4)
# we should get "-2LLR 0.1446316 etc....
y <- c(-2,-2,-2,1.5,-1)
emplikh.disc2(x=x,d=y,K=0.7,fun=fun4,theta=4)
```

Description

Use empirical likelihood ratio and Wilks theorem to test the null hypothesis that

\[
\int f_1(t)I_{[dH_1<1]} \log(1 - dH_1(t)) - \int f_2(t)I_{[dH_2<1]} \log(1 - dH_2(t)) = \theta
\]

where \( H_*(t) \) is the (unknown) discrete cumulative hazard function; \( f_*(t) \) can be any predictable functions of \( t \). \( \theta \) is the parameter. The given value of \( \theta \) in these computation are the value to be tested. The data can be right censored and left truncated.

When the given constants \( \theta \) is too far away from the NPMLE, there will be no hazard function satisfy this constraint and the -2 Log empirical likelihood ratio will be infinite. In this case the computation will stop.

Usage

```r
emplikh.disc2(x1, d1, y1=-Inf, x2, d2, y2=-Inf,
               theta, fun1, fun2, tola = 1e-6, maxi, mini)
```

Arguments

- **x1**: a vector, the observed survival times, sample 1.
- **d1**: a vector, the censoring indicators, 1-uncensor; 0-censor.
- **y1**: optional vector, the left truncation times.
- **x2**: a vector, the observed survival times, sample 2.
- **d2**: a vector, the censoring indicators, 1-uncensor; 0-censor.
- **y2**: optional vector, the left truncation times.
- **fun1**: a predictable function used to calculate the weighted discrete hazard in \( H_0 \). \( \text{fun1}(x) \) must be able to take a vector input \( x \).
- **fun2**: similar to fun1, but for sample 2.
tola
an optional positive real number, the tolerance of iteration error in solve the non-linear equation needed in constrained maximization.

theta
a given real number, for Ho constraint.

maxi
upper bound for lambda, usually positive.

mini
lower bound for lambda, usually negative.

Details
The log likelihood been maximized is the ‘binomial’ empirical likelihood:

$$\sum D_{1i} \log w_i + (R_{1i} - D_{1i}) \log[1 - w_i] + \sum D_{2j} \log v_j + (R_{2j} - D_{2j}) \log[1 - v_j]$$

where $w_i = \Delta H_1(t_i)$ is the jump of the cumulative hazard function at $t_i$, $D_{1i}$ is the number of failures observed at $t_i$, $R_{1i}$ is the number of subjects at risk at time $t_i$.

For discrete distributions, the jump size of the cumulative hazard at the last jump is always 1. We have to exclude this jump from the summation in the constraint calculation since $\log(1 - dH(\cdot))$ do not make sense.

The constants theta must be inside the so called feasible region for the computation to continue. This is similar to the requirement that in ELR testing the value of the mean, the value must be inside the convex hull of the observations. It is always true that the NPMLE values are feasible. So when the computation stops, try move the theta closer to the NPMLE. When the computation stops, the -2LLR should have value infinite.

Value
A list with the following components:

times
the location of the hazard jumps.

wts
the jump size of hazard function at those locations.

lambda
the final value of the Lagrange multiplier.

"-2LLR"
The -2Log Likelihood ratio.

pval
P-value

niter
number of iterations used

Author(s)
Mai Zhou

References
Examples

```r
if(require("boot", quietly = TRUE)) {
    ###library(boot)
data(channing)
ymale <- channing[1:97,2]
dmale <- channing[1:97,5]
xmale <- channing[1:97,3]
yfemale <- channing[98:462,2]
dfemale <- channing[98:462,5]
xfemale <- channing[98:462,3]
fun1 <- function(x) { as.numeric(x <= 960) }
emplikhH1(x=xmale, d=dmale, y=ymale, theta=0.2, fun1=fun1, fun2=fun1, maxi=4, mini=-10)
emplikhH1(x=xfemale, d=dfemale, y=yfemale, theta=0.25, fun1=fun1, fun2=fun1, maxi=4, mini=-5)
}
```

Description

Use empirical likelihood ratio and Wilks theorem to test the null hypothesis that

\[ \int f(t) dH(t) = \theta \]

with right censored, left truncated data. Where \( H(t) \) is the unknown cumulative hazard function; \( f(t) \) can be any given function and \( \theta \) a given constant. In fact, \( f(t) \) can even be data dependent, just have to be ‘predictable’.

Usage

```r
emplikhH1.test(x, d, y = -Inf, theta, fun, tola=Machine$double.eps^*.5)
```

Arguments

- **x**
  - a vector of the censored survival times.
- **d**
  - a vector of the censoring indicators, 1-uncensor; 0-censor.
- **y**
  - a vector of the observed left truncation times.
- **theta**
  - a real number used in the \( H_0 \) to set the hazard to this value.
fun a left continuous (weight) function used to calculate the weighted hazard in $H_0$. 
fun must be able to take a vector input. See example below.

tola an optional positive real number specifying the tolerance of iteration error in 
solve the non-linear equation needed in constrained maximization.

Details

This function is designed for the case where the true distributions are all continuous. So there should 
be no tie in the data.

The log empirical likelihood used here is the ‘Poisson’ version empirical likelihood:

$$\sum_{i=1}^{n} \delta_i \log(dH(x_i)) - [H(x_i) - H(y_i)]^\sim.$$

If there are ties in the data that are resulted from rounding, you may break the tie by adding a 
different tiny number to the tied observation(s). If those are true ties (thus the true distribution is 
discrete) we recommend use emplikdisc.test().

The constant theta must be inside the so called feasible region for the computation to continue. 
This is similar to the requirement that in testing the value of the mean, the value must be inside the 
convex hull of the observations. It is always true that the NPMLE values are feasible. So when 
the computation complains that there is no hazard function satisfy the constraint, you should try to 
move the theta value closer to the NPMLE. When the computation stops prematurely, the -2LLR 
should have value infinite.

Value

A list with the following components:

times the location of the hazard jumps.
wts the jump size of hazard function at those locations.
lambda the Lagrange multiplier.
"-2LLR" the -2Log Likelihood ratio.
Pval P-value
niters number of iterations used

Author(s)

Mai Zhou

References

of Multivariate Analysis 80, 166-188.
Examples

fun <- function(x) { as.numeric(x <= 6) }
emplikH2.test( x=c(1,2,3,4,5), d=c(1,1,0,1,1), theta=2, fun=fun)
fun2 <- function(x) (exp(-x))
emplikH2.test( x=c(1,2,3,4,5), d=c(1,1,0,1,1), theta=0.2, fun=fun2)

Description

Use empirical likelihood ratio and Wilks theorem to test the null hypothesis that
\[ \int f(t, \ldots) dH(t) = K \]

with right censored, left truncated data, where \( H(t) \) is the (unknown) cumulative hazard function; \( f(t, \ldots) \) can be any given left continuous function in \( t \); (of course the integral must be finite).

Usage

emplikH2.test(x, d, y = -Inf, K, fun, tola = .Machine$double.eps^*.5, ...)

Arguments

- \( x \) a vector containing the censored survival times.
- \( d \) a vector of the censoring indicators, 1-uncensor; 0-censor.
- \( y \) a vector containing the left truncation times. If left as default value, -Inf, it means no truncation.
- \( K \) a real number used in the constraint, i.e. to set the weighted integral of hazard to this value.
- \( \text{fun} \) a left continuous (in \( t \)) weight function used to calculate the weighted hazard in \( H_0 \). \( \text{fun}(t, \ldots) \) must be able to take a vector input \( t \).
- \( \text{tola} \) an optional positive real number specifying the tolerance of iteration error in solve the non-linear equation needed in constrained maximization.
- \( \ldots \) additional parameter(s), if any, passing along to \( \text{fun} \). This allows an implicit function of \( \text{fun} \).

Details

This version works for implicit function \( f(t, \ldots) \).

This function is designed for continuous distributions. Thus we do not expect tie in the observation \( x \). If you believe the true underlying distribution is continuous but the sample observations have tie due to rounding, then you might want to add a small number to the observations to break tie.
The likelihood used here is the ‘Poisson’ version of the empirical likelihood

$$\prod_{i=1}^{n}(dH(x_i))^\delta_i \exp[-H(x_i) + H(y_i)].$$

For discrete distributions we recommend use `emplikdisc.test()`.

Please note here the largest observed time is NOT automatically defined to be uncensored. In the `el.cen.EM()`, it is (to make F a proper distribution always).

The constant K must be inside the so called feasible region for the computation to continue. This is similar to the requirement that when testing the value of the mean, the value must be inside the convex hull of the observations for the computation to continue. It is always true that the NPMLE value is feasible. So when the computation cannot continue, that means there is no hazard function dominated by the Nelson-Aalen estimator satisfy the constraint. You may try to move the theta and K closer to the NPMLE. When the computation cannot continue, the -2LLR should have value infinite.

**Value**

A list with the following components:

- `times` the location of the hazard jumps.
- `wts` the jump size of hazard function at those locations.
- `lambda` the Lagrange multiplier.
- `"-2LLR"` the -2Log Likelihood ratio.
- `pval` P-value
- `niter` number of iterations used

**Author(s)**

Mai Zhou

**References**


**See Also**

`emplikHs.test2`

**Examples**

```r
z1<-(1,2,3,4,5)
d1<-(1,1,0,1,1)
fun4 <- function(x, theta) { as.numeric(x <= theta) }
emplikh2.test(x=z1,d=d1, K=0.5, fun=fun4, theta=3.5)
#Next, test if H(3.5) = log(2). 
emplikh2.test(x=z1,d=d1, K=log(2), fun=fun4, theta=3.5)
```
# Next, try one sample log rank test
indi <- function(x,y){ as.numeric(x > y) }
fun3 <- function(t,z){rowsum(outer(z,t,FUN="indi"),group=rep(1,length(z))))
emlikH2.test(x=z1, d=d1, K=sum(c(0.25*z1)), fun=fun3, z=z1)
##this is testing if the data is from an exp(0.25) population.

emlikHs.disc2  Two sample empirical likelihood ratio for discrete hazards with right
censored, left truncated data. Many constraints.

Description

Use empirical likelihood ratio and Wilks theorem to test the null hypothesis that
\[
\int f_1(t) I_{[dH_1 < 1]} \log(1 - dH_1(t)) - \int f_2(t) I_{[dH_2 < 1]} \log(1 - dH_2(t)) = \theta
\]

where \(H_*(t)\) are the (unknown) discrete cumulative hazard functions; \(f_*(t)\) can be any predictable functions of \(t\). \(\theta\) is a vector of parameters (dim=q >= 1). The given value of \(\theta\) in these computation are the value to be tested. The data can be right censored and left truncated.

When the given constants \(\theta\) is too far away from the NPMLE, there will be no hazard function satisfy this constraint and the -2 Log empirical likelihood ratio will be infinite. In this case the computation will stop.

Usage

emlikHs.disc2(x1, d1, y1= -Inf, x2, d2, y2 = -Inf,
          theta, fun1, fun2, maxit=25,tola = 1e-6, itertrace =FALSE)

Arguments

- **x1**: a vector, the observed survival times, sample 1.
- **d1**: a vector, the censoring indicators, 1-uncensor; 0-censor.
- **y1**: optional vector, the left truncation times.
- **x2**: a vector, the observed survival times, sample 2.
- **d2**: a vector, the censoring indicators, 1-uncensor; 0-censor.
- **y2**: optional vector, the left truncation times.
- **fun1**: a predictable function used to calculate the weighted discrete hazard in \(H_0\).
  \(\text{fun1}(x)\) must be able to take a vector input (length n) \(x\), and output a matrix of \(n \times q\).
- **fun2**: Ditto.
- **tola**: an optional positive real number, the tolerance of iteration error in solve the non-linear equation needed in constrained maximization.
- **theta**: a given vector of length \(q\) for \(H_0\) constraint.
- **maxit**: integer, maximum number of iteration.
- **itertrace**: Logocal, lower bound for lambda
Details

The log empirical likelihood been maximized is the 'binomial empirical likelihood':

\[ \sum D_{1i} \log w_i + (R_{1i} - D_{1i}) \log[1 - w_i] + \sum D_{2j} \log v_j + (R_{2j} - D_{2j}) \log[1 - v_j] \]

where \( w_i = \Delta H_1(t_i) \) is the jump of the cumulative hazard function at \( t_i \), \( D_{1i} \) is the number of failures observed at \( t_i \), and \( R_{1i} \) is the number of subjects at risk at time \( t_i \) (for sample one). Similar for sample two.

For discrete distributions, the jump size of the cumulative hazard at the last jump is always 1. We have to exclude this jump from the summation in the constraint calculation since \( \log(1 - dH(\cdot)) \) do not make sense. In the likelihood, this term contribute a zero (0*Inf).

This function can handle multiple constraints. So \( \text{dim}(\theta) = q \). The constants \( \theta \) must be inside the so called feasible region for the computation to continue. This is similar to the requirement that in testing the value of the mean, the value must be inside the convex hull of the observations. It is always true that the NPMLE values are feasible. So when the computation stops, try move the \( \theta \) closer to the NPMLE. When the computation stops, the -2LLR should have value infinite.

This code can also be used to compute one sample problems. You need to artificially supply data for sample two (with minimal sample size \((2q+2)\)), and supply a function \( \text{fun2} \) that ALWAYS returns zero (zero vector or zero matrix). In the output, read the -2LLR(sample1).

Value

A list with the following components:

- times1: the location of the hazard jumps in sample 1.
- times2: the location of the hazard jumps in sample 2.
- lambda: the final value of the Lagrange multiplier.
- "-2LLR": The -2Log Likelihood ratio.
- "-2LLR(sample1)": The -2Log Likelihood ratio for sample 1 only.
- niter: number of iterations used.

Author(s)

Mai Zhou

References


Examples

```r
if(require("boot", quietly = TRUE)) {
  library(boot)
  data(channing)
  ymale <- channing[1:97,2]
```
Two sample empirical likelihood ratio test for hazards with right censored, left truncated data. Many constraints.

Use empirical likelihood ratio and Wilks theorem to test the null hypothesis that

$$ \int f_1(t) dH_1(t) - \int f_2(t) dH_2(t) = \theta $$

where $H_*(t)$ is the (unknown) cumulative hazard functions; $f_*(t)$ can be any predictable functions of $t$. $\theta$ is a vector of parameters (dim=q). The given value of $\theta$ in these computation are the value to be tested. The data can be right censored and left truncated.

When the given constants $\theta$ is too far away from the NPMLE, there will be no hazard function satisfy this constraint and the $-2$ Log empirical likelihood ratio will be infinite. In this case the computation will stop.

Usage

emplikHs.test2(x1, d1, y1= -Inf, x2, d2, y2 = -Inf, theta, fun1, fun2, maxit=25, tola = 1e-7, itertrace = FALSE)

Arguments

x1 a vector of length n1, the observed survival times, sample 1.
d1 a vector, the censoring indicators, 1-uncensor; 0-censor.
y1 optional vector, the left truncation times.
x2 a vector of length n2, the observed survival times, sample 2.
d2

a vector, the censoring indicators, 1-uncensor; 0-censor.
y2

optional vector, the left truncation times.
fun1

a predictable function used to calculate the weighted discrete hazard to form the null hypothesis \( H_0 \). \( \text{fun1}(x) \) must be able to take a vector input (length \( n_1 \) x \( x \)), and output a matrix of \( n_1 \) x \( q \). When \( q=1 \), the output can also be a vector.

fun2

Ditto, but for length \( n_2 \)
tola

an optional positive real number, the tolerance of iteration error in solve the non-linear equation needed in constrained maximization.
theta

a given vector of length \( q \) for Ho constraint.
maxit

integer, maximum number of Newton-Raphson type iterations.
itertrace

Logocal, if the results of each iteration needs to be printed.

Details

The log likelihood been maximized is the Poisson likelihood:

\[
\sum D_{1i} \log w_i - \sum R_{1i} w_i + \sum D_{2j} \log v_j - \sum R_{2j} v_j
\]

where \( w_i = \Delta H_1(t_i) \) is the jump of the cumulative hazard function at \( t_i \) (for first sample), \( D_{1i} \) is the number of failures observed at \( t_i \), \( R_{1i} \) is the number of subjects at risk at time \( t_i \). Dido for sample two.

For (proper) discrete distributions, the jump size of the cumulative hazard at the last jump is always 1. So, in the likelihood ratio, it cancels. But the last jump of size 1 still matter when computing the constraint.

The constants \( \theta \) must be inside the so called feasible region for the computation to continue. This is similar to the requirement that in testing the value of the mean, the value must be inside the convex hull of the observations. It is always true that the NPMLE values are feasible. So when the computation stops, try move the \( \theta \) closer to the NPMLE, which we print out first thing in this function, even when other later computations do not go. When the computation stops, the \(-2\text{LLR}\) should have value infinite.

You can also use this function for one sample problems. You need to artificially supply data for sample two of minimal size (like size 2\( q+2 \), and specify a \( \text{fun2}() \) that \textit{ALWAYS} return 0's (zero vector, with length=\( n_2 \) vector length, or zero matrix, with dim \( n_2 \) x \( q \) as the input). Then, look for \(-2\text{LLR}(\text{sample1})\) in the output.

Value

A list with the following components:

"\(-2\text{LLR}\)"

The \(-2\text{Log empirical Likelihood ratio}."

\(\lambda\)

the final value of the Lagrange multiplier.

"\(-2\text{LLR(sample1)}\)"

The \(-2\text{Log empirical likelihood ratio for sample one only}. Useful in one sample problems.

"\(\text{Llog(sample1)}\)"

The numerator only of the above "\(-2\text{LLR(sample1)}\)\), without -2.
Author(s)
Mai Zhou

References

See Also
emplikH2.test

Examples
if(require("boot", quietly = TRUE)) {
  ## library(boot)
  data(channing)
  ymale <- channing[1:97,2]
  dmale <- channing[1:97,5]
  xmale <- channing[1:97,3]
  yfemale <- channing[98:462,2]
  dfemale <- channing[98:462,5]
  xfemale <- channing[98:462,3]
  fun1 <- function(x) { as.numeric(x <= 960) }
  fun2 <- function(x){ cbind(as.numeric(x <= 960), as.numeric(x <= 860))}
  emplikHs.test(x1=xfemale, d1=dfemale, y1=yfemale, x2=xmale, d2=dmale, y2=ymale, theta=c(0,0), fun1=fun2, fun2=fun2)
}

## Second example:
if(require("KMsurv", quietly = TRUE)) {
  ## library(KMsurv)
  data(kidney)
  ## these functions counts the risk set size, so delta=1 always ##
  temp1 <- Wdataclean3(z=kidney$time[kidney[,3]==1], d=rep(1,43) )
  temp2 <- DnR(x=temp1$value, d=temp1$dd, w=temp1$weight)
  TIME <- temp2$times
  RISK <- temp2$n.risk
  fR1 <- approxfun(x=TIME, y=RISK, method="constant", yright=0, rule=2, f=1)
  temp1 <- Wdataclean3(z=kidney$time[kidney[,3]==2], d=rep(1,76) )
  temp2 <- DnR(x=temp1$value, d=temp1$dd, w=temp1$weight)
  TIME <- temp2$times
  RISK <- temp2$n.risk
  fR2 <- approxfun(x=TIME, y=RISK, method="constant", yright=0, rule=2, f=1)

  ## the weight function for two sample Gehan-Wilcoxon type test ##
  fun <- function(t) { fR1(t)*fR2(t)/(76*43)*sqrt(119/(76*43)) }
  ## Here comes the test: ##
  emplikHs.test2(x1=kidney[kidney[,3]==1,1],d1=kidney[kidney[,3]==1,2],
                 x2=kidney[kidney[,3]==2,1],d2=kidney[kidney[,3]==2,2],
...
### Description

This program uses simple search to find the upper and lower (Wilks) confidence limits based on the -2 log likelihood ratio, which the required input fun is supposed to supply.

Basically, starting from MLE, we search on both directions, by step away from MLE, until we find values that have -2LLR = level. (the value of -2LLR at MLE is supposed to be zero.)
At current implementation, only handles one dimensional parameter, i.e. only confidence intervals, not confidence regions.

For examples of using this function to find confidence interval, see the pdf vignettes file.

**Usage**

```r
findUL (step = 0.01, initStep =0, fun, MLE, level = 3.84, ...)
```

**Arguments**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>step</code></td>
<td>a positive number. The starting step size of the search. Reasonable value should be about 1/5 of the SD of MLE.</td>
</tr>
<tr>
<td><code>initStep</code></td>
<td>a nonnegative number. The first step size of the search. Sometimes, you may want to put a larger iniitStep to speed the search.</td>
</tr>
<tr>
<td><code>fun</code></td>
<td>a function that returns a list. One of the item in the list should be &quot;,-2LLR&quot;, which is the -2 log (empirical) likelihood ratio. The first input of <code>fun</code> must be the parameter for which we are seeking the confidence interval. (The MLE or NPMLE of this parameter should be supplied as in the input MLE). The rest of the input to <code>fun</code> are typically the data. If the first input of <code>fun</code> is set to MLE, then the returned -2LLR should be 0.</td>
</tr>
<tr>
<td><code>MLE</code></td>
<td>The MLE of the parameter. No need to be exact, as long as it is inside the confidence interval.</td>
</tr>
<tr>
<td><code>level</code></td>
<td>an optional positive number, controls the confidence level. Default to 3.84 = chisq(0.95, df=1). Change to 2.70=chisq(0.90, df=1) to get a 90% confidence interval.</td>
</tr>
<tr>
<td><code>...</code></td>
<td>additional arguments, if any, to pass to <code>fun</code>.</td>
</tr>
</tbody>
</table>

**Details**

Basically we repeatedly testing the value of the parameter, until we find those which the -2 log likelihood value is equal to 3.84 (or other level, if set differently).

If there is no value exactly equal to 3.84, we stop at the value which result a -2 log likelihood just below 3.84. (as in the discrete case, like quantiles.)

**Value**

A list with the following components:

- **Low** the lower limit of the confidence interval.
- **Up** the upper limit of the confidence interval.
- **FstepL** the final step size when search lower limit. An indication of the precision.
- **FstepU** Ditto. An indication of the precision of the upper limit.
- **Lvalue** The -2LLR value of the final Low value. Should be approximately equal to level. If larger than level, than the confidence interval limit Low is wrong.
- **Uvalue** Ditto. Should be approximately equa to level.
Author(s)
Mai Zhou

References

Examples

```r
## example with tied observations. Kaplan-Meier mean=4.0659.
## For more examples see vignettes.
x <- c(1, 1.5, 2, 3, 4, 5, 6, 5, 4, 1, 2, 4.5)
d <- c(1, 1, 0, 1, 0, 1, 1, 1, 0, 0, 1)
myfun6 <- function(theta, x, d) {
el.cen.EM2(x, d, fun=function(t)(t), mu=theta)
}
findUL(step=0.2, fun=myfun6, MLE=4.0659, x=x, d=d)
```

Description

Krall, Uthoff, and Harley (1975) analyzed data from a study on multiple myeloma in which researchers treated 65 patients with alkylating agents.

Of those patients, 48 died during the study and 17 survived. In the data set MYELOMA, the variable TIME represents the survival time in months from diagnosis. The variable VSTATUS consists of two values, 0 and 1, indicating whether the patient was alive or dead, respectively, at the end of the study. If the value of VSTATUS is 0, the corresponding value of TIME is censored.

The variables thought to be related to survival are LOGBUN (log BUN at diagnosis), HGB (hemoglobin at diagnosis), PLATELET (platelets at diagnosis: 0=abnormal, 1=normal), AGE (age at diagnosis in years), LOGWBC (log WBC at diagnosis), FRAC (fractures at diagnosis: 0=none, 1=present), LOGPBM (log percentage of plasma cells in bone marrow), PROTEIN (proteinuria at diagnosis), and SCALC (serum calcium at diagnosis).


Usage

data(myeloma)
Format

A data frame containing 65 observations on 11 variables:

- [,1] "time"
- [,2] "vstatus"
- [,3] "logBUN"
- [,4] "HGB"
- [,5] "platelet"
- [,6] "age"
- [,7] "logWBC"
- [,8] "FRAC"
- [,9] "logPBM"
- [,10] "protein"
- [,11] "SCALC"

References


Usage

RankRegTest(y, d, x, beta, type="Gehan")

Arguments

- y: a vector of length N, containing the censored responses.
- d: a vector (length N) of either 1's or 0's. d=1 means y is uncensored; d=0 means y is right censored.
- x: a matrix of size N by q.
- beta: a vector of length q. the value of the regression coefficient to be tested in the model \( y_i = \beta x_i + e_i \).
- type: default to Gehan type. The other option is Logrank type.
Details

The estimator of beta can be obtained by function rankaft( ) in the package rankreg. But here you may test other values of beta. If you test the beta value that is obtained from the rankaft( ), then the -2LLR should be 0 and the p-value should be 1.

The above likelihood should be understood as the likelihood of the error term, so in the regression model the error $e_i$ should be iid.

The estimation equation used when maximize the empirical likelihood is

$$0 = \sum_i \phi(e_i) d_i \Delta F(e_i) (x_i - \bar{x}_i) / (nw_i)$$

which was described in detail in the references below.

See also the function RankRegTestH, which is based on the hazard likelihood.

Value

A list with the following components:

- "-2LLR" the -2 loglikelihood ratio; should have approximate chisq distribution under $H_0$.
- logel2 the log empirical likelihood, under estimating equation.
- logel the log empirical likelihood of the Kaplan-Meier of e’s.
- prob the probabilities that max the empirical likelihood under rank estimating equation constraint.

Author(s)

Mai Zhou.

References


Examples

data(myeloma)
RankRegTest(y=myeloma[,1], d=myeloma[,2], x=myeloma[,3], beta= -15.50147)

# you should get "-2LLR" = 9.050426e-05 (practically zero)
# The beta value, -15.50147, was obtained by rankaft() from the rankreg package.
RankRegTestH

*Test the AFT model, Rank Regression estimator by (Hazard)Empirical Likelihood*

**Description**

Use the empirical likelihood ratio and Wilks theorem to test if the regression coefficient is equal to beta, based on the rank estimator/estimating equation of the AFT model.

The log empirical likelihood been maximized is the hazard empirical likelihood.

**Usage**

`RankRegTestH(y, d, x, beta, type=“Gehan”)`

**Arguments**

- `y`: a vector of length N, containing the censored responses.
- `d`: a vector (length N) of either 1’s or 0’s. d=1 means y is uncensored; d=0 means y is right censored.
- `x`: a matrix of size N by q.
- `beta`: a vector of length q. the value of the regression coefficient to be tested in the model $y_i = \beta x_i + \epsilon_i$.
- `type`: default to Gehan type. The other option is Logrank type.

**Details**

The estimator of beta can be obtained by function `rankaft()` in the package `rankreg`. But here you may test other values of beta. If you test the beta value that is obtained from the `rankaft()`, then the -2LLR should be 0 and the p-value should be 1.

The above likelihood should be understood as the likelihood of the error term, so in the regression model the error $\epsilon_i$ should be iid.

The estimating equation used when maximize the empirical likelihood is

$$0 = \sum_i R(e_i)\phi(e_i)d_i\Delta A(e_i)(x_i - \bar{x}_i)$$

where all notation was described in detail in the references below.

**Value**

A list with the following components:

- `"-2LLR"`: the -2 loglikelihood ratio; should have approximate chisq distribution under $H_0$.
- `logel2`: the log empirical likelihood, under estimating equation.
- `logel1`: the log empirical likelihood of the Kaplan-Meier of e’s.
Author(s)
Mai Zhou

References

Examples
data(myeloma)
RankRegTestH(y=myeloma[,1], d=myeloma[,2], x=myeloma[,3], beta=-15.50147)
# you should get "-2LLR" = 9.050426e-05 (practically zero)
# The beta value, -15.50147, was obtained by rankaft() from
# the rankreg package.

ROCnp

Test the ROC curve by Empirical Likelihood

Description
Use empirical likelihood ratio to test the hypothesis Ho: (1-b0)th quantile of sample 1 = (1-t0)th quantile of sample 2. This is the same as testing Ho: R(t0)= b0, where R(.) is the ROC curve.
The log empirical likelihood been maximized is
\[ \sum_{d1=1} \log \Delta F_1(t1i) + \sum_{d1=0} \log[1 - F_1(t1i)] + \sum_{d2=1} \log \Delta F_2(t2j) + \sum_{d2=0} \log[1 - F_2(t2j)]. \]
This empirical likelihood ratio has a chi square limit under Ho.

Usage
ROCnp(t1, d1, t2, d2, b0, t0)

Arguments
\begin{itemize}
  \item \texttt{t1} a vector of length n. Observed times, may be right censored.
  \item \texttt{d1} a vector of length n, censoring status. d=1 means t is uncensored; d=0 means t is right censored.
  \item \texttt{t2} a vector of length m. Observed times, may be right censored.
  \item \texttt{d2} a vector of length m, censoring status.
  \item \texttt{b0} a scalar between 0 and 1.
  \item \texttt{t0} a scalar, between 0 and 1.
\end{itemize}
Details

Basically, we first test (1-b0)th quantile of sample 1 = c and also test (1-t0)th quantile of sample 2 = c. This way we obtain two log likelihood ratios.

Then we minimize the sum of the two log likelihood ratio over c.

See the tech report below for details on a similar setting.

Value

A list with the following components:

- "-2LLR" the -2 loglikelihood ratio; have approximate chisq distribution under $H_0$.
- cstar the estimated common quantile.

Author(s)

Mai Zhou.

References


Examples

```r
cCCCC an example of testing the equality of two medians. No censoring.
ROCnp(t1=rexp(100), d1=rep(1,100), t2=rexp(120), d2=rep(1,120), b0=0.5, t0=0.5)

CCCC nextL an example of finding 90 percent confidence interval of $R(0.5)$
RoCnp( t1=t1, d1=rep(1, 200), t2=t2, d2=rep(1, 200), b0=0.5, t0=0.5)$"-2LLR"

CCCC since the -2LLR value is less than 2.705543 = qchisq(0.9, df=1), so the
CCCC confidence interval contains 0.5.
#gridpoints <- 35:65/100
#ELvalues <- gridpoints
#for( i in 1:31 ) ELvalues[i] <- ROCnp(t1=t1, d1=rep(1, 200),
  # t2=t2, d2=rep(1, 200), b0=gridpoints[i], t0=0.5)$"-2LLR"
#myfun1 <- approxfun(x=gridpoints, y=ELvalues)
#uniroot( f = function(x){myfun1(x)-2.705543}, interval= c(0.35, 0.5) )
#uniroot( f = function(x){myfun1(x)-2.705543}, interval= c(0.5, 0.65) )

CCCC so, taking the two roots, we see the 90 percent confidence interval for $R(0.5)
CCCC in this case is [0.4478001, 0.5889425].
```
Test the ROC curve by Empirical Likelihood

Description

Use empirical likelihood ratio to test the hypothesis $H_0$: $(1-b_0)$th quantile of sample 1 = $(1-t_0)$th quantile of sample 2. This is the same as testing $H_0$: $R(t_0) = b_0$, where $R(.)$ is the ROC curve.

The log empirical likelihood been maximized is

$$\sum_{d_1=1}^{d_1} \log \Delta F_1(t_1_i) + \sum_{d_1=0}^{d_1} \log[1 - F_1(t_1_i)] + \sum_{d_2=1}^{d_2} \log \Delta F_2(t_2_j) + \sum_{d_2=0}^{d_2} \log[1 - F_2(t_2_j)].$$

This empirical likelihood ratio has a chi square limit under $H_0$.

Usage

ROCnp2(t1, d1, t2, d2, b0, t0)

Arguments

t1 \quad a vector of length n. Observed times, sample 1. may be right censored.
d1 \quad a vector of length n, censoring status. d=1 means t is uncensored; d=0 means t is right censored.
t2 \quad a vector of length m. Observed times, sample 2. may be right censored.
d2 \quad a vector of length m, censoring status.
b0 \quad a scalar, between 0 and 1.
t0 \quad a scalar, between 0 and 1.

Details

First, we test $(1-b0)$th quantile of sample 1 = c and also test $(1-t0)$th quantile of sample 2 = c. This way we obtain two log likelihood ratios.

Then we minimize the sum of the two log likelihood ratios over c.

This version use an exhaust search for the minimum (over c). Since the objective (log lik) are piecewise constants, the optimum( ) function in R do not work well. See the tech report below for details on a similar setting.

Value

A list with the following components:

-2LLR \quad the -2 loglikelihood ratio; have approximate chisq distribution under $H_0$.
cstar \quad the estimated common quantile.
Author(s)

Mai Zhou

References


Examples

#### An example of testing the equality of two medians.
#### No censoring.
# ROCnp2(t1=rexp(100), d1=rep(1,100), t2=rexp(120),
#     d2=rep(1,120), b0=0.5, t0=0.5)

This example do not work on the Solaris Sparc machine. But works fine on other platforms.

Next, an example of finding 90 percent confidence interval of R(0.5)

Note: We are finding confidence interval for R(0.5).

So we are testing

R(0.5)= 0.35, 0.36, 0.37, 0.38, etc. try to find

values so that testing R(0.5) = L, U has p-value

of 0.10, then [L, U] is the 90 percent confidence interval for R(0.5).

set.seed(123)
t1 <- rexp(200)
t2 <- rexp(200)
#ROCnp(t1=t1, d1=rep(1,200), t2=t2, d2=rep(1,200),
#     b0=0.5, t0=0.5)$"-2LLR"

since the -2LLR value is less than

2.705543 = qchisq(0.9, df=1), so the confidence interval contains 0.5.

gridpoints <- 35:65/100
ELvalues <- gridpoints
#for(i in 1:31) ELvalues[i] <- ROCnp2(t1=t1, d1=rep(1,200),
#     t2=t2, d2=rep(1,200), b0=gridpoints[i], t0=0.5)$"-2LLR"
#myfun1 <- approxfun(x=gridpoints, y=ELvalues)
#uniroot(f=function(x)(myfun1(x)-2.705543),
#       interval= c(0.35, 0.5) )
#uniroot(f= function(x)(myfun1(x)-2.705543),
#       interval= c(0.5, 0.65) )

So, taking the two roots, we see the 90 percent confidence interval for R(0.5) in this case is [0.4457862, 0.5907723].
smallcell  

Smallcell Lung Cancer Data

Description

There are 121 observations on 4 variables. Arm is the indication of two treatments. Entry is the age of the patient at entry. Survival is the survival time and indicator is the censoring indicator (right censoring). For more details please see the reference below.


Usage

data(smallcell)

Format

A data frame containing 121 observations on 4 variables:

[,1]  "arm"
[,2]  "entry"
[,3]  "survival"
[,4]  "indicator"

References


WRegEst  

Compute the casewise weighted regression estimator for AFT model

Description

For the AFT model, this function computes the case weighted estimator of beta. Either the least squares estimator or the regression quantile estimator.

Usage

WRegEst(x, y, delta, LS=TRUE, tau=0.5)

Arguments

x  

a matrix of size N by q.
y a vector of length N, containing the censored responses. Usually the log of the original observed failure times.
delta a vector (length N) of either 1’s or 0’s. d=1 means y is uncensored; d=0 means y is right censored.
LS a logical value. If TRUE then the function will return the least squares estimator. If FALSE then the function will return the quantile regression estimator, with the quantile level specified by tau .
tau a scalar, between 0 and 1. The quantile to be used in quantile regression. If tau=0.5 then it is the median regression. If LS=TRUE, then it is ignored.

Details
Due to the readily available minimizer, we only provide least squares and quantile regression here. However, in the companion testing function \texttt{wregtest} the user can supply a self defined psi function, corresponding to the general M-estimation in the regression modeling. (since there is no minimization needed).
The estimator is the minimizer of
\[ \sum_{i=1}^{n} w_i \rho(Y_i - X_i b) \]
Assuming a correlation model
\[ Y_i = X_i \beta + \sigma(X_i) \epsilon_i \]
where \( \rho() \) is either the square or the absolute value function.

Value
The estimator \( \hat{\beta} \).

Author(s)
Mai Zhou.

References

Examples
```
data(smallcell)
\texttt{WRegEst}(x=cbind(1,smallcell[,[1],smallcell[,[2]],
y=smallcell[,[3], delta=smallcell[,[4]])

# you should get
# x1  x2  x3
# -59.22126 -488.41306  16.03259

WRegEst(x=cbind(1,smallcell[,[1],smallcell[,[2]],
y=log10(smallcell[,[3]], delta=smallcell[,[4], LS=FALSE)
```

```
### you should get
### [1]  2.603342985  -0.263000044  0.003836832

```
x <- c(28, -44, 29, 30, 26, 27, 22, 23, 33, 16, 24, 29, 24, 40, 21, 31, 34, -2, 25, 19)
```

---

**WRegTest**  
*Test the case weighted regression estimator by Empirical Likelihood*

---

**Description**

Use the empirical likelihood ratio and Wilks theorem to test if the regression coefficient is equal to $\beta_0$, by the case weighted estimation method.

The log empirical likelihood been maximized is

$$\sum_{d=1}^{nd} \log \Delta F(y_i) + \sum_{d=0}^{nd-1} \log[1 - F(y_i)].$$

**Usage**

```
WRegTest(x, y, delta, beta0, psifun=function(t)(t))
```

**Arguments**

- `x` a matrix of size N by q. Random design matrix.
- `y` a vector of length N, containing the censored responses.
- `delta` a vector (length N) of either 1's or 0's. delta=1 means y is uncensored; delta=0 means y is right censored.
- `beta0` a vector of length q. The value of the regression coefficient to be tested in the linear model.
- `psifun` the estimating function. The definition of it determines the type of estimator under testing.

**Details**

The above likelihood should be understood as the likelihood of the censored responses $y$ and $\delta$.

This version can handle the model where beta is a vector (of length q).

The estimation equations used when maximize the empirical likelihood is

$$0 = \sum \delta_i \Delta F(Y_i) X_i (Y_i - X_i \beta_0)$$

which was described in detail in the reference below.

For median regression (Least Absolute Deviation) estimator, you should define the `psifun` as $+1, -1$ or 0 when $t$ is $>0$, $<0$ or $=0$.

For ordinary least squares estimator, `psifun` should be the identity function `psifun <- function(t) t`.  

Value

A list with the following components:

- `-2LLR` the -2 log likelihood ratio; have approximate chisq distribution under $H_0$.
- `pMval` the p-value using the chi-square approximation.

Author(s)

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References


Examples

```r
xx <- c(28, -44, 29, 30, 26, 22, 23, 33, 16, 24, 29, 24, 40, 21, 31, 34, -2, 25, 19)
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