

# Package ‘LBI’

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**Version** 0.2.2

**Title** Likelihood Based Inference

**Description** Maximum likelihood estimation and likelihood ratio test are essential for modern statistics. This package supports in calculating likelihood based inference.

Reference: Pawitan Y. (2001, ISBN:0-19-850765-8).

**Depends** R (>= 3.0.0)

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## Contents

LBI-package	2
LBCIvar	3
Llbin	4
LInorm	5
LInormVar	6
Llpois	7
Llvar	8
LlvRatio	9
Llvtest	10
LRT	11
OneTwo	12
ORLI	13
RDLI	14
RRLI	15
<b>Index</b>	<b>17</b>

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LBI-package

*Likelihood Based Inference*

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### **Description**

It conducts likelihood based inference.

### **Details**

Modern likelihood concept and maximum likelihood estimation are established by Fisher RA, while Likelihood Ratio Test (LRT) is established by Neyman J. Post-Fisher methods - generalized linear model, survival analysis, and mixed effects model - are all likelihood based. Inferences from the perspective of Fisherian and pure likelihoodist are suggested here.

### **Author(s)**

Kyun-Seop Bae <k@acr.kr>

### **References**

1. Wilks SS. The Large-sample Distribution of the Likelihood Ratio for Testing Composite Hypotheses. *Ann Math Stat.* 1938;9(1):60-62.
2. Edwards AWF. *Likelihood.* 1972.
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LBCIvar	<i>Likelihood Based Confidence Interval of sd and variance assuming Normal Distribution</i>
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**Description**

Likelihood based confidence interval of sd and variance assuming normal distribution. It usually shows narrower interval than conventional chi-square interval. This uses estimated likelihood, not profile likelihood.

**Usage**

```
LBCIvar(x, conf.level=0.95)
```

**Arguments**

x	a vector of observation
conf.level	confidence level

**Details**

It calculates (same height) likelihood based confidence interval of sd and variance assuming normal distribution in one group. The likelihood interval is asymmetric and there is no standard error in the output.

**Value**

PE	maximum likelihood estimate
LL	lower limit of likelihood interval
UL	upper limit of likelihood interval

**Author(s)**

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**Examples**

```
LBCIvar(lh)
(length(lh) - 1)*var(lh)/qchisq(c(0.975, 0.025), length(lh) - 1)
```

---

 Llbin

*Likelihood Interval for a Proportion or a Binomial Distribution*


---

**Description**

Likelihood interval of a proportion in one group

**Usage**

```
Llbin(y, n, k, conf.level=0.95, eps=1e-8)
```

**Arguments**

y	positive event count of a group
n	total count of a group
k	1/k likelihood interval will be calculated
conf.level	approximately corresponding confidence level. If k is specified, this is ignored.
eps	Values less than eps are considered as 0.

**Details**

It calculates likelihood interval of a proportion in one group. The likelihood interval is asymmetric and there is no standard error in the output. If you need percent scale, multiply the output by 100.

**Value**

y	positive (concerning) event count
n	total trial count
PE	maximum likelihood estimate on the proportion
LL	lower limit of likelihood interval
UL	upper limit of likelihood interval

**Author(s)**

Kyun-Seop Bae k@acr.kr

**References**

Fisher RA. Statistical methods and scientific inference. 3e. 1973. pp68-76.

**See Also**

binom.test, prop.test

**Examples**

```

LInorm(x, k, conf.level=0.95, PLOT="", LOCATE=FALSE, Resol=201)
LInorm(x, k, conf.level=0.95, PLOT="1d", LOCATE=FALSE, Resol=201)
LInorm(x, k, conf.level=0.95, PLOT="2d", LOCATE=FALSE, Resol=201)
LInorm(x, k, conf.level=0.95, PLOT="1d", LOCATE=TRUE, Resol=201)
LInorm(x, k, conf.level=0.95, PLOT="2d", LOCATE=TRUE, Resol=201)
# binom.test(3, 14)
# prop.test(3, 14)

```

---

LInorm	<i>Likelihood Interval of mean, sd and variance assuming Normal Distribution</i>
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---

**Description**

Likelihood interval of mean and sd assuming normal distribution. This is estimated likelihood interval, not profile likelihood interval.

**Usage**

```
LInorm(x, k, conf.level=0.95, PLOT="", LOCATE=FALSE, Resol=201)
```

**Arguments**

x	a vector of observation
k	1/k likelihood interval will be calculated
conf.level	approximately corresponding confidence level. If k is specified, this is ignored.
PLOT	"1d" for profile plot or "2d" for contour plot.
LOCATE	use locator. This works only with PLOT="2D" option.
Resol	resolution for plot. This works only with PLOT=TRUE option.

**Details**

It calculates likelihood interval of mean and sd assuming normal distribution in one group. There is no standard error in the output.

**Value**

PE	maximum likelihood estimate
LL	lower limit of likelihood interval
UL	upper limit of likelihood interval

**Author(s)**

Kyun-Seop Bae k@acr.kr

**Examples**

```
x = c(-5.3, -4.5, -1.0, -0.7, 3.7, 3.9, 4.2, 5.5, 6.8, 7.4, 9.3)
LInorm(x, k=1/0.15) # Pawitan Ex10-9 p289
LInorm(x)
LInorm(x, PLOT="1d")
LInorm(x, PLOT="2d", LOCATE=TRUE)
```

---

LInormVar

*Likelihood Interval of sd and variance assuming Normal Distribution*


---

**Description**

Likelihood interval of sd and variance assuming normal distribution. This is estimated likelihood interval, not profile likelihood interval.

**Usage**

```
LInormVar(x, k, conf.level=0.95)
```

**Arguments**

x	a vector of observation
k	1/k likelihood interval will be calculated
conf.level	approximately corresponding confidence level. If k is specified, this is ignored.

**Details**

It calculates likelihood interval of sd and variance assuming normal distribution in one group. The likelihood interval is asymmetric and there is no standard error in the output.

**Value**

PE	maximum likelihood estimate
LL	lower limit of likelihood interval
UL	upper limit of likelihood interval

**Author(s)**

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**Examples**

```
x = c(-5.3, -4.5, -1.0, -0.7, 3.7, 3.9, 4.2, 5.5, 6.8, 7.4, 9.3)
LInormVar(x, k=1/0.15) # Pawitan Ex10-9 p289
LInormVar(x)
```

---

 LIpois

*Likelihood Interval of the Mean assuming Poisson Distribution*


---

**Description**

Likelihood interval of lambda assuming Poisson distribution.

**Usage**

```
LIpois(x, k, n = 1, conf.level = 0.95, eps = 1e-8)
```

**Arguments**

x	raw data vector or a mean value. If the length of x is 1, x is considered as a mean.
k	1/k likelihood interval will be calculated.
n	number of observations. If the length of x is 1, x is considered as the mean.
conf.level	approximately corresponding confidence level. If k is specified, this is ignored.
eps	estimated values less than this eps are considered as 0.

**Details**

It calculates likelihood interval of mean(lambda) assuming Poisson distribution. The likelihood interval is asymmetric and there is no standard error in the output.

**Value**

PE	maximum likelihood estimate on the lambda
LL	lower limit of likelihood interval
UL	upper limit of likelihood interval
n	number of observations
k	1/k likelihood interval provided
logk	log(k) of k value
maxLL without factorial	maximum log likelihood without factorial part

**Author(s)**

Kyun-Seop Bae k@acr.kr

**Examples**

```

LIPois(4, k=15)      # Fisher
LIPois(4, k=exp(2)) # Edwards
LIPois(4, k=1/0.15) # Pawitan
LIPois(4, k=8)      # Rhode
LIPois(4, n=4)      # Bae
LIPois(4)           # Bae
# poisson.test(4)
LIPois(4, k=32)     # 0.7454614 11.7893612
LIPois(2.1, n=60)  # 1.750222 2.493533

```

---

LIVar *Likelihood Interval of variance and sd assuming Normal Distribution  
with sample mean and sample size*

---

**Description**

Likelihood interval of sd and variance assuming normal distribution. This is estimated likelihood interval, not profile likelihood interval.

**Usage**

```
LIVar(s1, n1, k, conf.level=0.95)
```

**Arguments**

s1	standard deviation of the sample
n1	sample size
k	1/k likelihood interval will be calculated
conf.level	approximately corresponding confidence level. If k is specified, this is ignored.

**Details**

It calculates likelihood interval of sd and variance assuming normal distribution in one group. The likelihood interval is asymmetric and there is no standard error in the output.

**Value**

PE	maximum likelihood estimate on the population variance
LL	lower limit of likelihood interval
UL	upper limit of likelihood interval

**Author(s)**

Kyun-Seop Bae k@acr.kr



**Examples**

```
x = c(-5.3, -4.5, -1.0, -0.7, 3.7, 3.9, 4.2, 5.5, 6.8, 7.4, 9.3)
LInormVar(x)
LIvar(sd(x), length(x))
```

LIVRatio

*Likelihood Interval of the ratio of two variances from two groups***Description**

Likelihood interval of the ratio of two variances from two groups assuming normal distribution. Likelihood interval usually gives a narrower interval when the likelihood function is asymmetric.

**Usage**

```
LIVRatio(x, y, k, conf.level=0.95)
```

**Arguments**

x	observations from the first group, the test group, used for the numerator
y	observations from the second group, the control group, used for the denominator
k	1/k likelihood interval will be provided
conf.level	approximate confidence level

**Details**

It calculates likelihood interval of the ratio of two variances from two groups. Likelihood interval usually gives a narrower interval when the likelihood function is asymmetric.

**Value**

PE	maximum likelihood estimate on the ratio
LL	lower limit of likelihood interval
UL	upper limit of likelihood interval
logk	log(k) value used for LI
maxLL	maximum log likelihood
conf.level	approximate confidence level

**Author(s)**

Kyun-Seop Bae k@acr.kr

**Examples**

```
LIVRatio(mtcars$drat, mtcars$wt)
var.test(mtcars$drat, mtcars$wt)
LIVRatio(mtcars$qsec, mtcars$wt)
var.test(mtcars$qsec, mtcars$wt)
LIVtest(sd(mtcars$qsec), nrow(mtcars), sd(mtcars$wt), nrow(mtcars))
```

---

LIVtest	<i>Likelihood Interval of variance and sd assuming Normal Distribution using means and SDs</i>
---------	--

---

**Description**

Likelihood interval of variance and sd assuming normal distribution. This is estimated likelihood interval, not profile likelihood interval.

**Usage**

```
LIVtest(s1, n1, s2, n2, k, conf.level=0.95)
```

**Arguments**

s1	sample standard deviation of the first group
n1	sample size of the first group
s2	sample standard deviation of the second group
n2	sample size of the second group
k	1/k likelihood interval will be calculated
conf.level	approximate confidence level. If k is specified, this is ignored.

**Details**

It calculates likelihood interval of variance and sd using sufficient statistics. There is no standard error in the output.

**Value**

PE	maximum likelihood estimate on the ratio
LL	lower limit of likelihood interval
UL	upper limit of likelihood interval
logk	log(k) value used for LI
maxLL	maximum log likelihood
conf.level	approximate confidence level

**Author(s)**

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**Examples**

```
LIvtest(10.5, 3529, 8.9, 5190)
LIvtest(3, 10, 2, 10)
LIvtest(3, 10, 2, 10, k=15)
```

---

LRT

*Likelihood Ratio Test*


---

**Description**

Likelihood ratio test with given fitting results, sample size, number of parameters, log-likelihoods, and alpha

**Usage**

```
LRT(n, pFull, pReduced, logLikFull, logLikReduced, alpha=0.05, Wilks=FALSE)
```

**Arguments**

n	number of observations
pFull	number of parameters of full model
pReduced	number of parameters of reduced model
logLikFull	log likelihood of full model
logLikReduced	log likelihood of reduced model
alpha	alpha value for type I error, significance level
Wilks	if TRUE, Wilks theorem (chi-square distribution) will be used, otherwise F distribution will be used.

**Details**

It performs likelihood ratio test with given fitting results. The default test is using F distribution. For small n (i.e. less than 100), you need to use F distribution. If the residuals are normally distributed, the delta -2 log likelihood (the difference between -2LL, the objective function value of each model) follows exactly an F-distribution, independent of sample size. When the distribution of the residuals is not normal (no matter what the distribution of the residuals is), it approaches a chi-square distribution as sample size increases (Wilks' theorem). The extreme distribution of the F-distribution (when the degrees of freedom in the denominator go to infinity) is chi-square distribution. The p-value from the F-distribution is slightly larger than the p-value from the chi-square distribution, meaning the F-distribution is more conservative. The difference decreases as sample size increases.

**Value**

n	number of observations
paraFull	number of parameters of full model
paraReduced	number of parameters of reduced model
deltaPara	difference of parameter counts
cutoff	cutoff, threshold, critical value of log-likelihood for the test
deltaLogLik	difference of log likelihood, if negative 0 is used.
Chisq or Fval	statistics according to the used distribution Chi-square of F
pval	p-value of null hypothesis. i.e. the reduced model is better.
Verdict	the model preferred.

**Author(s)**

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**References**

1. Ruppert D, Cressie N, Carroll RJ. A Transformation/Weighting Model For Estimating Michaelis-Menten Parameters. School of Operations Research and Industrial Engineering, College of Engineering, Cornell University. Technical Report No. 796. May 1988.
2. Scheffé H. The Analysis of Variance. Wiley. 1959.
3. Wilks SS. The Large-Sample Distribution of the Likelihood Ratio for Testing Composite Hypotheses. *Annals Math. Statist.* 1938;9:60-62

**Examples**

```
LRT(20, 4, 2, -58.085, -60.087)
LRT(20, 4, 2, -58.085, -60.087, Wilks=TRUE)
LRT(20, 4, 2, -57.315, -66.159)
LRT(20, 4, 2, -57.315, -66.159, Wilks=TRUE)

r1 = lm(mpg ~ disp + drat + wt, mtcars)
r2 = lm(mpg ~ disp + drat, mtcars)
anova(r2, r1)
LRT(nrow(mtcars), r1$rank, r2$rank, logLik(r1), logLik(r2))
```

---

OneTwo

*Likelihood Ratio Test for One group vs Two group gaussian mixture model*

---

**Description**

With a given vector, it performs likelihood ratio test which model - one or two group - is better.

**Usage**

```
OneTwo(x, alpha=0.05)
```

**Arguments**

x	a vector of numbers
alpha	alpha value for type I error, significance level

**Details**

It performs likelihood ratio test using both F distribution and Chi-square distribution (by Wilks' theorem).

**Value**

Estimate	n, Mean, SD for each group assumption and prior probability of each group in two group model
Delta	delta number of parameters and log-likelihoods
Statistic	Statistics from both the F distribution and Chi-square distribution. Cutoff is in terms of log-likelihood not the statistic.

**Author(s)**

Kyun-Seop Bae k@acr.kr

**Examples**

```
OneTwo(c(7, 5, 17, 13, 16, 5, 7, 3, 8, 10, 8, 14, 14, 11, 14, 17, 2, 12, 15, 19))
OneTwo(c(5, 3, 0, 6, 5, 2, 6, 6, 4, 4, 15, 13, 18, 18, 19, 14, 19, 13, 19, 18))
```

---

ORLI	<i>Odds Ratio and its Likelihood Interval between two groups without strata</i>
------	---

---

**Description**

Odds ratio and its likelihood interval between two groups without stratification

**Usage**

```
ORLI(y1, n1, y2, n2, conf.level=0.95, k, eps=1e-8)
```

**Arguments**

y1	positive event count of test (the first) group
n1	total count of the test (the first) group. Maximum allowable value is 1e8.
y2	positive event count of control (the second) group
n2	total count of control (the second) group. Maximum allowable value is 1e8.
conf.level	approximate confidence level to calculate k when k is missing.
k	1/k likelihood interval will be provided
eps	absolute value less than eps is regarded as negligible

**Details**

It calculates risk (proportion) difference and its likelihood interval between the two groups. The likelihood interval is asymmetric, and there is no standard error in the output. This does not support stratification.

**Value**

There is no standard error.

odd1	odd from the first group, $y1/(n1 - y1)$
odd2	odd from the second group, $y2/(n2 - y2)$
OR	odds ratio, $odd1/odd2$
lower	lower likelihood limit of OR
upper	upper likelihood limit of OR

**Author(s)**

Kyun-Seop Bae k@acr.kr

**Examples**

```
ORLI(7, 10, 3, 10)
ORLI(3, 10, 7, 10)
```

---

RDLI

*Risk (Proportion) Difference and its Likelihood Interval between two groups without strata*

---

**Description**

Risk difference and its likelihood interval between two groups without stratification

**Usage**

```
RDLI(y1, n1, y2, n2, conf.level=0.95, k, eps=1e-8)
```

**Arguments**

y1	positive event count of test (the first) group
n1	total count of the test (the first) group. Maximum allowable value is 1e8.
y2	positive event count of control (the second) group
n2	total count of control (the second) group. Maximum allowable value is 1e8.
conf.level	approximate confidence level to calculate k when k is missing.
k	1/k likelihood interval will be provided
eps	absolute value less than eps is regarded as negligible

**Details**

It calculates risk (proportion) difference and its likelihood interval between the two groups. The likelihood interval is asymmetric, and there is no standard error in the output. This does not support stratification.

**Value**

There is no standard error.

p1	proportion from the first group, $y1/n1$
p2	proportion from the second group, $y2/n2$
RD	risk difference, $p1 - p2$
lower	lower likelihood limit of RD
upper	upper likelihood limit of RD

**Author(s)**

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**Examples**

```
RDLI(7, 10, 3, 10)
RDLI(3, 10, 7, 10)
```

---

RRLI

*Relative Risk and its Likelihood Interval between two groups without strata*

---

**Description**

Relative risk and its likelihood interval between two groups without stratification

**Usage**

```
RRLI(y1, n1, y2, n2, conf.level=0.95, k, eps=1e-8)
```

**Arguments**

y1	positive event count of test (the first) group
n1	total count of the test (the first) group. Maximum allowable value is 1e8.
y2	positive event count of control (the second) group
n2	total count of control (the second) group. Maximum allowable value is 1e8.
conf.level	approximate confidence level to calculate k when k is missing.
k	1/k likelihood interval will be provided
eps	absolute value less than eps is regarded as negligible

**Details**

It calculates relative risk and its likelihood interval between the two groups. The likelihood interval is asymmetric, and there is no standard error in the output. This does not support stratification.

**Value**

There is no standard error.

p1	proportion from the first group, $y1/n1$
p2	proportion from the second group, $y2/n2$
RR	relative risk, $p1/p2$
lower	lower likelihood limit of RR
upper	upper likelihood limit of RR

**Author(s)**

Kyun-Seop Bae [k@acr.kr](mailto:k@acr.kr)

**Examples**

```
RRLI(7, 10, 3, 10)
RRLI(3, 10, 7, 10)
```



# Index

LBCIvar, [3](#)  
LBI (LBI-package), [2](#)  
LBI-package, [2](#)  
LIbin, [4](#)  
LInorm, [5](#)  
LInormVar, [6](#)  
LIpois, [7](#)  
LIvar, [8](#)  
LIvRatio, [9](#)  
LIvtest, [10](#)  
LRT, [11](#)

OneTwo, [12](#)  
ORLI, [13](#)

RDLI, [14](#)  
RRLI, [15](#)