Package ‘ebci’

April 7, 2020

Title Robust empirical Bayes confidence intervals

Version 0.0.0.9000

Description Computes empirical Bayes confidence estimators and confidence intervals (EBCIs) in a normal means model. The EBCIs are robust in the sense that they achieve correct coverage regardless of the distribution of the means. If the means are treated as fixed, the EBCIs have an average coverage guarantee.

Depends R (>= 3.6.0)

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Encoding UTF-8

LazyData true

Suggests spelling,
testthat (>= 2.1.0),
lpSolve,
parallel

Language en-US

URL `https://github.com/kolesarm/ebci`

BugReports `https://github.com/kolesarm/ebci/issues`

Roxygen list(markdown = TRUE)

RoxygenNote 7.1.0

R topics documented:

ct *Neighborhood effects data from Chetty and Hendren (2018)*

Description

This dataset contains a subset of the publicly available data from Chetty and Hendren (2018). It contains raw estimates and standard errors of neighborhood effects at the county level

Usage

```
ct
```

Format

A data frame with 741 rows corresponding to counties and 12 columns corresponding to the variables:

ct County ID

cz ID of commuting zone to which the county belongs.

ctname County name

state 2-digit state code

pop Population of the county according to the year 2000 Census

pop_cz Population of the CZ to which the county belongs according to the year 2000 Census

theta25 Fixed-effect estimate of the causal effect of living in the county for one year on children's percentile rank in the national distribution of household earnings at age 26 relative to others in the same birth cohort for children growing up with parents at the 25th percentile of national income distribution

theta75 Fixed-effect estimate of the causal effect of living in the county for one year on children's percentile rank in the national distribution of household earnings at age 26 relative to others in the same birth cohort for children growing up with parents at the 75th percentile of national income distribution

se25 Standard error of `theta25`

se75 Standard error of `theta75`

stayer25 Average percentile rank in the national distribution of household earnings at age 26 relative to others in the same birth cohort for stayers (children who grew up in the county and did not move) with parents at the 25th percentile of national income distribution.

stayer75 Average percentile rank in the national distribution of household earnings at age 26 relative to others in the same birth cohort for stayers (children who grew up in the county and did not move) with parents at the 75th percentile of national income distribution.

Source

https://opportunityinsights.org/data/?paper_id=599

References

Chetty, R., & Hendren, N. (2018). The Impacts of Neighborhoods on Intergenerational Mobility II: County-Level Estimates. The Quarterly Journal of Economics, 133(3), 1163–1228. doi:10.1093/qje/qjy006

`cva` *Compute average coverage critical value under moment constraints.*

Description

Computes the critical value $cva_\alpha(m_2, \kappa)$ from Armstrong, Kolesár, and Plagborg-Møller (2020).

Usage

```
cva(B, kappa = Inf, alpha = 0.05, check = TRUE)
```

Arguments

`B`	Bound on the square root of the average squared normalized bias, $\sqrt{m_2}$
`kappa`	Bound on the kurtosis of the normalized bias, κ
`alpha`	Determines confidence level, $1 - \alpha$.
`check`	If `TRUE`, verify accuracy of the solution by checking that the implied least favorable distribution satisfies the `B` and `kappa` constraints and yields the same non-coverage rate. If this fails (perhaps due to numerical accuracy issues), solve a finite-grid approximation (by discretizing the support of the bias) to the primal linear programing problem, and check that it agrees with the dual solution.

Value

Returns a list with 4 components:

`cv` Critical value for constructing two-sided confidence intervals.

`size` The argument `alpha`.

`x` Support points for the least favorable distribution for the squared normalized bias, b^2.

`p` Probabilities associated with the support points.

Examples

```
## Critical value without imposing a constraint on kurtosis
cva(1, kappa=Inf)
## With a constraint
cva(1, kappa=3)
```

cva_tbl — *Table of pre-computed critical values*

Description

Table of pre-computed critical values

Usage

```
cva_tbl
```

Format

A data frame with 4 variables:

- `B` B Bound on the square root of the average squared normalized bias
- `kappa` Bound on the kurtosis of the normalized bias
- `cv` Critical value
- `alpha` Determines confidence level, $1 - \alpha$.

Source

Computed using the `cva` function in this package

cz — *Neighborhood effects data from Chetty and Hendren (2018)*

Description

This dataset contains a subset of the publicly available data from Chetty and Hendren (2018). It contains raw estimates and standard errors of neighborhood effects at the commuting zone level

Usage

```
cz
```

Format

A data frame with 741 rows corresponding to commuting zones (CZ) and 10 columns corresponding to the variables:

- **cz** Commuting zone ID
- **czname** Name of CZ
- **state** 2-digit state code

pop Population according to the year 2000 Census

theta25 Fixed-effect estimate of the causal effect of living in the CZ for one year on children's percentile rank in the national distribution of household earnings at age 26 relative to others in the same birth cohort for children growing up with parents at the 25th percentile of national income distribution

theta75 Fixed-effect estimate of the causal effect of living in the CZ for one year on children's percentile rank in the national distribution of household earnings at age 26 relative to others in the same birth cohort for children growing up with parents at the 75th percentile of national income distribution

se25 Standard error of `theta25`

se75 Standard error of `theta75`

stayer25 Average percentile rank in the national distribution of household earnings at age 26 relative to others in the same birth cohort for stayers (children who grew up in the CZ and did not move) with parents at the 25th percentile of national income distribution.

stayer75 Average percentile rank in the national distribution of household earnings at age 26 relative to others in the same birth cohort for stayers (children who grew up in the CZ and did not move) with parents at the 75th percentile of national income distribution.

Source

https://opportunityinsights.org/data/?paper_id=599

References

Chetty, R., & Hendren, N. (2018). The Impacts of Neighborhoods on Intergenerational Mobility II: County-Level Estimates. The Quarterly Journal of Economics, 133(3), 1163–1228. doi:10.1093/qje/qjy006

`ebci` *Compute empirical Bayes confidence intervals by shrinking toward regression*

Description

Computes empirical Bayes estimators based on shrinking towards a regression, and associated robust empirical Bayes confidence intervals (EBCIs), as well as length-optimal robust EBCIs.

Usage

```
ebci(
  formula,
  data,
  se,
  weights,
  alpha = 0.1,
  kappa = NULL,
  tstat = FALSE,
  cores = max(parallel::detectCores() - 1L, 1L)
)
```

Arguments

- `formula` — object of class "formula" (or one that can be coerced to that class) of the form `Y ~ predictors`, where `Y` is a preliminary unbiased estimator, and `predictors` are predictors X that guide the direction of shrinkage. For shrinking toward the grand mean, use `Y ~ 1`, and for shrinking toward `0` use `Y ~ 0`
- `data` — optional data frame, list or environment (or object coercible by `as.data.frame` to a data frame) containing the preliminary estimator `Y` and the predictors. If not found in `data`, these variables are taken from `environment(formula)`, typically the environment from which the function is called.
- `se` — Standard errors σ associated with the preliminary estimates `Y`
- `weights` — An optional vector of weights to be used in the fitting process in computing δ, μ_2 and κ. Should be `NULL` or a numeric vector.
- `alpha` — Determines confidence level, $1 - \alpha$.
- `kappa` — If non-`NULL`, use pre-specified value for the kurtosis κ of $\theta - X'\delta$ (such as `Inf`), instead of computing it.
- `tstat` — If `TRUE`, shrink the t-statistics `Y/se` rather than the preliminary estimates `Y`.
- `cores` — Number of cores to use. By default, the computation of the length-optimal shrinkage factors `w_opt` is parallelized to speed up the calculations.

Value

Returns a list with the following components:

- `sqrt_mu2` Square root of the estimated second moment of $\theta - X'\delta$, $\sqrt{\mu_2}$
- `kappa` Estimated kurtosis κ of $\theta - X'\delta$
- `delta` Estimated regression coefficients δ
- `df` Data frame with components described below.

`df` has the following components:

- `w_eb` EB shrinkage factors, $\mu_2/(\mu_2 + \sigma_i^2)$
- `w_opt` Optimal shrinkage factors `w_opt`
- `ncov_pa` Maximal non-coverage of parametric EBCIs
- `len_eb` Half-length of EBCIs based on EB shrinkage, so that the intervals take the form `cbind(th_eb-len_eb,th_eb+len_e`
- `len_op` Half-length of EBCIs based on length-optimal shrinkage, so that the intervals take the form `cbind(th_op-len_op,th_op+len_op)`
- `len_pa` Half-length of parametric EBCIs, which take the form `cbind(th_eb-len_pa,th_eb+len_a)`
- `len_us` Half-length of unshrunk CIs that take the form `cbind(th_us-len_us,th_us+len_us)`
- `th_us` Unshrunk estimate Y
- `th_eb` EB estimate.
- `th_eb` Estimate based on length-optimal shrinkage.
- `se` Standard error σ, as supplied by the argument `se`.

Examples

```
ebci(theta25 ~ stayer25, cz, se25, pop/pop, tstat=TRUE)
ebci(theta25 ~ 0, cz, se25, pop/pop, tstat=TRUE)
```

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w_eb *Empirical Bayes estimator and confidence intervals*

Description

Compute empirical Bayes shrinkage factor w_{eb} and the normalized half-length of of the associated robust Empirical Bayes confidence interval (EBCI).

Usage

```
w_eb(S, kappa = Inf, alpha = 0.05)
```

Arguments

S	Square root of the signal-to-noise ratio $\sqrt{\mu_2}/\sigma$, where $\sqrt{\mu_2}$ is the variance of $\theta - X'\delta$, and σ^2 is the variance of the preliminary estimator.
kappa	Kurtosis of $\theta - X'\delta$.
alpha	Determines confidence level, $1 - \alpha$.

Value

Returns a list with 3 components:

`w` Empirical Bayes shrinkage factor w_{eb}

`length` Normalized half-length of the corresponding confidence interval, so that the interval obtains by taking the estimator based on shrinkage given by `w`, and adding and subtracting `length` times the standard error σ of the preliminary estimator.

`B` Square root of the normalized bias, $1/S$.

Examples

```
w_opt(1, 3)
## No constraint on kurtosis yields the same shrinkage, but larger half-length
w_opt(1, Inf)
```

w_opt *Optimal shrinkage for Empirical Bayes confidence intervals*

Description

Compute linear shrinkage factor w_{opt} to minimize the length of the resulting Empirical Bayes confidence interval (EBCI).

Usage

```
w_opt(S, kappa, alpha = 0.05, cv_tbl = NULL)
```

Arguments

S	Square root of the signal-to-noise ratio $\sqrt{\mu_2}/\sigma$, where $\sqrt{\mu_2}$ is the variance of $\theta - X'\delta$, and σ^2 is the variance of the preliminary estimator.
kappa	Kurtosis of $\theta - X'\delta$.
alpha	Determines confidence level, $1 - \alpha$.
cv_tbl	Optionally, supply a data frame of critical values. `cva(B,kappa,alpha)`, for different values of `B`, such as a subset of the data frame `cva_tbl`, that matches the supplied values of `alpha` and `kappa`. The data frame needs to contain two variables, `B`, corresponding to the value of average squared normalized bias, and `cv`, with the corresponding value of `cva(B,kappa,alpha)`. If non `NULL`, for the purposes of optimizing the shrinkage factor, compute the critical value `cva` by interpolating between the critical values in this data frame, instead of computing them from scratch. This can speed up the calculations.

Value

Returns a list with 3 components:

- `w` Optimal shrinkage factor w_{opt}
- `length` Normalized half-length of the corresponding confidence interval, so that the interval obtains by taking the estimator based on shrinkage given by `w`, and adding and subtracting `length` times the standard error σ of the preliminary estimator.
- `B` Square root of the normalized bias, $(1/w - 1)S$

Examples

```
w_opt(1, 3)
## Use precomputed critical value table
w_opt(1, 3, cv_tbl=cva_tbl[cva_tbl$kappa==3 & cva_tbl$alpha==0.05, ])
```

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