

# Package ‘BCEA’

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**Type** Package

**Title** Bayesian Cost Effectiveness Analysis

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**Suggests** R2jags, R2OpenBUGS, ggplot2, grid, INLA, splancs, mgcv, ldr

**Imports** MASS

**Additional\_repositories** <https://www.math.ntnu.no/inla/R/stable>

**Description** Produces an economic evaluation of a Bayesian model in the form of MCMC simulations. Given suitable variables of cost and effectiveness / utility for two or more interventions, This package computes the most cost-effective alternative and produces graphical summaries and probabilistic sensitivity analysis.

**License** GPL (>= 2)

**URL** <http://www.statistica.it/gianluca/BCEA>,  
<http://www.statistica.it/gianluca>

**Depends** R (>= 2.10)

**NeedsCompilation** no

**Repository** CRAN

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## R topics documented:

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BCEA-package

*BCEA: A package for Bayesian Cost-Effectiveness Analysis*

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## Description

A package to post-process the results of a Bayesian health economic model and produce standardised output for the analysis of the results

## Details

|           |            |
|-----------|------------|
| Package:  | BCEA       |
| Type:     | Package    |
| Version:  | 2.2-5      |
| Date:     | 2016-11-18 |
| License:  | GPL2       |
| LazyLoad: | yes        |

Given the results of a Bayesian model (possibly based on MCMC) in the form of simulations from the posterior distributions of suitable variables of costs and clinical benefits for two or more interventions, produces a health economic evaluation. Compares one of the interventions (the "reference") to the others ("comparators"). Produces many summary and plots to analyse the results

**Author(s)**

Gianluca Baio, Andrea Berardi, Anna Heath

Maintainer: Gianluca Baio <gianluca@stats.ucl.ac.uk>

**References**

Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.

Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

Baio G., Berardi A., Heath A. (forthcoming). *Bayesian Cost Effectiveness Analysis with the R package BCEA*. Springer

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bcea

*Bayesian Cost-Effectiveness Analysis*

---

**Description**

Cost-effectiveness analysis based on the results of a simulation model for a variable of clinical benefits (e) and of costs (c). Produces results to be post-processed to give the health economic analysis. The output is stored in an object of the class "bcea"

**Usage**

```
bcea(e, c, ref = 1, interventions = NULL, Kmax = 50000,
     wtp = NULL, plot = FALSE)
```

```
## Default S3 method:
```

```
bcea(e, c, ref = 1, interventions = NULL, Kmax = 50000,
     wtp = NULL, plot = FALSE)
```

**Arguments**

- |               |   |
|---------------|---|
| e             | An object containing <code>nsim</code> simulations for the variable of clinical effectiveness for each intervention being considered. In general it is a matrix with <code>nsim</code> rows and <code>nint</code> columns.  |
| c             | An object containing <code>nsim</code> simulations for the variable of cost for each intervention being considered. In general it is a matrix with <code>nsim</code> rows and <code>nint</code> columns.  |
| ref           | Defines which intervention (columns of e or c) is considered to be the reference strategy. The default value <code>ref=1</code> means that the intervention associated with the first column of e or c is the reference and the one(s) associated with the other column(s) is(are) the comparators. |
| interventions | Defines the labels to be associated with each intervention. By default and if <code>NULL</code> , assigns labels in the form "Intervention1", ... , "Intervention T".   |

|      |  |
|------|--|
| Kmax | Maximum value of the willingness to pay to be considered. Default value is $k=50000$ . The willingness to pay is then approximated on a discrete grid in the interval $[0, Kmax]$ . The grid is equal to wtp if the parameter is given, or composed of 501 elements if wtp=NULL (the default). |
| wtp  | A(n optional) vector wtp including the values of the willingness to pay grid. If not specified then BCEA will construct a grid of 501 values from 0 to Kmax. This option is useful when performing intensive computations (eg for the EVPPI).  |
| plot | A logical value indicating whether the function should produce the summary plot or not.  |

### Value

An object of the class "bcea" containing the following elements

|               |   |
|---------------|---|
| n.sim         | Number of simulations produced by the Bayesian model  |
| n.comparators | Number of interventions being analysed  |
| n.comparisons | Number of possible pairwise comparisons   |
| delta.e       | For each possible comparison, the differential in the effectiveness measure   |
| delta.c       | For each possible comparison, the differential in the cost measure  |
| ICER          | The value of the Incremental Cost-Effectiveness Ratio   |
| Kmax          | The maximum value assumed for the willingness to pay threshold  |
| k             | The vector of values for the grid approximation of the willingness to pay   |
| ceac          | The value for the Cost-Effectiveness Acceptability Curve, as a function of the willingness to pay   |
| ib            | The distribution of the Incremental Benefit, for a given willingness to pay   |
| eib           | The value for the Expected Incremental Benefit, as a function of the willingness to pay   |
| kstar         | The grid approximation of the break even point(s)   |
| best          | A vector containing the numeric label of the intervention that is the most cost-effective for each value of the willingness to pay in the selected grid approximation   |
| U             | An array including the value of the expected utility for each simulation from the Bayesian model, for each value of the grid approximation of the willingness to pay and for each intervention being considered |
| vi            | An array including the value of information for each simulation from the Bayesian model and for each value of the grid approximation of the willingness to pay  |
| Ustar         | An array including the maximum "known-distribution" utility for each simulation from the Bayesian model and for each value of the grid approximation of the willingness to pay                                  |
| ol            | An array including the opportunity loss for each simulation from the Bayesian model and for each value of the grid approximation of the willingness to pay  |
| evi           | The vector of values for the Expected Value of Information, as a function of the willingness to pay   |

|               |   |
|---------------|---|
| interventions | A vector of labels for all the interventions considered   |
| ref           | The numeric index associated with the intervention used as reference in the analysis            |
| comp          | The numeric index(es) associated with the intervention(s) used as comparator(s) in the analysis |
| step          | The step used to form the grid approximation to the willingness to pay                          |
| e             | The e matrix used to generate the object (see Arguments)  |
| c             | The c matrix used to generate the object (see Arguments)  |

**Author(s)**

Gianluca Baio, Andrea Berardi

**References**

- Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.
- Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

**Examples**

```
# See Baio G., Dawid A.P. (2011) for a detailed description of the
# Bayesian model and economic problem
#
# Load the processed results of the MCMC simulation model
data(Vaccine)
#
# Runs the health economic evaluation using BCEA
m <- bcea(e=e,c=c,          # defines the variables of
          # effectiveness and cost
          ref=2,          # selects the 2nd row of (e,c)
          # as containing the reference intervention
          interventions=treats, # defines the labels to be associated
          # with each intervention
          Kmax=50000,     # maximum value possible for the willingness
          # to pay threshold; implies that k is chosen
          # in a grid from the interval (0,Kmax)
          plot=TRUE      # plots the results
)
#
# Creates a summary table
summary(m,              # uses the results of the economic evaluation
         # (a "bcea" object)
         wtp=25000      # selects the particular value for k
)

#
# Plots the cost-effectiveness plane using base graphics
ceplane.plot(m,        # plots the Cost-Effectiveness plane
```

```

        comparison=1, # if more than 2 interventions, selects the
                    # pairwise comparison
        wtp=25000,   # selects the relevant willingness to pay
                    # (default: 25,000)
        graph="base" # selects base graphics (default)
    )
    #
    # Plots the cost-effectiveness plane using ggplot2
    if(requireNamespace("ggplot2")){
        ceplane.plot(m, # plots the Cost-Effectiveness plane
                    comparison=1, # if more than 2 interventions, selects the
                                # pairwise comparison
                    wtp=25000,   # selects the relevant willingness to pay
                                # (default: 25,000)
                    graph="ggplot2"# selects ggplot2 as the graphical engine
        )
        #
        # Some more options
        ceplane.plot(m,
                    graph="ggplot2",
                    pos="top",
                    size=5,
                    ICER.size=1.5,
                    label.pos=FALSE,
                    opt.theme=ggplot2::theme(text=ggplot2::element_text(size=8))
        )
    }
    #
    # Plots the contour and scatterplot of the bivariate
    # distribution of (Delta_e,Delta_c)
    contour(m,      # uses the results of the economic evaluation
           # (a "bcea" object)
           comparison=1, # if more than 2 interventions, selects the
                       # pairwise comparison
           nlevels=4,   # selects the number of levels to be
                       # plotted (default=4)
           levels=NULL, # specifies the actual levels to be plotted
                       # (default=NULL, so that R will decide)
           scale=0.5,  # scales the bandwidths for both x- and
                       # y-axis (default=0.5)
           graph="base" # uses base graphics to produce the plot
    )
    #
    # Plots the contour and scatterplot of the bivariate
    # distribution of (Delta_e,Delta_c)
    contour2(m,     # uses the results of the economic evaluation
            # (a "bcea" object)
            wtp=25000, # selects the willingness-to-pay threshold
            x1=NULL,  # assumes default values
            y1=NULL   # assumes default values
    )
    #
    # Using ggplot2

```

```

if(requireNamespace("ggplot2")){
contour2(m,          # uses the results of the economic evaluation
          # (a "bcea" object)
          graph="ggplot2",# selects the graphical engine
          wtp=25000,  # selects the willingness-to-pay threshold
          xl=NULL,   # assumes default values
          yl=NULL,   # assumes default values
          label.pos=FALSE # alternative position for the wtp label
)
}
#
# Plots the Expected Incremental Benefit for the "bcea" object m
eib.plot(m)
#
# Plots the distribution of the Incremental Benefit
ib.plot(m,          # uses the results of the economic evaluation
          # (a "bcea" object)
          comparison=1, # if more than 2 interventions, selects the
          # pairwise comparison
          wtp=25000,  # selects the relevant willingness
          # to pay (default: 25,000)
          graph="base" # uses base graphics
)
#
# Produces a plot of the CEAC against a grid of values for the
# willingness to pay threshold
ceac.plot(m)
#
# Plots the Expected Value of Information for the "bcea" object m
evi.plot(m)
#

```

---

ceac.plot

*Cost-Effectiveness Acceptability Curve (CEAC) plot*


---

### Description

Produces a plot of the Cost-Effectiveness Acceptability Curve (CEAC) against the willingness to pay threshold

### Usage

```
ceac.plot(he, comparison = NULL, pos = c(1,0),
          graph = c("base","ggplot2"))
```

### Arguments

he                    A bcea object containing the results of the Bayesian modelling and the economic evaluation.

|            |  |
|------------|--|
| comparison | Selects the comparator, in case of more than two interventions being analysed. Default as NULL plots all the comparisons together. Any subset of the possible comparisons can be selected (e.g., <code>comparison=c(1,3)</code> or <code>comparison=2</code> ).  |
| pos        | Parameter to set the position of the legend (only relevant for multiple interventions, ie more than 2 interventions being compared). Can be given in form of a string ( <code>bottom top</code> ) ( <code>right left</code> ) for base graphics and <code>bottom</code> , <code>top</code> , <code>left</code> or <code>right</code> for <code>ggplot2</code> . It can be a two-elements vector, which specifies the relative position on the x and y axis respectively, or alternatively it can be in form of a logical variable, with <code>FALSE</code> indicating to use the default position and <code>TRUE</code> to place it on the bottom of the plot. Default value is <code>c(1,0)</code> , that is the bottomright corner inside the plot area. |
| graph      | A string used to select the graphical engine to use for plotting. Should (partial-)match the two options <code>"base"</code> or <code>"ggplot2"</code> . Default value is <code>"base"</code> .  |

### Value

`ceac` A `ggplot` object containing the plot. Returned only if `graph="ggplot2"`.

The function produces a plot of the cost-effectiveness acceptability curve against the discrete grid of possible values for the willingness to pay parameter. Values of the CEAC closer to 1 indicate that uncertainty in the cost-effectiveness of the reference intervention is very low. Similarly, values of the CEAC closer to 0 indicate that uncertainty in the cost-effectiveness of the comparator is very low.

### Author(s)

Gianluca Baio, Andrea Berardi

### References

Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.

Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

### See Also

[bcea](#)

---

`ceaf.plot`

*Cost-Effectiveness Acceptability Frontier (CEAF) plot*

---

### Description

Produces a plot the Cost-Effectiveness Acceptability Frontier (CEAF) against the willingness to pay threshold



**Usage**

```
ceaf.plot(mce, graph=c("base", "ggplot2"))
```

**Arguments**

|       |  |
|-------|--|
| mce   | The output of the call to the function <a href="#">multi.ce</a>  |
| graph | A string used to select the graphical engine to use for plotting. Should (partial-)match the two options "base" or "ggplot2". Default value is "base". |

**Value**

|      |  |
|------|--|
| ceaf | A ggplot object containing the plot. Returned only if graph="ggplot2". |
|------|--|

**Author(s)**

Gianluca Baio, Andrea Berardi

**References**

Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.

Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

**See Also**

[bcea](#), [multi.ce](#)

**Examples**

```
# See Baio G., Dawid A.P. (2011) for a detailed description of the
# Bayesian model and economic problem
#
# Load the processed results of the MCMC simulation model
data(Vaccine)
#
# Runs the health economic evaluation using BCEA
m <- bcea(e=e,c=c,          # defines the variables of
          ref=2,           # effectiveness and cost
          # selects the 2nd row of (e,c)
          # as containing the reference intervention
          interventions=treats, # defines the labels to be associated
          # with each intervention
          Kmax=50000,      # maximum value possible for the willingness
          # to pay threshold; implies that k is chosen
          # in a grid from the interval (0,Kmax)
          plot=FALSE      # inhibits graphical output
)
#
mce <- multi.ce(m)       # uses the results of the economic analysis
```

```

#
ceef.plot(mce)           # plots the CEAF

#
ceef.plot(mce, graph="g") # uses ggplot2

# Use the smoking cessation dataset
data(Smoking)
m <- bcea(e,c,ref=4,intervention=treats,Kmax=500,plot=FALSE)
mce <- multi.ce(m)
ceef.plot(mce)

```

---

ceef.plot

*Cost-Effectiveness Efficiency Frontier (CEAF) plot*


---

## Description

Produces a plot of the Cost-Effectiveness Efficiency Frontier (CEEF)

## Usage

```

ceef.plot(he, comparators = NULL, pos = c(1, 1),
start.from.origins = TRUE, threshold = NULL, flip = FALSE,
dominance = TRUE, relative = FALSE, print.summary = TRUE,
graph = c("base", "ggplot2"), ...)

```

## Arguments

|             |  |
|-------------|--|
| he          | A bcea object containing the results of the Bayesian modelling and the economic evaluation. The list needs to include the e and c matrices used to generate the object; see Details.   |
| comparators | Vector specifying the comparators to be included in the frontier analysis. Must be of length > 1. Default as NULL includes all the available comparators.  |
| pos         | Parameter to set the position of the legend. Can be given in form of a string (bottom top)(right left) for base graphics and bottom, top, left or right for ggplot2. It can be a two-elements vector, which specifies the relative position on the x and y axis respectively, or alternatively it can be in form of a logical variable, with FALSE indicating to use the default position and TRUE to place it on the bottom of the plot. Default value is c(1,1), that is the topright corner inside the plot area. |

|                                 |  |
|---------------------------------|--|
| <code>start.from.origins</code> | Logical. Should the frontier start from the origins of the axes? The argument is reset to FALSE if the average effectiveness and/or costs of at least one comparator are negative.   |
| <code>threshold</code>          | Specifies if the efficiency should be defined based on a willingness-to-pay threshold value. If set to NULL (the default), no conditions are included on the slope increase. If a positive value is passed as argument, to be efficient an intervention also requires to have an ICER for the comparison versus the last efficient strategy not greater than the specified threshold value. A negative value will be ignored with a warning. |
| <code>flip</code>               | Logical. Should the axes of the plane be inverted?   |
| <code>dominance</code>          | Logical. Should the dominance regions be included in the plot?   |
| <code>relative</code>           | Logical. Should the plot display the absolute measures (the default as FALSE) or the differential outcomes versus the reference comparator?  |
| <code>print.summary</code>      | Logical. Should the efficiency frontier summary be printed along with the graph? See Details for additional information.   |
| <code>graph</code>              | A string used to select the graphical engine to use for plotting. Should (partial-)match the two options "base" or "ggplot2". Default value is "base".   |
| <code>...</code>                | If <code>graph="ggplot2"</code> and a named theme object is supplied, it will be added to the ggplot object. Ignored if <code>graph="base"</code> . Setting the optional argument <code>include.ICER</code> to TRUE will print the ICERs in the summary tables, if produced.   |

## Details

The `bcea` objects did not include the generating `e` and `c` matrices in BCEA versions <2.1-0. This function is not compatible with objects created with previous versions. The matrices can be appended to `bcea` objects obtained using previous versions, making sure that the class of the object remains unaltered.

The argument `print.summary` allows for printing a brief summary of the efficiency frontier, with default to TRUE. Two tables are plotted, one for the interventions included in the frontier and one for the dominated interventions. The average costs and clinical benefits are included for each intervention. The frontier table includes the slope for the increase in the frontier and the non-frontier table displays the dominance type of each dominated intervention. Please note that the slopes are defined as the increment in the costs for a unit increment in the benefits even if `flip = TRUE` for consistency with the ICER definition. The angle of increase is in radians and depends on the definition of the axes, i.e. on the value given to the `flip` argument.

If the argument `relative` is set to TRUE, the graph will not display the absolute measures of costs and benefits. Instead the axes will represent differential costs and benefits compared to the reference intervention (indexed by `ref` in the `bcea` function).

## Value

`ceplane` A ggplot object containing the plot. Returned only if `graph="ggplot2"`.

The function produces a plot of the cost-effectiveness efficiency frontier. The dots show the simulated values for the intervention-specific distributions of the effectiveness and costs. The circles

indicate the average of each bivariate distribution, with the numbers referring to each included intervention. The numbers inside the circles are black if the intervention is included in the frontier and grey otherwise. If the option dominance is set to TRUE, the dominance regions are plotted, indicating the areas of dominance. Interventions in the areas between the dominance region and the frontier are in a situation of extended dominance.

### Author(s)

Andrea Berardi, Gianluca Baio

### References

Baio G. (2012). Bayesian Methods in Health Economics. CRC/Chapman Hall, London.  
 IQWIG (2009). General methods for the Assessment of the Relation of Benefits to Cost, Version 1.0. IQWIG, November 2009.

### See Also

[bcea](#)

### Examples

```
### create the bcea object m for the smoking cessation example
data(Smoking)
m <- bcea(e,c,ref=4,Kmax=500,interventions=treats)
### produce the plot
ceef.plot(m,graph="base")

### tweak the options
ceef.plot(m,flip=TRUE,dominance=FALSE,start.from.origins=FALSE,
          print.summary=FALSE,graph="base")
### or use ggplot2 instead
if(require(ggplot2)){
  ceef.plot(m,dominance=TRUE,start.from.origins=FALSE,pos=TRUE,
            print.summary=FALSE,graph="ggplot2")
}
```

---

ceplane.plot

*Cost-effectiveness plane plot*

---

### Description

Produces a scatter plot of the cost-effectiveness plane, together with the sustainability area, as a function of the selected willingness to pay threshold

**Usage**

```
ceplane.plot(he, comparison = NULL, wtp = 25000, pos=c(1,1),
             size=NULL, graph=c("base", "ggplot2"),
             xlim=NULL, ylim=NULL, ...)
```

**Arguments**

|            |  |
|------------|--|
| he         | A bcea object containing the results of the Bayesian modelling and the economic evaluation.  |
| comparison | Selects the comparator, in case of more than two interventions being analysed. Default as NULL plots all the comparisons together. Any subset of the possible comparisons can be selected (e.g., comparison=c(1, 3) or comparison=2).  |
| wtp        | The value of the willingness to pay parameter. Not used iff graph="base" for multiple comparisons.   |
| pos        | Parameter to set the position of the legend; for a single comparison plot, the ICER legend position. Can be given in form of a string (bottom top)(right left) for base graphics and bottom top left right for ggplot2. It can be a two-elements vector, which specifies the relative position on the x and y axis respectively, or alternatively it can be in form of a logical variable, with FALSE indicating to use the default position and TRUE to place it on the bottom of the plot. Default value is c(1, 1), that is the topright corner inside the plot area. |
| size       | Value (in millimetres) of the size of the willingness to pay label. Used only if graph="ggplot2", otherwise is ignored with a message.   |
| graph      | A string used to select the graphical engine to use for plotting. Should (partial-)match the two options "base" or "ggplot2". Default value is "base".   |
| xlim       | The range of the plot along the x-axis. If NULL (default) it is determined by the range of the simulated values for delta.e  |
| ylim       | The range of the plot along the y-axis. If NULL (default) it is determined by the range of the simulated values for delta.c  |
| ...        | If graph="ggplot2" and a named theme object is supplied, it will be added to the ggplot object. In addition, if graph="ggplot2", ICER.size can be used to resize the red dot representing the ICER (i.e. showing them if multiple comparisons are selected), and label.pos=FALSE will place the willingness to pay label in a different position at the bottom of the graph.   |

**Value**

ceplane      A ggplot object containing the plot. Returned only if graph="ggplot2".

The function produces a plot of the cost-effectiveness plane. Grey dots show the simulated values for the joint distribution of the effectiveness and cost differentials. The larger red dot shows the ICER and the grey area identifies the sustainability area, i.e. the part of the plan for which the simulated values are below the willingness to pay threshold. The proportion of points in the sustainability area effectively represents the CEAC for a given value of the willingness to pay. If the comparators are more than 2 and no pairwise comparison is specified, all scatterplots are graphed using different colors.

**Author(s)**

Gianluca Baio, Andrea Berardi

**References**

Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.

Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

**See Also**

[bcea](#)

**Examples**

```
### create the bcea object m for the smoking cessation example
data(Smoking)
m <- bcea(e,c,ref=4,Kmax=500,interventions=treats)
### produce the plot
ceplane.plot(m,wtp=200,graph="base")
### select only one comparator
ceplane.plot(m,wtp=200,graph="base",comparator=3)
### or use ggplot2 instead
if(requireNamespace("ggplot2")){
  ceplane.plot(m,wtp=200,pos="right",ICER.size=2,graph="ggplot2")
}
```

---

CEriskav

*Cost-effectiveness analysis including a parameter of risk aversion*

---

**Description**

Extends the standard cost-effectiveness analysis to modify the utility function so that risk aversion of the decision maker is explicitly accounted for

**Usage**

```
CEriskav(he, r = NULL, comparison = 1)
```

```
## Default S3 method:
```

```
CEriskav(he, r = NULL, comparison = 1)
```

**Arguments**

|            |   |
|------------|---|
| he         | A bcea object containing the results of the Bayesian modelling and the economic evaluation.   |
| r          | A vector of values for the risk aversion parameter. If NULL, default values are assigned by R. The first (smallest) value ( $r \rightarrow 0$ ) produces the standard analysis with no risk aversion. |
| comparison | In case of more than 2 interventions being analysed, selects which plot should be made. By default the first possible choice is selected as the comparator.   |

**Value**

An object of the class CEriskav containing the following elements:

|        |  |
|--------|--|
| Ur     | An array containing the simulated values for all the "known-distribution" utilities for all interventions, all the values of the willingness to pay parameter and for all the possible values of r |
| Urstar | An array containing the simulated values for the maximum "known-distribution" expected utility for all the values of the willingness to pay parameter and for all the possible values of r         |
| IBr    | An array containing the simulated values for the distribution of the Incremental Benefit for all the values of the willingness to pay and for all the possible values of r                         |
| eibr   | An array containing the Expected Incremental Benefit for each value of the willingness to pay parameter and for all the possible values of r   |
| vir    | An array containing all the simulations for the Value of Information for each value of the willingness to pay parameter and for all the possible values of r                                       |
| evir   | An array containing the Expected Value of Information for each value of the willingness to pay parameter and for all the possible values of r  |
| R      | The number of possible values for the parameter of risk aversion r   |
| r      | The vector containing all the possible values for the parameter of risk aversion r   |

**Author(s)**

Gianluca Baio

**References**

- Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.
- Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

**See Also**

[bcea](#)

## Examples

```

# See Baio G., Dawid A.P. (2011) for a detailed description of the
# Bayesian model and economic problem
#
# Load the processed results of the MCMC simulation model
data(Vaccine)
#
# Runs the health economic evaluation using BCEA
m <- bcea(e=e,c=c,          # defines the variables of
          # effectiveness and cost
          ref=2,           # selects the 2nd row of (e,c)
          # as containing the reference intervention
          interventions=treats, # defines the labels to be associated
          # with each intervention
          Kmax=50000       # maximum value possible for the willingness
          # to pay threshold; implies that k is chosen
          # in a grid from the interval (0,Kmax)
)
#
# Define the vector of values for the risk aversion parameter, r, eg:
r <- c(0.0000000001,0.005,0.020,0.035)
#
# Run the cost-effectiveness analysis accounting for risk aversion

cr <- CERiskav(m,         # uses the results of the economic evaluation
              # (a "bcea" object)
              r=r,        # defines the vector of values for the risk
              # aversion parameter
              comparison=1 # if more than 2 interventions, selects the
              # pairwise comparison
)

```

---

contour.bcea

*Contour method for objects in the class bcea*

---

## Description

Produces a scatterplot of the cost-effectiveness plane, with a contour-plot of the bivariate density of the differentials of cost (y-axis) and effectiveness (x-axis)

## Usage

```

## S3 method for class 'bcea'
contour(x, comparison = 1, scale = 0.5, nlevels = 4, levels = NULL,
        pos = c(1,0), xlim=NULL, ylim=NULL, graph=c("base","ggplot2"), ...)

```



**Arguments**

|            |  |
|------------|--|
| x          | A bcea object containing the results of the Bayesian modelling and the economic evaluation   |
| comparison | In case of more than 2 interventions being analysed, selects which plot should be made. By default the first comparison among the possible ones will be plotted. If graph="ggplot2" any subset of the possible comparisons can be selected, and comparison=NULL will yield a plot of all the possible comparisons together.  |
| scale      | Scales the plot as a function of the observed standard deviation.  |
| levels     | Numeric vector of levels at which to draw contour lines. Will be ignored using graph="ggplot2".  |
| nlevels    | Number of levels to be plotted in the contour.   |
| pos        | Parameter to set the position of the legend. Can be given in form of a string (bottom top)(right left) for base graphics and bottom, top, left or right for ggplot2. It can be a two-elements vector, which specifies the relative position on the x and y axis respectively, or alternatively it can be in form of a logical variable, with FALSE indicating to use the default position and TRUE to place the legend on the bottom of the plot. Default value is c(1, 0), that is the bottomright corner inside the plot area. |
| graph      | A string used to select the graphical engine to use for plotting. Should (partial-)match the two options "base" or "ggplot2". Default value is "base".   |
| xlim       | The range of the plot along the x-axis. If NULL (default) it is determined by the range of the simulated values for delta.e  |
| ylim       | The range of the plot along the y-axis. If NULL (default) it is determined by the range of the simulated values for delta.c  |
| ...        | Additional arguments to 'plot.window', 'title', 'Axis' and 'box', typically graphical parameters such as 'cex.axis'. Will be ignored if graph="ggplot2".   |

**Value**

ceplane            A ggplot object containing the plot. Returned only if graph="ggplot2".

Plots the cost-effectiveness plane with a scatterplot of all the simulated values from the (posterior) bivariate distribution of (Delta\_e,Delta\_c), the differentials of effectiveness and costs; superimposes a contour of the distribution and prints the estimated value of the probability of each quadrant (combination of positive/negative values for both Delta\_e and Delta\_c)

**Author(s)**

Gianluca Baio, Andrea Berardi

**References**

- Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. Statistical Methods in Medical Research doi:10.1177/0962280211419832.
- Baio G. (2012). Bayesian Methods in Health Economics. CRC/Chapman Hall, London

**See Also**

[bcea](#), [ceplane.plot](#), [contour2](#)

---

contour2

*Specialised contour plot for objects in the class "bcea"*

---

**Description**

Produces a scatterplot of the cost-effectiveness plane, with a contour-plot of the bivariate density of the differentials of cost (y-axis) and effectiveness (x-axis). Also adds the sustainability area (i.e. below the selected value of the willingness-to-pay threshold).

**Usage**

```
contour2(he, wtp=25000, xlim=NULL, ylim=NULL, comparison=NULL,
         graph=c("base", "ggplot2"), ...)
```

**Arguments**

|            |  |
|------------|--|
| he         | A "bcea" object containing the results of the Bayesian modelling and the economic evaluation   |
| wtp        | The selected value of the willingness-to-pay. Default is 25000.  |
| xlim       | Limits on the x-axis (default=NULL, so that R will select appropriate limits).   |
| ylim       | Limits on the y-axis (default=NULL, so that R will select appropriate limits).   |
| comparison | The comparison being plotted. Default to NULL chooses the first comparison if graph="base". If graph="ggplot2" the default value will choose all the possible comparisons. Any subset of the possible comparisons can be selected (e.g., comparison=c(1,3)). |
| graph      | A string used to select the graphical engine to use for plotting. Should (partial-)match the two options "base" or "ggplot2". Default value is "base".   |
| ...        | Arguments to be passed to <a href="#">ceplane.plot</a> . See the relative manual page for more details.  |

**Value**

contour A ggplot item containing the requested plot. Returned only if graph="ggplot2".

Plots the cost-effectiveness plane with a scatterplot of all the simulated values from the (posterior) bivariate distribution of (Delta\_e,Delta\_c), the differentials of effectiveness and costs; superimposes a contour of the distribution and prints the value of the ICER, together with the sustainability area.

**Author(s)**

Gianluca Baio, Andrea Berardi

## References

Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.

Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

## See Also

[bcea](#), [ceplane.plot](#), [contour.bcea](#)

## Examples

```
### create the bcea object m for the smoking cessation example
data(Smoking)
m=bcea(e,c,ref=4,interventions=treats,Kmax=500)
### produce the plot
contour2(m, wtp=200, graph="base")

### or use ggplot2 to plot multiple comparisons
contour2(m, wtp=200, ICER.size=2, graph="ggplot2")
```

---

CreateInputs

*CreateInputs*

---

## Description

Creates an object containing the matrix with the parameters simulated using the MCMC procedure (using JAGS or BUGS) and a vector of parameters (strings) that can be used to perform the expected value of partial information analysis

## Usage

```
CreateInputs(x)
```

## Arguments

**x** A `rjags` or `bugs` object, containing the results of a call to either "jags" (under `R2jags`) or `bugs` (under "R2WinBUGS" or "R2OpenBUGS").

## Value

**mat** A matrix containing all the simulations for all the monitored parameters

**parameters** A character vectors listing the names of all the monitored parameters

## Author(s)

Gianluca Baio

**See Also**

[bcea](#), [evppi](#)

---

diag.evppi

*diag.evppi*

---

**Description**

Performs diagnostic plots for the results of the EVPPI

**Usage**

```
diag.evppi(x,y,diag=c("residuals","qqplot"),int=1)
```

**Arguments**

|      |   |
|------|---|
| x    | A evppi object obtained by running the function evppi on a bcea model.  |
| y    | A bcea object containing the results of the Bayesian modelling and the economic evaluation.                           |
| diag | The type of diagnostics to be performed. It can be the 'residual plot' or the 'qqplot plot'.                          |
| int  | Specifies the interventions for which diagnostic tests should be performed (if there are many options being compared) |

**Value**

The function produces either a residual plot comparing the fitted values from the INLA-SPDE Gaussian Process regression to the residuals. This is a scatter plot of residuals on the y axis and fitted values (estimated responses) on the x axis. The plot is used to detect non-linearity, unequal error variances, and outliers. A well-behaved residual plot supporting the appropriateness of the simple linear regression model has the following characteristics: 1) The residuals bounce randomly around the 0 line. This suggests that the assumption that the relationship is linear is reasonable. 2) The residuals roughly form a horizontal band around the 0 line. This suggests that the variances of the error terms are equal. 3) None of the residual stands out from the basic random pattern of residuals. This suggests that there are no outliers.

The second possible diagnostic is the qqplot for the fitted value. This is a graphical method for comparing the fitted values distributions with the assumed underlying normal distribution by plotting their quantiles against each other. First, the set of intervals for the quantiles is chosen. A point (x,y) on the plot corresponds to one of the quantiles of the second distribution (y-coordinate) plotted against the same quantile of the first distribution (x-coordinate). If the two distributions being compared are identical, the Q-Q plot follows the 45 degrees line.

**Author(s)**

Gianluca Baio, Anna Heath

**References**

- Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.
- Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

**See Also**

[bcea](#), [evppi](#)

---

eib.plot

*Expected Incremental Benefit (EIB) plot*

---

**Description**

Produces a plot of the Expected Incremental Benefit (EIB) as a function of the willingness to pay

**Usage**

```
eib.plot(he, comparison=NULL, pos=c(1,0), size=NULL,
         plot.cri = NULL, graph=c("base", "ggplot2"), ...)
```

**Arguments**

- |            |   |
|------------|---|
| he         | A bcea object containing the results of the Bayesian modelling and the economic evaluation.   |
| comparison | Selects the comparator, in case of more than two interventions being analysed. Default as NULL plots all the comparisons together. Any subset of the possible comparisons can be selected (e.g., <code>comparison=c(1, 3)</code> or <code>comparison=2</code> ).  |
| pos        | Parameter to set the position of the legend; for a single comparison plot, the ICER legend position. Can be given in form of a string ( <code>bottom top</code> ) ( <code>right left</code> ) for base graphics and <code>bottom top left right</code> for ggplot2. It can be a two-elements vector, which specifies the relative position on the x and y axis respectively, or alternatively it can be in form of a logical variable, with FALSE indicating to use the default position and TRUE to place it on the bottom of the plot. Default value is <code>c(1, 0)</code> , that is the bottomright corner inside the plot area. |
| size       | Value (in millimetres) of the size of the willingness to pay label. Used only if <code>graph="ggplot2"</code> , otherwise it will be ignored with a message. If set to NA, the break-even point line(s) and label(s) are suppressed, with both base graphics and ggplot2.   |
| plot.cri   | Logical value. Should the credible intervals be plotted along with the expected incremental benefit? Default as NULL draws the 95% credible intervals if only one comparison is selected, and does not include them for multiple comparisons. Setting <code>plot.cri=TRUE</code> or <code>plot.cri=FALSE</code> forces the function to add the intervals or not. The level of the intervals can be also set, see ... for more details.  |

graph A string used to select the graphical engine to use for plotting. Should (partial-)match the two options "base" or "ggplot2". Default value is "base".

... If graph="ggplot2" and a named theme object is supplied, it will be added to the ggplot object. If plot.cri=TRUE the level of the interval can be set using the argument alpha, with default at alpha=0.05. Additionally the method of calculation of the credible intervals can be chosen with the option cri.quantile: the default value TRUE indicates that the credible intervals are defined as the interval between the alpha/2-th and 1-alpha/2-th quantiles of the IB distribution. Setting cri.quantile=FALSE will use a normal approximation on the IB distribution to calculate the intervals.

### Value

eib A ggplot object containing the requested plot. Returned only if graph="ggplot2".

The function produces a plot of the Expected Incremental Benefit as a function of the discrete grid approximation of the willingness to pay parameter. The break even point (i.e. the point in which the EIB=0, ie when the optimal decision changes from one intervention to another) is also showed by default. The value k\* is the discrete grid approximation of the ICER.

### Author(s)

Gianluca Baio, Andrea Berardi

### References

Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. Statistical Methods in Medical Research doi:10.1177/0962280211419832.

Baio G. (2012). Bayesian Methods in Health Economics. CRC/Chapman Hall, London

### See Also

[bcea](#), [ib.plot](#), [ceplane.plot](#)

---

evi.plot

*Expected Value of Information (EVI) plot*

---

### Description

Plots the Expected Value of Information (EVI) against the willingness to pay

### Usage

```
evi.plot(he, graph=c("base", "ggplot2"))
```

**Arguments**

|       |  |
|-------|--|
| he    | A bcea object containing the results of the Bayesian modelling and the economic evaluation.  |
| graph | A string used to select the graphical engine to use for plotting. Should (partially) match the two options "base" or "ggplot2". Default value is "base". |

**Value**

evi                    A ggplot object containing the requested plot. Returned only if graph="ggplot2".

The function produces a plot of the Expected Value of Information as a function of the discrete grid approximation of the willingness to pay parameter. The break even point(s) (i.e. the point in which the EIB=0, ie when the optimal decision changes from one intervention to another) is(are) also showed.

**Author(s)**

Gianluca Baio, Andrea Berardi

**References**

- Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.
- Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

**See Also**

[bcea](#), [ceac.plot](#), [ceplane.plot](#)

---

|       |  |
|-------|--|
| evppi | <i>Expected Value of Perfect Partial Information (EVPPI) for selected parameters</i> |
|-------|--|

---

**Description**

Calculates the Expected Value of Perfect Partial Information (EVPPI) for subsets of parameters. Uses GAM non-parameteric regression for single parameter EVPPI and the SPDE-INLA method for larger parameter subsets.

**Usage**

```
evppi(parameter, input, he, N=NULL, plot=F, residuals=T, ...)
```

```
## Default S3 method:
```

```
evppi(parameter, input, he, N=NULL, plot=F, residuals=T, ...)
```

**Arguments**

|                        |  |
|------------------------|--|
| <code>parameter</code> | A vector of parameters for which the EVPPI should be calculated. This can be given as a string (or vector of strings) of names or a numeric vector, corresponding to the column numbers of important parameters.   |
| <code>input</code>     | A matrix containing the simulations for all the parameters monitored by the call to JAGS or BUGS. The matrix should have column names matching the names of the parameters and the values in the vector parameter should match at least one of those values.   |
| <code>he</code>        | A <code>bcea</code> object (the result of the call to the function <code>bcea</code> ).  |
| <code>N</code>         | The number of PSA simulations used to calculate the EVPPI. The default uses all the available samples.   |
| <code>plot</code>      | A logical value indicating whether the triangular mesh for SPDE-INLA should be plotted. Default set to <code>F</code> .  |
| <code>residuals</code> | A logical value indicating whether the fitted values for the SPDE-INLA method should be outputted. Default set to <code>T</code> .   |
| <code>...</code>       | <p>Additional arguments. The default methods to compute the EVPPI are: - For single-parameter: GAM regression. - For multi-parameter: INLA/SPDE. However, it is possible (mainly for backward compatibility) to use different methods. For single-parameter, the user can specify the method of Sadatsafavi et al or the method of Strong &amp; Oakley. In order to do so, it is necessary to include the extra parameter <code>method</code> which takes as value a string "sad" in the former case and a string "so" in the latter. In case "sal" is selected, then it is possible to also specify the number of "separators" (e.g. <code>n.seps=3</code>). If none is specified, the default value <code>n.seps=1</code> is used. If "so" is used as method for the calculation of the EVPPI, then the user <i>*needs*</i> to also specify the number of "blocks" (e.g. <code>n.blocks=20</code>).</p> <p>For multi-parameter, the user can select 3 possible methods. If <code>method="GAM"</code> (BCEA will accept also "gam", "G" or "g"), then the computations are based on GAM regression. The user can also specify the formula for the regression. The default option is to use a tensor product (e.g. if there are two main parameters, <code>p1</code> and <code>p2</code>, this amounts to setting <code>formula="te(p1 , p2)"</code>, which indicates that the two parameters interact). Alternatively, it is possible to specify a model in which the parameters are independent using the notation <code>formula="s(p1)+s(p2)"</code>. This may lead to worse accuracy in the estimates.</p> <p>The second possible method is the GP regression derived by Strong et al. This is used if <code>method="GP"</code> (BCEA will also accept the specification <code>method="gp"</code>). In this case, the user can also specify the number of PSA runs that should be used to estimate the hyperparameters of the model (e.g. <code>n.sim=100</code>). This value is set by default to 500. Finally, it is also possible to specify some INLA-related options. These are all rather technical and are described in detail in Baio, Berardi and Heath. The optional parameter vector <code>int.ord</code> can take integer values (<code>c(1,1)</code> is default) and will force the predictor to include interactions: if <code>int.ord=c(k,h)</code>, then all <code>k</code>-way interactions will be used for the effects and all <code>h</code>-way interactions will be used for the costs. Also, the user can specify the feature of the mesh for the "spatial" part of the model. The optional parameter</p> |



cutoff (default 0.3) controls the density of the points inside the mesh. Acceptable values are typically in the interval (0.1,0.5), with lower values implying more points (and thus better approximation and greater computational time). The construction of the boundaries for the mesh can be controlled by the optional inputs `convex.inner` (default = -0.4) and `convex.outer` (default = -0.7). These should be negative values and can be decreased (say to -0.7 and -1, respectively) to increase the distance between the points and the outer boundary, which also increases precision and computational time. The optional argument `robust` can be set to `TRUE`, in which case INLA will use a `t` prior distribution for the coefficients of the linear predictor. Finally, the user can control the accuracy of the INLA grid-search for the estimation of the hyperparameters. This is done by setting a value `h.value` (default=0.00005). Lower values imply a more refined search (and hence better accuracy), at the expense of computational speed. The `method` argument can also be given as a list allowing different regression methods for the effects and costs, and the different incremental decisions. The first list element should contain a vector of methods for the incremental effects and the second for the costs, for example `method=list(c("GAM"),c("INLA"))`. The `int.ord` argument can also be given as a list to give different interaction levels for each regression curve.

## Details

The single parameter EVPPI has been calculated using the non-parametric GAM regression developed by Strong et al. (2014). The multi-parameter EVPPI is calculated using the SPDE-INLA regression method for Gaussian Process regression developed by Heath et al. (2015)

## Value

|                             |  |
|-----------------------------|--|
| <code>evppi</code>          | The computed values of <code>evppi</code> for all values of the parameter of willingness to pay                        |
| <code>index</code>          | A numerical vector with the index associated with the parameters for which the EVPPI was calculated                    |
| <code>k</code>              | The vector of values for the willingness to pay  |
| <code>evi</code>            | The vector of values for the overall EVPPI   |
| <code>fitted.costs</code>   | The fitted values for the costs  |
| <code>fitted.effects</code> | The fitted values for the effects  |
| <code>parameters</code>     | A single string containing the names of the parameters for which the EVPPI was calculated, used for plotting the EVPPI |
| <code>time</code>           | Computational time (in seconds)  |
| <code>fit.c</code>          | The object produced by the model fit for the costs   |
| <code>fit.e</code>          | The object produced by the model fit for the effects   |
| <code>formula</code>        | The formula used to fit the model  |
| <code>method</code>         | A string indicating the method used to estimate the EVPPI  |

## Author(s)

Anna Heath, Gianluca Baio

## References

Strong M., Oakley J. and Brennan A. (2014). Estimating multi-parameter partial Expected Value of Perfect Information from a probabilistic sensitivity analysis sample: a non-parametric regression approach. *Medical Decision Making*.

Sadatsafavi M., Bansback N., Zafari Z., Najafzadeh M., Marra C. (2013). Need for speed: an efficient algorithm for calculation of single-parameter expected value of partial perfect information. *Value in Health*

Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

Heath A., Manolopoulou I., Baio G. (2016). Estimating the Expected Value of Partial Perfect Information in Health Economic Evaluations using Integrated Nested Laplace Approximation. *Statistics in Medicine*. <http://onlinelibrary.wiley.com/doi/10.1002/sim.6983/full>

## See Also

[plot.evppi](#), [bcea](#)

## Examples

```
# See Baio G., Dawid A.P. (2011) for a detailed description of the
# Bayesian model and economic problem
#
# Load the processed results of the MCMC simulation model
data(Vaccine)
#
# Runs the health economic evaluation using BCEA
m <- bcea(e,c,ref=2,interventions=treats)
#
# Computes the EVPPI for a bunch of parameters
inp <- CreateInputs(vaccine)
# Computes the EVPPI using INLA/SPDE
# x0 <- evppi(parameter=c(38:40),input=inp$mat,he=m)
# Now uses GAM regression
# x1 <- evppi(parameter=c(38:40),input=inp$mat,he=m,method="GAM")
# Now uses the GP regression
# x2 <- evppi(parameter=c(38:40),input=inp$mat,he=m,method="GP")
# Now plots the results
# plot(x0)
# points(x0$k,x0$evppi,lwd=2,lty=2,t="l")
# points(x1$k,x1$evppi,t="l",col="red")
# points(x2$k,x2$evppi,t="l",col="blue")
```

---

ib.plot

*Incremental Benefit (IB) distribution plot*

---

## Description

Plots the distribution of the Incremental Benefit (IB) for a given value of the willingness to pay threshold

**Usage**

```
ib.plot(he, comparison = NULL, wtp = 25000, bw = nbw, n = 512,  
        xlim = NULL, graph=c("base", "ggplot2"))
```

**Arguments**

|            |  |
|------------|--|
| he         | A bcea object containing the results of the Bayesian modelling and the economic evaluation.  |
| comparison | In the case of multiple interventions, specifies the one to be used in comparison with the reference. Default value of NULL forces R to consider the first non-reference intervention as the comparator. |
| wtp        | The value of the willingness to pay threshold. Default value at 25000.   |
| bw         | Identifies the smoothing bandwidth used to construct the kernel estimation of the IB density.  |
| n          | The number of equally spaced points at which the density is to be estimated.   |
| xlim       | The limits of the plot on the x-axis.  |
| graph      | A string used to select the graphical engine to use for plotting. Should (partial-)match the two options "base" or "ggplot2". Default value is "base".   |

**Value**

ib                    A ggplot object containing the requested plot. Returned only if graph="ggplot2".

The function produces a plot of the distribution of the Incremental Benefit for a given value of the willingness to pay parameter. The dashed area indicates the positive part of the distribution (ie when the reference is more cost-effective than the comparator).

**Author(s)**

Gianluca Baio, Andrea Berardi

**References**

Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. Statistical Methods in Medical Research doi:10.1177/0962280211419832.

Baio G. (2012). Bayesian Methods in Health Economics. CRC/Chapman Hall, London

**See Also**

[bcea](#), [ib.plot](#), [ceplane.plot](#)

info.rank

*Info-rank plot***Description**

Produces a plot similar to a Tornado-plot, but based on the analysis of the EVPPI. For each parameter and value of the willingness-to-pay threshold, a barchart is plotted to describe the ratio of EVPPI (specific to that parameter) to EVPI. This represents the relative 'importance' of each parameter in terms of the expected value of information.

**Usage**

```
info.rank(parameter, input, he, wtp=he$k[ $\min(\text{which}(he\$k \geq he\$ICER))$ ], ...)
```

**Arguments**

|           |   |
|-----------|---|
| parameter | A vector of parameters for which the individual EVPPI should be calculated. This can be given as a string (or vector of strings) of names or a numeric vector, corresponding to the column numbers of important parameters.   |
| input     | A matrix containing the simulations for all the parameters monitored by the call to JAGS or BUGS. The matrix should have column names matching the names of the parameters and the values in the vector parameter should match at least one of those values.  |
| he        | A bcea object (the result of the call to the function <a href="#">bcea</a> ).   |
| wtp       | A value of the wtp for which the analysis should be performed. If not specified then the break-even point for the current model will be used.   |
| ...       | Additional options. These include graphical parameters that the user can specify. xlim = limits of the x-axis; ca = font size for the axis label (default = 0.7 of full size); cn = font size for the parameter names vector (default = 0.7 of full size); mai = margins of the graph (default = c(1.36,1.5,1,1)); rel = logical argument that specifies whether the ratio of EVPPI to EVPI (rel=TRUE, default) or the absolute value of the EVPPI should be used for the analysis. |

**Value**

res A data.frame containing the ranking of the parameters with the value of the selected summary, for the chosen wtp.

The function produces a 'Info-rank' plot. This is an extension of standard 'Tornado plots' and presents a ranking of the model parameters in terms of their impact on the expected value of information. For each parameter, the specific individual EVPPI is computed and used to measure the impact of uncertainty in that parameter over the decision-making process, in terms of how large the expected value of gaining more information is.

**Author(s)**

Anna Heath, Gianluca Baio

**References**

- Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. Statistical Methods in Medical Research doi:10.1177/0962280211419832.
- Baio G. (2012). Bayesian Methods in Health Economics. CRC/Chapman Hall, London

**See Also**

[bcea](#), [evppi](#)

---

mce.plot

*Plots the probability that each intervention is the most cost-effective*

---

**Description**

Plots the probability that each of the `n_int` interventions being analysed is the most cost-effective.

**Usage**

```
mce.plot(mce, pos=c(1, 0.5), graph=c("base", "ggplot2"))
```

**Arguments**

|                    |  |
|--------------------|--|
| <code>mce</code>   | The output of the call to the function <code>multi.ce</code> .   |
| <code>pos</code>   | Parameter to set the position of the legend. Can be given in form of a string ( <code>bottom top</code> )( <code>right left</code> ) for base graphics and <code>bottom top left right</code> for <code>ggplot2</code> . It can be a two-elements vector, which specifies the relative position on the x and y axis respectively, or alternatively it can be in form of a logical variable, with <code>TRUE</code> indicating to use the first standard and <code>FALSE</code> to use the second one. Default value is <code>c(1, 0.5)</code> , that is on the right inside the plot area. |
| <code>graph</code> | A string used to select the graphical engine to use for plotting. Should (partial-)match the two options <code>"base"</code> or <code>"ggplot2"</code> . Default value is <code>"base"</code> .  |

**Value**

`mceplot` A `ggplot` object containing the plot. Returned only if `graph="ggplot2"`.

**Author(s)**

Gianluca Baio, Andrea Berardi

**References**

- Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. Statistical Methods in Medical Research doi:10.1177/0962280211419832.
- Baio G. (2012). Bayesian Methods in Health Economics. CRC/Chapman Hall, London

**See Also**[bcea](#)**Examples**

```

# See Baio G., Dawid A.P. (2011) for a detailed description of the
# Bayesian model and economic problem
#
# Load the processed results of the MCMC simulation model
data(Vaccine)
#
# Runs the health economic evaluation using BCEA
m <- bcea(e=e,c=c,          # defines the variables of
          # effectiveness and cost
          ref=2,           # selects the 2nd row of (e,c)
          # as containing the reference intervention
          interventions=treats, # defines the labels to be associated
          # with each intervention
          Kmax=50000,      # maximum value possible for the willingness
          # to pay threshold; implies that k is chosen
          # in a grid from the interval (0,Kmax)
          plot=FALSE      # inhibits graphical output
)
#
mce <- multi.ce(m)        # uses the results of the economic analysis
#
mce.plot(mce,             # plots the probability of being most cost-effective
          graph="base")   # using base graphics
#
if(require(ggplot2)){
  mce.plot(mce,           # the same plot
            graph="ggplot2") # using ggplot2 instead
}

```

mixedAn

*Cost-effectiveness analysis when multiple (possibly non cost-effective) interventions are present on the market*

**Description**

Runs the cost-effectiveness analysis, but accounts for the fact that more than one intervention is present on the market

**Usage**

```
mixedAn(he, mkt.shares = NULL, plot = FALSE)
```

```
## Default S3 method:
```

```
mixedAn(he, mkt.shares = NULL, plot = FALSE)
```

**Arguments**

|            |  |
|------------|--|
| he         | A bcea object containing the results of the Bayesian modelling and the economic evaluation.  |
| mkt.shares | A vector of market shares associated with the interventions. Its size is the same as the number of possible comparators. By default, assumes uniform distribution for each intervention. |
| plot       | Logical value indicating whether the function should produce graphical output, via <code>plot.mixedAn</code> , or not. Default is set to FALSE.  |

**Value**

Creates an object in the class `mixedAn` which contains the results of the health economic evaluation in the mixed analysis case

|               |   |
|---------------|---|
| Ubar          | An array with the simulations of the "known-distribution" mixed utilities, for each value of the discrete grid approximation of the willingness to pay parameter                        |
| OL.star       | An array with the simulations of the distribution of the Opportunity Loss for the mixed strategy, for each value of the discrete grid approximation of the willingness to pay parameter |
| evi.star      | The Expected Value of Information for the mixed strategy, for each value of the discrete grid approximation of the willingness to pay parameter   |
| k             | The discrete grid approximation of the willingness to pay parameter used for the mixed strategy analysis  |
| Kmax          | The maximum value of the discrete grid approximation for the willingness to pay parameter   |
| step          | The step used to form the grid approximation to the willingness to pay  |
| ref           | The numeric index associated with the intervention used as reference in the analysis  |
| comp          | The numeric index(es) associated with the intervention(s) used as comparator(s) in the analysis   |
| mkt.shares    | The vector of market shares associated with each available intervention   |
| n.comparisons | The total number of pairwise comparisons available  |
| interventions | A vector of labels for all the interventions considered   |
| evi           | The vector of values for the "optimal" Expected Value of Information, as a function of the willingness to pay   |

The function can also produce a graph showing the difference between the "optimal" version of the EVPI (when only the most cost-effective intervention is included in the market) and the mixed strategy one (when more than one intervention is considered in the market)

**Author(s)**

Gianluca Baio

## References

Baio, G. and Russo, P. (2009). A decision-theoretic framework for the application of cost-effectiveness analysis in regulatory processes. *Pharmacoeconomics* 27(8), 645-655 doi:10.2165/11310250

Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.

Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

## See Also

[bcea](#)

## Examples

```
# See Baio G., Dawid A.P. (2011) for a detailed description of the
# Bayesian model and economic problem
#
# Load the processed results of the MCMC simulation model
data(Vaccine)
#
# Runs the health economic evaluation using BCEA
m <- bcea(e=e,c=c,          # defines the variables of
          # effectiveness and cost
          ref=2,           # selects the 2nd row of (e,c)
          # as containing the reference intervention
          interventions=treats, # defines the labels to be associated
          # with each intervention
          Kmax=50000,      # maximum value possible for the willingness
          # to pay threshold; implies that k is chosen
          # in a grid from the interval (0,Kmax)
          plot=FALSE      # inhibits graphical output
)
#
ma <- mixedAn(m,          # uses the results of the mixed strategy
              # analysis (a "mixedAn" object)
              mkt.shares=NULL, # the vector of market shares can be defined
              # externally. If NULL, then each of the T
              # interventions will have 1/T market share
              plot=TRUE      # produces the plots
)
```

---

multi.ce

*Cost-effectiveness analysis with multiple comparison*

---

## Description

Computes and plots the probability that each of the `n_int` interventions being analysed is the most cost-effective and the cost-effectiveness acceptability frontier



**Usage**

```
multi.ce(he)
```

**Arguments**

he                    A bcea object containing the results of the Bayesian modelling and the economic evaluation.

**Value**

m.ce                A matrix including the probability that each intervention is the most cost-effective for all values of the willingness to pay parameter

ceaf                A vector containing the cost-effectiveness acceptability frontier

**Author(s)**

Gianluca Baio

**See Also**

[bcea](#), [mce.plot](#), [ceaf.plot](#)

**Examples**

```
# See Baio G., Dawid A.P. (2011) for a detailed description of the
# Bayesian model and economic problem
#
# Load the processed results of the MCMC simulation model
data(Vaccine)
#
# Runs the health economic evaluation using BCEA
m <- bcea(e=e,c=c,          # defines the variables of
          ref=2,           # effectiveness and cost
          interventions=treats, # selects the 2nd row of (e,c)
          # as containing the reference intervention
          # defines the labels to be associated
          # with each intervention
          Kmax=50000,      # maximum value possible for the willingness
          # to pay threshold; implies that k is chosen
          # in a grid from the interval (0,Kmax)
          plot=FALSE      # inhibits graphical output
)
#
mce <- multi.ce(m         # uses the results of the economic analysis
)
```

plot.bcea

*Summary plot of the health economic analysis***Description**

Plots in a single graph the Cost-Effectiveness plane, the Expected Incremental Benefit, the CEAC and the EVPI

**Usage**

```
## S3 method for class 'bcea'
plot(x, comparison=NULL, wtp=25000, pos=FALSE,
      graph=c("base", "ggplot2"), ...)
```

**Arguments**

|            |  |
|------------|--|
| x          | A bcea object containing the results of the Bayesian modelling and the economic evaluation.  |
| comparison | Selects the comparator, in case of more than two interventions being analysed. The value is passed to <a href="#">ceplane.plot</a> , <a href="#">eib.plot</a> and <a href="#">ceac.plot</a> .  |
| wtp        | The value of the willingness to pay parameter. It is passed to <a href="#">ceplane.plot</a> .  |
| pos        | Parameter to set the position of the legend. Can be given in form of a string, a single logical value, or a two-element vector with the respective relative positions on the x and y axis. Default as FALSE sets the legend position to the default one for each plot (see the details section), while TRUE puts it on the bottom of each plot. Changes will affect all the individual plots.                        |
| graph      | A string used to select the graphical engine to use for plotting. Should (partial-)match the two options "base" or "ggplot2". Default value is "base".   |
| ...        | Arguments to be passed to the methods <a href="#">ceplane.plot</a> and <a href="#">eib.plot</a> . Please see the manual pages for the individual functions. Arguments like <code>size</code> , <code>ICER.size</code> and <code>plot.cri</code> can be supplied to the functions in this way. In addition if <code>graph="ggplot2"</code> and the arguments are named theme objects they will be added to each plot. |

**Details**

The default position of the legend for the cost-effectiveness plane (produced by [ceplane.plot](#)) is set to `c(1, 1.025)` overriding its default for `pos=FALSE`, since multiple `ggplot2` plots are rendered in a slightly different way than single plots.

For more information see the documentation of each individual plot function.

**Value**

The function produces a plot with four graphical summaries of the health economic evaluation.

**Author(s)**

Gianluca Baio, Andrea Berardi

**References**

Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.

Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

**See Also**

[bcea](#), [ceplane.plot](#), [eib.plot](#), [ceac.plot](#), [evi.plot](#)

**Examples**

```
# See Baio G., Dawid A.P. (2011) for a detailed description of the
# Bayesian model and economic problem
#
# Load the processed results of the MCMC simulation model
data(Vaccine)
#
# Runs the health economic evaluation using BCEA
m <- bcea(e=e,c=c,          # defines the variables of
          ref=2,           # effectiveness and cost
          # selects the 2nd row of (e,c)
          interventions=treats, # as containing the reference intervention
          # defines the labels to be associated
          # with each intervention
          Kmax=50000,      # maximum value possible for the willingness
          # to pay threshold; implies that k is chosen
          # in a grid from the interval (0,Kmax)
          plot=FALSE      # does not produce graphical outputs
)
#
# Plots the summary plots for the "bcea" object m using base graphics
plot(m,graph="base")

# Plots the same summary plots using ggplot2
if(require(ggplot2)){
  plot(m,graph="ggplot2")
}

##### Example of a customized plot.bcea with ggplot2
plot(m,
      graph="ggplot2",          # use ggplot2
      theme=theme(plot.title=element_text(size=rel(1.25))), # theme elements must have a name
      ICER.size=1.5,           # hidden option in ceplane.plot
      size=rel(2.5)            # modifies the size of k= labels
)
# in ceplane.plot and eib.plot
}
```

---

|               |  |
|---------------|--|
| plot.CEriskav | <i>Summary plot of the health economic analysis when risk aversion is included</i> |
|---------------|--|

---

### Description

Plots the EIB and the EVPI when risk aversion is included in the utility function

### Usage

```
## S3 method for class 'CEriskav'
plot(x, pos=c(0,1), graph=c("base","ggplot2"), ...)
```

### Arguments

|       |   |
|-------|---|
| x     | An object of the class <code>CEriskav</code> , containing the results of the economic analysis performed accounting for a risk aversion parameter (obtained as output of the function <code>CEriskav</code> ).  |
| pos   | Parameter to set the position of the legend. Can be given in form of a string (bottom top)(right left) for base graphics and bottom top left right for ggplot2. It can be a two-elements vector, which specifies the relative position on the x and y axis respectively, or alternatively it can be in form of a logical variable, with FALSE indicating to use the default position and TRUE to place it on the bottom of the plot. Default value is <code>c(0,1)</code> , that is in the topleft corner inside the plot area. |
| graph | A string used to select the graphical engine to use for plotting. Should (partial-)match the two options "base" or "ggplot2". Default value is "base".  |
| ...   | Arguments to be passed to methods, such as graphical parameters (see <a href="#">par</a> ).   |

### Value

`list(eib,evi)` A two-elements named list of the ggplot objects containing the requested plots. Returned only if `graph="ggplot2"`.

The function produces two plots for the risk aversion analysis. The first one is the EIB as a function of the discrete grid approximation of the willingness parameter for each of the possible values of the risk aversion parameter,  $r$ . The second one is a similar plot for the EVPI.

### Author(s)

Gianluca Baio, Andrea Berardi

### References

Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.

Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

**See Also**[bcea, CEriskav](#)**Examples**

```

# See Baio G., Dawid A.P. (2011) for a detailed description of the
# Bayesian model and economic problem
#
# Load the processed results of the MCMC simulation model
data(Vaccine)
#
# Runs the health economic evaluation using BCEA
m <- bcea(e=e,c=c,          # defines the variables of
          # effectiveness and cost
          ref=2,           # selects the 2nd row of (e,c)
          # as containing the reference intervention
          interventions=treats, # defines the labels to be associated
          # with each intervention
          Kmax=50000,      # maximum value possible for the willingness
          # to pay threshold; implies that k is chosen
          # in a grid from the interval (0,Kmax)
          plot=FALSE      # inhibits graphical output
)
#
# Define the vector of values for the risk aversion parameter, r, eg:
r <- c(0.000000000001,0.005,0.020,0.035)
#
# Run the cost-effectiveness analysis accounting for risk aversion

cr <- CEriskav(m,         # uses the results of the economic evaluation
              # (a "bcea" object)
              r=r,        # defines the vector of values for the risk
              # aversion parameter
              comparison=1 # if more than 2 interventions, selects the
              # pairwise comparison
)

#
# Now produce the plots

plot(cr # uses the results of the risk aversion
      # analysis (a "CEriskav" object)
)

### Alternative options, using ggplot2

plot(cr,
      graph="ggplot2",
      plot="ask"          # plot option can be specified as
                        # "dev.new" (default), "x11" or "ask"
)

```

---

plot.evppi

*plot.evppi*


---

### Description

Plots a graph of the Expected Value of Partial Information with respect to a set of parameters

### Usage

```
## S3 method for class 'evppi'
plot(x, pos = c(0, 0.8), graph = c("base", "ggplot2"),
     col = NULL, ...)
```

### Arguments

|       |  |
|-------|--|
| x     | An object in the class <code>evppi</code> , obtained by the call to the function <code>evppi</code> .  |
| pos   | Parameter to set the position of the legend. Can be given in form of a string <code>(bottom top)(right left)</code> for base graphics and <code>bottom top left right</code> for <code>ggplot2</code> . It can be a two-elements vector, which specifies the relative position on the x and y axis respectively, or alternatively it can be in form of a logical variable, with <code>FALSE</code> indicating to use the default position and <code>TRUE</code> to place it on the bottom of the plot. Default value is <code>c(0, 1)</code> , that is in the topleft corner inside the plot area. |
| graph | A string used to select the graphical engine to use for plotting. Should (partial-)match the two options <code>"base"</code> or <code>"ggplot2"</code> . Default value is <code>"base"</code> .  |
| col   | Sets the color for the lines depicted in the graph.  |
| ...   | Arguments to be passed to methods, such as graphical parameters (see <code>par</code> ).   |

### Author(s)

Gianluca Baio, Andrea Berardi

### References

Baio G. (2012). Bayesian Methods in Health Economics. CRC/Chapman Hall, London

### See Also

[bcea](#), [evppi](#)

---

|              |   |
|--------------|---|
| plot.mixedAn | <i>Summary plot of the health economic analysis when the mixed analysis is considered</i> |
|--------------|---|

---

## Description

Compares the optimal scenario to the mixed case in terms of the EVPI

## Usage

```
## S3 method for class 'mixedAn'
plot(x, y.limits = NULL, pos=c(0,1), graph=c("base","ggplot2"), ...)
```

## Arguments

|          |   |
|----------|---|
| x        | An object of class <code>mixedAn</code> , given as output of the call to the function <code>mixedAn</code> .  |
| y.limits | Range of the y-axis for the graph. The default value is <code>NULL</code> , in which case the maximum range between the optimal and the mixed analysis scenarios is considered.   |
| pos      | Parameter to set the position of the legend. Can be given in form of a string <code>(bottom top)(right left)</code> for base graphics and <code>bottom top left right</code> for <code>ggplot2</code> . It can be a two-elements vector, which specifies the relative position on the x and y axis respectively, or alternatively it can be in form of a logical variable, with <code>FALSE</code> indicating to use the default position and <code>TRUE</code> to place it on the bottom of the plot. Default value is <code>c(0,1)</code> , that is in the topleft corner inside the plot area. |
| graph    | A string used to select the graphical engine to use for plotting. Should (partial-)match the two options <code>"base"</code> or <code>"ggplot2"</code> . Default value is <code>"base"</code> .   |
| ...      | Arguments to be passed to methods, such as graphical parameters (see <code>par</code> ).  |

## Value

`evi` A `ggplot` object containing the plot. Returned only if `graph="ggplot2"`.

The function produces a graph showing the difference between the "optimal" version of the EVPI (when only the most cost-effective intervention is included in the market) and the mixed strategy one (when more than one intervention is considered in the market).

## Author(s)

Gianluca Baio, Andrea Berardi

## References

Baio, G. and Russo, P. (2009). A decision-theoretic framework for the application of cost-effectiveness analysis in regulatory processes. *Pharmacoeconomics* 27(8), 645-655 doi:10.2165/11310250

Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.

Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

## See Also

[bcea](#), [mixedAn](#)

## Examples

```
# See Baio G., Dawid A.P. (2011) for a detailed description of the
# Bayesian model and economic problem
#
# Load the processed results of the MCMC simulation model
data(Vaccine)
#
# Runs the health economic evaluation using BCEA
m <- bcea(e=e,c=c,          # defines the variables of
          ref=2,           # effectiveness and cost
          # selects the 2nd row of (e,c)
          # as containing the reference intervention
          interventions=treats, # defines the labels to be associated
          # with each intervention
          Kmax=50000,      # maximum value possible for the willingness
          # to pay threshold; implies that k is chosen
          # in a grid from the interval (0,Kmax)
          plot=FALSE      # inhibits graphical output
)
#
ma <- mixedAn(m,          # uses the results of the mixed strategy
              # analysis (a "mixedAn" object)
              mkt.shares=NULL # the vector of market shares can be defined
              # externally. If NULL, then each of the T
              # interventions will have 1/T market share
)
#
# Can also plot the summary graph
plot(ma,graph="base")
#
# Or with ggplot2
if(require(ggplot2)){
  plot(ma,graph="ggplot2")
}
```



---

|           |   |
|-----------|---|
| sim.table | <i>Table of simulations for the health economic model</i> |
|-----------|---|

---

**Description**

Using the input in the form of MCMC simulations and after having run the health economic model, produces a summary table of the simulations from the cost-effectiveness analysis

**Usage**

```
sim.table(he, wtp = 25000)
```

**Arguments**

|     |   |
|-----|---|
| he  | A bcea object containing the results of the Bayesian modelling and the economic evaluation. |
| wtp | The value of the willingness to pay threshold to be used in the summary table.              |

**Value**

Produces the following elements:

|            |   |
|------------|---|
| Table      | A table with the simulations from the economic model  |
| names.cols | A vector of labels to be associated with each column of the table   |
| wtp        | The selected value of the willingness to pay  |
| ind.table  | The index associated with the selected value of the willingness to pay threshold in the grid used to run the analysis |

**Author(s)**

Gianluca Baio

**References**

Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.

Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

**See Also**

[bcea](#)

**Examples**

```

# See Baio G., Dawid A.P. (2011) for a detailed description of the
# Bayesian model and economic problem
#
# Load the processed results of the MCMC simulation model
data(Vaccine)
#
# Runs the health economic evaluation using BCEA
m <- bcea(e=e,c=c,          # defines the variables of
          # effectiveness and cost
          ref=2,          # selects the 2nd row of (e,c)
          # as containing the reference intervention
          interventions=treats, # defines the labels to be associated
          # with each intervention
          Kmax=50000      # maximum value possible for the willingness
          # to pay threshold; implies that k is chosen
          # in a grid from the interval (0,Kmax)
)
#
# Now can save the simulation exercise in an object using sim.table()
st <- sim.table(m, # uses the results of the economic evaluation
               # (a "bcea" object)
               wtp=25000 # selects the particular value for k
)
#
# The table can be explored. For example, checking the
# element 'Table' of the object 'st'

```

---

Smoking

*Data set for the Bayesian model for the cost-effectiveness of smoking cessation interventions*


---

**Description**

This data set contains the results of the Bayesian analysis used to model the clinical output and the costs associated with the health economic evaluation of four different smoking cessation interventions.

**Usage**

```
data(Smoking)
```

**Format**

A data list including the variables needed for the smoking cessation cost-effectiveness analysis. The variables are as follows:

**c** a matrix of 500 simulations from the posterior distribution of the overall costs associated with the four strategies

`data` a dataset containing the characteristics of the smokers in the UK population

`e` a matrix of 500 simulations from the posterior distribution of the clinical benefits associated with the four strategies

`life.years` a matrix of 500 simulations from the posterior distribution of the life years gained with each strategy

`pi` a matrix of 500 simulations from the posterior distribution of the event of smoking cessation with each strategy

`smoking` a data frame containing the inputs needed for the network meta-analysis model. The `data.frame` object contains: `nobs`: the record ID number, `s`: the study ID number, `i`: the intervention ID number, `r_i`: the number of patients who quit smoking, `n_i`: the total number of patients for the row-specific arm and `b_i`: the reference intervention for each study

`smoking_output` a `rjags` object obtained by running the network meta-analysis model based on the data contained in the `smoking` object

`smoking_mat` a matrix obtained by running the network meta-analysis model based on the data contained in the `smoking` object

`treats` a vector of labels associated with the four strategies

### Source

Effectiveness data adapted from Hasselblad V. (1998). Meta-analysis of Multitreatment Studies. *Medical Decision Making* 1998;18:37-43.

Cost and population characteristics data adapted from various sources:

- Taylor, D.H. Jr, et al. (2002). Benefits of smoking cessation on longevity. *American Journal of Public Health* 2002;92(6)
- ASH: Action on Smoking and Health (2013). ASH fact sheet on smoking statistics, [http://ash.org.uk/files/documents/ASH\\_106.pdf](http://ash.org.uk/files/documents/ASH_106.pdf)
- Flack, S., et al. (2007). Cost-effectiveness of interventions for smoking cessation. York Health Economics Consortium, January 2007
- McGhan, W.F.D., and Smith, M. (1996). Pharmacoeconomic analysis of smoking-cessation interventions. *American Journal of Health-System Pharmacy* 1996;53:45-52

### References

Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

### Examples

```
data(Smoking)
```

```
m=bcea(e,c,ref=4,interventions=treats,Kmax=500)
```

---

 struct.psa

*Structural PSA*


---

**Description**

Computes the weights to be associated with a set of competing models in order to perform structural PSA

**Usage**

```
struct.psa(models, effect, cost, ref = 1, interventions = NULL,
           Kmax = 50000, plot = F)
```

**Arguments**

|               |  |
|---------------|--|
| models        | A list containing the output from either R2jags or R2OpenBUGS/R2WinBUGS for all the models that need to be combined in the model average   |
| effect        | A list containing the measure of effectiveness computed from the various models (one matrix with n.sim x n.ints simulations for each model)  |
| cost          | A list containing the measure of costs computed from the various models (one matrix with n.sim x n.ints simulations for each model)  |
| ref           | Defines which intervention is considered to be the reference strategy. The default value ref=1 means that the intervention appearing first is the reference and the other(s) is(are) the comparator(s)   |
| interventions | Defines the labels to be associated with each intervention. By default and if NULL, assigns labels in the form "Intervention1", ... , "Intervention T"   |
| Kmax          | Maximum value of the willingness to pay to be considered. Default value is k=50000. The willingness to pay is then approximated on a discrete grid in the interval [0,Kmax]. The grid is equal to wtp if the parameter is given, or composed of 501 elements if wtp=NULL (the default) |
| plot          | A logical value indicating whether the function should produce the summary plot or not   |

**Author(s)**

Gianluca Baio

**References**

Baio G. (2012). Bayesian Methods in Health Economics. CRC/Chapman Hall, London

**See Also**

[bcea](#)

---

`summary.bcea`*Summary method for objects in the class bcea*

---

**Description**

Produces a table printout with some summary results of the health economic evaluation

**Usage**

```
## S3 method for class 'bcea'  
summary(object, wtp = 25000, ...)
```

**Arguments**

|                     |   |
|---------------------|---|
| <code>object</code> | A bcea object containing the results of the Bayesian modelling and the economic evaluation. |
| <code>wtp</code>    | The value of the willingness to pay threshold to be used in the summary table.              |
| <code>...</code>    | Additional arguments affecting the summary produced.  |

**Value**

Prints a summary table with some information on the health economic output and synthetic information on the economic measures (EIB, CEAC, EVPI).

**Author(s)**

Gianluca Baio

**References**

Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.

Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

**See Also**

[bcea](#)

---

`summary.mixedAn`*Summary methods for objects in the class mixedAn (mixed analysis)*

---

**Description**

Prints a summary table for the results of the mixed analysis for the economic evaluation of a given model

**Usage**

```
## S3 method for class 'mixedAn'  
summary(object, wtp = 25000,...)
```

**Arguments**

|                     |  |
|---------------------|--|
| <code>object</code> | An object of the class <code>mixedAn</code> , which is the results of the function <code>mixedAn</code> , generating the economic evaluation of a set of interventions, considering given market shares for each option. |
| <code>wtp</code>    | The value of the willingness to pay chosen to present the analysis.  |
| <code>...</code>    | Additional arguments affecting the summary produced.   |

**Value**

Produces a table with summary information on the loss in expected value of information generated by the inclusion of non cost-effective interventions in the market.

**Author(s)**

Gianluca Baio

**References**

Baio, G. and Russo, P. (2009). A decision-theoretic framework for the application of cost-effectiveness analysis in regulatory processes. *Pharmacoeconomics* 27(8), 645-655 doi:10.2165/11310250

Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.

Baio G. (2012). *Bayesian Methods in Health Economics*. CRC/Chapman Hall, London

**See Also**

[bcea](#), [mixedAn](#)

**Examples**

```

# See Baio G., Dawid A.P. (2011) for a detailed description of the
# Bayesian model and economic problem
#
# Load the processed results of the MCMC simulation model
data(Vaccine)
#
# Runs the health economic evaluation using BCEA
m <- bcea(e=e,c=c,          # defines the variables of
          ref=2,           # effectiveness and cost
          # selects the 2nd row of (e,c)
          # as containing the reference intervention
          interventions=treats, # defines the labels to be associated
          # with each intervention
          Kmax=50000       # maximum value possible for the willingness
          # to pay threshold; implies that k is chosen
          # in a grid from the interval (0,Kmax)
)
#
ma <- mixedAn(m,          # uses the results of the mixed strategy
              # analysis (a "mixedAn" object)
              mkt.shares=NULL # the vector of market shares can be defined
              # externally. If NULL, then each of the T
              # interventions will have 1/T market share
)
#
# Prints a summary of the results
summary(ma,             # uses the results of the mixed strategy analysis
        # (a "mixedAn" object)
        wtp=25000      # selects the relevant willingness to pay
        # (default: 25,000)
)

```

---

Vaccine

*Data set for the Bayesian model for the cost-effectiveness of influenza vaccination*


---

**Description**

This data set contains the results of the Bayesian analysis used to model the clinical output and the costs associated with an influenza vaccination.

**Usage**

```
data(Vaccine)
```

**Format**

A data list including the variables needed for the influenza vaccination. The variables are as follows:

`c` a matrix of simulations from the posterior distribution of the overall costs associated with the two treatments

`cost.GP` a matrix of simulations from the posterior distribution of the costs for GP visits associated with the two treatments

`cost.hosp` a matrix of simulations from the posterior distribution of the costs for hospitalisations associated with the two treatments

`cost.otc` a matrix of simulations from the posterior distribution of the costs for over-the-counter medications associated with the two treatments

`cost.time.off` a matrix of simulations from the posterior distribution of the costs for time off work associated with the two treatments

`cost.time.vac` a matrix of simulations from the posterior distribution of the costs for time needed to get the vaccination associated with the two treatments

`cost.travel` a matrix of simulations from the posterior distribution of the costs for travel to get vaccination associated with the two treatments

`cost.trt1` a matrix of simulations from the posterior distribution of the overall costs for first line of treatment associated with the two interventions

`cost.trt2` a matrix of simulations from the posterior distribution of the overall costs for second line of treatment associated with the two interventions

`cost.vac` a matrix of simulations from the posterior distribution of the costs for vaccination

`e` a matrix of simulations from the posterior distribution of the clinical benefits associated with the two treatments

`N` the number of subjects in the reference population

`N.outcomes` the number of clinical outcomes analysed

`N.resources` the number of health-care resources under study

`QALYs.adv` a vector from the posterior distribution of the QALYs associated with advert events

`QALYs.death` a vector from the posterior distribution of the QALYs associated with death

`QALYs.hosp` a vector from the posterior distribution of the QALYs associated with hospitalisation

`QALYs.inf` a vector from the posterior distribution of the QALYs associated with influenza infection

`QALYs.pne` a vector from the posterior distribution of the QALYs associated with pneumonia

`treats` a vector of labels associated with the two treatments

`vaccine` a `rjags` object containing the simulations for the parameters used in the original model

`vaccine_mat` a matrix containing the simulations for the parameters used in the original model

**Source**

Adapted from Turner D, Wailoo A, Cooper N, Sutton A, Abrams K, Nicholson K. The cost-effectiveness of influenza vaccination of healthy adults 50-64 years of age. *Vaccine*. 2006;24:1035-1043.



**References**

Baio, G., Dawid, A. P. (2011). Probabilistic Sensitivity Analysis in Health Economics. *Statistical Methods in Medical Research* doi:10.1177/0962280211419832.

**Examples**

```
data(Vaccine)
```

```
m=bcea(e,c,ref=1,interventions=treats)
```

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