

Package ‘ICEinfer’

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Title Incremental Cost-Effectiveness Inference using Two Unbiased Samples

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Depends R (>= 3.5.0), lattice

Description Given two unbiased samples of patient level data on cost and effectiveness for a pair of treatments, make head-to-head treatment comparisons by (i) generating the bivariate bootstrap resampling distribution of ICE uncertainty for a specified value of the shadow price of health, lambda, (ii) form the wedge-shaped ICE confidence region with specified confidence fraction within [0.50, 0.99] that is equivariant with respect to changes in lambda, (iii) color the bootstrap outcomes within the above confidence wedge with economic preferences from an ICE map with specified values of lambda, beta and gamma parameters, (iv) display VAGR and ALICE acceptability curves, and (v) illustrate variation in ICE preferences by displaying potentially non-linear indifference(iso-preference) curves from an ICE map with specified values of lambda, beta and either gamma or eta parameters.

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ICEinfer-package	<i>ICE Statistical Inference and Economic Preference Variation</i>
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Description

Functions in the ICE Statistical Inference package make head-to-head comparisons between patients in two treatment cohorts (assumed to be unbiased samples) in two distinct dimensions, cost and effectiveness.

Bootstrap resampling methods quantify the endogenous Distribution of ICE Uncertainty and define Wedge-Shaped Statistical Confidence Regions equivariant relative to exogenous choice for the numerical Shadow Price of Health, lambda.

Preference maps with (linear or nonlinear) indifference curves can be viewed or superimposed upon endogenous confidence wedges to illustrate that considerable additional, potentially self-contradictory Economic Preference Uncertainty results from deliberately varying lambda.

Details

```

Package: ICEinfer
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```

Statistical inference using functions from the ICEinfer package usually starts with (possibly multiple) invocations of ICEScale() to help determine a reasonable value for the Shadow Price of Health, lambda. This is invariably followed by a single call to ICEuncrt to generate the Bootstrap Distribution of ICE Uncertainty corresponding to the chosen value of lambda. The print() and plot() functions for objects of type ICEuncrt have optional arguments, lfact and swu, to help users quantify and visualize the consequences of changing lambda and switching between cost and effe units.

A single call to ICEwedge() then yields the equivariant, wedge-shaped region of specified statistical confidence within [.50, .99] ...by computing ICE Angle Order Statistics around a circle with center at the ICE Origin: (DeltaEffe, DeltaCost) = (0, 0).

Researchers wishing to view alternative ICE Acceptability Curves would then invoke `ICEalice()`.

Finally, multiple calls to `ICEcolor` for different values of λ and/or different forms of (linear or nonlinear) ICE Preference Maps are typically used to illustrate the considerable additional Economic Preference Uncertainty that can be introduced in these ways. This Economic Preference uncertainty is superimposed on top of the inherent Statistical Uncertainty contained within even unbiased, patient level data on the relative cost and effectiveness of two treatments for the same disease or health condition.

Author(s)

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References

Black WC. The CE plane: a graphic representation of cost-effectiveness. *Med Decis Making* 1990; **10**: 212-214.

Hoch JS, Briggs AH, Willan AR. Something old, something new, something borrowed, something blue: a framework for the marriage of health econometrics and cost-effectiveness analysis. *Health Economics* 2002; **11**: 415-430.

Laupacis A, Feeny D, Detsky AS, Tugwell PX. How attractive does a new technology have to be to warrant adoption and utilization? Tentative guidelines for using clinical and economic evaluations. *Can Med Assoc J* 1992; **146(4)**: 473-81.

O'Brien B, Gersten K, Willan A, Faulkner L. Is there a kink in consumers' threshold value for cost-effectiveness in health care? *Health Economics* 2002; **11**: 175-180.

Obenchain RL. ICE Preference Maps: Nonlinear Generalizations of Net Benefit and Acceptability. *Health Serv Outcomes Res Method* 2008; **8**: 31-56. DOI 10.1007/s10742-007-0027-2. Open Access.

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Stinnett AA, Mullahy J. Net health benefits: a new framework for the analysis of uncertainty in cost-effectiveness analysis. *Medical Decision Making*, Special Issue on Pharmacoeconomics 1998; **18**: s68-s80.

Examples

```
demo(fluoxpin)
```

dpunc	<i>Output list object of class ICEuncrt for the High Uncertainty numerical example in the ICEinfer package, data(dulxparx).</i>
-------	---

Description

dpunc is the output list object of class ICEuncrt resulting from the following time consuming computation: `dpunc <- ICEuncrt(dulxparx, dulx, idb, ru, lambda=0.26)`

Usage

```
data(dpunc)
```

Format

Output list object of class ICEuncrt.

df Saved value of the name of the data.frame input to ICEuncrt.

lambda Saved positive value of lambda input to ICEuncrt.

ceunit Saved value of ceunit ("cost" or "effe") input to ICEuncrt.

R Saved integer value for number of bootstrap replications input to ICEuncrt.

trtm Saved name of the treatment indicator within the df data.frame.

xeffe Saved name of the treatment effectiveness variable within the df data.frame.

ycost Saved name of the treatment cost variable within the df data.frame.

effcst Saved value of the sorted 3-variable (trtm,effe,cost) data.frame.

t1 Observed value of (DeltaEffe, DeltaCost) when each patient is included exactly once.

t R x 2 matrix of values of (DeltaEffe, DeltaCost) computed from bootstrap resamples.

seed Saved value of the seed used to start pseudo random number generation.

Examples

```
# Intermediate ICEinfer Output List for the dulxparx dataset...
data(dpunc)
plot(dpunc)
```

dpwdg	<i>Output list object of class ICEwedge for the High Uncertainty example, data(dulxparx)</i>
-------	--

Description

dpwdg is the output list object of class ICEwdg resulting from the following time consuming computation: `dpwdg <- ICEwedge(dpunc)`

Usage

```
data(dpwdg)
```

Format

Output list object of class ICEwedge.

ICEinp Name of the ICEuncrt object input to ICEwedge().

lambda Positive value of $lfact * ICEu\lambda$

lfact Positive Multiplier for the $ICEu\lambda$ value input to ICEwedge().

ceunit Saved value of ceunit ("cost" or "effe") input to ICEuncrt.

conf Statistical Confidence Level within [0.50, 0.99] input to ICEwedge.

R Saved integer value for number of bootstrap replications input to ICEuncrt.

axys R x 4 data.frame with ICE Angle in column 1, bootstrap resampled values of (DeltaEffe, DeltaCost) in columns 2 and 3, and the binary flag with 0 => outcome outside the Confidence Wedge and 1 => outcome inside the Confidence Wedge in column 4.

t1 Observed value of (DeltaEffe, DeltaCost) when each patient is sampled exactly once.

ia1 The ICE Angle corresponding to the Observed ICE Ratio.

center The largest value of j such that $axys[j, 1] < ia1 \leq axys[j+1, 1]$.

jlo Number of the ICE Angle Order Statistic defining the Clockwise or lower ICE Ray boundary of the Confidence Wedge.

kup Number of the ICE Angle Order Statistic defining the Counter-Clockwise or upper ICE Ray boundary of the Confidence Wedge.

subangle Subtended Polar ICE Angle between Order Statistics jlo and kup.

xmax Alias plots of ICEwedge have horizontal range [-xmax, +xmax].

ymax Alias plots of ICEwedge have vertical range [-ymax, +ymax].

ab ICE angle computation perspective of alibi or alias.

Examples

```
# Intermediate ICEinfer Output List for the dulxparx dataset...
data(dpwdg)
plot(dpwdg)
```

dulxparx	<i>Data for the High Uncertainty numerical example of Obenchain et al. (2005)</i>
----------	---

Description

The data are from two arms of a double-blind clinical trial in which 91 patients were randomized to the SNRI duloxetine 80 mg/d (40 mg BID) and 87 patients were randomized to the SSRI paroxetine 20 mg/d for treatment of major depressive disorder (MDD). Missing-data- imputation and sensitivity-analyses were needed to make meaningful cost-effectiveness comparisons in this study.

Usage

```
data(dulxparx)
```

Format

A data frame of 3 variables on 178 patients; no NAs.

idb This measure of overall effectiveness is *integrated decrease in HAMD-17 score from baseline to endpoint*, Hamilton (1967). This is a (signed) area-under-the-curve measure with larger values more favorable. Missing values were imputed via the MMRM models reported in Goldstein et al. (2004).

ru Patient self-reported health-care resource utilization above and beyond that provided within study protocol was collected using the Resource Utilization Survey, Copley-Merriman et al. (1992), with published 1998 dollars-per-unit costs, Schoenbaum et al. (2001), rounded to the nearest 50 dollars. Dollars/week were then calculated by multiplying (total accumulated cost) for a patient by 7 and dividing by the (total days of cost accumulation) for that patient. For patients who discontinued early, this is Average-Value-Carried-Forward imputation.

dulx Treatment indicator variable. `dulx = 1` implies receipt of duloxetine 80 mg/d (40 mg BID). `dulx = 0` implies receipt of paroxetine 20 mg/d.

References

Copley-Merriman C, Egbuonu-Davis L, Kotsanos JG, Conforti P, Franson T, Gordon G. Clinical economics: a method for prospective health resource data collection. *Pharmacoeconomics* 1992; **1(5)**: 370–376.

Goldstein DJ, Lu Y, Detke MJ, Wiltse C, Mallinckrodt C, Demitrack MA. Duloxetine in the treatment of depression - A double-blind, placebo-controlled comparison with paroxetine. *J Clin Psychopharmacol* 2004; **24**: 389–399.

Hamilton M. Development of a rating scale for primary depressive illness. *British Journal of Social and Clinical Psychology* 1967; **6**: 278–296.

Obenchain RL, Robinson RL, Swindle RW. Cost-effectiveness inferences from bootstrap quadrant confidence levels: three degrees of dominance. *J Biopharm Stat* 2005; **15(3)**: 419–436.

Schoenbaum M, Unutzer J, Sherbourne C, Duan N, Rubenstein LV, Miranda J, Meredith LS, Carney MF, Wells K. Cost-effectiveness of practice-initiated quality improvement for depression: results of a randomized controlled trial. *JAMA* 2001; **286(11)**: 1325–1330.

Examples

```
data(dulxparx)
ICEScale(dulxparx, dulx, idb, ru)
```

fluoxpin	<i>Data from a double-blind clinical trial comparing fluoxetine plus pindolol with fluoxetine alone</i>
----------	---

Description

These data are from a Spanish double-blind clinical trial in which 55 patients were randomized to fluoxetine (an SSRI) plus pindolol (a Beta Blocker) and 56 patients were randomized to fluoxetine plus placebo for treatment of major depressive disorder (MDD), Sacristan et al. (2000).

Usage

```
data(fluoxpin)
```

Format

A data frame of 3 variables on 111 patients; no NAs.

respond Patients are considered to have responded to treatment when a 50% or greater decrease in HAMD-17 total score occurred between baseline and end-point (at day 42), with no more than 10% additional variation between intermediate visits.

cost Resource utilization was prospectively collected alongside the clinical trial. Patients and caregivers were interviewed by the researcher concerning all resources consumed during the study period. Resources dictated by the protocol were not counted. Costs are expressed in Pesetas (Pts.) at 1996 prices (1 Dollar = 145 Pts.) Observed differences in average direct medical costs were mainly due to hospitalizations within the FlxPin = 0 group.

flxpin Treatment indicator variable. FlxPin = 1 implies receipt of fluoxetine 20 mg/day plus pindolol 7.5 mg/day (2.5 mg tid). FlxPin = 0 implies receipt of fluoxetine 20 mg/day plus placebo (tid).

Details

Since both samples are rather small (55 and 56 patients) here and the Effectiveness variable, respond, is binary, this example illustrates how the Law of Large Numbers can fail to apply to ICE inferences. Specifically, the bootstrap distribution of sample differences between AVERAGES appears to be quite different from bivariate normal in three ways: (i) The Bootstrap Distribution of ICE Uncertainty appears to consist of vertical stripes because the horizontal variable is discrete here while the vertical variable is continuous. (ii) The Bootstrap Distribution of cost differences appears to end somewhat abruptly near the horizontal axis at DeltaCost = 0, rather than have a long upwards tail like its downwards tail. (iii) The equal density contours of the bivariate Bootstrap Distribution appear to NOT be elliptical. This third point can be dramatically illustrated by computing the Owen Empirical Likelihood contour that passes through the origin of the ICE plane.

References

- Hamilton M. Development of a rating scale for primary depressive illness. *British Journal of Social and Clinical Psychology* 1967; **6**: 278–296.
- Sacristan JA, Obenchain RL. Reporting cost-effectiveness analyses with confidence. *JAMA* 1997; **277**: 375.
- Obenchain RL, Sacristan JA. In reply to: The negative side of cost-effectiveness ratios. *JAMA* 1997; **277**: 1931–1933.
- Sacristan JA, Gilaberte I, Boto B, Buesching DP, Obenchain RL, Demitrack M, Perez Sola V, Alvarez E, and Artigas F. Cost-effectiveness of fluoxetine plus pindolol in patients with major depressive disorder: results from a randomized, double blind clinical trial. *Int Clin Psychopharmacol* 2000; **15**: 107–113.
- Owen AB. *Empirical Likelihood* New York: Chapman and Hall/CRC. 2001.

Examples

```
data(fluoxpin)
ICEscale(fluoxpin, flxpin, respond, cost)
```

fluoxzca	<i>Cost-Effectiveness data for 1242 MDD patients from Marketscan(SM) claims database</i>
----------	--

Description

In 1990-1992, the Marketscan(SM) database included medical and pharmacy claims for approximately 700,000 individuals whose health insurance was provided by large corporations throughout the United States. Outcomes for 1242 patients treated with either fluoxetine (SSRI) or with a TCA / HCA for major depressive disorder (MDD) were discussed in Croghan et al. (1996) and Obenchain et al. (1997). All 1242 patients were continuously enrolled for at least 4 months prior to their initial antidepressant prescription and for the following 12 months.

Usage

```
data(fluoxzca)
```

Format

A data frame of 3 variables on 1242 patients; no NAs.

stable stable = 1 indicates that the patient remained on his/her initial antidepressant medication for at least six consecutive months.

cost cost is the Marketscan(SM) 12 month total annual charge for a patient.

flux Treatment indicator variable; flux = 1 indicates receipt of fluoxetine 20 mg/d by 799 patients. flux = 0 implies receipt of either a tricyclic (TCA) or a heterocyclic (HCA) by 443 patients.

Details

This dataset contains measures of cost and effectiveness for 799 patients treated with fluoxetine (a Selective Serotonin Reuptake Inhibitor or SSRI), 104 patients treated with a first generation tricyclic, TCA (amitriptyline or imipramine), 250 patients treated with a second generation TCA (desipramine or nortriptyline), and 89 patients treated with trazodone (a heterocyclic, HCA).

References

Croghan TW, Lair TJ, Engelhart L, et al. Effect of antidepressant therapy on health care utilization and costs in primary care. Working paper, Eli Lilly and Company, 1996. (Presented in part at the *Association for Health Services Research* meeting, Chicago, June 9, 1995.)

Obenchain RL, Melfi CA, Croghan TW, Buesching DP. Bootstrap analyses of cost-effectiveness in antidepressant pharmacotherapy. *Pharmacoeconomics* 1997; **17**: 1200–1206.

Sclar DA, Robison LM, Skaer TL, Legg RF, Nemec NL, Galin RS, Hugher TE, Buesching DP. Antidepressant pharmacotherapy: economic outcomes in a health maintenance organization. *Clin Ther* 1994; **16**: 715–730.

Examples

```
data(fluoxtca)
ICEscale(fluoxtca, fluox, stable, cost)
```

ICEalice

Functions to compute and display ICE Acceptability Curves

Description

ICEalice() computes statistics for the VAGR Acceptability Curve and for the Buckingham ALICE curve. Plots for the resulting ICEalice object are of two types: [1] a VAGR curve where the horizontal axis is the Willingness to Pay (WTP) ICE Ratio, and [2] a monotone ALICE curve where the horizontal axis is the Absolute Value of the ICE Polar Angle, which varies from +45 degrees to +135 degrees. Printing an ICEalice object yields a 13 x 5 table (matrix) of numerical values for Absolute ICEangle, WTP, VAGR Acceptability, WTA and ALICE acceptability, respectively.

Usage

```
ICEalice(ICEw)
```

Arguments

ICEw An object of class ICEwedge.

Details

The VAGR Acceptability Curve displays the fraction of outcomes within the Bootstrap distribution of ICE Uncertainty that lie below and/or to the right of a rotating straight line through the origin of the ICE plane. This straight line starts out horizontal, representing $\lambda = \text{WTP} = 0$, and rotates counter-clockwise until it becomes vertical, representing $\lambda = \text{WTP} = +\text{Inf}$.

The Buckingham ALICE Curve assumes that λ is held fixed. It displays the fraction of outcomes within the Bootstrap distribution of ICE Uncertainty that lie on or between a pair of rotating ICE rays (emanating from the ICE origin) with slopes representing KINKed values of $\text{WTP} < \text{WTA}$ that always satisfy Obenchain's LINK function, $\lambda = \sqrt{\text{WTP} \cdot \text{WTA}}$, with λ held fixed. The right-hand ray for WTP starts out horizontal and pointing to the right, then rotates counter-clockwise until it is vertical, as in a VAGR curve. The left-hand ray for WTA starts out vertical and pointing downwards, then rotates clockwise until it is horizontal. Since λ is held fixed, the slopes of the rotating rays corresponding to decreasing WTA as WTP increases. The starting point of an ALICE curve at an Absolute ICE Angle of 45 degrees always represents the fraction of outcomes in the Bootstrap Distribution of ICE Uncertainty for which the new treatment is both less costly AND more effective than the std treatment. The ending point of an ALICE curve at an Absolute ICE Angle of 135 degrees always represents the fraction of outcomes in the Bootstrap Distribution of ICE Uncertainty for which the new treatment is either less costly OR more effective than the std treatment. The middle point of an ALICE curve at an Absolute ICE Angle of 90 degrees represents the fraction of outcomes in the Bootstrap Distribution of ICE Uncertainty falling below and/or to the right of the straight line through the ICE origin of slope $\lambda = \text{WTP} = \text{WTA}$.

Value

Objects of class ICEalice contain the following output list:

<code>lambda</code>	Positive numerical value for the Shadow Price of Health, λ .
<code>ceunit</code>	Common unit of measurement - either "cost" or "effe".
<code>ia</code>	R x 1 Vector of Sorted ICE Angles. Default value is R = 25000.
<code>acc</code>	13 x 5 Matrix of Absolute ICEangle, WTP, VAGR Acceptability, WTA and AL-ICE statistics.

Author(s)

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References

Van Hout BA, Al MJ, Gordon GS, Rutten FFH. Costs, effects and C/E ratios alongside a clinical trial. (VAGR curve) *Health Economics* 1994; **3**: 309-319.

Buckingham K. Personal communications including a draft manuscript entitled: Representing the cumulative probability of Acceptability Levels In Cost Effectiveness. (ALICE curve) 2003.

Fenwick E, O'Brien BJ, Briggs AH. Cost-effectiveness acceptability curves - facts, fallacies and frequently asked questions. *Health Economics* 2004; **13**: 405-415.

Obenchain RL. ICE Preference Maps: Nonlinear Generalizations of Net Benefit and Acceptability. *Health Serv Outcomes Res Method* 2008; **8**: 31-56. DOI 10.1007/s10742-007-0027-2. Open Access.

See Also

[ICEwedge](#) and [ICEcolor](#)

Examples

```
# Read in previously computed ICEwedge output list.
data(dpwdg)
dpacc <- ICEalice(dpwdg)
# Display the ALICE curve.
plot(dpacc, show="Alice")
dpacc
```

ICEcolor	<i>Compute Preference Colors for Outcomes within a Bootstrap Confidence Wedge</i>
----------	---

Description

Assuming the input ICEw object is of class ICEwedge, ICEcolor uses $\lambda = \text{lfact} * \text{ICEw}\$lambda$ to define an ICE Preference Map with specified parameters (lfact, beta, gamma) to compute Economic Preference values. Only the Bootstrap re-sampled points within the ICE confidence wedge are used. Thus, assuming that the overall level of confidence (statistical size of the wedge) is held fixed, the points to be colored are always the very same points for all choices of lambda. However, the numerical value of preference (and thus the color) of each such point as well as the overall symmetry or asymmetry in the resulting ICE map can depend greatly upon lambda.

Usage

```
ICEcolor(ICEw, lfact = 1, beta = 1, gamma = 3+2*sqrt(2))
```

Arguments

ICEw	Existing ICEwedge object.
lfact	Strictly positive multiplier for ICEw\$lambda.
beta	Strictly positive Returns-to-Scale power parameter for the ICE Preference Map. beta = 1 implies linear (constant) Returns to Scale. beta > 0 and < 1 implies diminishing Returns to Scale. beta > 1 implies increasing Returns to Scale.
gamma	Strictly positive Directional power parameter. The smallest reasonable value for gamma is usually gamma = beta, which yields a (generalized) linear map. The largest reasonable value for gamma is usually gamma = beta*(3+2*sqrt(2)), which yields a map that satisfies the Cartesian Monotonicity Axiom and also admits all possible finite values for WTP and WTA, i.e. all values greater than or equal to 0 but less than +Inf.

Details

Multiple calls to ICEcolor() are usually made for different lfact multipliers of LCEw\$lambda item as well as different choices for the ICE Preference power parameters, beta and gamma. Calls to plot(x, alibi) for these alternative ICEcolor x-objects can be used to illustrate that exogenous Economic Uncertainty can literally SWAMP the Statistical Uncertainty endogenous to patient level data on the relative cost and effectiveness of two treatments.

Value

Object of class ICEcolor containing an output list with the following items:

df	Saved value of the name of the data.frame input to ICEcolor.
lambda	Saved positive value of lambda input to ICEcolor.
unit	Saved value of unit, cost or effe, input to ICEcolor.
R	Saved integer value for number of bootstrap replications input to ICEcolor.
trtm	Saved name of the treatment indicator within the df data.frame.
xeffe	Saved name of the treatment effectiveness variable within the df data.frame.
ycost	Saved name of the treatment cost variable within the df data.frame.
effcst	Saved value of the sorted 3-variable (trtm,effe,cost) data.frame.
t1	Observed value of (DeltaEffe, DeltaCost) when each patient is sampled exactly once.
t	R x 2 matrix of values of (DeltaEffe, DeltaCost) computed from bootstrap re-samples.
seed	Saved value of the seed used to start pseudo random number generation.

Author(s)

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References

Cook JR, Heyse JF. Use of an angular transformation for ratio estimation in cost-effectiveness analysis. *Statistics in Medicine* 2000; **19**: 2989-3003.

Obenchain RL. ICE Preference Maps: Nonlinear Generalizations of Net Benefit and Acceptability. *Health Serv Outcomes Res Method* 2008; **8**: 31-56. DOI 10.1007/s10742-007-0027-2. Open Access.

See Also

[ICEwedge](#), [plot.ICEcolor](#) and [print.ICEcolor](#)

Examples

```
# Read in previously computed ICEwedge output list.
data(dpwdg)
dpcol <- ICEcolor(dpwdg)
# Display preference coloring for the stored value of lambda.
plot(dpcol, show="RBOW")
dpcolX <- ICEcolor(dpwdg, lfact=10)
# Display preference coloring when lambda is increased by a factor of 10.
plot(dpcolX, show="RBOW")
```

ICEepmap

*Set Parameter Values defining ICE Economic Preference Maps***Description**

ICEepmap() and ICEomega() set numerical values for lambda (the full, fair shadow price of health) and for the two so-called power-parameters of a parametric ICE Preference Map. These functions return a value, epm, that is an output list object of class ICEepmap for display using print(epm) or plot(epm, xygrid). The primary purpose of such plots is to allow the user to more easily visualize the profound effects that changing numerical values for lambda, beta and either gamma or eta = gamma / beta can have on the iso-preference contours (level curves) of an ICE map.

From the statistical prospective championed here, lambda is little more than a nuisance parameter. For example, the wedge-shaped ICE confidence regions formed by ICEwedge() are equivariant under changes in lambda. Unfortunately, the resulting economic preferences that can be visualized using ICEcolor() can change drastically with changes in lambda.

A standardized ICE map results when the specified value of lambda is used to assure that the x effect difference and the y cost difference are both expressed in the same units (i.e. both in cost units or else both in effect units.) Unfortunately, the only way to assure display of this particular sort of rescaling in ICE plane depictions is to use alibi = TRUE in plot.ICEuncrt(). Both plot.ICEwedge() and plot.ICEcolor() always default to alias axis scaling. Thus the equivariance property of the ICE confidence wedge is depicted as if the rays determining its upper and lower limits are invariant under changes in lambda.

The easy way to visualize a standardized ICE map is to always use the default value of lambda = 1 in ICEepmap() and ICEomega(). A standardized ICE map always has the following two characteristics: [i] it always assigns a zero overall preference to all (x, y) outcomes everywhere along the x = y ICE diagonal, and [ii] its iso-preference contours are always exactly symmetric about the x = -y (upper-left to lower-right) ICE diagonal.

Usage

```
ICEepmap(lambda = 1, beta = 1, gamma = 3+2*sqrt(2))
ICEomega(lambda = 1, beta = 1, eta = 3+2*sqrt(2))
```

Arguments

lambda	Positive value for the fair, full-retail Shadow Price of Health.
beta	Positive Returns-to-Scale Power parameter for the ICE Preference Map. beta = 1 implies linear (constant) Returns-to-Scale. A beta > 0 and < 1 implies diminishing Returns-to-Scale. A beta > 1 implies increasing Returns-to-Scale.
gamma	Positive Directional Power parameter for ICEepmap(). The smallest reasonable value for gamma is usually gamma = beta, which yields a (generalized) linear map. The largest reasonable value for gamma is usually gamma = beta*(3+2*sqrt(2)), which yields a map that satisfies Cartesian Monotonicity and also yields WTP and WTA values within [0, +Inf).
eta	Positive Power Parameter Ratio for ICEomega(). Generalized linear maps result when eta = 1. The eta for the more realistic Nonlinear maps is greater than one, but not greater than the ICE Omega limit of (3+2*sqrt(2)), which is approximately 5.828. This upper limit on eta is required to assure that Cartesian Monotonicity of preferences holds.

Details

The ICEepmap() and ICEomega() functions specify numerical values for the Shadow Price of Health Parameter, lambda, for the Returns to Scale Power Parameter, beta, and for either the Directional Power Parameter, gamma, or else the Power Parameter Ratio, eta = gamma / beta.

Value

Object of class ICEepmap containing an output list with the following items:

lambda	Saved positive value of Shadow Price of Health, lambda, read by the print and plot methods for objects of class ICEepmap.
beta	Saved Positive Returns-to-Scale Power parameter, beta, read by the print and plot methods for objects of class ICEepmap.
gamma	Saved Positive Directional Power parameter, gamma, read by the print and plot methods for objects of class ICEepmap.

Author(s)

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References

- Cook JR, Heyse JF. Use of an angular transformation for ratio estimation in cost-effectiveness analysis. *Statistics in Medicine* 2000; **19**: 2989-3003.
- Obenchain RL. Incremental Cost-Effectiveness (ICE) Preference Maps. 2001 *JSM Proceedings (Biopharmaceutical Section) on CD-ROM*. (10 pages.) Alexandria, VA: American Statistical Association. 2002.
- Obenchain RL. ICE Preference Maps: Nonlinear Generalizations of Net Benefit and Acceptability. *Health Serv Outcomes Res Method* 2008; **8**: 31-56. DOI 10.1007/s10742-007-0027-2. Open Access.

See Also

[plot.ICEepmap](#) and [print.ICEepmap](#)

Examples

```
pm <- ICEomega(beta=0.8)
require(lattice)
plot(pm)
```

ICEpref	<i>Compute ICE Economic Preference Scores from Numeric Cost and Effe Measures</i>
---------	---

Description

This function calculates Incremental Net Monetary Benefit (INMB) Scores that are expressed in Cost units. While these scores are of "linear" form, $(\lambda * Effe) - Cost$, when $\eta == \gamma / \beta == 1$, they are "Nonlinear" when η is either > 1 or < 1 .

Usage

```
ICEpref(tr, ex, cy, lambda = 1, beta = 1, eta = 3 + 2 * sqrt(2))
```

Arguments

tr	Binary [0 or 1] indicator of Treatment Regimen received by each patient [Experimental Unit]: tr == 0 denotes the "Standard" Regimen, tr == 1 denotes a "New" Regimen.
ex	Numeric vector representing Effe measures observed for 2 or more experimental units.
cy	Corresponding numeric vector reporting Total Cost Incurred by patients during treatment. The tr, ex and cy vectors must be of the same length, $n \geq 2$, and $1 < \text{sum}(tr) < n$.
lambda	Positive value for the fair, full-retail Shadow Price of Health. When ex is measured in QALYs and cy in U.S. Dollars, lambda = 50000 is traditionally assumed appropriate.
beta	Positive Returns-to-Scale Power parameter for ICE Preference calculations. beta = 1 implies Linear (Constant) Returns-to-Scale. A beta > 0 but < 1 implies Returns-to-Scale that are Diminishing and tend to be highly Realistic. Any beta > 1 implies Increasing Returns-to-Scale.
eta	Positive Power Parameter Ratio: γ / β . Generalized "linear" maps result when $\eta = 1$. An eta ratio > 1 can yield a realistic "Nonlinear" map, but maps with $\eta > 3+2*\text{sqrt}(2) = 5.828$ (Obenchain's "Omega") violate the "Cartesian Monotonicity" Axiom.

Value

Object of class "numeric" of the same length as the tr, ex and cy vectors input:

pref Computed ICE Economic Preference Scores.

Author(s)

Bob Obenchain <wizbob@att.net>

References

Hoch JS, Briggs AH, Willan AR. Something old, something new, something borrowed, something blue: a framework for the marriage of health econometrics and cost-effectiveness analysis. *Health Economics* 2002; **11**: 415-430.

Obenchain RL. ICE Preference Maps: Nonlinear Generalizations of Net Benefit and Acceptability. *Health Serv Outcomes Res Method* 2008; **8**: 31-56. DOI 10.1007/s10742-007-0027-2. Open Access.

See Also

[plot.ICEepmap](#) and [print.ICEepmap](#)

Examples

```
data(sepsis)
attach(sepsis)
icedr <- ICEpref(tr=icuc, ex=qalypres, cy=totcost, lambda=50000, beta=0.6) # Diminishing Returns.
summary(icedr)
```

ICEscale

ICEscale() functions compute or print ICE Statistical Inference Summary Statistics relative to choice for the numerical value of the Shadow Price of Health, lambda

Description

ICEscale() computes Summary Statistics for 2-sample, 2-variable inference where one variable is a measure of effectiveness (higher values are better) and the other variable is a measure of cost (lower values are better). The 2 samples are of patients receiving only 1 of the 2 possible treatments. The treatment called new is the one with the higher numerical level for the specified treatment indicator variable, while the treatment called std corresponds to the lower numerical level. The pivotal statistic for inference is (DeltaEffe, DeltaCost), which are the head-to-head mean differences for new treatment minus std treatment. Each sample is assumed to provide unbiased estimates of the overall expected effectiveness and cost for that treatment.

Usage

```
ICEscale(df, trtm, xeffe, ycost, lambda = 1, ceunit = "cost")
```


Arguments

<code>df</code>	Required; Existing data.frame object containing the <code>trtm</code> , <code>xeffe</code> and <code>ycost</code> variables.
<code>trtm</code>	Required; Name of the treatment indicator variable contained within the <code>df</code> data.frame that assumes one of only two different numerical values for each patient.
<code>xeffe</code>	Required; Name of the treatment effectiveness variable within the <code>df</code> data.frame.
<code>ycost</code>	Required; Name of the treatment cost variable within the <code>df</code> data.frame.
<code>lambda</code>	Optional; <code>lambda</code> strictly positive value for the Shadow Price of Health.
<code>ceunit</code>	Optional; <code>ceunit</code> character string containing either <code>cost</code> (default) or <code>effe</code> .

Details

After an initial call with the default value of `lambda = 1`, multiple additional calls to `ICEscale()` with different numerical values for `lambda` are usually made at the very beginning of analyses using other functions from the `ICEinfer` package. For example, the statistical choice for `lambda` assures that the `DeltaEffe` and `DeltaCost` mean treatment differences (new minus std) will have approximately equal variability when expressed in either cost or effe ceunits. The power of ten value of `lambda` that is closest to the statistical value for `lambda` assures use of ceunits that, except for the position of the decimal point, are identical to the cost/effectiveness ratio implied by the scales in which data values are stored within the input data.frame.

Value

Object of class `ICEscale` containing an output list with the following items:

<code>trtm</code>	Saved name of the treatment indicator within the input data.frame.
<code>xeffe</code>	Saved name of the treatment effectiveness variable within the input data.frame.
<code>ycost</code>	Saved name of the treatment cost variable within the input data.frame.
<code>effcst</code>	Saved value of the sorted 3-variable (<code>trtm</code> , <code>effe</code> , <code>cost</code>) data.frame.
<code>lambda</code>	Value for the Shadow Price of Health, <code>lambda</code> , input to <code>ICEscals()</code> .
<code>t1</code>	Observed values of (<code>DeltaEffe</code> , <code>DeltaCost</code>) when each distinct patient is sampled exactly once.
<code>s1</code>	Observed values for the standard deviations of (<code>DeltaEffe</code> , <code>DeltaCost</code>) when each distinct patient is sampled exactly once.
<code>slam</code>	Statistical Shadow Price computed as $s1[2]/s1[1]$ and rounded to digits = 3.
<code>potlam</code>	Power-of-Ten Shadow Price computed as $10^{(as.integer(\log_{10}(slam)))}$.

Author(s)

Bob Obenchain <wizbob@att.net>

References

Obenchain RL. Issues and algorithms in cost-effectiveness inference. *Biopharmaceutical Reports* 1997; **5(2)**: 1-7. Washington, DC: American Statistical Association.

Cook JR, Heyse JF. Use of an angular transformation for ratio estimation in cost-effectiveness analysis. *Statistics in Medicine* 2000; **19**: 2989-3003.

See Also

[ICEscale](#), [plot.ICEuncrt](#) and [print.ICEuncrt](#)

Examples

```
data(dulxparx)
ICEScale(dulxparx, dulx, idb, ru)
```

ICEuncrt	<i>Compute Bootstrap Distribution of ICE Uncertainty for given Shadow Price of Health, lambda</i>
----------	---

Description

ICEuncrt() uses bootstrap resampling (with replacement) to compute the distribution of uncertainty for 2-sample, 2-variable statistical inference. The 2 variables must be measures of effectiveness (higher values are better) and cost (lower values are better). The 2 samples are of patients receiving only 1 of the 2 possible treatments. The treatment called new is the one with the higher numerical level for the specified treatment indicator variable, while the treatment called std corresponds to the lower numerical level. The pivotal statistic for inference is (DeltaEffe, DeltaCost), which are the head-to-head mean differences for new treatment minus std treatment. Each sample is assumed to provide unbiased estimates of the overall expected effectiveness and cost for that treatment.

Usage

```
ICEuncrt(df, trtm, xeffe, ycost, lambda = 1, ceunit = "cost", R = 25000, seed = 0)
```

Arguments

df	Required; Existing data.frame object containing the trtm, xeffe and ycost variables.
trtm	Required; Name of the treatment indicator variable contained within the df data.frame that assumes one of only two different numerical values for each patient.
xeffe	Required; Name of the treatment effectiveness variable within the df data.frame.
ycost	Required; Name of the treatment cost variable within the df data.frame.
lambda	Optional; lambda strictly positive value for the Shadow Price of Health.
ceunit	Optional; ceunit character string containing either cost (default) or effe.

R	Optional; R positive integer value for the number of Bootstrap Replications desired. Minimum allowed value is 50; default value is 25000.
seed	Optional; seed is an integer between 0 and 25000. A seed value of 0 causes a random integer seed between 1 and 25000 to be generated. To reproduce results from a previous invocation of ICEuncrt(), use the seed value saved in its output list object.

Details

A single call to ICEuncrt() is usually made for a particular value of the Shadow Price of Health, lambda. Alternative statistical choices for lambda can be suggested by making calls to ICEscale() with different values for lambda. Because the bootstrap distribution of ICE uncertainty is equivariant under changes in lambda, it is much faster to transform an existing bootstrap distribution than to generate a new one for a different value of lambda. The print.ICEuncrt() and plot.ICEuncrt() functions thus have 2 special parameters, lfact and swa, that can change lambda and switch the ceunit of measurement, respectively, without actually generating a new bootstrap distribution via a call to ICEuncrt().

Value

Object of class ICEuncrt containing an output list with the following items:

df	Saved value of the name of the data.frame input to ICEuncrt.
lambda	Saved positive value of lambda input to ICEuncrt.
ceunit	Saved value of ceunit (cost or effe) input to ICEuncrt.
R	Saved integer value for number of bootstrap replications input to ICEuncrt.
trtm	Saved name of the treatment indicator within the df data.frame.
xeffe	Saved name of the treatment effectiveness variable within the df data.frame.
ycost	Saved name of the treatment cost variable within the df data.frame.
effcst	Saved value of the sorted 3-variable (trtm,effe,cost) data.frame.
t1	Observed value of (DeltaEffe, DeltaCost) when each patient is included exactly once.
t	R x 2 matrix of values of (DeltaEffe, DeltaCost) computed from bootstrap re-samples.
seed	Saved value of the seed used to start pseudo random number generation.

Author(s)

Bob Obenchain <wizbob@att.net>

References

- Obenchain RL, Melfi CA, Croghan TW, Buesching DP. Bootstrap analyses of cost-effectiveness in antidepressant pharmacotherapy. *Pharmacoeconomics* 1997; **17**: 1200-1206.
- Obenchain RL. Resampling and multiplicity in cost-effectiveness inference. *Journal of Biopharmaceutical Statistics* 1999; **9(4)**: 563-582.

See Also

[ICEScale](#), [plot.ICEuncrt](#) and [print.ICEuncrt](#)

Examples

```
data(dulxparx)
# Generating a bootstrap ICE uncertainty distribution is time consuming.
dpunc <- ICEuncrt(dulxparx, dulx, idb, ru, lambda=0.26)
plot(dpunc)
# Transforming an existing bootstrap ICE uncertainty distribution is fast.
dpuncX <- plot(dpunc, lfact=10)
```

ICEwedge

Equivariant Wedge-Shaped ICE Region with Confidence Level from 0.50 to 0.99

Description

ICEwedge() uses the Bootstrap Distribution of ICE Uncertainty generated by ICEuncrt() to calculate and sort ICE Angle Order Statistics around a circle. ICEwedge() then counts outwards the same number of ICE Angle Order Statistics, $\text{floor}(R \cdot \text{conf}/2)$, both Counter-Clockwise and Clockwise from the so-called "center" Order Statistic (the one nearest to the Observed ICE Ratio) to define a pair of ICE Ray Endpoints at ICE Angle Order Statistics (reported as numbers jlo and kup, respectively) that subtend an ICE Polar Angle reported in degrees.

Usage

```
ICEwedge(ICEu, lfact = 1, conf = 0.95)
```

Arguments

ICEu	Output list object of class ICEuncrt.
lfact	Either a strictly positive multiplicative factor for ICEu item lambda or else 0 to cause ICEwedge to compute the positive lfact and lambda values that transform the alibi display to have an alias interpretation.
conf	Statistical Confidence Level within [0.50, 0.99].

Details

The plot() of an object of class ICEwedge displays the Bootstrap Distribution of ICE Uncertainty with a small, circular, colored dot (pch = 20). Outcomes outside the Wedge are displayed in black, while outcomes inside the Wedge are displayed in cyan. Upper and lower ICE Ray Limits are displayed as solid black lines, and the ICE Ray through the center ICE Angle Order Statistic is shown as a dashed black line.

Value

An object of class ICEwedge with the following output list:

ICEinp	Name of the ICEuncrt object input to ICEwedge().
lambda	Positive value of lfact * ICEu item lambda
lfact	Positive Multiplier for the ICEu item lambda value input to ICEwedge().
unit	Saved value of unit, cost or effe, input to ICEuncrt.
conf	Statistical Confidence Level within [0.50, 0.99] input to ICEwedge.
R	Saved integer value for number of bootstrap replications input to ICEuncrt.
axys	R x 4 data.frame with ICE Angle in column 1, bootstrap resampled values of (DeltaEffe, DeltaCost) in columns 2 and 3, and the binary flag with 0 => outcome outside the Confidence Wedge and 1 => outcome inside the Confidence Wedge in column 4.
t1	Observed value of (DeltaEffe, DeltaCost) when each patient is sampled exactly once.
ia1	The center ICE Angle closest to the Observed ICE Ratio.
center	The largest value of j such that axys[j, 1] < ia1 <= axys[j+1, 1].
jlo	Number of the ICE Angle Order Statistic defining the Clockwise or lower ICE Ray boundary of the Confidence Wedge.
kup	Number of the ICE Angle Order Statistic defining the Counter-Clockwise or upper ICE Ray boundary of the Confidence Wedge.
subangle	Subtended Polar ICE Angle between Order Statistics numbers jlo and kup.
xmax	Alias plots of ICEwedge have horizontal range [-xmax, +xmax].
ymax	Alias plots of ICEwedge have vertical range [-ymax, +ymax].
ab	ICE angle computation perspective of alibi or alias.

Author(s)

Bob Obenchain <wizbob@att.net>

References

Cook JR, Heyse JF. Use of an angular transformation for ratio estimation in cost-effectiveness analysis. *Statistics in Medicine* 2000; **19**: 2989-3003.

Obenchain RL. Resampling and multiplicity in cost-effectiveness inference. *Journal of Biopharmaceutical Statistics* 1999; **9(4)**: 563-582.

Obenchain RL. ICE Preference Maps: Nonlinear Generalizations of Net Benefit and Acceptability. *Health Serv Outcomes Res Method* 2008; **8**: 31-56. DOI 10.1007/s10742-007-0027-2. Open Access.

See Also

[ICEuncrt](#) and [ICEcolor](#)

Examples

```

data(dpunc)
# ICEwedge() calculations may take more than 5 seconds...
dpwdg <- ICEwedge(dpunc)
plot(dpwdg)
# ICEwedge() computations from an alias (rather than alibi) perspective...
dpwdg0 <- ICEwedge(dpunc, lfact=0)
plot(dpwdg0)

```

plot.ICEcolor	<i>Display Economic Preferences for ICE Outcomes within a Bootstrap Confidence Wedge</i>
---------------	--

Description

Assuming x is an object of class `ICEcolor`, the default invocation of `plot(x)` first displays a Histogram depicting the Distribution of Economic Preferences within an ICE Confidence Wedge then applies a rainbow of colors to these same points on a display of the ICE Bootstrap re-sampling Scatter. An invocation of the form `plot(x, alibi=TRUE)` uses alibi (rather than alias) scaling when displaying the Bootstrap Scatter plot. When ready, the user should press the ENTER Key to overwrite the Histogram display with the Scatter plot.

Usage

```

## S3 method for class 'ICEcolor'
plot(x, alibi = FALSE, show = "Both", ...)

```

Arguments

<code>x</code>	Required; Output list object of class <code>ICEcolor</code> .
<code>alibi</code>	Optional; Logical value of <code>TRUE</code> or <code>FALSE</code> to control scaling of axes. <code>alibi = FALSE</code> produces the default alias graphic in which points in the bootstrap uncertainty scatter are held fixed in space, and changes in lambda change the scaling (tick marks) along either the horizontal axis of a cost unit display or else along the vertical axis of an effe unit display. <code>alibi = TRUE</code> produces an alibi graphic in which the scaling (and range) is the same along both axes, and changes in lambda cause the points in the bootstrap uncertainty scatter to move either left or right in a cost unit display or else up or down in an effe unit display.
<code>show</code>	Optional; Character string of <code>"Hist"</code> , <code>"RBOW"</code> or <code>"Both"</code> . <code>show = "Hist"</code> displays a Histogram depicting the distribution of Economic Preferences within the ICE Wedge, while <code>show = "RBOW"</code> applies a rainbow of colors (Red–Tan–Yellow–Green) to depict the Economic Preference level associated with each re-sampled point within the ICE Wedge. <code>show = "Both"</code> is the default; it requires the user to press the ENTER key when ready to overwrite the initial <code>"Hist"</code> display with the corresponding <code>"RBOW"</code> plot.
<code>...</code>	Optional; Argument(s) passed on to <code>plot()</code> .

Details

To illustrate the sensitivity of Economic Preferences to choice of lambda, multiple calls are usually made to ICEcolor() for different values of lambda as well as for different choices of the beta and gamma parameters that determine the shape of (and spacing between) Indifference Curves on an ICE Economic Preference Map.

The plot() of an object of class ICEcolor displays the Bootstrap Distribution of ICE Uncertainty using small, circular, colored dots (pch = 20). Outcomes outside the Confidence Wedge are displayed in black, while outcomes inside the Wedge are displayed in a rainbow of colors (within the Red–Tan–Yellow–Green range) that represent Economic Preferences.

Upper and lower ICE Confidence Limits are again displayed as Solid black Rays. The Dashed black LINE through the ICE Origin, (0,0), has slope 1, indicating the ZERO Preference boundary that literally bisects the North-East and South-West ICE Quadrants. This Dashed Line may not "appear" to have slope 1, but that happens only when the horizontal and vertical RANGES displayed are quite different.

Value

NULL

Author(s)

Bob Obenchain <wizbob@att.net>

References

Cook JR, Heyse JF. Use of an angular transformation for ratio estimation in cost-effectiveness analysis. *Statistics in Medicine* 2000; **19**: 2989-3003.

Obenchain RL. Incremental Cost-Effectiveness (ICE) Preference Maps. 2001 *JSM Proceedings (Biopharmaceutical Section) on CD-ROM*. (10 pages.) Alexandria, VA: American Statistical Association. 2002.

Obenchain RL. ICE Preference Maps: Nonlinear Generalizations of Net Benefit and Acceptability. *Health Serv Outcomes Res Method* 2008; **8**: 31-56. DOI 10.1007/s10742-007-0027-2. Open Access.

See Also

[ICEcolor](#), [ICEscale](#) and [ICEwedge](#).

Examples

```
data(dpwdg)
dpcol <- ICEcolor(dpwdg)
plot(dpcol, show="RBOW")
plot(dpcol, alibi=TRUE, show="RBOW")
```

plot.ICEepmap	<i>Display Indifference Curves on a standardized ICE Economic Preference Map</i>
---------------	--

Description

Display plots of the Indifference Curves of an ICE Economic Preference Map using the `contourplot()` and `expand.grid()` functions from the **lattice** R-package.

Usage

```
## S3 method for class 'ICEepmap'
plot(x, xygrid = FALSE, ...)
```

Arguments

<code>x</code>	Output list object from either ICEepmap or ICEomega.
<code>xygrid</code>	Either FALSE or a grid object for a lattice of (x, y) plotting positions.
<code>...</code>	Optional argument(s) passed on to <code>contourplot()</code> .

Details

If `xygrid == FALSE`, the default `xygrid` will be a 201 x 201 lattice of equally spaced plotting positions covering the `x=DeltaEffe` and `y=DeltaCost` ranges `[-10,+10]`. This default is: `x <- seq(-10, +10, length = 201)`; `y <- x`; `xygrid <- expand.grid(x = x, y = y)`

Value

NULL

Author(s)

Bob Obenchain <wizbob@att.net>

References

Cook JR, Heyse JF. Use of an angular transformation for ratio estimation in cost-effectiveness analysis. *Statistics in Medicine* 2000; **19**: 2989-3003.

Obenchain RL. Incremental Cost-Effectiveness (ICE) Preference Maps. 2001 *JSM Proceedings (Biopharmaceutical Section) on CD-ROM*. (10 pages.) Alexandria, VA: American Statistical Association. 2002.

Obenchain RL. ICE Preference Maps: Nonlinear Generalizations of Net Benefit and Acceptability. *Health Serv Outcomes Res Method* 2008; **8**: 31-56. DOI 10.1007/s10742-007-0027-2. Open Access.

See Also

[ICEepmap](#) and [ICEomega](#)

Examples

```
epr <- ICEomega(beta=0.8)
require(lattice)
plot(epr)
```

plot.ICEuncrt	<i>Display Scatter for a possibly Transformed Bootstrap Distribution of ICE Uncertainty</i>
---------------	---

Description

Assuming `x` is an output list object of class `ICEuncrt`, the default invocation of `plot(x)` graphically displays the bootstrap distrib of ICE uncertainty currently stored in `x`. An invocation of the form `x10 <- plot(x, lfact=10)` increases the value of `x` item `lambda` by a factor of 10, displays that transformed bootstrap distribution, and stores it in object `x10`. When the `x` item unit is `cost`, an invocation of the form `xs <- plot(x, swu=TRUE)` displays the bootstrap distribution stored in `x` using `effe` units and stores the transformed distribution in object `xs`.

Usage

```
## S3 method for class 'ICEuncrt'
plot(x, lfact = 1, swu = FALSE, alibi = FALSE, ...)
```

Arguments

<code>x</code>	Output list object of class <code>ICEuncrt</code> .
<code>lfact</code>	Positive factor multiplying the stored value of <code>x</code> item <code>lambda</code> .
<code>swu</code>	Logical value of <code>TRUE</code> or <code>FALSE</code> to control switching the stored value of <code>x</code> item unit between the 2 possibilities, <code>cost</code> and <code>effe</code> .
<code>alibi</code>	Logical value of <code>TRUE</code> or <code>FALSE</code> to control scaling of axes. <code>alibi = FALSE</code> produces the default alias graphic in which points in the bootstrap uncertainty scatter are held fixed in space, and changes in <code>lambda</code> merely change the scaling (tick marks) along either the horizontal axis of a <code>cost</code> unit display or else along the vertical axis of an <code>effe</code> unit display. <code>alibi = TRUE</code> produces an alibi graphic in which the scaling (and range) is the same along both axes, and changes in <code>lambda</code> cause the points in the bootstrap uncertainty scatter to literally move either left or right in a <code>cost</code> unit display or else up or down in an <code>effe</code> unit display.
<code>...</code>	Optional argument(s) passed on to <code>plot()</code> .

Details

After a single call to ICEuncrt() for an initial value of the Shadow Price of Health, lambda, and an initial choice of display unit (cost or effe), multiple calls to plot.ICEuncrt() are usually made. Alternative economic choices for lambda can be suggested by making calls to ICEscale() with different values for lambda. Because the Bootstrap Distribution of ICE Uncertainty is equivariant under changes in lambda, it is much faster to transform an existing bootstrap distribution than to generate a new one for a different value of lambda. The print.ICEuncrt() and plot.ICEuncrt() functions thus have 2 special parameters, lfact and swa, that can change lambda and switch the units of measurement, respectively, without actually regenerating the bootstrap distribution via a call to ICEuncrt().

Value

Object of class ICEuncrt containing a possibly TRANSFORMED output list with items:

df	Saved value of the name of the data.frame in the original call to ICEuncrt().
lambda	Possibly changed, positive value of lfact * (x item lambda).
unit	Possibly switched value of x item unit, cost or effe.
R	Saved integer value for number of bootstrap replications input to ICEuncrt.
trtm	Saved name of the treatment indicator within the df data.frame.
xeffe	Saved name of the treatment effectiveness variable within the df data.frame.
ycost	Saved name of the treatment cost variable within the df data.frame.
effcst	Saved value of the sorted 3-variable (trtm,effe,cost) data.frame.
t1	Observed value of (DeltaEffe, DeltaCost) when each patient is included exactly once.
tb	R x 2 matrix of values of (DeltaEffe, DeltaCost) computed by transformation.
seed	Saved value of the seed used to start pseudo random number generation.

Author(s)

Bob Obenchain <softrx@iquest.net>

References

- Obenchain RL. Issues and algorithms in cost-effectiveness inference. *Biopharmaceutical Reports* 1997; **5**(2): 1-7. Washington, DC: American Statistical Association.
- Obenchain RL. Resampling and multiplicity in cost-effectiveness inference. *Journal of Biopharmaceutical Statistics* 1999; **9**(4): 563-582.
- Cook JR, Heyse JF. Use of an angular transformation for ratio estimation in cost-effectiveness analysis. *Statistics in Medicine* 2000; **19**: 2989-3003.

See Also

[ICEuncrt](#), [ICEscale](#) and [ICEwedge](#).

Examples

```

data(dpunc)
dpunc
# Transformation of a bootstrap distribution is fast.
dpuncs <- plot(dpunc, swu=TRUE)

```

print.ICEuncrt	<i>Summary Statistics for a possibly Transformed Bootstrap Distribution of ICE Uncertainty</i>
----------------	--

Description

Assuming x is an output list object of class `ICEuncrt`, the default invocations of x or `print(x)` describe the bootstrap distribution of ICE uncertainty currently stored in x . An invocation of the form `x10 <- print(x, lfact=10)` increases the value of x item `lambda` by a factor of 10, describes that transformed bootstrap distribution, and stores it in object `x10`. When x item unit is `cost`, an invocation of the form `xs <- print(x, swu=TRUE)` describes the bootstrap distribution stored in x using `effe` units and stores the transformed distribution in object `xs`.

Usage

```

## S3 method for class 'ICEuncrt'
print(x, lfact = 1, swu = FALSE, ...)

```

Arguments

<code>x</code>	Required; Output list object of class <code>ICEuncrt</code> .
<code>lfact</code>	Optional; Positive factor multiplying the stored value of x item <code>lambda</code> .
<code>swu</code>	Optional; Logical value of <code>TRUE</code> or <code>FALSE</code> to control switching the stored value of x item unit between the 2 possibilities, <code>cost</code> and <code>effe</code> .
<code>...</code>	Optional; argument(s) passed on to <code>plot()</code> .

Details

After a single call to `ICEuncrt()` for an initial value of the Shadow Price of Health, `lambda`, and an initial choice of common display unit (`cost` or `effe`), multiple `print()` and/or `plot()` calls are usually made. Because the bootstrap distribution of ICE uncertainty is equivariant under changes in `lambda`, it is much faster to transform an existing Bootstrap ICE Uncertainty Distribution than to generate a new one for a different value of `lambda`.

The `print.ICEuncrt()` and `plot.ICEuncrt()` functions thus have 2 special parameters, `lfact` and `swa`, that can change `lambda` and switch the units of measurement, respectively, without actually regenerating the bootstrap distribution via a new call to `ICEuncrt()`.

Value

Object of class ICEuncrt containing a possibly TRANSFORMED output list with items:

df	Saved value of the name of the data.frame in the original call to ICEuncrt().
lambda	Possibly changed, positive value of (lfact * x item lambda).
unit	Possibly switched value of x item unit, cost or effe.
R	Saved integer value for number of bootstrap replications input to ICEuncrt.
trtm	Saved name of the treatment indicator within the df data.frame.
xeffe	Saved name of the treatment effectiveness variable within the df data.frame.
ycost	Saved name of the treatment cost variable within the df data.frame.
effcst	Saved value of the sorted 3-variable (trtm,effe,cost) data.frame.
t1	Observed value of (DeltaEffe, DeltaCost) when each patient is included exactly once.
tb	R x 2 matrix of values of (DeltaEffe, DeltaCost) computed by transformation.
seed	Saved value of the seed used to start pseudo random number generation.

Author(s)

Bob Obenchain <wizbob@att.net>

References

Obenchain RL. Issues and algorithms in cost-effectiveness inference. *Biopharmaceutical Reports* 1997; **5(2)**: 1-7. Washington, DC: American Statistical Association.

Obenchain RL. Resampling and multiplicity in cost-effectiveness inference. *Journal of Biopharmaceutical Statistics* 1999; **9(4)**: 563-582.

Cook JR, Heyse JF. Use of an angular transformation for ratio estimation in cost-effectiveness analysis. *Statistics in Medicine* 2000; **19**: 2989-3003.

See Also

[ICEuncrt](#), [ICEScale](#) and [ICEwedge](#).

Examples

```
data(dpunc)
dpunc
# Transformation of bootstrap distributions is fast.
dpuncX <- print(dpunc, lfact=10)
```

sepsis	<i>Artificial data.frame of 7 characteristics of patients treated for septic shock</i>
--------	--

Description

These simulated data describe the characteristics of 94 pseudo-patients treated for sepsis by two alternative Intensive Care Units.

Usage

```
data(sepsis)
```

Format

A data frame of 7 characteristics of 94 sepsis patients; no NAs.

patid Unique patient I.D. number; 1 through 94.

icu Intensive Care Unit type: 1 is type "new", and 0 is type "std".

qalypres Quality Adjusted Life Years preserved by treatment for sepsis.

totcost Total Cost of Resources Utilized in treatment for sepsis.

age Patient Age in years (integer).

apache Apache II score (integer).

orgfails Number of Organ Failures experienced (integer).

Details

Since only 47 patients from each of 2 Intensive Care Units are provided, this example illustrates how the Law of Large Numbers can fail to apply to ICE inferences. Unlike the 3 other "ICEinfer" example data.frames provided, the "sepsis" data.frame contains 3 additional patient characteristics (confounders) for potential use in covariate-adjustment via linear models.

References

Obenchain RL, Sacristan JA. In reply to: The negative side of cost-effectiveness ratios. *JAMA* 1997; **277**: 1931–1933.

Hoch JS, Briggs AH, Willan AR. Something old, something new, something borrowed, something blue: a framework for the marriage of health econometrics and cost effectiveness analysis. *Health Economics* 2002; **11**: 415-430.

Examples

```
data(sepsis)
ICEScale(sepsis, icu, qalypres, totcost, lambda = 50000)
## Not run: demo(sepsis)
```

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