

Package ‘FuzzyPovertyR’

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Title Estimation of Fuzzy Poverty Measures

Version 2.0.1

Description Estimates fuzzy measures of poverty and deprivation. It also estimates the sampling variance of these measures using bootstrap or jackknife repeated replications.

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belhadj2015	<i>Fuzzy monetary poverty estimation</i>
-------------	--

Description

Fuzzy monetary poverty estimation

Usage

belhadj2015(x, z1, z2, z, b)

Arguments

x	A numeric vector of a monetary variable (or poverty predicate)
z1	Parameter
z2	Parameter
z	Parameter
b	Parameter

Value

The fuzzy membership function as of Belhadj (2015).

bootP	<i>Fuzzy monetary poverty estimation</i>
-------	--

Description

Calculates bootstrap percentiles from Zedini and Belhadj (2015)

Usage

bootP(x, R = 500)

Arguments

x	A numeric vector of a predicate variable (or poverty predicate)
R	The number of bootstrap replicates (defaults to 500)

Value

A matrix of bootstrapped percentiles

References

Zedini, A., & Belhadj, B. (2015). A New Approach to Unidimensional Poverty Analysis: Application to the Tunisian Case. *Review of Income and Wealth*, 61(3), 465-476.

 eq_predicate

Fuzzy predicate poverty estimation

Description

This function takes as input a numeric vector representing a predicate variable and turns it into its equivalised version using different equivalence scales.

Usage

```
eq_predicate(predicate, ncomp, age, scale.eq, newscale)
```

Arguments

predicate	A numeric vector representing the poverty predicate (i.e. income or expenditure)
ncomp	A numerical vector of the total number of components for the j-th family.
age	A numerical vector of the number of components for the j-th family less than 16 years-old
scale.eq	The equivalence scale. Options are: Carbonaro, n.par (non parametric), OECD7050, modifiedOECD or new
newscale	a data.frame with two columns: "ncomp" defining the number of components and "s.eq" that define the corresponding

Value

A data.frame containing the equivalised predicate variable.

Examples

```
aa=runif(100, 0, 1000) # predicate
ncomp=rep(c(1,3,5,7,4),20) #n componenti
age16=ncomp-1 #componenti < 16
eq_predicate(predicate=aa, ncomp=ncomp, scale.eq="carbonaro") #carbonaro
eq_predicate(predicate=aa, ncomp=ncomp, scale.eq="n.par") #non-parametric
eq_predicate(predicate=aa, ncomp=ncomp, age=age16, scale.eq="OECD7050") #OECD7050
eq_predicate(predicate=aa, ncomp=ncomp, age=age16, scale.eq="modifiedOECD") #modifiedOECD
newscale=data.frame("ncomp"=c(1:9), "s.eq"=runif(9,1,10)) # new
ncomp=rep(c(10,3,5,7,4),20)
eq_predicate(predicate=aa, ncomp=ncomp,scale.eq="new", newscale=newscal)
```

eusilc

Eusilc data

Description

Eusilc data

Usage

```
data(eusilc)
```

Format

An object of class "data.frame"

HB020 Country of residence

ID ID

HY022 Total disposable household income before social transfer

HS040 Capacity to afford paying for one week annual holiday

HS050 Capacity to afford a meal with meat

HS060 Capacity to face unexpected financial expenses

HS070 Ownership of a telephone

HS080 Ownership of a color TV

HS090 Ownership of a computer

HS100 Ownership of a washing machine

HS110 Ownership of a car

HS120 Ability to make ends meet

HS160 Problems with the dwelling: too dark, not enough light

HS170 Noise from neighbors or from the street

HS180 Pollution, crime or other environmental problems

HS190 Crime violence or vandalism in the area

HH010 Dwelling type

HH020 Tenure Status

HH040 Leaking roof, damp walls,floors,foundation

HH050 Ability to keep home adequately warm

HH081 Bath or shower in dwelling

HH091 Indoor flushing toilet for sole use of household

HX040 Household size

DB090 Household cross-sectional weight

db040 Sub-domain

stratum Stratum
psu Primary selection unit
ncomp Size of the household
age16 Number of household members aged less than 16 year
eq_income Equivalised income

Source

Created by authors following the EU-SILC structure

fm_belhadj2011	<i>Fuzzy monetary poverty estimation</i>
----------------	--

Description

constructs fuzzy monetary poverty estimates as of Belhadj (2011)

Usage

```
fm_belhadj2011(x, z_min, z_max, weight, breakdown, ID)
```

Arguments

x	poverty predicate
z_min	parameter
z_max	parameter
weight	A numeric vector of sampling weights. if NULL simple random sampling weights will be used.
breakdown	A factor of sub-domains to calculate estimates for.
ID	A numeric or character vector of IDs. if NULL (the default) it is set as the row sequence.

Value

a list containing the membership function values and its expected value

fm_belhadj2015	<i>Fuzzy monetary poverty estimation</i>
----------------	--

Description

Fuzzy monetary poverty estimation

Usage

fm_belhadj2015(x, z1, z2, b, breakdown, weight, ID)

Arguments

x	A numeric vector of a monetary variable (or poverty predicate)
z1	Parameter
z2	Parameter
b	Parameter
breakdown	A factor of sub-domains to calculate estimates for (using the same alpha).
weight	A numeric vector of sampling weights
ID	A numeric or character vector of IDs. if NULL (the default) it is set as the row sequence.

Value

a list containing the fuzzy membership function and the value of z found as of Belhadj(2015).

fm_cerioli	<i>Fuzzy monetary poverty estimation</i>
------------	--

Description

constructs fuzzy monetary poverty estimates as of Cerioli Zani

Usage

fm_cerioli(x, z1, z2, weight, breakdown, ID)

Arguments

x	poverty predicate
z1	parameter
z2	parameter
weight	A numeric vector of sampling weights. if NULL simple random sampling weights will be used.
breakdown	A factor of sub-domains to calculate estimates for.
ID	A numeric or character vector of IDs. if NULL (the default) it is set as the row sequence.

Value

a list containing the membership function values and its expected value

fm_Chakravarty	<i>Fuzzy monetary poverty estimation</i>
----------------	--

Description

Fuzzy monetary poverty estimation

Usage

```
fm_Chakravarty(x, z, weight, breakdown, ID)
```

Arguments

x	A numeric vector of a poverty predicate
z	The parameter of the f.m. function (see Chakravarty (2006))
weight	A numeric vector of sampling weights. if NULL simple random sampling weights will be used.
breakdown	A factor of sub-domains to calculate estimates for (using the same alpha).
ID	A numeric or character vector of IDs. if NULL (the default) it is set as the row sequence.

Value

The membership grades

References

Chakravarty, S. R. (2019). An axiomatic approach to multidimensional poverty measurement via fuzzy sets. Poverty, social exclusion and stochastic dominance, 123-141.

Examples

```
x = rchisq(1000, 15)
breakdown = sample(letters, size = length(x), replace = TRUE )
fm_construct(predicate = x, weight = NULL, breakdown = breakdown, fm = "chakravarty", z = 10)
```

fm_construct

*Fuzzy monetary poverty estimation***Description**

fm_construct constructs fuzzy monetary poverty estimates.

Usage

```
fm_construct(
  predicate,
  weight = NULL,
  fm = "verma",
  ID = NULL,
  HCR,
  interval = c(1, 10),
  alpha = NULL,
  hh.size,
  z_min,
  z_max,
  z1,
  z2,
  b,
  z,
  breakdown = NULL,
  data = NULL,
  verbose = FALSE
)
```

Arguments

predicate	A numeric vector representing the poverty predicate (i.e. income or expenditure)
weight	A numeric vector of sampling weights. if NULL simple random sampling weights will be used.
fm	The membership function (default is "verma". Other options are "ZBM", "bel-hadj", "chakravarty", "cerioli", "verma1999" and "TFR". See Betti et. al (2023) The fuzzy approach to poverty measurement. Research handbook of measuring poverty and deprivation (ed. by J. Silber))
ID	A numeric or character vector of IDs. if NULL (the default) it is set as the row sequence.

HCR	If fm="verma" or fm="verma1999" or fm="TFR" . The value of the head count ratio.
interval	If fm="verma" or fm="verma1999" or fm="TFR". A numeric vector of length two to look for the value of alpha (if not supplied).
alpha	If fm="verma" or fm="verma1999" or fm="TFR". The value of the exponent in equation $E(\mu)^{(\alpha-1)} = HCR$. If NULL it is calculated so that it equates the expectation of the membership function to HCR
hh.size	If fm="ZBM". A numeric vector of household size.
z_min	A parameter of the membership function if fm="belhadj2011"
z_max	A parameter of the membership function if fm="belhadj2011"
z1	A parameter of the membership function if fm="belhadj2015" or fm="cerioli"
z2	A parameter of the membership function if fm="belhadj2015" or fm="cerioli"
b	A parameter of the membership function if fm="belhadj2015". The shape parameter (if b=1 the mf is linear between z1 and z2)
z	A parameter of the membership function if fm="chakravarty".
breakdown	A factor of sub-domains to calculate estimates for (using the same alpha).
data	an optional data frame containing the variables to be used.
verbose	Logical. whether to print the proceeding of the procedure.

Details

It implements the fuzzy set approach to monetary poverty measurement where the usual dichotomy poor (1) not-poor(0) is replaced with a continuum score in $(0,1)$

Value

an object of class FuzzyMonetary containing the (fuzzy) membership function for each individual in the sample, the estimated expected value (estimate) of the function and the parameters of the membership functions (supplied or calculated). If breakdown is supplied it gives an output for each level.

Examples

```
data(eusilc)
HCR <- .154
hh.size <- sample(1:4, 1000, replace = TRUE)
fm_construct(predicate = eusilc$eq_income, weight = eusilc$DB090,
fm = "verma", HCR = HCR, ID = eusilc$ID)
```

fm_equate	<i>Fuzzy monetary poverty estimation</i>
-----------	--

Description

Solves the non-linear equation in Betti et. al, 2018.

Usage

```
fm_equate(predicate.ord, weight.ord, interval, verbose)
```

Arguments

predicate.ord	a sorted vector of a predicate variable
weight.ord	a sorted vector of weights (in the same order of predicate.ord)
interval	The interval to look for the solution of the equation.
verbose	Logical. whether to print the proceeding of the procedure.

Details

Calculates the exponent parameter alpha of the non-linear equation of Betti et al, 2018 so that the expected value of the fuzzy membership function equated the head count ratio.

Value

the obtained exponent

fm_FL	<i>Fuzzy monetary poverty estimation</i>
-------	--

Description

This function calculates the fuzzy membership function as defined in Betti et. al, 2018.

Usage

```
fm_FL(predicate.ord, weight.ord)
```

Arguments

predicate.ord	A sorted vector of a predicate variable (in ascending order).
weight.ord	A sorted vector of weights (in the same order of s.ord)

Value

A numeric vector containing the estimated membership function.

fm_mu *Fuzzy monetary poverty estimation*

Description

This function calculates the fuzzy membership function as defined in Betti et. al, 2018.

Usage

```
fm_mu(predicate.ord, weight.ord, alpha)
```

Arguments

predicate.ord	A sorted vector of a predicate variable (in ascending order).
weight.ord	A sorted vector of weights (in the same order of s.ord)
alpha	The value of the exponent parameter to use in the non-linear equation as of Betti et. al, 2018.

Value

A numeric vector containing the estimated membership function.

fm_mu2 *Fuzzy predicate poverty estimation*

Description

Fuzzy predicate poverty estimation

Usage

```
fm_mu2(predicate.ord, weight.ord, alpha)
```

Arguments

predicate.ord	A ordered numeric vector of a predicate variable (i.e. equalised income or expenditure)
weight.ord	A numeric vector of sampling weights. if NULL simple random sampling weights will be used.
alpha	The value of the exponent in equation $E(\mu)^{(\alpha-1)} = HCR$. If NULL it is calculated so that it equates the expectation of the membership function to HCR

Value

A numeric vector containing the estimated membership function.

fm_mu_TFR	<i>Fuzzy monetary poverty estimation</i>
-----------	--

Description

Fuzzy monetary poverty estimation

Usage

```
fm_mu_TFR(predicate.ord, weight.ord, alpha)
```

Arguments

predicate.ord	A ordered numeric vector of a predicate variable (i.e. equivalised income or expenditure)
weight.ord	A numeric vector of sampling weights. if NULL simple random sampling weights will be used.
alpha	The value of the exponent in equation $E(\mu)^{(\alpha-1)} = HCR$. If NULL it is calculated so that it equates the expectation of the membership function to HCR

Value

A numeric vector containing the estimated membership function.

fm_objective	<i>Fuzzy monetary poverty estimation.</i>
--------------	---

Description

Fuzzy monetary poverty estimation.

Usage

```
fm_objective(predicate.ord, weight.ord, alpha, HCR, fm, verbose)
```

Arguments

predicate.ord	A sorted vector of a predicate variable (in ascending order).
weight.ord	A sorted vector of weights (in the same order of s.ord)
alpha	The value of the exponent parameter to use in the non-linear equation as of Betti et. al, 2018.
HCR	The head count ratio.
fm	the type of membership function to use
verbose	prints the proceeding of the routine.

Value

The value of the objective function

 fm_TFR

Fuzzy monetary poverty estimation

Description

constructs fuzzy monetary poverty estimates.

Usage

fm_TFR(predicate, weight, ID, HCR, interval, alpha, breakdown, verbose)

Arguments

predicate	A numeric vector of a predicate variable (i.e. equivalised income or expenditure)
weight	A numeric vector of sampling weights. if NULL simple random sampling weights will be used.
ID	A numeric or character vector of IDs. if NULL (the default) it is set as the row sequence.
HCR	The value of the head count ratio (this is not used in the case that alpha is supplied by the user).
interval	A numeric vector of length two to look for the value of alpha (if not supplied).
alpha	The value of the exponent in equation $E(\mu)^{(\alpha-1)} = HCR$. If NULL it is calculated so that it equates the expectation of the membership function to HCR
breakdown	A factor of sub-domains to calculate estimates for (using the same alpha).
verbose	Logical. whether to print the proceeding of the procedure.

Value

The membership function of the Total Fuzzy and Relative indicator.

fm_var

Fuzzy monetary poverty estimation

Description

This function estimates the variance of the fuzzy monetary poverty index

Usage

```
fm_var(
  predicate,
  weight,
  fm,
  ID = NULL,
  type = "bootstrap",
  R = 100,
  M = NULL,
  stratum,
  psu,
  f = 0.01,
  verbose = FALSE,
  HCR,
  interval = c(1, 10),
  alpha = NULL,
  hh.size,
  z_min,
  z_max,
  z1,
  z2,
  b,
  z,
  breakdown = NULL,
  data = NULL
)
```

Arguments

predicate	A numeric vector representing the poverty predicate (i.e. income or expenditure)
weight	A numeric vector of sampling weights. if NULL simple random sampling weights will be used.
fm	the type of membership function to use
ID	A numeric or character vector of IDs. if NULL (the default) it is set as the row sequence.
type	The variance estimation method chosen. One between bootstrap (default) or jackknife.

R	The number of bootstrap replicates. Default is 500.
M	The size of bootstrap samples. Default is <code>nrow(data)</code> .
stratum	The vector identifying the stratum (if 'jackknife' is chosen as variance estimation technique).
psu	The vector identifying the psu (if 'jackknife' is chosen as variance estimation technique).
f	The finite population correction fraction (if 'jackknife' is chosen as variance estimation technique).
verbose	Logical. whether to print the proceeding of the variance estimation procedure.
HCR	If <code>fm="verma"</code> or <code>fm="verma1999"</code> or <code>fm="TFR"</code> . The value of the head count ratio.
interval	If <code>fm="verma"</code> or <code>fm="verma1999"</code> or <code>fm="TFR"</code> . A numeric vector of length two to look for the value of alpha (if not supplied).
alpha	If <code>fm="verma"</code> or <code>fm="verma1999"</code> or <code>fm="TFR"</code> . The value of the exponent in equation $E(\mu)^{(\alpha-1)} = HCR$. If NULL it is calculated so that it equates the expectation of the membership function to HCR
hh.size	If <code>fm="ZBM"</code> . A numeric vector of household size.
z_min	A parameter of the membership function if <code>fm="belhadj2011"</code>
z_max	A parameter of the membership function if <code>fm="belhadj2011"</code>
z1	A parameter of the membership function if <code>fm="belhadj2015"</code> or <code>fm="cerioli"</code>
z2	A parameter of the membership function if <code>fm="belhadj2015"</code> or <code>fm="cerioli"</code>
b	A parameter of the membership function if <code>fm="belhadj2015"</code> . The shape parameter (if <code>b=1</code> the mf is linear between <code>z1</code> and <code>z2</code>)
z	A parameter of the membership function if <code>fm="chakravarty"</code> .
breakdown	A factor of sub-domains to calculate estimates for (using the same alpha). If numeric will be coerced to a factor.
data	an optional data frame containing the variables to be used.

Value

An object of class `FuzzyMonetary` containing the estimate of variance with the method selected. if `breakdown` is not NULL, the variance is estimated for each sub-domain.

Examples

```
data(eusilc)
HCR <- 0.14
hh.size <- rep(1, 1000)
fm_var(predicate = eusilc$eq_income, weight = eusilc$DB090,
fm = "verma", breakdown = eusilc$db040, type = "bootstrap", HCR = .14, alpha = 9)
```

fm_verma	<i>Fuzzy monetary poverty estimation</i>
----------	--

Description

fm_construct constructs fuzzy monetary poverty estimates.

Usage

```
fm_verma(predicate, weight, ID, HCR, interval, alpha, breakdown, verbose)
```

Arguments

predicate	A numeric vector of a predicate variable (i.e. equivalised income or expenditure)
weight	A numeric vector of sampling weights. if NULL simple random sampling weights will be used.
ID	A numeric or character vector of IDs. if NULL (the default) it is set as the row sequence.
HCR	The value of the head count ratio (this is not used in the case that alpha is supplied by the user).
interval	A numeric vector of length two to look for the value of alpha (if not supplied).
alpha	The value of the exponent in equation $E(\mu)^{(\alpha-1)} = HCR$. If NULL it is calculated so that it equates the expectation of the membership function to HCR
breakdown	A factor of sub-domains to calculate estimates for (using the same alpha).
verbose	Logical. whether to print the proceeding of the procedure.

Details

It implements the fuzzy set approach to monetary poverty measurement where the usual dichotomy poor (1) not-poor(0) is replaced with a continuum score in $(0,1)$

Value

A list containing the (fuzzy) membership function for each individual in the sample, the estimated expected value of the function, the alpha parameter.

fm_verma2

*Fuzzy monetary poverty estimation***Description**

fm_construct constructs fuzzy monetary poverty estimates.

Usage

```
fm_verma2(predicate, weight, ID, HCR, interval, alpha, breakdown, verbose)
```

Arguments

predicate	A numeric vector of a predicate variable (i.e. equivalised income or expenditure)
weight	A numeric vector of sampling weights. if NULL simple random sampling weights will be used.
ID	A numeric or character vector of IDs. if NULL (the default) it is set as the row sequence.
HCR	The value of the head count ratio (this is not used in the case that alpha is supplied by the user).
interval	A numeric vector of length two to look for the value of alpha (if not supplied).
alpha	The value of the exponent in equation $E(\mu)^{(\alpha-1)} = HCR$. If NULL it is calculated so that it equates the expectation of the membership function to HCR
breakdown	A factor of sub-domains to calculate estimates for (using the same alpha).
verbose	Logical. whether to print the proceeding of the procedure.

Details

It implements the fuzzy set approach to monetary poverty measurement where the usual dichotomy poor (1) not-poor(0) is replaced with a continuum score in $(0,1)$

Value

A list containing the (fuzzy) membership function for each individual in the sample, the estimated expected value of the function, the alpha parameter.

fm_ZBM	<i>Fuzzy monetary poverty estimation</i>
--------	--

Description

Fuzzy monetary poverty estimation

Usage

fm_ZBM(predicate, hh.size, weight, breakdown, ID)

Arguments

predicate	A numeric vector of a predicate variable (or poverty predicate)
hh.size	A numeric vector with the size of the household
weight	A numeric vector of sampling weights. if NULL simple random sampling weights will be used
breakdown	A factor of sub-domains to calculate estimates for (using the same alpha).
ID	A numeric or character vector of IDs. if NULL (the default) it is set as the row sequence.

Value

The membership grades for each poverty state

References

Zedini, A., & Belhadj, B. (2015). A New Approach to Unidimensional Poverty Analysis: Application to the Tunisian Case. *Review of Income and Wealth*, 61(3), 465-476. Belhadj, B., & Matoussi, M. S. (2010). Poverty in tunisia: A fuzzy measurement approach. *Swiss Journal of Economics and Statistics*, 146(2), 431-450.

FN	<i>Fuzzy monetary poverty estimation</i>
----	--

Description

Fuzzy monetary poverty estimation

Usage

FN(x, a, b, c)

Arguments

x	A numeric vector of a predicate variable (or poverty predicate)
a	Membership function parameter
b	Membership function parameter
c	Membership function parameter

Value

The membership grade

References

Zedini, A., & Belhadj, B. (2015). A New Approach to Unidimensional Poverty Analysis: Application to the Tunisian Case. *Review of Income and Wealth*, 61(3), 465-476.

 fs_construct

Fuzzy supplementary poverty estimation.

Description

Step 7. Constructs the fuzzy supplementary poverty measure based on Steps 1-6.

Usage

```
fs_construct(steps4_5, weight, alpha, breakdown = NULL)
```

Arguments

steps4_5	The results from fs_equate.
weight	A numeric vector of sampling weights. If NULL simple random sampling weights will be used
alpha	The value of the exponent in equation $E(\mu)^{(\alpha-1)} = HCR$. If NULL it is calculated so that it equates the expectation of the membership function to HCR.
breakdown	A Dimension of sub-domains to calculate estimates for (using the same alpha). If numeric will be coerced to a Dimension.

Value

An object of class FuzzySupplementary containing the fuzzy membership function for each unit, the point estimate (i.e. the expected value of the function), and the alpha parameter.

Examples

```

data(eusilc)
step2 = fs_transform(eusilc[,4:23], weight = eusilc$DB090, ID = eusilc$ID)
dimensions = c(1,1,1,1,2,2,2,2,2,3,3,3,3,4,4,4,4,5,5,5)
steps4_5 = fs_weight(dimensions, step2 = step2, rho = NULL)
alpha <- fs_equate(steps4_5 = steps4_5,
weight = eusilc$DB090, HCR = .16, interval = c(1,10))

fs_results = fs_construct(steps4_5 = steps4_5,
weight = eusilc$DB090, alpha = alpha, breakdown = NULL)

fs_results = fs_construct(steps4_5 = steps4_5,
weight = eusilc$DB090, alpha = alpha, breakdown = eusilc$db040)

```

fs_construct_all	<i>Fuzzy supplementary poverty estimation.</i>
------------------	--

Description

Fuzzy supplementary poverty estimation.

Usage

```

fs_construct_all(
  data,
  weight = NULL,
  ID = NULL,
  dimensions,
  rho = NULL,
  HCR,
  interval = c(1, 10),
  alpha = NULL,
  breakdown = NULL
)

```

Arguments

data	A matrix or a data frame of identified items (see Step 1 of Betti et. al, 2018)
weight	A numeric vector of sampling weights. if NULL simple random sampling weights will be used
ID	A numeric or character vector of IDs. if NULL (the default) it is set as the row sequence.
dimensions	A numeric vector (of length ncol(data)) of assignments of items in data to dimensions.
rho	The critical value to be used for calculation of weights in the kendall correlation matrix.

HCR	The value of the head count ratio.
interval	A numeric vector of length two to look for the value of alpha (if not supplied).
alpha	The value of the exponent in equation $E(\mu)^{(\alpha-1)} = HCR$. If NULL it is calculated so that it equates the expectation of the membership function to HCR.
breakdown	A Dimension of sub-domains to calculate estimates for (using the same alpha). If numeric will be coerced to a Dimension.

Value

An object of class FuzzySupplementary containing the fuzzy membership function for each unit, the point estimate (i.e. the expected value of the function), and the alpha parameter.

Examples

```
data("eusilc")
FS <- fs_construct_all(data = eusilc[,4:23], weight = eusilc$DB090, # step 2
                      dimensions = c(1,1,1,1,2,2,2,2,2,3,3,3,3,4,4,4,4,5,5,5), # step 3
                      rho = NULL, # steps 4 and 5
                      HCR = .12, # step 6
                      breakdown = eusilc$db040) # step 7 with breakdowns

summary(FS)
plot(FS)
```

 fs_equate

Fuzzy supplementary poverty estimation

Description

Step 6. This function solves $E(\mu)^{(\alpha-1)} = HCR$ for alpha.

Usage

```
fs_equate(steps4_5, weight, HCR, interval = c(1, 10), verbose = TRUE)
```

Arguments

steps4_5	The results obtained from fs_weight.
weight	A numeric vector of sampling weights. if NULL simple random sampling weights will be used
HCR	The head count ratio.
interval	The range to look for the value of alpha.
verbose	Logical. whether to print the proceeding of the procedure.

Value

The alpha parameter that solves the non-linear equation $E(\mu) = HCR$

Examples

```

data(eusilc)
step2 = fs_transform(eusilc[,4:23], weight = eusilc$DB090, ID = eusilc$ID)
dimensions = c(1,1,1,1,2,2,2,2,2,3,3,3,3,4,4,4,4,5,5,5)
steps4_5 = fs_weight(dimensions, step2 = step2, rho = NULL)
alpha <- fs_equate(steps4_5 = steps4_5, weight = eusilc$DB090, HCR = .16, interval = c(1,10))

```

fs_mu	<i>Fuzzy supplementary poverty estimation.</i>
-------	--

Description

Fuzzy supplementary poverty estimation.

Usage

```
fs_mu(s.ord, w.ord, alpha)
```

Arguments

s.ord	A vector of ordered deprivation scores.
w.ord	A vector of ordered sampling weights. In the same order of s.ord.
alpha	The alpha parameter.

Value

the fuzzy membership function.

fs_objective	<i>Fuzzy supplementary poverty estimation</i>
--------------	---

Description

The objective function to find the root of.

Usage

```
fs_objective(s.ord, w.ord, alpha, HCR, verbose)
```

Arguments

s.ord	A vector of ordered deprivation scores.
w.ord	A vector of ordered sampling weights. In the same order of s.ord.
alpha	The alpha parameter.
HCR	The head count ratio.
verbose	Logical. whether to print the proceeding of the procedure.

Value

The difference between the expected value of the membership function and the head count ratio.

fs_order	<i>Fuzzy monetary poverty estimation</i>
----------	--

Description

Detects and inverts deprivation items for FS

Usage

```
fs_order(data, vec_order)
```

Arguments

data	a data-set of n columns with the considered items
vec_order	a vector length n with TRUE or FALSE. True if the order of the variable is to be inverted, False otherwise

Value

A data.frame with the same item of data with inverted order for those with vec_order==TRUE

Examples

```
#Create data
data=data.frame("X"=rep(c(1,2,3,4),20), "Y"=rep(c(7,8,9,1),20))
#Crete vec_order
vec_order=c(TRUE,FALSE)
##
fs_order(data=data, vec_order)
```

fs_transform	<i>Fuzzy supplementary poverty estimation</i>
--------------	---

Description

Step 2. This function maps a set of answers to binary or categorical items to the (0,1) interval.

Usage

```
fs_transform(data, weight = NULL, ID = NULL, depr.score = "s", ...)
```


Arguments

data	A matrix or a data frame of identified items (see Step 1 of Betti et. al, 2018)
weight	A numeric vector of sampling weights. if NULL simple random sampling weights will be used
ID	A numeric or character vector of IDs. if NULL (the default) it is set as the row sequence.
depr.score	The deprivation score to be used (see d or s in Betti et al (2018))
...	other parameters

Details

The function calculates deprivation score. To obtain consistent measures of supplementary poverty it is important that items are in the right order. Lower levels of the items have to correspond to more deprivation while higher levels of the items to a less deprivation.

Value

An object of class FuzzySupplementary containing a matrix of the same dimension of data with items mapped into the (0,1) interval

References

Betti, G., Gagliardi, F., Lemmi, A., & Verma, V. (2015). Comparative measures of multidimensional deprivation in the European Union. *Empirical Economics*, 49(3), 1071-1100.

Betti, G., Gagliardi, F., & Verma, V. (2018). Simplified Jackknife variance estimates for fuzzy measures of multidimensional poverty. *International Statistical Review*, 86(1), 68-86.

Examples

```
data(eusilc)
step2 = fs_transform(eusilc[,4:23], weight = eusilc$DB090, ID = eusilc$ID)
```

fs_var

Fuzzy supplementary poverty estimation.

Description

Fuzzy supplementary poverty estimation.

Usage

```

fs_var(
  data,
  weight = NULL,
  ID = NULL,
  dimensions,
  HCR,
  breakdown = NULL,
  alpha,
  rho = NULL,
  type = "bootstrap",
  R = 500,
  M = NULL,
  stratum,
  psu,
  f = 0.01,
  verbose = TRUE
)

```

Arguments

data	A matrix or data frame of items.
weight	A numeric vector of sampling weights. if NULL simple random sampling weights will be used
ID	A numeric or character vector of IDs. if NULL (the default) it is set as the row sequence.
dimensions	A numeric vector (of length <code>ncol(data)</code>) of assignments of items in data to dimensions.
HCR	The head count ratio.
breakdown	A factor of sub-domains to calculate estimates for (using the same alpha). If numeric will be coerced to a factor.
alpha	The value of the exponent in equation $E(\mu)^{(\alpha-1)} = HCR$. If NULL it is calculated so that it equates the expectation of the membership function to HCR.
rho	The critical value to be used for calculation of weights in the kendall correlation matrix.
type	The variance estimation method chosen. One between bootstrap (default) or jackknife.
R	The number of bootstrap replicates. Default is 500.
M	The size of bootstrap samples. Default is <code>nrow(data)</code> .
stratum	The vector identifying the stratum (if 'jackknife' is chosen as variance estimation technique).
psu	The vector identifying the psu (if 'jackknife' is chosen as variance estimation technique).
f	The finite population correction fraction (if 'jackknife' is chosen as variance estimation technique).
verbose	Logical. whether to print the proceeding of the variance estimation procedure.

Value

An object of class FuzzySupplementary containing the estimated variance.

Examples

```
dimensions = c(1,1,1,1,2,2,2,2,2,3,3,3,3,4,4,4,4,5,5,5)
fs_var(data = eusilc[,4:23], weight = eusilc$DB090, ID = NULL,
dimensions = dimensions, breakdown = NULL, HCR = .16, alpha = 2,
rho = NULL, type = 'bootstrap', M = NULL, R = 2, verbose = TRUE)
```

fs_weight

Fuzzy supplementary poverty estimation

Description

Step 4 and Step 5. Calculates the weights of dimensions discovered after Dimension analysis.

Usage

```
fs_weight(dimensions, step2, rho = NULL)
```

Arguments

dimensions	A numeric vector (of length ncol(data)) of assignments of items in data to dimensions.
step2	The data frame resulting from step2.
rho	The critical value to be used for calculation of weights in the kendall correlation matrix.

Details

This function calculates the two set of weights w_a and w_b (see References)

Value

An object of class FuzzySupplementary with calculated weights and deprivation scores in each dimension identified.

References

Betti, G., Gagliardi, F., & Verma, V. (2018). Simplified Jackknife variance estimates for fuzzy measures of multidimensional poverty. *International Statistical Review*, 86(1), 68-86.

Examples

```
data(eusilc)
step2 = fs_transform(eusilc[,4:23], weight = eusilc$DB090, ID = eusilc$ID)
dimensions = c(1,1,1,1,2,2,2,2,2,3,3,3,3,4,4,4,4,5,5,5)
steps4_5 = fs_weight(dimensions, step2 = step2, rho = NULL)
```

FuzzyPoverty	<i>s3 class fuzzy poverty</i>
--------------	-------------------------------

Description

s3 class fuzzy poverty

Usage

```
FuzzyPoverty(x)
```

Arguments

x an object

Value

an object of class FuzzyPoverty

fuzzyScaleItem	<i>Fuzzy supplementary poverty estimation</i>
----------------	---

Description

Step 2. It calculates deprivation score

Usage

```
fuzzyScaleItem(item, weight, ID, ...)
```

Arguments

item	A factor or numeric vector representing answers to an item (a column of data) that has to be rescaled. it will be converted to an ordered factor.
weight	A vector of sampling weights. If it is NULL (the default) weights are assigned assuming simple random sampling of units.
ID	A vector of length nrow(data) containing individuals IDs. if NULL (the default) row numbers will be used.
...	other parameters

Value

The item rescaled according to Betti et. al 2018.

References

#' Betti, G., Gagliardi, F., & Verma, V. (2018). Simplified Jackknife variance estimates for fuzzy measures of multidimensional poverty. *International Statistical Review*, 86(1), 68-86.

FuzzySupplementary *s3 class fuzzy poverty*

Description

s3 class fuzzy poverty

Usage

FuzzySupplementary(x)

Arguments

x an object

Value

an object of class FuzzyPoverty

Fuzzy_conv *Fuzzy monetary poverty estimation*

Description

Fuzzy monetary poverty estimation

Usage

Fuzzy_conv(x)

Arguments

x A numeric vector of fuzzy numbers

Value

the convolution of fuzzy numbers

HCR*Head Count Ratio (HCR)*

Description

This function calculates the head count ratio.

Usage

```
HCR(predicate, weight = NULL, p = 0.5, q = 0.6, poverty.line = NULL)
```

Arguments

<code>predicate</code>	A numeric vector of a predicate variable (i.e. income or expenditure)
<code>weight</code>	A numeric vector of sampling weights. if NULL simple random sampling weights will be used.
<code>p</code>	The quantile to be calculated from the predicate variable. Default is the median.
<code>q</code>	The percentage of the quantile to be used in determining the poverty line. default is 0.6.
<code>poverty.line</code>	The poverty line. If it is NULL it is estimated from data.

Details

The head count ration is defined as the sum of the sampling weight of statistical units whose vale of the predicate variable is below the poverty line. The poverty line is usually defined as a fraction of a weighted quantile (in official statistics the median) of the predicate distribution

Value

A list containing the classification of the units as poor (TRUE) and not-poor (FALSE), the estimated Head Count Ratio, and the poverty line.

Examples

```
N <- 100
p <- 0.5
q <- 0.6
predicate <- rchisq(N, 15) # predicate variable
HCR(predicate)
```

 MemberhsipGradesMatrix

Fuzzy monetary poverty estimation

Description

Fuzzy monetary poverty estimation

Usage

MemberhsipGradesMatrix(x, P)

Arguments

x	A numeric vector of a predicate variable (or poverty predicate)
P	A matrix of bootstapped percentiles

Value

The membership grade matrix

 modifiedSum

Fuzzy supplementary poverty estimation.

Description

Fuzzy supplementary poverty estimation.

Usage

modifiedSum(x, y)

Arguments

x	a numeric vector
y	a numeric vector

Value

the sum of x,y

plot.FuzzyMonetary *The plot of a FuzzyMonetary object*

Description

plot method for class "FuzzyMonetary"

Usage

```
## S3 method for class 'FuzzyMonetary'  
plot(x, ...)
```

Arguments

x An object of class "FuzzyMonetary"
... Additional options

Value

The plot

plot.FuzzySupplementary
The plot of a FuzzySupplementary object

Description

plot method for class "FuzzySupplementary"

Usage

```
## S3 method for class 'FuzzySupplementary'  
plot(x, ...)
```

Arguments

x An object of class "FuzzySupplementary"
... Additional options

Value

The plot

summary.FuzzyMonetary *The summary of a FuzzyMonetary object*

Description

Summary method for class "FuzzyMonetary"

Usage

```
## S3 method for class 'FuzzyMonetary'  
summary(object, ...)
```

Arguments

object	An object of class "FuzzyMonetary"
...	Additional options

Value

The summary method for class "FuzzyMonetary"

summary.FuzzySupplementary
The summary of a FuzzySupplementary object

Description

Summary method for class "FuzzySupplementary"

Usage

```
## S3 method for class 'FuzzySupplementary'  
summary(object, ...)
```

Arguments

object	An object of class "FuzzySupplementary"
...	Additional options

Value

The summary method for class "FuzzySupplementary"

ub1 *Fuzzy monetary poverty estimation*

Description

Fuzzy monetary poverty estimation

Usage

ub1(x, z1, b)

Arguments

x	A numeric vector of a monetary variable (or poverty predicate)
z1	Parameter
b	Parameter

Value

returns one of the two membership functions as of Belhadj (2015).

ub2 *Fuzzy monetary poverty estimation*

Description

Fuzzy monetary poverty estimation

Usage

ub2(x, z2, b)

Arguments

x	A numeric vector of a monetary variable (or poverty predicate)
z2	Parameter
b	Parameter

Value

returns one of the two membership functions as of Belhadj (2015).

wb.jh *Fuzzy supplementary poverty estimation.*

Description

Fuzzy supplementary poverty estimation.

Usage

wb.jh(j, step2, dimensions, rho, ...)

Arguments

j	The number identifying one of the latent dimensions discovered
step2	The result obtained from Step2 of the fuzzy supplementary procedure.
dimensions	A numeric vector enumerating the dimensions discovered
rho	The critical value to be used for calculation of weights in the kendall correlation matrix.
...	other parameters

Value

The weight obtained for item j in dimension h as of Formula 12 of Betti and Verma 2008.

References

Betti, G., & Verma, V. (2008). Fuzzy measures of the incidence of relative poverty and deprivation: a multi-dimensional perspective. *Statistical Methods and Applications*, 17(2), 225-250.

weighted_quantile *Calculating a weighted quantile.*

Description

This function calculates a weighted quantile

Usage

weighted_quantile(x, w, p)

Arguments

x	a numeric vector representing a statistical variable
w	a numeric vector containing sampling weights
p	the order of quantile

Value

a weighted quantile

z_fun

Fuzzy monetary poverty estimation

Description

Fuzzy monetary poverty estimation

Usage

z_fun(x, z1, z2, b)

Arguments

x	A numeric vector of a monetary variable (or poverty predicate)
z1	Parameter
z2	Parameter
b	Parameter

Value

the difference between membership functions

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