gridrho.f

Support function for ui.causal

Description

Divides the rho interval into a grid

Usage

gridrho.f(rho, gridn, rho.plotrange, plot)

Arguments

rho interval that should be divided
gridn number of gridpoints
rho.plotrange a larger interval of grids to be used in a plot
plot whether or not the larger interval of grids should be created
**grr**

*Gradient for the loglikelihood used by ui.probit*

**Description**

This function derives the gradient in order for `ui.probit` to run faster.

**Usage**

\[
grr(par, rho, X.z = X.z, X.y = X.y, y = y, z = z)
\]

**Arguments**

- `par` Coefficients.
- `rho` Rho.
- `X.z` Covariate matrix for missingness.
- `X.y` Covariate matrix for outcome.
- `y` Outcome.
- `z` Missing or not.

**hess**

*Hessian for the loglikelihood used by ui.probit*

**Description**

This function derives the hessian in order for `ui.probit` to run faster.

**Usage**

\[
hess(par, rho, X.z = X.z, X.y = X.y, y = y, z = z)
\]

**Arguments**

- `par` Coefficients.
- `rho` Rho.
- `X.z` Covariate matrix for missingness.
- `X.y` Covariate matrix for outcome.
- `y` Outcome.
- `z` Missing or not.
**interv.p**  \( \text{Print interval in parantesis} \)

**Description**

This function allows you to print an interval (vector of two elements) in a parantesis single element.

**Usage**

\[ \text{interv.p}(v, \text{digits} = 3) \]

**Arguments**

<table>
<thead>
<tr>
<th>v</th>
<th>Lower and upper bounds.</th>
</tr>
</thead>
<tbody>
<tr>
<td>digits</td>
<td>Number of decimals.</td>
</tr>
</tbody>
</table>

---

**lambda0**  \( \text{Inverse Mills ratio} \)

**Description**

This function allows you to calculate the inverse Mills ratio.

**Usage**

\[ \text{lambda0}(x) \]

**Arguments**

| x          | Vector               |

---

**lambda1**  \( \text{Inverse Mills ratio} \)

**Description**

This function allows you to calculate the inverse Mills ratio.

**Usage**

\[ \text{lambda1}(x) \]

**Arguments**

| x          | Vector               |
LogL.probit

Description
This function derives the Loglikelihood for ui.probit.

Usage
LogL.probit(par, rho, X.z = X.z, X.y = X.y, y = y, z = z)

Arguments
par Coefficient values the loglikelihood should be derived at.
rho The value of the sensitivity parameter.
X.z covariate matrix for missingness mechanism
X.y covariate matrix for the outcome regression
y outcome vector
z indicator of whether y is missing or not

LogL.sandACT

Description
Loglikelihood used in sandwich estimator of average causal effect on the treated for DR, support function for ui.causal

Usage
LogL.sandACT(x, X, z)

Arguments
x coefficients.
X Covariate matrix.
z Missing or not.
**ML.probit**  
*Fit maximum likelihood for fixed values of rho*

**Description**  
This is a support function for `ui.probit`

**Usage**  
```r
ML.probit(out.formula, mis.formula = NULL, data, rho = c(-0.5, 0.5),
progress = TRUE, method = "NR")
```

**Arguments**
- `out.formula`: Formula for outcome regression.
- `mis.formula`: Formula for regression model for the missingness mechanism.
- `data`: Data frame containing the variables in the formulas
- `rho`: Vector containing the values of rho for which we want to fit the likelihood.
- `progress`: If TRUE prints out process time for each maximazation of the likelihood.
- `method`: Maximazation method to be passed through maxLik

**plot.uicausal**  
*Plot of UI and CI*

**Description**  
Plot function for objects returned from `ui.causal`. Plots confidence intervals for different values of rho and the uncertainty interval.

**Usage**
```r
## S3 method for class 'uicausal'
plot(x, DR = TRUE, main = "", xlab = NULL,
ylab = "", ...)
```

**Arguments**
- `x`: An object of class uicausal
- `DR`: If TRUE the doubly robust estimator is plotted, otherwise the outcome regression estimator is plotted.
- `main`: Main title, default is no title.
- `xlab`: Title for xaxis, default is `expression(rho)`.
- `ylab`: Title for y axis, default is no title.
- `...`: Additional arguments, use is discouraged.
plot.uiols  

Plot of UI and CI

Description

Plot function for objects returned from `ui.ols`. Plots confidence intervals, coefficients and significants assuming ignorability and the uncertainty interval under non-ignorability.

Usage

```r
## S3 method for class 'uiols'
plot(x, plot.all = TRUE, which = NA,
     intercept = FALSE, ylab = NULL, col = c("black", "red"), ...)
```

Arguments

- `x`  
  An object of class `uiols`
- `plot.all`  
  If TRUE, plots all covariates.
- `which`  
  Specify which variables should be plotted by either sending in their names in a vector or a vector with their numbers (1 intercept, 2 for the first covariate etc.).
- `intercept`  
  If TRUE, also plots the intercept.
- `ylab`  
  Vector of names for the y-axis, default is the variable names.
- `col`  
  Vector containing the color of confidence intervals (default black) and uncertainty intervals (default red).
- `...`  
  Additional arguments, use is discouraged.

plot.uioprobit  

Plot of UI and CI

Description

Plot function for objects returned from `ui.probit`. Plots confidence intervals, coefficients and significants assuming ignorability and the uncertainty interval under non-ignorability.

Usage

```r
## S3 method for class 'uioprobit'
plot(x, plot.all = TRUE, which = NA,
     intercept = FALSE, ylab = NULL, col = c("black", "red"), ...)
```
print.uicausal

Arguments

x  An object of class uiprobit
plot.all  If TRUE, plots all covariates.
which  Specify which variables should be plotted by either sending in their names in a vector or a vector with their numbers (1 for the first covariate, 2 for the second etc.). To plot the intercept, set intercept as TRUE.
intercept  If TRUE, also plots the intercept.
ylab  Vector of names for the y-axis, default is the variable names.
col  Vector containing the color of confidence intervals (default black) and uncertainty intervals (default red).
...  Additional arguments, use is discouraged.

print.uicausal  

Description

Print function for object of class uicausal

Usage

## S3 method for class 'uicausal'

print(x, digits = 3, digitsci = digits, digitsui = digits, ...)

Arguments

x  An object of returned from ui.causal
digits  number of digits to be printed.
digitsci  number of digits to be printed in the confidence interval.
digitsui  number of digits to be printed in the uncertainty interval.
...  Additional arguments, use is discouraged.
print.uiols

Prints objects of class uiols

Description

Prints objects of class uiols

Usage

## S3 method for class 'uiols'
print(x, digits = 3, digitsci = digits, 
digitsui = digits, ...)

Arguments

  x               an objects returned from ui.ols
  digits          number of digits to be printed.
  digitsci        number of digits to be printed in the confidence interval.
  digitsui        number of digits to be printed in the uncertainty interval.
  ...             Additional arguments, use is discouraged.

print.uiprobit

Prints objects of class uiprobit

Description

Prints objects of class uiprobit

Usage

## S3 method for class 'uiprobit'
print(x, digits = 3, digitsci = digits, 
digitsui = digits, ...)

Arguments

  x               an objects returned from ui.probit
  digits          number of digits to be printed.
  digitsci        number of digits to be printed in the confidence interval.
  digitsui        number of digits to be printed in the uncertainty interval.
  ...             Additional arguments, use is discouraged.
profile.uiols

Plot of UI and CI

Description

Plot function for objects returned from `ui.causal`. Plots confidence intervals for different values of $\rho_0=\rho_1=\rho$.

Usage

```r
## S3 method for class 'uicausal'
profile(fitted, DR = TRUE, main = "", xlab = NULL, ylab = "", ...)
```

Arguments

- `fitted`: An object of class `uicausal`
- `DR`: If TRUE, plots both DR if FALSE OR.
- `main`: Main title, default is no title.
- `xlab`: Title for x-axis, default is `$\rho$`.
- `ylab`: Title for y-axis, default is the variable names.
- `...`: Additional arguments, use is discouraged.

profile.uiols

Plot of UI and CI

Description

Plot function for objects returned from `ui.ols`. Plots confidence intervals for different values of $\rho$ and the uncertainty interval.

Usage

```r
## S3 method for class 'uiols'
profile(fitted, plot.all = TRUE, which = NA, intercept = FALSE, xlab = NULL, ylab = NULL, ...)
```
profile.uiprobit

Arguments

fitted An object of class uilos
plot.all If TRUE, plots all covariates.
which Specify which variables should be plotted by either sending in their names in a vector or a vector with their numbers (1 intercept, 2 for the first covariate etc.).
intercept If TRUE, also plots the intercept.
xlab Title for x-axis, default is expression(rho).
ylab Title for y-axis, default is the variable names.
... Additional arguments, for instance margins.

profile.uiprobit  Plot of UI and CI

Description

Plot function for objects returned from ui.probit. Plots confidence intervals for different values of rho and the uncertainty interval.

Usage

## S3 method for class 'uiprobit'
profile(fitted, plot.all = TRUE, which = NA,
         intercept = FALSE, xlab = NULL, ylab = NULL, cex.lab = 2,
         mar = c(6, 6, 2, 2), ...)

Arguments

fitted An object of class uiprobit
plot.all If TRUE, plots all covariates.
which Specify which variables should be plotted by either sending in their names in a vector or a vector with their numbers (1 intercept, 2 for the first covariate etc.).
intercept If TRUE, also plots the intercept.
xlab Title for x-axis, default is expression(rho).
ylab Title for y-axis, default is the variable names.
cex.lab Size of labels.
mar Margin around panels in plot.
... Additional arguments, use is discouraged.
sandACT  

*Calculates standard error of Average causal effect on the treated*

**Description**

This is a support function for `ui.causal` and calculates standard error of Average causal effect on the treated for the doubly robust estimator.

**Usage**

```r
sandACT(deltasigma1, X, Xz, y, z, u, BetaOLSy0, phat, NaivEst, n1, n0, N, p, pz)
```

**Arguments**

- `deltasigma1`: Coefficients.
- `X`: Covariate matrix outcome.
- `y`: Outcome vector.
- `z`: Missingness indicator.
- `u`: Fitted values from propensity score regression.
- `BetaOLSy0`: Coefficients from non-treated regression.
- `phat`: Fitted propensity scores.
- `NaivEst`: Naiv estimates.
- `n1`: Number of treated.
- `n0`: Number of non-treated.
- `N`: Total number.
- `p`: Number of covariates outcome regression.
- `pz`: Number of covariates treatment regression.

sandImpACE  

*Calculates standard error of Average causal effect*

**Description**

This is a support function for `ui.causal` and calculates standard error of Average causal effect for the regression imputation estimator.

**Usage**

```r
sandImpACE(X, y, z, BetaOLSy0, BetaOLSy1, NaivEst, N, p)
```
Arguments

- **X**  Covariate matrix.
- **y**  Outcome vector.
- **z**  missingness indicator.
- **BetaOLSy0**  Coefficients from non-treated regression.
- **BetaOLSy1**  Coefficients from treated regression.
- **NaivEst**  Naiv estimates.
- **N**  Total number.
- **p**  Number of covariates outcome regression.

---

**sandImpACT**  
*Calculates standard error of Average causal effect on the treated*

---

Description

This is a support function for `ui.causal` and calculates standard error of Average causal effect on the treated for the regression imputation estimator.

Usage

```
sandImpACT(X, y, z, BetaOLSy0, NaivEst, n1, N, p)
```

Arguments

- **X**  Covariate matrix.
- **y**  Outcome vector.
- **z**  missingness indicator
- **BetaOLSy0**  Coefficients from non-treated regression
- **NaivEst**  Naiv estimates.
- **n1**  Number of treated.
- **N**  Total number.
- **p**  Number of covariates outcome regression.
### se.ols

**Calculation of se for OLS**

**Description**

This function calculates the se for UI based on OLS when we have MNAR data, for `ui.ols`.

**Usage**

```
se.ols(X, sigmaOLScor, u, gridrho)
```

**Arguments**

- `X`: Covariate matrix.
- `sigmaOLScor`: Output from `sigmaOLScor1`.
- `u`: Fitted values from `mis.model`.
- `gridrho`: Values of rho.

### sigmaOLScor0

**Correction of OLS sigma for causal effects**

**Description**

This function is a bias correction of the residual standard deviation under MNAR, for `ui.causal`.

**Usage**

```
sigmaOLScor0(X, sigmaOLS, n, p, u, gridrho)
```

**Arguments**

- `X`: Covariate matrix outcome.
- `sigmaOLS`: Residual sd from outcome regression.
- `n`: Number of complete cases.
- `p`: Number of covariates outcome regression.
- `u`: Fitted values from propensity score regression.
- `gridrho`: Values of rho.
**sigmaOLScor1**

*CORRECTION OF OLS SIGMA*

**Description**

This function is a bias correction of the residual standard deviation under MNAR, used by `ui.causal` and `ui.ols`.

**Usage**

```
sigmaOLScor1(X, sigmaOLS, n, p, u, gridrho)
```

**Arguments**

- **X**: Covariate matrix outcome.
- **sigmaOLS**: Residual sd from outcome regression.
- **n**: Number of complete cases.
- **p**: Number of covariates outcome regression.
- **u**: Fitted values from propensity score regression.
- **gridrho**: Values of rho.

---

**ui.causal**

*Uncertainty intervals for Average Causal Effects*

**Description**

This function allows you to derive uncertainty intervals for the average causal effect (ACE) or the average causal effect on the treated (ACT). The function uses a regression imputation estimator and a doubly robust estimator. The uncertainty intervals can be used as a sensitivity analysis to unconfoundedness. Note that rho=0 render the same results as assuming no unobserved confounding.

**Usage**

```
ui.causal(out.formula, treat.formula, data, rho = c(-0.3, 0.3),
          rho0 = NULL, rho1 = NULL, ACT = FALSE, sand = TRUE, gridn = 21,
          plot = TRUE, rho.plotrange = c(-0.5, 0.5), alpha = 0.05)
```
Arguments

out.formula  Formula for the outcome regression models

Arguments

treat.formula  Formula for the propensity score model (regression model for treatment assignment).
data  data.frame containing the variables in the formula.
rho  Pre-specified interval for \( \rho_0 \) and \( \rho_1 \).
rho0  Pre-specified value of \( \rho_0 \), if an interval it has to be the same as \( \rho_1 \).
rho1  Pre-specified value of \( \rho_1 \), if an interval it has to be the same as \( \rho_0 \).
ACT  If TRUE Average Causal effect of the Treated is calculated, if FALSE Average Causal effect is calculated. Default is FALSE.
sand  Specifies which estimator of the standard errors should be used for OR, see details.
griddn  Number of fixed points within the \( \rho \) interval for which \( \sigma_0 \) and \( \sigma_1 \) should be estimated.
plot  If TRUE the function runs slightly slower but you will be able to plot your results using plot.uicausal.
rho.plotrange  an interval larger than \( \rho \) for the plot using plot.uicausal.
alpha  Default 0.05 corresponding to a confidence level of 95 for CI and UI.

Details

In order to visualize the results, you can use plot.uicausal. Details about estimators can be found in Genbäck and de Luna (2018).

The standard errors are calculated with the following estimators:

DR ACE - simplified sandwich estimator

DR ACT - sandwich estimator

OR ACE - if sand=TRUE sandwich estimator (default and recommended), if sand=FALSE large sample variance

OR ACT - if sand=TRUE sandwich estimator (default and recommended), if sand=FALSE large sample variance

Value

A list containing:

call  The matched call

rho0  The rage of \( \rho_0 \) from which the ui is calculated

rho1  If ACT==FALSE,range of \( \rho_1 \) from which the ui is calculated

out.model0  Outcome regression model for non-treated.

treat.model  Regression model for treatment mechanism (propensity score).

sigma0  Consistent estimate of \( \sigma_0 \) for different values of \( \rho_0 \)
Consistent estimate of \( \sigma_1 \) for different values of \( \rho_1 \)

DR inference, confidence intervals for different pre-specified values of \( \rho \) for the OR estimator, uncertainty interval, coefficient estimates, confounding bias, identification interval, standard error etc.

OR inference, confidence intervals for different pre-specified values of \( \rho \) for the OR estimator, uncertainty interval, coefficient estimates, confounding bias, identification interval, standard error etc.

Author(s)
Minna Genbäck

References

Examples
```r
library(MASS)
n<-500
delta<-c(-0.3,0.65)
rhoc<0.3
X<-cbind(rep(1,n),rnorm(n))
x<-X[,1]
s0<-2
s1<-3
t<2
error<-mvrnorm(n, c(0,0,0), matrix(c(1,0.6,0.9,0.6,4,0.54,0.9,0.54,9), ncol=3))
zstar<-X%*%delta+error[,1]
z<- zstar>0
y1< ifelse(x<-1,0.2*x-0.1*x^2, ifelse(x<1,0.3*x, ifelse(x<3,0.4-0.1*x^2,-0.2-0.1*x)))+error[,3]
y0< ifelse(x<1.5, x-0.4*x^2, ifelse(x<2, -0.15-0.25*x+0.5*x^2, 1.85-0.25*x))+error[,2]
y<-y0
y[z==1]<y1[z==1]
data<-data.frame(y,z,x)

ui<-ui.causal(y~x, z~x, data=data, rho=c(0,0.3), ACT=FALSE)
ui
plot(ui)
profile(ui)
mean(y1-y0)

ui<-ui.causal(y~x, z~x, data=data, rho=c(0,0.3), ACT=TRUE)
ui
plot(ui)
mean(y1[z==1]-y0[z==1])
```
ui.ols  

Uncertainty intervals for OLS regression

Description

This function allows you to derive uncertainty intervals for OLS regression when there is missing data in the continuous outcome. The uncertainty intervals can be used as a sensitivity analysis to ignorability (missing at random). Note that rho=0 render the same results as a complete case analysis.

Usage

ui.ols(out.formula, mis.formula = NULL, data, rho = c(-0.3, 0.3), alpha = 0.05, gridn = 101)

Arguments

out.formula Formula for outcome regression.
mis.formula Formula for missingness mechanism. If NULL the same covariates as in the outcome regression will be used.
data data.frame containing the variables in the formula.
rho The limits of rho for which the uncertainty interval should be constructed.
alpha Default 0.05 corresponding to a confidence level of 95 for CI and UI.
gridn The number of distinct points within the interval rho at which confidence intervals should be constructed. Default is 101.

details

In order to visualize the results, you can use plot.uiols or profile.uiols.

Value

A list containing:
call The matched call
ci Confidence intervals for different values of rho
ui Uncertainty intervals
coeff Estimated coefficients (outcome regression) for different values of rho
out.model Outcome regression model when rho=0.
mis.model Regression model for missingness mechanism (selection).
rho The range of rho for which we want to construct an uncertainty interval
gridrho The values of rho for which bias and standard errors are derived
sigma Consistant estimate of sigma
se Standard error for different values of rho
ciols Confidence intervals from a complete case analysis
ident.bounds Bounds for the coefficient estimates.
ui.probit

Author(s)
Minna Genbäck

References

Examples
```r
library(MASS)
n<-500
delta<-c(0.5,0.3,0.1)
beta<-c(0.8,-0.2,0.3)
X<-cbind(rep(1,n),rnorm(n),rbinom(n,1,0.5))
x<-X[,1]
rho=0.4
error<-mvrnorm(n,c(0,0),matrix(c(1,rho*2,rho*2,4),2))
zstar<-X%*%delta+error[,1]
z<-as.numeric(zstar>0)
y<-X%*%beta+error[,2]
y[z==0]<-NA
data<-data.frame(y,x,z)
ui<-ui.ols(y~X1+X2,data=data,rho=c(-0.5,0.5))
ui
plot(ui)
```

ui.probit

*Uncertainty intervals for probit regression*

Description
This function allows you to derive uncertainty intervals for probit regression when there is missing data in the binary outcome. The uncertainty intervals can be used as a sensitivity analysis to ignorability (missing at random), and are derived by maximum likelihood. Note that rho=0 render the same results as a complete case analysis.

Usage
```r
ui.probit(out.formula, mis.formula = NULL, data, rho = c(-0.3, 0.3),
progress = TRUE, max.grid = 0.1, alpha = 0.05, method = "NR")
```

Arguments
- `out.formula`: Formula for outcome regression.
- `mis.formula`: Formula for missingness mechanism. If NULL the same covariates as in the outcome regression will be used.
data.frame containing the variables in the formula.

rho Vector containing the values of rho for which we want to fit the likelihood.

progress If TRUE prints out process time for each maximization of the likelihood.

max.grid Maximum distance between two elements in rho, if too wide there can difficulties with convergence of the maximum likelihood.

alpha Default 0.05 corresponding to a confidence level of 95 for CI and UI.

method Maximation method to be passed through maxLik

Details
In order to visualize the results, you can use plot.ui.probit or profile.ui.probit.

Value
A list containing:

coeff Estimated coefficients (outcome regression) for different values of rho.

crho The values of rho for which the likelihood is maximized.

cov Covariance matrix.

ci Confidence intervals for different values of rho.

cui Uncertainty intervals.

c.model Outcome regression model when rho=0.

c.model Regression model for missingness mechanism (selection).

cse Standard errors from outcome regression.

cvalue Value of maximum likelihood for different values of rho.

c y Outcome vector.

c z Indicator variable of observed outcome.

c.X.y Covariate matrix for outcome regression.

c.X.z Covariate matrix for missingness mechanism (selection regression model).

c.max.info Information about the maximization procedure. Includes whether it converged, message, method and number of iterations.

Author(s)
Minna Genbäck

References
Examples

```r
library(MASS)

n<-500

delta<-c(0.5,0.6,0.1,-1,1)
beta<-c(-0.3,-0.5,0,-0.4,-0.3)

X<-cbind(rep(1,n),rnorm(n),runif(n),rbinom(n,2,0.5),rbinom(n,1,0.5))
x<-X[,1]
rho<-0.4
error<-mvrnorm(n,c(0,0),matrix(c(1,rho,rho,1),2))

zstar<-X%*%delta+error[,1]
z<-as.numeric(zstar>0)

ystar<-X%*%beta+error[,2]
y<-as.integer(ystar>0)
y[z==0]<-NA
data=data.frame(y=y,x1=x[,1],x2=x[,2],x3=x[,3],x4=x[,4])

m<-ui.probit(y~x1+x2+x3+x4,data=data,rho=c(0,0.5))
m
plot(m)
profile(m)
```
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