Package ‘ui’

November 11, 2019

Title Uncertainty Intervals and Sensitivity Analysis for Missing Data
Version 0.1.1
Author Minna Genbaeck [aut, cre],
Maintainer Minna Genbaeck <minna.genback@umu.se>
Depends R (>= 3.5)
Imports Matrix, maxLik, mvtnorm, numDeriv, graphics, stats
Suggests MASS
Encoding UTF-8
LazyData true
License GPL-2
RoxygenNote 6.1.1
NeedsCompilation no
Repository CRAN
Date/Publication 2019-11-11 13:10:02 UTC

R topics documented:

gridrho.f ......................................................... 2
grr .......................................................... 3
hess ......................................................... 3
interv.p ...................................................... 4
lambda0 .................................................. 4
lambda1 .................................................. 4
LogL.probit ............................................... 5
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

```r
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

```r
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**  
*Print interval in parantesis*

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

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

**Arguments**  
- \( v \): Lower and upper bounds.
- \( \text{digits} \): Number of decimals.

---

**lambda0**  
*Inverse Mills ratio*

**Description**  
This function allows you to calculate the inverse Mills ratio.

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

**Arguments**  
- \( x \): Vector

---

**lambda1**  
*Inverse Mills ratio*

**Description**  
This function allows you to calculate the inverse Mills ratio.

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

**Arguments**  
- \( x \): Vector
**LogL.probit**

*Loglikelihood used by ui.probit*

---

**Description**

This function derives the Loglikelihood for **ui.probit**.

**Usage**

\[
\text{LogL.probit}(\text{par}, \rho, X.z = X.z, X.y = X.y, y = y, z = z)
\]

**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**

*Loglikelihood used in sandwich estimator of average causal effect on the treated for DR*

---

**Description**

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

**Usage**

\[
\text{Logl.sandACT}(x, X, z)
\]

**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 \texttt{ui.ols}. Plots confidence intervals, coefficients and significans assuming ignorability and the uncertainty interval under non-ignorability.

Usage

\begin{verbatim}
## S3 method for class 'uiols'
plot(x, plot.all = TRUE, which = NA,
intercept = FALSE, ylab = NULL, col = c("black", "red"), ...)
\end{verbatim}

Arguments

\begin{itemize}
\item \texttt{x} An object of class \texttt{uiols}
\item \texttt{plot.all} If \texttt{TRUE}, plots all covariates.
\item \texttt{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.).
\item \texttt{intercept} If \texttt{TRUE}, also plots the intercept.
\item \texttt{ylab} Vector of names for the y-axis, default is the variable names.
\item \texttt{col} Vector containing the color of confidence intervals (default black) and uncertainty intervals (default red).
\item \texttt{...} Additional arguments, use is discouraged.
\end{itemize}

plot.uioprobit  

Plot of UI and CI

Description
Plot function for objects returned from \texttt{ui.probit}. Plots confidence intervals, coefficients and significans assuming ignorability and the uncertainty interval under non-ignorability.

Usage

\begin{verbatim}
## S3 method for class 'uioprobit'
plot(x, plot.all = TRUE, which = NA,
intercept = FALSE, ylab = NULL, col = c("black", "red"), ...)
\end{verbatim}
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**

*Print function for object of class uicausal*

---

**Description**

Print function for object of class uicausal

**Usage**

```r
## 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

Print 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

Print 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

Description

Plot function for objects returned from \texttt{ui.causal}. Plots confidence intervals for different values of \( \rho_0 = \rho_1 = \rho \).

Usage

\begin{verbatim}
## S3 method for class 'uicausal'
profile(fitted, DR = TRUE, main = "", xlab = NULL, ylab = "", ...
\end{verbatim}

Arguments

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

profile.uiols

Description

Plot function for objects returned from \texttt{ui.ols}. Plots confidence intervals for different values of \( \rho \) and the uncertainty interval.

Usage

\begin{verbatim}
## S3 method for class 'uiols'
profile(fitted, plot.all = TRUE, which = NA, intercept = FALSE, xlab = NULL, ylab = NULL, ...
\end{verbatim}
Profile of UI and CI

## 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.

### Description
Plot function for objects returned from uiprobit. Plots confidence intervals for different values of rho and the uncertainty interval.

### Usage
```r
## 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**

```
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**

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

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.

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**
```r
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**
```r
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**

```r
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**

```r
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.
- **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.
- **gridn**: 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.ui.causal`.
- **rho.plotrange**: an interval larger than rho for the plot using `plot.ui.causal`.
- **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.ui.causal`. 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.
- **out.model1**: Outcome regression model for treated.
- **treat.model**: Regression model for treatment mechanism (propensity score).
- **sigma0**: Consistent estimate of sigma0 for different values of rho0
Consistent estimate of sigma1 for different values of rho1

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
library(MASS)
 n<-500
delta<-c(-0.3,0.65)
rhoc<-.3
X<-cbind(rep(1,n),rnorm(n))
x<-X[,1]
s0<-2
s1<-3
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< 1.0,0.3*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**

```r
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
- `coef`: 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.bound`: Bounds for the coefficient estimates.
Author(s)
Minna Genbäck

References

Examples
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
delta+0)
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 $\rho=0$ renders the same results as a complete case analysis.

Usage
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.

data

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

rho

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

progress

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

max.grid

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

alpha

method Maximization method to be passed through maxLik

method

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.

coeff

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

rho

vcov Covariance matrix.

vcov

ci Confidence intervals for different values of rho.

ci

ui Uncertainty intervals.

ui

out.model Outcome regression model when rho=0.

out.model

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

mis.model

se Standard errors from outcome regression.

se

value Value of maximum likelihood for different values of rho.

value

y Outcome vector.

y

z Indicator variable of observed outcome.

z

X.y Covariate matrix for outcome regression.

X.y

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

X.z

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

max.info

Author(s)

Minna Genbäck

References

Examples

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)
Index

gridrho.f, 2
grg, 3

hess, 3

interv.p, 4

lambda0, 4
lambda1, 4
LogL.probit, 5
Logl.sandACT, 5

ML.probit, 6

plot.uicausal, 6, 16
plot.uiols, 7, 18
plot.uioprobit, 7, 20
print.uicausal, 8
print.uiols, 9
print.uioprobit, 9
profile.uicausal, 10
profile.uiols, 10, 18
profile.uioprobit, 11, 20

sandACT, 12
sandImpACE, 12
sandImpACT, 13
se.ols, 14
sigmaOLScor0, 14
sigmaOLScor1, 15

ui.causal, 2, 5, 6, 8, 10, 12–15, 15
ui.ols, 7, 9, 10, 14, 15, 18
ui.probit, 3, 5–7, 9, 11, 19