

# Package ‘ATE’

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**Type** Package

**Title** Inference for Average Treatment Effects using Covariate  
Balancing

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**Description** Nonparametric estimation and inference for average treatment effects based on covariate balancing.

**License** GPL (>= 2)

**NeedsCompilation** no

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ATE-package

*Nonparametric efficient inference of the average treatment effects for observational data*

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**Description**

This package provides a user-friendly interface for nonparametric efficient inference of average treatment effects for observational data. The package provides point estimates for average treatment effects, average treatment effect on the treated and can also handle the case of multiple treatments. The package also allows inference by consistent variance estimates. The point estimates for the treatment effect and variance estimates are described in Chan et al. (2015).

**Details**

Package: ATE  
Type: Package  
Version: 0.2.0  
Date: 2015-02-16  
License: GPL (>= 2)

The package includes the following functions:

[ATE](#): Estimate the average treatment effect  
[summary.ATE](#): summary method for class "ATE"  
[plot.ATE](#): Plot function for class "RIPW"  
[cr.rho](#): The Cressie and Read class of objective functions

**Author(s)**

Asad Haris, Gary Chan

Maintainer: Asad Haris <aharis@uw.edu>

**References**

Chan, K. C. G. and Yam, S. C. P. and Zhang, Z. (2015). "Globally Efficient Nonparametric Inference of Average Treatment Effects by Empirical Balancing Calibration Weighting", under review.

**See Also**

[ATE](#), [summary.ATE](#), [plot.ATE](#), [cr.rho](#)

**Description**

The main function for estimating the average treatment effect or the average treatment effect on the treated. This function creates an ATE object which can be used as inputs for generic S3 plot or summary functions. This function uses a covariate balancing method which creates weights for each subject, without a need to specific a propensity score or an outcome regression model. The main function depends on a Newton-Raphson algorithm with backtracking. For details of the estimator see Chan et al. (2015).

**Usage**

```
ATE (Y, Ti, X, theta = 0, ATT = FALSE,
     verbose = FALSE, max.iter = 100, tol = 1e-10,
     initial.values = NULL,
     backtrack = TRUE, backtrack.alpha = 0.3,
     backtrack.beta = 0.5, ...)
```

**Arguments**

Y	The response vector of length $n$ . This has to be a numeric vector.
Ti	The vector of treatment assignments of length $n$ . Must be coded as $\{0, 1, \dots, 0, 1, \dots\}$ and must be binary vector when ATT=TRUE.
X	A $n \times p$ -matrix of covariates $X$ to be matched. This matrix does not need to include an intercept.
theta	A real scalar parameter for the Cressie-Read family of objective functions. The default is $\theta = 0$ (exponential tilting). Other popular examples are $\theta = -1$ (exponential tilting) and $\theta = 1$ (quadratic loss).
ATT	A logical value indicating whether to estimate the treatment effect on the treated.
verbose	A logical value indicating whether to print the progress of the function. FALSE by default.
max.iter	The maximum number of iterations for the Newton-Raphson methods. For most problems (e.g. with well-behaved functions $\rho$ and $u$ ) convergence of Newton-Raphson should be fairly quick.
tol	The absolute tolerance used to determine a stopping criteria for the Newton-Raphson algorithm.
initial.values	A numeric vector or matrix of possible initial values for the Newton-Raphson algorithm. Must be a $J \times K$ matrix where $J$ is the number of treatment arms. For ATT = TRUE this must be a $K$ -vector.
backtrack	A logical value indicating whether to use backtracking in the Newton-Raphson algorithm.

<code>backtrack.alpha</code>	A scalar parameter for backtracking with $\alpha \in (0, 0.5)$ .
<code>backtrack.beta</code>	A scalar parameter for backtracking with $\beta \in (0, 1)$ .
<code>...</code>	Additional arguments.

**Value**

The function reruns an object of type "ATE", a list with the following elements

<code>est</code>	The vector of point estimates for the average treatment effect. For a binary treatment it also contains the average difference of treatment effects.
<code>vcov</code>	The estimated variance covariance matrix for the estimates of the treatment effects for each treatment group.
<code>lam</code>	The resulting solution of the main optimization problems, $\hat{\lambda}$ , as described in Chan et al.(2015). In the case of a simple, binary treatment study, the object has <code>lam.p</code> and <code>lam.q</code> and when <code>ATT = TRUE</code> , we only have <code>lam.q</code> . For a multiple treatment study design we have <code>lam.mat</code> , a matrix with each $\hat{\lambda}$ corresponding to each treatment arm.
<code>weights</code>	The weights obtained by the balancing covariate method for each treatment group. In the case of <code>ATT = TRUE</code> , we only have weights for the untreated. For binary treatment the list would contain either <code>weights.q</code> or <code>weights.p</code> or both. For multiple treatment effect the list contains a $J \times n$ matrix <code>weights.mat</code> .
<code>gp</code>	A string specifying the type of study design. For binary treatment effect with <code>ATT = FALSE</code> is denoted by group "simple". With <code>ATT = TRUE</code> we have "ATT" and finally "MT" is for multiple treatment arms.
<code>conv</code>	A logical value indicating convergence of Newton-Raphson algorithm.
<code>X, Y, Ti</code>	The data which was used for estimation.
<code>rho, rho1, rho2</code>	The Cressie-Read functions $\rho$ used for estimation along with the first and second derivatives.
<code>FUNu</code>	A function that append a vector of constants to the covariates. Required to make sure that the weights sum to 1 in each group.
<code>J</code>	A scalar indicating the number of treatment arms.
<code>K</code>	A scalar indicating the one plus the dimension of the range space of X.
<code>call</code>	The matched call.

**Author(s)**

Asad Haris, Gary Chan.

**References**

- Chan, K. C. G. and Yam, S. C. P. and Zhang, Z. (2015). "Globally Efficient Nonparametric Inference of Average Treatment Effects by Empirical Balancing Calibration Weighting", under revision.
- Haris, Asad and Chan, K. C. G. (2015). "ATE: An R package for Nonparametric Inference of Average Treatment Effects ", under revision

**See Also**

[summary.ATE](#), [plot.ATE](#)

**Examples**

```

library(ATE)
#binary treatment

set.seed(25)
n <- 200
Z <- matrix(rnorm(4*n),ncol=4,nrow=n)
prop <- 1 / (1 + exp(Z[,1] - 0.5 * Z[,2] + 0.25*Z[,3] + 0.1 * Z[,4]))
treat <- rbinom(n, 1, prop)
Y <- 200 + 10*treat+ (1.5*treat-0.5)*(27.4*Z[,1] + 13.7*Z[,2] +
  13.7*Z[,3] + 13.7*Z[,4]) + rnorm(n)
X <- cbind(exp(Z[,1])/2,Z[,2]/(1+exp(Z[,1])),
  (Z[,1]*Z[,3]/25+0.6)^3, (Z[,2]+Z[,4]+20)^2)

#estimation of average treatment effects (ATE)
fit1<-ATE(Y,treat,X)
summary(fit1)
#plot(fit1)

#estimation of average treatment effects on treated (ATT)
fit2<-ATE(Y,treat,X,ATT=TRUE)
summary(fit2)
#plot(fit2)

#three treatment groups
set.seed(25)
n <- 200
Z <- matrix(rnorm(4*n),ncol=4,nrow=n)
prop1 <- 1 / (1 + exp(1+Z[,1] - 0.5 * Z[,2] + 0.25*Z[,3] + 0.1 * Z[,4]))
prop2 <- 1 / (1 + exp(Z[,1] - 0.5 * Z[,2] + 0.25*Z[,3] + 0.1 * Z[,4]))

U <-runif(n)
treat <- numeric(n)
treat[U>(1-prop2)]=2
treat[U<(1-prop2)& U>(prop2-prop1)]=1

Y <- 210 + 10*treat +(27.4*Z[,1] + 13.7*Z[,2] +
  13.7*Z[,3] + 13.7*Z[,4]) + rnorm(n)
X <- cbind(exp(Z[,1])/2,Z[,2]/(1+exp(Z[,1])),
  (Z[,1]*Z[,3]/25+0.6)^3, (Z[,2]+Z[,4]+20)^2)

fit3<-ATE(Y,treat,X)
summary(fit3)
#plot(fit3)

```

---

Cressie and Read objective functions

*Cressie and Read objective functions*

---

### Description

Cressie and Read class of objective functions parameterized by a scalar  $\theta$ .

### Usage

```
cr.rho(v, theta)
d.cr.rho(v, theta)
dd.cr.rho(v, theta)
```

### Arguments

v	A vector of points at which the function will be evaluated at.
theta	A user defined value for $\theta$ . This must be a scalar. See details.

### Details

This set of functions can be used for the main [ATE](#) function for the arguments theta. The class of functions, are defined by (see Cressie and Read (1984))

$$\rho(v) = -(1 + \theta v)^{(\theta+1)/\theta} / (\theta + 1),$$

where  $\theta$  is scalar. The expression is interpreted as limits for  $\theta = 0$  or  $\theta = -1$  (see Newey and Smith (2004)).

### Value

The output of the real values function for a given parameter  $\theta$ .

### Author(s)

Asad Haris, Gary Chan

### References

- Chan, K. C. G. and Yam, S. C. P. and Zhang, Z. (2015). "Globally Efficient Nonparametric Inference of Average Treatment Effects by Emperical Balancing Calibration Weighting", under revision.
- Chan, K. C. G. and Yam, S. C. P. (2014). "Oracle, Multiple Robust and Multipurpose Calibration in a Missing Response Problem". *Statistical Science* 29 (3): 380-386.
- Cressie, N. and Read, T. R. C. (1984). "Multinomial goodness-of-fit tests". *J. Roy. Statist. Soc. Ser. B* 46 440-464.
- Newey, W. K. and Smith, R. J. (2004). Higher order properties of GMM and generalized empirical likelihood estimators. *Econometrica* 72 219-255.

**Examples**

```
#Cressie-Read Family example
data("nsw")
Y<-nsw$re78[301:500]
X<-nsw[301:500,-c(1,9)]
treat<-nsw$treat[301:500]

#Exponential tilting
ATE(Y,treat,X,theta = 0)

#Empirical likelihood
ATE(Y,treat,X,theta = -1)

#Quadratic loss
ATE(Y,treat,X, theta = 1)
```

---

nhanes_bmi	<i>Subsample of National Health and Nutritional Examination Survey for School Children</i>
------------	--

---

**Description**

This data is a limited subset of the 2007-2008 National Health and Nutrition Examination Survey (NHANES), for studying whether participation of school meal programs lead to an increase in body mass index (BMI).

**Usage**

```
data(nhanes_bmi)
```

**Format**

A data frame with 2330 observations on the following 13 variables.

BMI The response variable. Body mass index.  
School\_meal Participation of school meal programs (1: Yes, 0: No)  
age Age of Child  
ChildSex Gender of the Child (1: Male, 0: Female)  
black Black Race (1: Black, 0: otherwise)  
mexam Hispanic Race (1: Hispanic: 0 otherwise)  
pir200\_plus Family above 200% of the federal poverty level (1: Yes, 0: No)  
WIC Participation in Special Supplemental Nutrition program (1: Yes, 0: No)  
Food\_Stamp Participation in foold stamp program (1: Yes, 0: No)  
fsdchbi Childhood food security (1: Secure, 0: insecure)  
AnyIns Any insurance (1: Yes, 0: No)  
RefSex Gender of the adult respondent (1: Male, 0: Female)  
RefAge Age of the adult respondent

**Source**

Data adapted from the 2007-2008 National Health and Nutrition Examination Survey (NHANES).  
<http://www.cdc.gov/nchs/nhanes.htm>

**Examples**

```
library(ATE)
data("nhanes_bmi")

Y<-nhanes_bmi[1:500,1]
treat<-nhanes_bmi[1:500,2]
X<-nhanes_bmi[1:500,-c(1,2)]

fit1<- ATE(Y,treat,X)
fit1
summary(fit1)
#plot(fit1)
```

---

nsw

*Lalonde subsample of the National Supported Work Demonstration Data (NSW)*

---

**Description**

This data was collected to evaluate the National Supported Work (NSW) Demonstration project in Lalonde (1986).

**Usage**

```
data(nsw)
```

**Format**

A data frame with 722 observations on the following 9 variables.

treat Vector indicating treatment assignment

age Age of subject

ed Years of schooling

black Black race (1 if Black, 0 otherwise)

hisp Hispanic race (1 if Hispanic, 0 otherwise)

married Marital status (1 if married, 0 otherwise)

nodeg College degree (1 if no college degree, 0 otherwise)

re75 Earnings in 1975

re78 The response variable. Earnings in 1978

## Details

This data set was obtained from "NSW Data Files" and is a subset of the data collected for the original National Supported Work Evaluation Study (see source below). A portion of the summary of the study is quoted below. This quote was obtained from the website of the "Interuniversity Consortium for Political and Social Research" (see source below).

"This study is an evaluation of the National Supported Work Demonstration project, a transitional, subsidized work experience program for four target groups of people with longstanding employment problems: ex-offenders, former drug addicts, women who were long-term recipients of welfare benefits, and school dropouts, many with criminal records. The program provided up to 12-18 months of employment to about 10,000 individuals at 15 locations across the country for four years. In ten of these sites – Atlanta, Chicago, Hartford, Jersey City, Newark, New York, Philadelphia, Oakland, San Francisco, and Wisconsin, 6,600 eligible applicants were randomly assigned either to experimental groups (offered a job in supported work) or to control groups, and an evaluation was conducted on the effects of the Supported Work Program. "

## Source

"NSW Data Files" from Rajeev Dehejia's website. URL: <http://users.nber.org/~rdehejia/data/nswdata2.html>

"National Supported Work Evaluation Study, 1975-1979: Public Use Files." from the Interuniversity Consortium for Political and Social Research. URL: <http://www.icpsr.umich.edu/icpsrweb/ICPSR/studies/7865>

## References

Lalonde, R. (1986). "Evaluating the Econometric Evaluations of Training Programs," American Economic Review, 76(4), 604-620.

Dehejia R. and Wahba S. (1999). "Causal Effects in Non-Experimental Studies: Re-Evaluating the Evaluation of Training Programs," JASA 94 (448), 1053-1062.

## Examples

```
library(ATE)
#NSW Data example
data("nsw")

Y<- nsw$re78
X<- nsw[,c(-1,-9)]
Ti<- nsw$treat

fit1<- ATE(Y,Ti,X)
fit1
summary(fit1)
#plot(fit1)
```

---

plot.ATE

*Plots of empirical and weighted CDF for covariates*


---

**Description**

Plot function for class "ATE"

**Usage**

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

**Arguments**

x                    An object of type "ATE".  
 ...                  Further arguments passed to or from the function.

**Details**

This function plots the empirical CDF and weighted empirical CDF for each covariate to demonstrate the effect of covariate balancing and for graphical diagnostics. In observational studies with confounding, the covariate distributions are different for each treatment arms. Comparisons of unweighted empirical CDF would demonstrate this difference. The balancing weights constructed by balancing moments of covariate distributions, and the weighted CDF would show an improved balance.

**Author(s)**

Asad Haris, Gary Chan

**See Also**

[ATE](#)

**Examples**

```
library(ATE)
#binary treatment

set.seed(25)
n <- 200
Z <- matrix(rnorm(4*n), ncol=4, nrow=n)
prop <- 1 / (1 + exp(Z[,1] - 0.5 * Z[,2] + 0.25*Z[,3] + 0.1 * Z[,4]))
treat <- rbinom(n, 1, prop)
Y <- 200 + 10*treat+ (1.5*treat-0.5)*(27.4*Z[,1] + 13.7*Z[,2] +
  13.7*Z[,3] + 13.7*Z[,4]) + rnorm(n)
X <- cbind(exp(Z[,1])/2,Z[,2]/(1+exp(Z[,1])),
  (Z[,1]*Z[,3]/25+0.6)^3, (Z[,2]+Z[,4]+20)^2)
```

```

#estimation of average treatment effects (ATE)
fit1<-ATE(Y,treat,X)
summary(fit1)
#####UNCOMMENT THE NEXT LINE#####
#plot(fit1)

#estimation of average treatment effects on treated (ATT)
fit2<-ATE(Y,treat,X,ATT=TRUE)
summary(fit2)
#####UNCOMMENT THE NEXT LINE#####
#plot(fit2)

#three treatment groups
set.seed(25)
n <- 200
Z <- matrix(rnorm(4*n),ncol=4,nrow=n)
prop1 <- 1 / (1 + exp(1+Z[,1] - 0.5 * Z[,2] + 0.25*Z[,3] + 0.1 * Z[,4]))
prop2 <- 1 / (1 + exp(Z[,1] - 0.5 * Z[,2] + 0.25*Z[,3] + 0.1 * Z[,4]))

U <-runif(n)
treat <- numeric(n)
treat[U>(1-prop2)]=2
treat[U<(1-prop2)& U>(prop2-prop1)]=1

Y <- 210 + 10*treat +(27.4*Z[,1] + 13.7*Z[,2] +
13.7*Z[,3] + 13.7*Z[,4]) + rnorm(n)
X <- cbind(exp(Z[,1])/2,Z[,2]/(1+exp(Z[,1])),
(Z[,1]*Z[,3]/25+0.6)^3,(Z[,2]+Z[,4]+20)^2)

fit3<-ATE(Y,treat,X)
summary(fit3)
#####UNCOMMENT THE NEXT LINE#####
#plot(fit3)

```

---

summary.ATE

*Summarizing output of study.*


---

## Description

summary method for class "ATE"

## Usage

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

```
## S3 method for class 'summary.ATE'
print(x, ...)
```

### Arguments

object	An object of class "ATE", usually a result of a call to <a href="#">ATE</a> .
x	An object of class "summary.ATE", usually a result of a call to <a href="#">summary.ATE</a> .
...	Further arguments passed to or from methods.

### Details

`print.summary.ATE` prints a simplified output similar to [print.summary.lm](#). The resulting table provides the point estimates, estimated standard errors, 95% Wald confidence intervals, the Z-statistic and the P-values for a Z-test.

### Value

The function `summary.ATE` returns a list with the following components

Estimate	A matrix with point estimates along with standard errors, confidence intervals etc. This is the matrix users see with the <code>print.summary.RIPW</code> function.
vcov	The variance-covariance matrix of the point estimates.
Conv	The convergence result of the object.
weights	The weights for each subject in each treatment arm. These are same as the weight component of the "RIPW" object.
call	The call passed on as an argument of the function which is equivalent to <code>object\$call</code> .

### Author(s)

Asad Haris, Gary Chan

### See Also

[ATE](#)

### Examples

```
library(ATE)
#binary treatment

set.seed(25)
n <- 200
Z <- matrix(rnorm(4*n), ncol=4, nrow=n)
prop <- 1 / (1 + exp(Z[,1] - 0.5 * Z[,2] + 0.25*Z[,3] + 0.1 * Z[,4]))
treat <- rbinom(n, 1, prop)
Y <- 200 + 10*treat + (1.5*treat-0.5)*(27.4*Z[,1] + 13.7*Z[,2] +
  13.7*Z[,3] + 13.7*Z[,4]) + rnorm(n)
X <- cbind(exp(Z[,1])/2, Z[,2]/(1+exp(Z[,1])),
```

```

(Z[,1]*Z[,3]/25+0.6)^3, (Z[,2]+Z[,4]+20)^2)

#estimation of average treatment effects (ATE)
fit1<-ATE(Y,treat,X)
summary(fit1)
#plot(fit1)

#estimation of average treatment effects on treated (ATT)
fit2<-ATE(Y,treat,X,ATT=TRUE)
summary(fit2)
#plot(fit2)

#three treatment groups
set.seed(25)
n <- 200
Z <- matrix(rnorm(4*n),ncol=4,nrow=n)
prop1 <- 1 / (1 + exp(1+Z[,1] - 0.5 * Z[,2] + 0.25*Z[,3] + 0.1 * Z[,4]))
prop2 <- 1 / (1 + exp(Z[,1] - 0.5 * Z[,2] + 0.25*Z[,3] + 0.1 * Z[,4]))

U <-runif(n)
treat <- numeric(n)
treat[U>(1-prop2)]=2
treat[U<(1-prop2)& U>(prop2-prop1)]=1

Y <- 210 + 10*treat +(27.4*Z[,1] + 13.7*Z[,2] +
13.7*Z[,3] + 13.7*Z[,4]) + rnorm(n)
X <- cbind(exp(Z[,1])/2,Z[,2]/(1+exp(Z[,1])),
(Z[,1]*Z[,3]/25+0.6)^3, (Z[,2]+Z[,4]+20)^2)

fit3<-ATE(Y,treat,X)
summary(fit3)
#plot(fit3)

```

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