

Package ‘twangMediation’

November 16, 2025

Title Twang Causal Mediation Modeling via Weighting

Version 1.2.1

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Description Provides functions for estimating natural direct and indirect effects for mediation analysis. It uses weighting where the weights are functions of estimates of the probability of exposure or treatment assignment (Hong, G (2010). <https://cepa.stanford.edu/sites/default/files/workshops/GH_JSM%20Proceedings%202010.pdf> Huber, M. (2014). <[doi:10.1002/jae.2341](https://doi.org/10.1002/jae.2341)>). Estimation of probabilities can use generalized boosting or logistic regression. Additional functions provide diagnostics of the model fit and weights. The vignette provides details and examples.

Depends R (>= 2.10)

Imports twang, gbm (>= 1.5-3), gridExtra, graphics, stats, lattice,
latticeExtra, survey

Suggests R.rsp, testthat (>= 3.0.0)

VignetteBuilder R.rsp

License GPL-3

Encoding UTF-8

RoxygenNote 7.3.2

LazyData true

Config/testthat/edition 3

NeedsCompilation no

Repository CRAN

Date/Publication 2025-11-16 08:20:02 UTC

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twangMediation-package

twangMediation: Twang Causal Mediation Modeling via Weighting

Description

Provides functions for estimating natural direct and indirect effects for mediation analysis. It uses weighting where the weights are functions of estimates of the probability of exposure or treatment assignment (Hong, G (2010). https://cepa.stanford.edu/sites/default/files/workshops/GH_JSM%20Proceedings%202010.pdf Huber, M. (2014). [doi:10.1002/jae.2341](https://doi.org/10.1002/jae.2341)). Estimation of probabilities can use generalized boosting or logistic regression. Additional functions provide diagnostics of the model fit and weights. The vignette provides details and examples.

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bal.table.mediation *Compute the balance table for mediation object*

Description

Compute the balance table for mediation object

Usage

```
bal.table.mediation(x, digits = 3, ...)
```

Arguments

x	A mediation object
digits	Number of digits to round to. Default: 3
...	Additional arguments.

Value

res	tables detailing covariate balance across exposure groups both before and after weighting
-----	-------------------------------------------------------------------------------------------

See Also

[print.bal.table.mediation, wgtmed](#)

Examples

```
data("tMdat")

## tMdat is small simulated data set included in twangMediation for
## demonstrating the functions. See ?tMdat for details

fit.es.max <- wgtmed(M ~ w1 + w2 + w3,
  data = tMdat,
  a_treatment = "A",
  y_outcome = "Y",
  total_effect_wts = tMdat$te.wgt,
  method = "logistic"
)

bal.table.mediation(fit.es.max)
```

calculate_effects	<i>Calculate the actual effects</i>
-------------------	-------------------------------------

Description

Calculate the actual effects

Usage

```
calculate_effects(w_11, w_00, w_10, w_01, y_outcome, sampw = NULL)
```

Arguments

w_11	The Y(1, M(1)) weights
w_00	The Y(0, M(0)) weights
w_10	The Y(1, M(0)) weights
w_01	The Y(0, M(1)) weights
y_outcome	The Y variable
sampw	Sampling weights, set to NULL by default.

Value

res	The actual effects
-----	--------------------

See Also

[wgtmed](#)

check_missing	<i>Check vector for NA or NAN values</i>
---------------	------------------------------------------

Description

check_missing raises an error if the data contains NA or NAN values.

Usage

```
check_missing(x)
```

Arguments

x	numeric The data set to check for NA or NAN values.
---	-----------------------------------------------------

Value

Indicator of the existence of NA or NAN values

desc.effects	<i>Describe the effects</i>
--------------	-----------------------------

Description

Describe the effects, and calculate standard errors and confidence intervals

Usage

```
desc.effects(x, ...)
```

Arguments

x	An object
...	list, optional Additional arguments.

Value

Effects, standard errors and confidence intervals of an object

See Also

[desc.effects.mediation](#), [wgtmed](#)

Examples

```
data("tMdat")

## tMdat is small simulated data set included in twangMediation for
## demonstrating the functions. See ?tMdat for details

fit.es.max <- wgtmed(M ~ w1 + w2 + w3,
  data = tMdat,
  a_treatment = "A",
  y_outcome = "Y",
  total_effect_wts = tMdat$te.wgt,
  method = "ps",
  ps_n.trees=1500,
  ps_shrinkage=0.01,
  ps_stop.method=c("es.max")
)

desc.effects(fit.es.max)
```

```
desc.effects.mediation
```

Describe the effects from a mediation object

Description

Describe the effects, and calculate standard errors and confidence intervals from a mediation object

Usage

```
## S3 method for class 'mediation'
desc.effects(x, y_outcome = NULL, ...)
```

Arguments

x	A mediation object
y_outcome	The outcome; if NULL, then Y must have been provided to the original mediation function.
...	Additional arguments..

Value

results	effects, standard errors, and confidence intervals of a mediation object
---------	--------------------------------------------------------------------------

See Also

[desc.effects](#), [wgtmed](#)

Examples

```
data("tMdat")

## tMdat is small simulated data set included in twangMediation for
## demonstrating the functions. See ?tMdat for details

fit.es.max <- wgtmed(M ~ w1 + w2 + w3,
  data = tMdat,
  a_treatment = "A",
  y_outcome = "Y",
  total_effect_wts = tMdat$te.wgt,
  method = "ps",
  ps_n.trees=1500,
  ps_shrinkage=0.01,
  ps_stop.method=c("es.max")
)

desc.effects(fit.es.max)
```

dx.wts.mediation *Compute diagnostics assessing covariates balance*

Description

dx.wts.mediation takes a ps object or a set of propensity scores and computes diagnostics assessing covariates balance.

Usage

```
dx.wts.mediation(
  x,
  data,
  estimand,
  vars = NULL,
  treat.var,
  x.as.weights = TRUE,
  sampw = NULL,
  perm.test.iters = 0
)
```

Arguments

x	A data frame, matrix, or vector of propensity score weights or a ps object. x can also be a data frame, matrix, or vector of propensity scores if x.as.weights=FALSE.
data	A data frame.
estimand	The estimand of interest: either "ATT" or "ATE".
vars	A vector of character strings naming variables in data on which to assess balance.
treat.var	A character string indicating which variable in data contains the 0/1 treatment group indicator.
x.as.weights	TRUE or FALSE indicating whether x specifies propensity score weights or propensity scores. Ignored if x is a ps object. Default: TRUE.
sampw	Optional sampling weights. If x is a ps object, then the sampling weights should have been passed to ps and not specified here. dx.wts.mediation will issue a warning if x is a ps object and sampw is also specified.
perm.test.iters	A non-negative integer giving the number of iterations of the permutation test for the KS statistic. If perm.test.iters=0, then the function returns an analytic approximation to the p-value. This argument is ignored if x is a ps object. Setting perm.test.iters=200 will yield precision to within 3% if the true p-value is 0.05. Use perm.test.iters=500 to be within 2%.

Details

Creates a balance table that compares unweighted and weighted means and standard deviations, computes effect sizes, and KS statistics to assess the ability of the propensity scores to balance the treatment and control groups.

Value

Returns a list containing

- `treat` The vector of 0/1 treatment assignment indicators.

See Also

[wgtmed](#), [bal.table.mediation](#), [print.mediation](#), [summary.mediation](#)

Examples

```
data("tMdat")

## tMdat is small simulated data set included in twangMediation for
## demonstrating the functions. See ?tMdat for details

fit.es.max <- wgtmed(M ~ w1 + w2 + w3,
                    data = tMdat,
                    a_treatment = "A",
                    y_outcome = "Y",
                    total_effect_wts = tMdat$te.wgt,
                    method = "ps",
                    ps_n.trees=1500,
                    ps_shrinkage=0.01,
                    ps_stop.method=c("es.max")
                    )

## dx.wts.mediation is used internally by bal.table.mediation,
## print.mediation, and summary.mediation

summary(fit.es.max)
```

NSDUH_female

A dataset containing the substance use condition and sexual orientation of 40293 women respondents to the 2017 & 2018 National Survey of Drug Use and Health

Description

A dataset containing the substance use condition and sexual orientation of 40293 women respondents to the 2017 & 2018 National Survey of Drug Use and Health

Usage

NSDUH_female

Format

A data frame with 40293 rows and 24 variables:

cigmon indiidual smoked any cigarettes within the past month, yes or no

educ education level, 1 = less than high school diploma, 2 = high school diploma, 3 = some college/associates degree, 4 = college degree or higher

income income level, 1 <= \$20,000, 2 = \$20,000 - \$49,999, 3 = \$50,000 - 70,000, 4 = \$75,000+

NSDUHwt NSDUH sampling weight

vestr NSDUH strata variable

verep NSDUH replicate within stratum

employ employment status, 1 = full-time employment, 2 = part-time employment, 3 = student, 4 = unemployed, 5 = other

race 1 = non-Hispanic white, 2 = non-Hispanic Black, 3 = student, 4 = multiracial/other race

alc15 initiated alcohol use prior to 15 years old

cig15 initiated smoking prior to 15 years old, yes or no

lgb_flag 1 = lesbian, gay or sexual, 0 = heterosexual

alc_cig_depend individual meets criteria for either past-year alcohol use disorder or nicotine dependence

weight2y NSDUH sampling weights(scaled for pooling 2017 and 2018 survey years)

age age, 1 = 18-25, 2 = 26-34, 3 = 35-49, 4 = 50+

Value

NSDUH_female A sample data for demonstration

Source

<https://nsduhweb.rti.org/respweb/homepage.cfm>

See Also

[wgtmed](#)

Examples

```
## Not run:  
data(NSDUH_female)  
  
## End(Not run)
```

plot.mediation *Plot the mediation object*

Description

Plot the mediation object

Usage

```
## S3 method for class 'mediation'
plot(
  x,
  plots = "optimize",
  subset = NULL,
  color = TRUE,
  model_subset = NULL,
  ...
)
```

Arguments

x	weighted_mediation object
plots	An indicator of which type of plot is desired. The options are <ul style="list-style-type: none"> • "optimize" A plot of the balance criteria as a function of the GBM iteration. • "boxplot" Boxplots of the propensity scores for the treatment and control cases • "es" or "asmd" Plots of the absolute value of the standardized mean difference (effect size) of the pre-treatment variables before and after reweighting • "density" Distribution plots of NIE1 (distribution of mediator for treatment sample weighted to match distribution of mediator under control for the population) and NIE0 (distribution of mediator for control sample weighted to match distribution of mediator under treatment for the population) for each mediator. For continuous mediators, distributions are plotted with density curves and for categorical (factor) mediators, distributions are plotted with barplots. • "weights" Histograms of the standardized weights by each stopping rule. Weights are standardized to sum to 1.
subset	Used to restrict which of the stop.methods will be used in the figure. For example subset = c(1, 3) would indicate that the first and third stop.methods (in alphabetical order of those specified in the original call to the mediation function) should be included in the figure. If x\$method = logistic or crossval, there is no need to subset as there is only one method used.
color	If color = FALSE, figures will be gray scale. Default: TRUE.

model_subset integer Choose either model A (1), model M0 (2), or model M1 (3) only. Argument is not relevant for plots = density' or weights'.

... Additional arguments.

Value

The plot of a mediation object, can be different types.

See Also

[wgtmed](#) for function input

Examples

```
data("tMdat")

## tMdat is small simulated data set included in twangMediation for
## demonstrating the functions. See ?tMdat for details

fit.es.max <- wgtmed(M ~ w1 + w2 + w3,
  data = tMdat,
  a_treatment = "A",
  y_outcome = "Y",
  total_effect_wts = tMdat$te.wgt,
  method = "ps",
  ps_n.trees=1500,
  ps_shrinkage=0.01,
  ps_stop.method=c("es.max")
)

plot(fit.es.max, plots="optimize")
plot(fit.es.max, plots="boxplot")
plot(fit.es.max, plots="asmd")
```

```
print.bal.table.mediation
```

Default print statement for mediation class

Description

Default print statement for mediation class

Usage

```
## S3 method for class 'bal.table.mediation'
print(x, ...)
```

Arguments

x A bal.table.mediation object.
 ... Additional arguments.

Value

Default print statement.

See Also

[bal.table.mediation](#), [wgtmed](#)

Examples

```
data("tMdat")

## tMdat is small simulated data set included in twangMediation for
## demonstrating the functions. See ?tMdat for details

fit.es.max <- wgtmed(M ~ w1 + w2 + w3,
  data = tMdat,
  a_treatment = "A",
  y_outcome = "Y",
  total_effect_wts = tMdat$te.wgt,
  method = "ps",
  ps_n.trees=1500,
  ps_shrinkage=0.01,
  ps_stop.method=c("es.max")
)

bal.table.mediation(fit.es.max)
```

print.mediation *Default print statement for mediation class*

Description

Default print statement for mediation class

Usage

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

Arguments

x A mediation object.
 ... Additional arguments.

Value

Default print statement.

See Also

[wgtmed](#) for in put.

Examples

```
data("tMdat")

## tMdat is small simulated data set included in twangMediation for
## demonstrating the functions. See ?tMdat for details

fit.es.max <- wgtmed(M ~ w1 + w2 + w3,
                    data = tMdat,
                    a_treatment = "A",
                    y_outcome = "Y",
                    total_effect_wts = tMdat$te.wgt,
                    method = "ps",
                    ps_n.trees=1500,
                    ps_shrinkage=0.01,
                    ps_stop.method=c("es.max")
                    )

print(fit.es.max)
```

summary.mediation	<i>Displays a useful description of a mediation object</i>
-------------------	------------------------------------------------------------

Description

Displays a useful description of a mediation object

Usage

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

Arguments

object	A mediation object
...	Additional arguments.

Value

ps_tables	Table of observations' propensity scores
mediator_distribution_check	balance tables for NIE_1 and NIE_0

See Also[wgtmed](#)**Examples**

```

data("tMdat")

## tMdat is small simulated data set included in twangMediation for
## demonstrating the functions. See ?tMdat for details

## The tMdat data contains the following variables
## See ?tMdat for details

fit.es.max <- wgtmed(M ~ w1 + w2 + w3,
                    data = tMdat,
                    a_treatment = "A",
                    y_outcome = "Y",
                    total_effect_wts = tMdat$te.wgt,
                    method = "ps",
                    ps_n.trees=1500,
                    ps_shrinkage=0.01,
                    ps_stop.method=c("es.max")
                    )

summary(fit.es.max)

```

swapTxCtrl

Auxiliary function to swap treatment and control in one element of a desc object from a ps object or dx.wts object

Description

Call this in the `wgtmed()` function and the `bal.table.mediation()` function.

Usage

```
swapTxCtrl(dd)
```

Arguments

`dd` numeric An element of a desc object from a ps or dx.wts object

Value

A desc object with swapped treatment and control

See Also[ps](#), [dx.wts.mediation](#)

tMdat

Simulated data for twangMediation

Description

A simulate dataset for demonstrating the functions in the twangMediation package

Usage

```
tMdat
```

Format

A data frame with 500 rows and 7 variables:

w1 Simulated continuous covariate

w2 Simulated continuous covariate

w3 Simulated continuous covariate

A Simulated dichotomous exposure indicator

Y Simulated continuous outcome

M Simulated mediator that has 11 unique values

te.wgt Estimated inverse probability weight, estimated using GBM via the twang ps function

Value

tMdat A sample of simulated data for demonstration

See Also

[wgtmed](#)

Examples

```
## Not run:  
data(tMdat)  
  
## End(Not run)
```

weighted_mean	<i>Calculate a weighted mean</i>
---------------	----------------------------------

Description

weighted_mean calculates a weighted mean, given a vector.

Usage

```
weighted_mean(x, weights, multiplier = NULL, na.rm = TRUE)
```

Arguments

x	numeric	The the data set
weights	numeric	The weights
multiplier	An additional vector to multiply	Default : NULL
na.rm	Whether to remove NA values.	Default: TRUE

Value

numeric The weighted mean of the data.

wgtmed	<i>Weighted mediation analysis</i>
--------	------------------------------------

Description

Estimate causal mediation mechanism of a treatment using propensity score weighting.

Usage

```
wgtmed(
  formula.med,
  data,
  a_treatment,
  y_outcome = NULL,
  total_effect_wts = NULL,
  total_effect_ps = NULL,
  total_effect_stop_rule = NULL,
  method = "ps",
  sampw = NULL,
  ps_n.trees = 10000,
  ps_interaction.depth = 3,
  ps_shrinkage = 0.01,
  ps_bag.fraction = 1,
```

```

ps_n.minobsinnode = 10,
ps_perm.test.iters = 0,
ps_verbose = FALSE,
ps_stop.method = c("ks.mean", "ks.max"),
ps_version = "gbm",
ps_ks.exact = NULL,
ps_n.keep = 1,
ps_n.grid = 25,
ps_cv.folds = 10,
ps_keep.data = FALSE
)

```

Arguments

formula.med	A object of class formula relating the mediator(s) to the covariates (potential confounding variables).
data	A dataset of class data.frame that includes the treatment indicator, mediator(s), and covariates.
a_treatment	The (character) name of the treatment variable, which must be dichotomous (0, 1).
y_outcome	The (character) name of the outcome variable, y. If this is not provided, then no effects will be calculated and a warning will be raised. Default : NULL.
total_effect_wts	A vector of total effect weights, which if left NULL then total_effect_ps must be supplied. Default : NULL.
total_effect_ps	A ps object that contains the total effect weights,
total_effect_stop_rule	The stopping rule (ks.mean, ks.max, es.mean, es.max) for the total effect weights, which only needs to be specified if total_effect_ps is provided. Default : NULL.
method	The method for getting weights ("ps", "logistic", or "crossval"). Default : "ps".
sampw	Optional sampling weights Default : NULL.
ps_n.trees	Number of gbm iterations passed on to gbm . Default: 10000.
ps_interaction.depth	A positive integer denoting the tree depth used in gradient boosting. Default: 3.
ps_shrinkage	A numeric value between 0 and 1 denoting the learning rate. See gbm for more details. Default: 0.01.
ps_bag.fraction	A numeric value between 0 and 1 denoting the fraction of the observations randomly selected in each iteration of the gradient boosting algorithm to propose the next tree. See gbm for more details. Default: 1.0.
ps_n.minobsinnode	An integer specifying the minimum number of observations in the terminal nodes of the trees used in the gradient boosting. See gbm for more details. Default: 10.

<code>ps_perm.test.iters</code>	A non-negative integer giving the number of iterations of the permutation test for the KS statistic. If <code>perm.test.iters=0</code> then the function returns an analytic approximation to the p-value. Setting <code>perm.test.iters=200</code> will yield precision to within 3% if the true p-value is 0.05. Use <code>perm.test.iters=500</code> to be within 2%. Default: 0.
<code>ps_verbose</code>	If TRUE, lots of information will be printed to monitor the the progress of the fitting. Default: FALSE.
<code>ps_stop.method</code>	A method or methods of measuring and summarizing balance across pretreatment variables. Current options are <code>ks.mean</code> , <code>ks.max</code> , <code>es.mean</code> , and <code>es.max</code> . <code>ks</code> refers to the Kolmogorov-Smirnov statistic and <code>es</code> refers to standardized effect size. These are summarized across the pretreatment variables by either the maximum (<code>.max</code>) or the mean (<code>.mean</code>). Default: <code>c("ks.mean", "ks.max")</code> .
<code>ps_version</code>	"gbm", "xgboost", or "legacy", indicating which version of the twang package to use. <ul style="list-style-type: none"> • "gbm" uses gradient boosting from the gbm package. • "xgboost" uses gradient boosting from the xgboost package. • "legacy" uses the prior implementation of the ps function.
<code>ps_ks.exact</code>	NULL or a logical indicating whether the Kolmogorov-Smirnov p-value should be based on an approximation of exact distribution from an unweighted two-sample Kolmogorov-Smirnov test. If NULL, the approximation based on the exact distribution is computed if the product of the effective sample sizes is less than 10,000. Otherwise, an approximation based on the asymptotic distribution is used. Warning: setting <code>ks.exact = TRUE</code> will add substantial computation time for larger sample sizes. Default: NULL.
<code>ps_n.keep</code>	A numeric variable indicating the algorithm should only consider every <code>n.keep</code> th iteration of the propensity score model and optimize balance over this set instead of all iterations. Default : 1.
<code>ps_n.grid</code>	A numeric variable that sets the grid size for an initial search of the region most likely to minimize the <code>stop.method</code> . A value of <code>n.grid=50</code> uses a 50 point grid from <code>1:n.trees</code> . It finds the minimum, say at grid point 35. It then looks for the actual minimum between grid points 34 and 36.If specified with <code>n.keep>1</code> , <code>n.grid</code> corresponds to a grid of points on the kept iterations as defined by <code>n.keep</code> . Default: 25.
<code>ps_cv.folds</code>	A numeric variable that sets the number of cross-validation folds if using <code>method='crossval'</code> . Default: 10.
<code>ps_keep.data</code>	A logical variable that determines if the dataset should be saved in the resulting ps model objects. Default: FALSE.

Details

For users comfortable with [ps](#), any options prefaced with `ps_` are passed directly to the `ps()` function. Model A is used to estimate $\Pr(A=1 \mid X)$ where X is the vector of background covariates specified in `formula.med`. If `method` equals "ps" model A is fit using the [twang](#) ps function with `estimand= "ATE"`. If `method` equals "logistic" then model A is fit using logistic regression. If `method` equals "crossval" then [gbm](#) using cross-validation is used to estimate model A. Because

X might include variables not used to estimate the user-provided total effect weights, model A is fit rather than using the user-provided total effect weights to derive $\Pr(A | X)$. If the user uses the same set of variables to estimate their provided total effect weights as they enter in the `wgtmed` function to estimate the cross-world weights and the user uses the same estimation method and arguments as specified in the `wgtmed` function, then the estimated model A will match the model the user used to obtain the provided total effect weights.

Value

mediation object The mediation object includes the following:

- `model_a` The model A `ps()` results.
- `model_m1` The model M1 `ps()` results.
- `model_m0` The model M0 `ps()` results.
- `data` The data set used to compute models
- `stopping_methods` The stopping methods passed to `stop.method`.
- `datestamp` The date when the analysis was run.
- For each `stop.method`, a list with the following:
 - `TE` The total effect.
 - `NDE_0` The natural direct effect, holding the mediator constant at 0.
 - `NIE_1` The natural indirect effect, holding the exposure constant at 1.
 - `NDE_1` The natural direct effect, holding the mediator constant at 1.
 - `NIE_0` The natural indirect effect, holding the exposure constant at 0.
 - `expected_treatment0_mediator0` $E(Y(0, M(0)))$
 - `expected_treatment1_mediator1` $E(Y(1, M(1)))$
 - `expected_treatment1_mediator0` $E(Y(1, M(0)))$
 - `expected_treatment0_mediator1` $E(Y(0, M(1)))$

See Also

[ps](#)

Examples

```
data("tMdat")

## tMdat is small simulated data set included in twangMediation for
## demonstrating the functions. See ?tMdat for details

head(tMdat)

## The tMdat data contains the following variables:
## w1, w2, w3 -- Simulated covariates
## A -- Simulated dichotomous exposure indicator
## M -- Simulated discrete mediator (11 values)
## Y -- Simulated continuous outcome
## te.wgt -- Estimated inverse probability weight, estimated using
```

```
##           GBM via the twang ps function

fit.es.max <- wgtmed(M ~ w1 + w2 + w3,
                    data = tMdat,
                    a_treatment = "A",
                    y_outcome = "Y",
                    total_effect_wts = tMdat$te.wgt,
                    method = "ps",
                    ps_n.trees=1500,
                    ps_shrinkage=0.01,
                    ps_stop.method=c("es.max")
                    )

fit.es.max
```

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