# Package 'robomit'

January 31, 2025

**Version** 1.0.7

**Date** 2025-01-12

**Title** Robustness Checks for Omitted Variable Bias

**Maintainer** Sergei Schaub <sergei.schaub@agroscope.admin.ch>

**Description** Robustness checks for omitted variable bias. The package includes robustness checks proposed by Oster (2019). The 'robomit' package computes i) the bias-adjusted treatment correlation or effect and ii) the degree of selection on unobservables relative to observables (with respect to the treatment variable) that would be necessary to eliminate the result based on the framework by Oster (2019). The code is based on the 'psacalc' command in 'Stata'. Additionally, 'robomit' offers a set of sensitivity analysis and visualization functions. See Oster, E. 2019. <doi:10.1080/07350015.2016.1227711>. Additionally, see Diegert, P., Masten, M. A., & Poirier, A. (2022) for a recent discussion of the topic: <doi:10.48550/arXiv.2206.02303>.

**License** MIT + file LICENSE

**Encoding** UTF-8

**RoxygenNote** 7.3.2

**Imports** plm, dplyr, ggplot2, broom, tidyr, tibble, stats,

**Suggests** testthat

**NeedsCompilation** no

**Author** Sergei Schaub [aut, cre] (<https://orcid.org/0000-0001-8477-3737>), ETH Zurich [cph]

**Repository** CRAN

**Date/Publication** 2025-01-31 17:20:02 UTC

## Contents

---

`o_beta` *beta**

---

## Description

Estimates beta*, i.e., the bias-adjusted treatment effect (or correlation) (following Oster 2019). The code is based on the psacalc command in Stata.

## Usage

```
o_beta(y, x, con, w = NULL, id = "none", time = "none", delta = 1,
R2max, type, data)
```

## Arguments

| | |
|---|---|
| `y` | Name of the dependent variable (as string). |
| `x` | Name of the independent treatment variable (i.e., variable of interest; as string). |
| `con` | Name of related control variables. Provided as string in the format: "w + z +...". |
| `w` | weights (only for weighted estimations). Warning: For weighted panel models R can report different R-square than Stata, leading deviation between R and Stata results. |
| `id` | Name of the individual id variable (e.g. firm or farm; as string). Only applicable for fixed effect panel models. |
| `time` | Name of the time id variable (e.g. year or month; as string). Only applicable for fixed effect panel models. |
| `delta` | delta for which beta* should be estimated (default is delta = 1). |
| `R2max` | Maximum R-square for which beta* should be estimated. |
| `type` | Model type (either *lm* or *plm*; as string). |
| `data` | Dataset. |

## Details

Estimates beta*, i.e., the bias-adjusted treatment effect (or correlation).

## Value

Returns tibble object, which includes beta* and various other information.

## References

Oster, E. (2019) Unobservable Selection and Coefficient Stability: Theory and Evidence. Journal of Business & Economic Statistics, 37, 187-204.

## Examples

```
# load data, e.g. the in-build mtcars dataset
data("mtcars")
data_oster <- mtcars

# preview of data
head(data_oster)

# load robomit
require(robomit)

# estimate beta*
o_beta(y = "mpg",           # dependent variable
       x = "wt",            # independent treatment variable
       con = "hp + qsec",   # related control variables
       delta = 1,           # delta
       R2max = 0.9,         # maximum R-square
       type = "lm",         # model type
       data = data_oster)   # dataset
```

---

# o_beta_boot *Bootstrapped beta*s*

---

## Description

Estimates bootstrapped beta*s, i.e., the bias-adjusted treatment effects (or correlations) (following Oster 2019).

## Usage

```
o_beta_boot(y, x, con, w = NULL, id = "none", time = "none", delta = 1,
R2max, sim, obs, rep, type, useed = NA, data)
```

## Arguments

| | |
|---|---|
| y | Name of the dependent variable (as string). |
| x | Name of the independent treatment variable (i.e., variable of interest; as string). |
| con | Name of related control variables. Provided as string in the format: "w + z +...". |
| w | weights (only for weighted estimations). Warning: For weighted panel models R can report different R-square than Stata, leading deviation between R and Stata results. |

| | |
|---|---|
| id | Name of the individual id variable (e.g. firm or farm; as string). Only applicable for fixed effect panel models. |
| time | Name of the time id variable (e.g. year or month; as string). Only applicable for fixed effect panel models. |
| delta | delta for which beta*s should be estimated (default is delta = 1). |
| R2max | Maximum R-square for which beta*s should be estimated. |
| sim | Number of simulations. |
| obs | Number of draws per simulation. |
| rep | Bootstrapping either with (= TRUE) or without (= FALSE) replacement. |
| type | Model type (either *lm* or *plm*; as string). |
| useed | User defined seed. |
| data | Dataset. |

## Details

Estimates bootstrapped beta*s, i.e., the bias-adjusted treatment effects (or correlations) (following Oster 2019). Bootstrapping can either be done with or without replacement. The function supports linear cross-sectional (see *lm* objects in R) and fixed effect panel (see *plm* objects in R) models.

## Value

Returns tibble object, which includes bootstrapped beta*s.

## References

Oster, E. (2019). Unobservable Selection and Coefficient Stability: Theory and Evidence. Journal of Business & Economic Statistics, 37, 187-204.

## Examples

```
# load data, e.g. the in-build mtcars dataset
data("mtcars")
data_oster <- mtcars

# preview of data
head(data_oster)

# load robomit
require(robomit)

# estimate bootstrapped beta*s
o_beta_boot(y = "mpg",            # dependent variable
            x = "wt",             # independent treatment variable
            con = "hp + qsec",    # related control variables
            delta = 1,            # delta
            R2max = 0.9,          # maximum R-square
            sim = 100,            # number of simulations
            obs = 30,             # draws per simulation
```

```
rep = FALSE,          # bootstrapping with or without replacement
type = "lm",          # model type
useed = 123,          # seed
data = data_oster)    # dataset
```

---

`o_beta_boot_inf` *Bootstrapped mean beta* and confidence intervals*

---

## Description

Provides the mean and confidence intervals of estimated bootstrapped beta*s, i.e., the bias-adjusted treatment effects (or correlations) (following Oster 2019).

## Usage

```
o_beta_boot_inf(y, x, con, w = NULL, id = "none", time = "none",
delta = 1, R2max, sim, obs, rep, CI, type, useed = NA, data)
```

## Arguments

| | |
|---|---|
| `y` | Name of the dependent variable (as string). |
| `x` | Name of the independent treatment variable (i.e., variable of interest; as string). |
| `con` | Name of related control variables. Provided as string in the format: "w + z +...". |
| `w` | weights (only for weighted estimations). Warning: For weighted panel models R can report different R-square than Stata, leading deviation between R and Stata results. |
| `id` | Name of the individual id variable (e.g. firm or farm; as string). Only applicable for fixed effect panel models. |
| `time` | Name of the time id variable (e.g. year or month; as string). Only applicable for fixed effect panel models. |
| `delta` | delta for which beta*s should be estimated (default is delta = 1). |
| `R2max` | Maximum R-square for which beta*s should be estimated. |
| `sim` | Number of simulations. |
| `obs` | Number of draws per simulation. |
| `rep` | Bootstrapping either with (= TRUE) or without (= FALSE) replacement |
| `CI` | Confidence intervals, indicated as vector. Can be and/or 90, 95, 99. |
| `type` | Model type (either *lm* or *plm*; as string). |
| `useed` | User defined seed. |
| `data` | Dataset. |

## Details

Provides the mean and confidence intervals of estimated bootstrapped beta*s, i.e., the bias-adjusted treatment effects (or correlations) (following Oster 2019). Bootstrapping can either be done with or without replacement. The function supports linear cross-sectional (see *lm* objects in R) and fixed effect panel (see *plm* objects in R) models.

## Value

Returns tibble object, which includes the mean and confidence intervals of estimated bootstrapped beta*s.

## References

Oster, E. (2019). Unobservable Selection and Coefficient Stability: Theory and Evidence. Journal of Business & Economic Statistics, 37, 187-204.

## Examples

```
# load data, e.g. the in-build mtcars dataset
data("mtcars")
data_oster <- mtcars

# preview of data
head(data_oster)

# load robomit
require(robomit)

# compute the mean and confidence intervals of estimated bootstrapped beta*s
o_beta_boot_inf(y = "mpg",            # dependent variable
                x = "wt",             # independent treatment variable
                con = "hp + qsec",    # related control variables
                delta = 1,            # delta
                R2max = 0.9,          # maximum R-square
                sim = 100,            # number of simulations
                obs = 30,             # draws per simulation
                rep = FALSE,          # bootstrapping with or without replacement
                CI = c(90,95,99),     # confidence intervals
                type = "lm",          # model type
                useed = 123,          # seed
                data = data_oster)    # dataset
```

---

# o_beta_boot_viz *Visualization of bootstrapped beta*s*

---

## Description

Estimates and visualizes bootstrapped beta*s, i.e., the bias-adjusted treatment effects (or correlations) (following Oster 2019).

## Usage

```
o_beta_boot_viz(y, x, con, w = NULL, id = "none", time = "none",
delta = 1, R2max, sim, obs, rep, CI, type, norm = TRUE, bin,
col = c("#08306b","#4292c6","#c6dbef"), nL = TRUE, mL = TRUE, useed = NA, data)
```

## Arguments

| | |
|---|---|
| y | Name of the dependent variable (as string). |
| x | Name of the independent treatment variable (i.e., variable of interest; as string). |
| con | Name of related control variables. Provided as string in the format: "w + z +...". |
| w | weights (only for weighted estimations). Warning: For weighted panel models R can report different R-square than Stata, leading deviation between R and Stata results. |
| id | Name of the individual id variable (e.g. firm or farm; as string). Only applicable for fixed effect panel models. |
| time | Name of the time id variable (e.g. year or month; as string). Only applicable for fixed effect panel models. |
| delta | delta for which beta*s should be estimated (default is delta = 1). |
| R2max | Maximum R-square for which beta*s should be estimated. |
| sim | Number of simulations. |
| obs | Number of draws per simulation. |
| rep | Bootstrapping either with (= TRUE) or without (= FALSE) replacement |
| CI | Confidence intervals, indicated as vector. Can be and/or 90, 95, 99. |
| type | Model type (either *lm* or *plm*; as string). |
| norm | Option to include a normal distribution in the plot (default is norm = TURE). |
| bin | Number of bins used in the histogram. |
| col | Colors used to indicate different confidence interval levels (indicated as vector). Needs to be the same length as the variable CI. The default is a blue color range. |
| nL | Option to include a red vertical line at 0 (default is nL = TRUE). |
| mL | Option to include a vertical line at mean of all beta*s (default is mL = TRUE). |
| useed | User defined seed. |
| data | Dataset. |

## Details

Estimates and visualizes bootstrapped beta*s, i.e., the bias-adjusted treatment effects (or correlations) (following Oster 2019). Bootstrapping can either be done with or without replacement. The function supports linear cross-sectional (see *lm* objects in R) and fixed effect panel (see *plm* objects in R) models.

## Value

Returns ggplot2 object, which depicts the bootstrapped beta*s.

## References

Oster, E. (2019). Unobservable Selection and Coefficient Stability: Theory and Evidence. Journal of Business & Economic Statistics, 37, 187-204.

## Examples

```
# load data, e.g. the in-build mtcars dataset
data("mtcars")
data_oster <- mtcars

# preview of data
head(data_oster)

# load robomit
require(robomit)

# estimate and visualize bootstrapped beta*s
o_beta_boot_viz(y = "mpg",            # dependent variable
                x = "wt",             # independent treatment variable
                con = "hp + qsec",    # related control variables
                delta = 1,            # delta
                R2max = 0.9,          # maximum R-square
                sim = 100,            # number of simulations
                obs = 30,             # draws per simulation
                rep = FALSE,          # bootstrapping with or without replacement
                CI = c(90,95,99),     # confidence intervals
                type = "lm",          # model type
                norm = TRUE,          # normal distribution
                bin = 200,            # number of bins
                useed = 123,          # seed
                data = data_oster)    # dataset
```

---

# o_beta_rsq *beta*s over a range of maximum R-squares*

---

## Description

Estimates beta*s, i.e., the bias-adjusted treatment effects (or correlations) (following Oster 2019) over a range of maximum R-squares.

## Usage

```
o_beta_rsq(y, x, con, w = NULL, id = "none", time = "none", delta = 1,
type, data)
```

## Arguments

| | |
|---|---|
| y | Name of the dependent variable (as string). |
| x | Name of the independent treatment variable (i.e., variable of interest; as string). |
| con | Name of related control variables. Provided as string in the format: "w + z +...". |
| w | weights (only for weighted estimations). Warning: For weighted panel models R can report different R-square than Stata, leading deviation between R and Stata results. |
| id | Name of the individual id variable (e.g. firm or farm; as string). Only applicable for fixed effect panel models. |
| time | Name of the time id variable (e.g. year or month; as string). Only applicable for fixed effect panel models. |
| delta | delta for which beta*s should be estimated (default is delta = 1). |
| type | Model type (either *lm* or *plm*; as string). |
| data | Dataset. |

## Details

Estimates beta*s, i.e., the bias-adjusted treatment effects (or correlations) (following Oster 2019) over a range of maximum R-squares. The range of maximum R-squares starts from the R-square of the controlled model rounded up to the next 1/100 to 1. The function supports linear cross-sectional (see *lm* objects in R) and fixed effect panel (see *plm* objects in R) models.

## Value

Returns tibble object, which includes beta*s over a range of maximum R-squares.

## References

Oster, E. (2019). Unobservable Selection and Coefficient Stability: Theory and Evidence. Journal of Business & Economic Statistics, 37, 187-204.

## Examples

```
# load data, e.g. the in-build mtcars dataset
data("mtcars")
data_oster <- mtcars

# preview of data
head(data_oster)

# load robomit
require(robomit)

# estimate delta*s over a range of maximum R-squares
o_beta_rsq(y = "mpg",            # dependent variable
           x = "wt",             # independent treatment variable
           con = "hp + qsec",    # related control variables
           delta = 1,            # delta
```

```
type = "lm",          # model type
data = data_oster)    # dataset
```

---

o_beta_rsq_viz *Visualization of beta*s over a range of maximum R-squares*

---

## Description

Estimates and visualizes beta*s, i.e., the bias-adjusted treatment effects (or correlations) (following Oster 2019) over a range of maximum R-squares.

## Usage

```
o_beta_rsq_viz(y, x, con, w = NULL, id = "none", time = "none", delta = 1,
type, data)
```

## Arguments

| | |
|---|---|
| y | Name of the dependent variable (as string). |
| x | Name of the independent treatment variable (i.e., variable of interest; as string). |
| con | Name of related control variables. Provided as string in the format: "w + z +...". |
| w | weights (only for weighted estimations). Warning: For weighted panel models R can report different R-square than Stata, leading deviation between R and Stata results. |
| id | Name of the individual id variable (e.g. firm or farm; as string). Only applicable for fixed effect panel models. |
| time | Name of the time id variable (e.g. year or month; as string). Only applicable for fixed effect panel models. |
| delta | delta for which beta*s should be estimated (default is delta = 1). |
| type | Model type (either *lm* or *plm*; as string). |
| data | Dataset. |

## Details

Estimates and visualizes beta*s, i.e., the bias-adjusted treatment effects (or correlations) (following Oster 2019) over a range of maximum R-squares. The range of maximum R-squares starts from the R-square of the controlled model rounded up to the next 1/100 to 1. The function supports linear cross-sectional (see *lm* objects in R) and fixed effect panel (see *plm* objects in R) models.

## Value

Returns ggplot2 object, which depicts beta*s over a range of maximum R-squares.

## References

Oster, E. (2019). Unobservable Selection and Coefficient Stability: Theory and Evidence. Journal of Business & Economic Statistics, 37, 187-204.

## Examples

```
# load data, e.g. the in-build mtcars dataset
data("mtcars")
data_oster <- mtcars

# preview of data
head(data_oster)

# load robomit
require(robomit)

# estimate and visualize beta*s over a range of maximum R-squares
o_beta_rsq_viz(y = "mpg",            # dependent variable
               x = "wt",             # independent treatment variable
               con = "hp + qsec",    # related control variables
               delta = 1,            # delta
               type = "lm",          # model type
               data = data_oster)    # dataset
```

---

o_delta *delta**

---

## Description

Estimates delta*, i.e., the degree of selection on unobservables relative to observables (with respect to the treatment variable) that would be necessary to eliminate the result (following Oster 2019). The code is based on the psacalc command in Stata.

## Usage

```
o_delta(y, x, con, w = NULL, id = "none", time = "none", beta = 0, R2max,
type, data)
```

## Arguments

| | |
|---|---|
| y | Name of the dependent variable (as string). |
| x | Name of the independent treatment variable (i.e., variable of interest; as string). |
| con | Name of related control variables. Provided as string in the format: "w + z +...". |
| w | weights (only for weighted estimations). Warning: For weighted panel models R can report different R-square than Stata, leading deviation between R and Stata results. |
| id | Name of the individual id variable (e.g. firm or farm; as string). Only applicable for fixed effect panel models. |
| time | Name of the time id variable (e.g. year or month; as string). Only applicable for fixed effect panel models. |
| beta | beta for which delta* should be estimated (default is beta = 0). |

| | |
|---|---|
| R2max | Maximum R-square for which delta* should be estimated. |
| type | Model type (either *lm* or *plm*; as string). |
| data | Dataset. |

## Details

Estimates delta*, i.e., the degree of selection on unobservables relative to observables (with respect to the treatment variable) that would be necessary to eliminate the result (following Oster 2019). The function supports linear cross-sectional (see *lm* objects in R) and fixed effect panel (see *plm* objects in R) models.

## Value

Returns tibble object, which includes delta* and various other information.

## References

Oster, E. (2019). Unobservable Selection and Coefficient Stability: Theory and Evidence. Journal of Business & Economic Statistics, 37, 187-204.

## Examples

```
# load data, e.g. the in-build mtcars dataset
data("mtcars")
data_oster <- mtcars

# preview of data
head(data_oster)

# load robomit
require(robomit)

# estimate delta*
o_delta(y = "mpg",           # dependent variable
        x = "wt",            # independent treatment variable
        con = "hp + qsec",   # related control variables
        beta = 0,            # beta
        R2max = 0.9,         # maximum R-square
        type = "lm",         # model type
        data = data_oster)   # dataset
```

---

# o_delta_boot *Bootstrapped delta*s*

---

## Description

Estimates bootstrapped delta*s, i.e., the degree of selection on unobservables relative to observables (with respect to the treatment variable) that would be necessary to eliminate the result (following Oster 2019).

## Usage

```
o_delta_boot(y, x, con, w = NULL, id = "none", time = "none", beta = 0, R2max,
sim, obs, rep, type, useed = NA, data)
```

## Arguments

| | |
|---|---|
| y | Name of the dependent variable (as string). |
| x | Name of the independent treatment variable (i.e., variable of interest; as string). |
| con | Name of related control variables. Provided as string in the format: "w + z +...". |
| w | weights (only for weighted estimations). Warning: For weighted panel models R can report different R-square than Stata, leading deviation between R and Stata results. |
| id | Name of the individual id variable (e.g. firm or farm; as string). Only applicable for fixed effect panel models. |
| time | Name of the time id variable (e.g. year or month; as string). Only applicable for fixed effect panel models. |
| beta | beta for which delta*s should be estimated (default is beta = 0). |
| R2max | Maximum R-square for which delta*s should be estimated. |
| sim | Number of simulations. |
| obs | Number of draws per simulation. |
| rep | Bootstrapping either with (= TRUE) or without (= FALSE) replacement. |
| type | Model type (either *lm* or *plm*; as string). |
| useed | User defined seed. |
| data | Dataset. |

## Details

Estimates bootstrapped delta*s, i.e., the degree of selection on unobservables relative to observables (with respect to the treatment variable) that would be necessary to eliminate the result (following Oster 2019). Bootstrapping can either be done with or without replacement. The function supports linear cross-sectional (see *lm* objects in R) and fixed effect panel (see *plm* objects in R) models.

## Value

Returns tibble object, which includes bootstrapped delta*s.

## References

Oster, E. (2019). Unobservable Selection and Coefficient Stability: Theory and Evidence. Journal of Business & Economic Statistics, 37, 187-204.

## Examples

```
# load data, e.g. the in-build mtcars dataset
data("mtcars")
data_oster <- mtcars

# preview of data
head(data_oster)

# load robomit
require(robomit)

# estimate bootstrapped delta*s
o_delta_boot(y = "mpg",          # dependent variable
             x = "wt",           # independent treatment variable
             con = "hp + qsec",  # related control variables
             beta = 0,           # beta
             R2max = 0.9,        # maximum R-square
             sim = 100,          # number of simulations
             obs = 30,           # draws per simulation
             rep = FALSE,        # bootstrapping with or without replacement
             type = "lm",        # model type
             useed = 123,        # seed
             data = data_oster)  # dataset
```

---

# o_delta_boot_inf *Bootstrapped mean delta* and confidence intervals*

---

## Description

Provides the mean and confidence intervals of bootstrapped delta*s, i.e., the degree of selection on unobservables relative to observables (with respect to the treatment variable) that would be necessary to eliminate the result (following Oster 2019).

## Usage

```
o_delta_boot_inf(y, x, con, w = NULL, id = "none", time = "none",
beta = 0, R2max, sim, obs, rep, CI, type, useed = NA, data)
```

## Arguments

| | |
|---|---|
| y | Name of the dependent variable (as string). |
| x | Name of the independent treatment variable (i.e., variable of interest; as string). |
| con | Name of related control variables. Provided as string in the format: "w + z +...". |
| w | weights (only for weighted estimations). Warning: For weighted panel models R can report different R-square than Stata, leading deviation between R and Stata results. |
| id | Name of the individual id variable (e.g. firm or farm; as string). Only applicable for fixed effect panel models. |

| | |
|---|---|
| time | Name of the time id variable (e.g. year or month; as string). Only applicable for fixed effect panel models. |
| beta | beta for which delta*s should be estimated (default is beta = 0).. |
| R2max | Maximum R-square for which delta*s should be estimated. |
| sim | Number of simulations. |
| obs | Number of draws per simulation. |
| rep | Bootstrapping either with (= TRUE) or without (= FALSE) replacement |
| CI | Confidence intervals, indicated as vector. Can be and/or 90, 95, 99. |
| type | Model type (either *lm* or *plm*; as string). |
| useed | User defined seed. |
| data | Dataset. |

## Details

Provides the mean and confidence intervals of bootstrapped delta*s, i.e., the degree of selection on unobservables relative to observables (with respect to the treatment variable) that would be necessary to eliminate the result (following Oster 2019). Bootstrapping can either be done with or without replacement. The function supports linear cross-sectional (see *lm* objects in R) and fixed effect panel (see *plm* objects in R) models.

## Value

Returns tibble object, which includes the mean and confidence intervals of bootstrapped delta*s.

## References

Oster, E. (2019). Unobservable Selection and Coefficient Stability: Theory and Evidence. Journal of Business & Economic Statistics, 37, 187-204.

## Examples

```
# load data, e.g. the in-build mtcars dataset
data("mtcars")
data_oster <- mtcars

# preview of data
head(data_oster)

# load robomit
require(robomit)

# compute the mean and confidence intervals of estimated bootstrapped delta*s
o_delta_boot_inf(y = "mpg",            # dependent variable
                 x = "wt",             # independent treatment variable
                 con = "hp + qsec",    # related control variables
                 beta = 0,             # beta
                 R2max = 0.9,          # maximum R-square
                 sim = 100,            # number of simulations
```

```
obs = 30,            # draws per simulation
rep = FALSE,         # bootstrapping with or without replacement
CI = c(90,95,99),    # confidence intervals
type = "lm",         # model type
useed = 123,         # seed
data = data_oster)   # dataset
```

---

`o_delta_boot_viz` *Visualization of bootstrapped delta*s*

---

## Description

Estimates and visualizes bootstrapped delta*s, i.e., the degree of selection on unobservables relative to observables (with respect to the treatment variable) that would be necessary to eliminate the result (following Oster 2019).

## Usage

```
o_delta_boot_viz(y, x, con, w = NULL, id = "none", time = "none",
beta = 0, R2max, sim, obs, rep, CI, type, norm = TRUE, bin,
col = c("#08306b","#4292c6","#c6dbef"), nL = TRUE, mL = TRUE, useed = NA, data)
```

## Arguments

| | |
|---|---|
| `y` | Name of the dependent variable (as string). |
| `x` | Name of the independent treatment variable (i.e., variable of interest; as string). |
| `con` | Name of related control variables. Provided as string in the format: "w + z +...". |
| `w` | weights (only for weighted estimations). Warning: For weighted panel models R can report different R-square than Stata, leading deviation between R and Stata results. |
| `id` | Name of the individual id variable (e.g. firm or farm; as string). Only applicable for fixed effect panel models. |
| `time` | Name of the time id variable (e.g. year or month; as string). Only applicable for fixed effect panel models. |
| `beta` | beta for which delta*s should be estimated (default is beta = 0). |
| `R2max` | Maximum R-square for which delta*s should be estimated. |
| `sim` | Number of simulations. |
| `obs` | Number of draws per simulation. |
| `rep` | Bootstrapping either with (= TRUE) or without (= FALSE) replacement |
| `CI` | Confidence intervals, indicated as vector. Can be and/or 90, 95, 99. |
| `type` | Model type (either *lm* or *plm*; as string). |
| `norm` | Option to include a normal distribution in the plot (default is norm = TURE). |
| `bin` | Number of bins used in the histogram. |

| | |
|---|---|
| col | Colors used to indicate different confidence interval levels (indicated as vector). Needs to be the same length as the variable CI. The default is a blue color range. |
| nL | Option to include a red vertical line at 0 (default is nL = TRUE). |
| mL | Option to include a vertical line at beta* mean (default is mL = TRUE). |
| useed | User defined seed. |
| data | Dataset. |

## Details

Estimates and visualizes bootstrapped delta*s, i.e., the degree of selection on unobservables relative to observables (with respect to the treatment variable) that would be necessary to eliminate the result (following Oster 2019). Bootstrapping can either be done with or without replacement. The function supports linear cross-sectional (see *lm* objects in R) and fixed effect panel (see *plm* objects in R) models.

## Value

Returns ggplot2 object, which depicts the bootstrapped delta*s.

## References

Oster, E. (2019). Unobservable Selection and Coefficient Stability: Theory and Evidence. Journal of Business & Economic Statistics, 37, 187-204.

## Examples

```
# load data, e.g. the in-build mtcars dataset
data("mtcars")
data_oster <- mtcars

# preview of data
head(data_oster)

# load robomit
require(robomit)

# estimate and visualize bootstrapped delta*s
o_delta_boot_viz(y = "mpg",           # dependent variable
                 x = "wt",            # independent treatment variable
                 con = "hp + qsec",   # related control variables
                 beta = 0,            # beta
                 R2max = 0.9,         # maximum R-square
                 sim = 100,           # number of simulations
                 obs = 30,            # draws per simulation
                 rep = FALSE,         # bootstrapping with or without replacement
                 CI = c(90,95,99),    # confidence intervals
                 type = "lm",         # model type
                 norm = TRUE,         # normal distribution
                 bin = 200,           # number of bins
                 useed = 123,         # seed
                 data = data_oster)   # dataset
```

`o_delta_rsq` *delta*s over a range of maximum R-squares*

## Description

Estimates delta*s, i.e., the degree of selection on unobservables relative to observables (with respect to the treatment variable) that would be necessary to eliminate the result (following Oster 2019) over a range of maximum R-squares following Oster (2019).

## Usage

```
o_delta_rsq(y, x, con, w = NULL, id = "none", time = "none", beta = 0,
type, data)
```

## Arguments

| | |
|---|---|
| `y` | Name of the dependent variable (as string). |
| `x` | Name of the independent treatment variable (i.e., variable of interest; as string). |
| `con` | Name of related control variables. Provided as string in the format: "w + z +...". |
| `w` | weights (only for weighted estimations). Warning: For weighted panel models R can report different R-square than Stata, leading deviation between R and Stata results. |
| `id` | Name of the individual id variable (e.g. firm or farm; as string). Only applicable for fixed effect panel models. |
| `time` | Name of the time id variable (e.g. year or month; as string). Only applicable for fixed effect panel models. |
| `beta` | beta for which delta*s should be estimated (default is beta = 0). |
| `type` | Model type (either *lm* or *plm*; as string). |
| `data` | Dataset. |

## Details

Estimates delta*s, i.e., the degree of selection on unobservables relative to observables (with respect to the treatment variable) that would be necessary to eliminate the result (following Oster 2019) over a range of maximum R-squares. The range of maximum R-squares starts from the R-square of the controlled model rounded up to the next 1/100 to 1. The function supports linear cross-sectional (see *lm* objects in R) and fixed effect panel (see *plm* objects in R) models.

## Value

Returns tibble object, which includes delta*s over a range of maximum R-squares.

## References

Oster, E. (2019). Unobservable Selection and Coefficient Stability: Theory and Evidence. Journal of Business & Economic Statistics, 37, 187-204.

## Examples

```
# load data, e.g. the in-build mtcars dataset
data("mtcars")
data_oster <- mtcars

# preview of data
head(data_oster)

# load robomit
require(robomit)

# estimate delta*s over a range of maximum R-squares
o_delta_rsq(y = "mpg",           # dependent variable
            x = "wt",            # independent treatment variable
            con = "hp + qsec",   # related control variables
            beta = 0,            # beta
            type = "lm",         # model type
            data = data_oster)   # dataset
```

---

`o_delta_rsq_viz` *Visualization of delta*s over a range of maximum R-squares*

---

## Description

Estimates and visualizes delta*s, i.e., the degree of selection on unobservables relative to observables (with respect to the treatment variable) that would be necessary to eliminate the result (following Oster 2019) over a range of maximum R-squares.

## Usage

```
o_delta_rsq_viz(y, x, con, w = NULL, id = "none", time = "none", beta = 0,
type, data)
```

## Arguments

| | |
|---|---|
| `y` | Name of the dependent variable (as string). |
| `x` | Name of the independent treatment variable (i.e., variable of interest; as string). |
| `con` | Name of related control variables. Provided as string in the format: "w + z +...". |
| `w` | weights (only for weighted estimations). Warning: For weighted panel models R can report different R-square than Stata, leading deviation between R and Stata results. |
| `id` | Name of the individual id variable (e.g. firm or farm; as string). Only applicable for fixed effect panel models. |
| `time` | Name of the time id variable (e.g. year or month; as string). Only applicable for fixed effect panel models. |
| `beta` | beta for which delta*s should be estimated (default is beta = 0). |
| `type` | Model type (either *lm* or *plm*; as string). |
| `data` | Dataset. |

## Details

Estimates and visualizes delta*s, i.e., the degree of selection on unobservables relative to observables (with respect to the treatment variable) that would be necessary to eliminate the result (following Oster 2019) over a range of maximum R-squares. The range of maximum R-squares starts from the R-square of the controlled model rounded up to the next 1/100 to 1. The function supports linear cross-sectional (see *lm* objects in R) and fixed effect panel (see *plm* objects in R) models.

## Value

Returns ggplot2 object, which depicts delta*s over a range of maximum R-squares.

## References

Oster, E. (2019). Unobservable Selection and Coefficient Stability: Theory and Evidence. Journal of Business & Economic Statistics, 37, 187-204.

## Examples

```
# load data, e.g. the in-build mtcars dataset
data("mtcars")
data_oster <- mtcars

# preview of data
head(data_oster)

# load robomit
require(robomit)

# estimate and visualize delta*s over a range of maximum R-squares
o_delta_rsq_viz(y = "mpg",           # dependent variable
                x = "wt",            # independent treatment variable
                con = "hp + qsec",   # related control variables
                beta = 0,            # beta
                type = "lm",         # model type
                data = data_oster)   # dataset
```

# Index