

Package ‘gravity’

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Type Package

Title Estimation Methods for Gravity Models

Version 1.1

Description A wrapper of different standard estimation methods for gravity models.
This package provides estimation methods for log-log models and multiplicative models.

URL <https://pacha.dev/gravity/>

BugReports <https://github.com/pachadotdev/gravity/issues/>

Imports lmtree, sandwich, glm2, MASS, stats, censReg, survival,
multiwayvcov, tibble, magrittr, dplyr, tidyr, purrr, rlang,
Rdpack, utils

RdMacros Rdpack

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VignetteBuilder knitr

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Lionel Henry [ctb] (simplified parts of the code),
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bv	<i>Bonus vetus OLS (BVU)</i>
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Description

bv estimates gravity models via Bonus vetus OLS with simple averages.

Usage

```

bv(
  dependent_variable,
  distance,
  additional_regressors = NULL,
  income_origin,
  income_destination,
  code_origin,
  code_destination,
  robust = FALSE,
  data,
  ...
)

```

Arguments

<code>dependent_variable</code>	(Type: character) name of the dependent variable. This dependent variable is divided by the product of unilateral incomes such (i.e. <code>income_origin</code> and <code>income_destination</code>) and logged afterwards.
<code>distance</code>	(Type: character) name of the distance variable that should be taken as the key independent variable in the estimation. The distance is logged automatically when the function is executed.
<code>additional_regressors</code>	(Type: character) names of the additional regressors to include in the model (e.g. a dummy variable to indicate contiguity). Unilateral metric variables such as GDP should be inserted via the arguments <code>income_origin</code> and <code>income_destination</code> . As country specific effects are subdued due to demeaning, no further unilateral variables apart from incomes can be added. Write this argument as <code>c(contiguity, common currency, ...)</code> . By default this is set to <code>NULL</code> .
<code>income_origin</code>	(Type: character) origin income variable (e.g. GDP) in the dataset.
<code>income_destination</code>	(Type: character) destination income variable (e.g. GDP) in the dataset.
<code>code_origin</code>	(Type: character) country of origin variable (e.g. ISO-3 country codes). The variables are grouped using this parameter.
<code>code_destination</code>	(Type: character) country of destination variable (e.g. country ISO-3 codes). The variables are grouped using this parameter.
<code>robust</code>	(Type: logical) whether robust fitting should be used. By default this is set to <code>FALSE</code> .
<code>data</code>	(Type: data.frame) the dataset to be used.
<code>...</code>	Additional arguments to be passed to the function.

Details

Bonus vetus OLS is an estimation method for gravity models developed by Baier and Bergstrand (2009); Baier and Bergstrand (2010) using simple averages to center a Taylor-series.

The `bv` function considers Multilateral Resistance terms and allows to conduct comparative statics. Country specific effects are subdued due to demeaning. Hence, unilateral variables apart from incomes cannot be included in the estimation.

`bv` is designed to be consistent with the Stata code provided at [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) when choosing robust estimation.

As, to our knowledge at the moment, there is no explicit literature covering the estimation of a gravity equation by `bv` using panel data, we do not recommend to apply this method in this case.

Value

The function returns the summary of the estimated gravity model as an `lm`-object.

References

For more information on gravity models, theoretical foundations and estimation methods in general see

Anderson JE (1979). “A Theoretical Foundation for the Gravity Equation.” *The American Economic Review*, **69**(1), 106–116. ISSN 00028282.

Anderson JE, van Wincoop E (2001). “Gravity with Gravitas: A Solution to the Border Puzzle.” Working Paper 8079, National Bureau of Economic Research. doi:10.3386/w8079.

Anderson JE (2010). “The Gravity Model.” Working Paper 16576, National Bureau of Economic Research. doi:10.3386/w16576.

Baier SL, Bergstrand JH (2009). “Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation.” *Journal of International Economics*, **77**(1), 77 - 85. ISSN 0022-1996, doi:10.1016/j.jinteco.2008.10.004.

Baier SL, Bergstrand JH (2010). “The Gravity Model in International Trade: Advances and Applications.” In van Bergeijk PAG, Brakman S (eds.), chapter 4. Cambridge University Press. doi:10.1017/CBO9780511762109.

Feenstra RC (2002). “Border effects and the gravity equation: consistent methods for estimation.” *Scottish Journal of Political Economy*, **49**(5), 491–506.

Head K, Mayer T, Ries J (2010). “The erosion of colonial trade linkages after independence.” *Journal of International Economics*, **81**(1), 1 - 14. ISSN 0022-1996, doi:10.1016/j.jinteco.2010.01.002.

Head K, Mayer T (2014). “Chapter 3 - Gravity Equations: Workhorse, Toolkit, and Cookbook.” In Gopinath G, Helpman E, Rogoff K (eds.), *Handbook of International Economics*, volume 4 of *Handbook of International Economics*, 131 - 195. Elsevier. doi:10.1016/B9780444543141.000033.

Silva JMCS, Tenreyro S (2006). “The Log of Gravity.” *The Review of Economics and Statistics*, **88**(4), 641-658. doi:10.1162/rest.88.4.641.

and the citations therein.

See [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) for gravity datasets and Stata code for estimating gravity models.

For estimating gravity equations using panel data see

Egger P, Pfaffermayr M (2003). “The proper panel econometric specification of the gravity equation: A three-way model with bilateral interaction effects.” *Empirical Economics*, **28**(3), 571–580. ISSN 1435-8921, doi:10.1007/s001810200146.

Gómez-Herrera E (2013). “Comparing alternative methods to estimate gravity models of bilateral trade.” *Empirical Economics*, **44**(3), 1087–1111. ISSN 1435-8921, doi:10.1007/s0018101205762.

and the references therein.

See Also

[lm](#), [coefstest](#), [vcovHC](#)

Examples

```
# Example for CRAN checks:
# Executable in < 5 sec
library(dplyr)
```

```

data("gravity_no_zeros")

# Choose 5 countries for testing
countries_chosen <- c("AUS", "CHN", "GBR", "BRA", "CAN")
grav_small <- filter(gravity_no_zeros, iso_o %in% countries_chosen)

fit <- bvw(
  dependent_variable = "flow",
  distance = "distw",
  additional_regressors = c("rta", "contig", "comcur"),
  income_origin = "gdp_o",
  income_destination = "gdp_d",
  code_origin = "iso_o",
  code_destination = "iso_d",
  robust = FALSE,
  data = grav_small
)

```

 bvw

Bonus vetus OLS (BVW)

Description

bvw estimates gravity models via Bonus vetus OLS with income-weights.

Usage

```

bvw(
  dependent_variable,
  distance,
  additional_regressors = NULL,
  income_origin,
  income_destination,
  code_origin,
  code_destination,
  robust = FALSE,
  data,
  ...
)

```

Arguments

`dependent_variable`

(Type: character) name of the dependent variable. This dependent variable is divided by the product of unilateral incomes such (i.e. `income_origin` and `income_destination`) and logged afterwards.

`distance`

(Type: character) name of the distance variable that should be taken as the key independent variable in the estimation. The distance is logged automatically when the function is executed.

<code>additional_regressors</code>	(Type: character) names of the additional regressors to include in the model (e.g. a dummy variable to indicate contiguity). Unilateral metric variables such as GDP should be inserted via the arguments <code>income_origin</code> and <code>income_destination</code> . As country specific effects are subdued due to demeaning, no further unilateral variables apart from incomes can be added. Write this argument as <code>c(contiguity, common currency, ...)</code> . By default this is set to NULL.
<code>income_origin</code>	(Type: character) origin income variable (e.g. GDP) in the dataset.
<code>income_destination</code>	(Type: character) destination income variable (e.g. GDP) in the dataset.
<code>code_origin</code>	(Type: character) country of origin variable (e.g. ISO-3 country codes). The variables are grouped using this parameter.
<code>code_destination</code>	(Type: character) country of destination variable (e.g. country ISO-3 codes). The variables are grouped using this parameter.
<code>robust</code>	(Type: logical) whether robust fitting should be used. By default this is set to FALSE.
<code>data</code>	(Type: data.frame) the dataset to be used.
<code>...</code>	Additional arguments to be passed to the function.

Details

Bonus vetus OLS is an estimation method for gravity models developed by Baier and Bergstrand (2009); Baier and Bergstrand (2010) using income-weights to center a Taylor series.

The `bvw` function considers Multilateral Resistance terms and allows to conduct comparative statics. Country specific effects are subdued due to demeaning. Hence, unilateral variables apart from `inc_o` and `inc_d` cannot be included in the estimation.

`bvw` is designed to be consistent with the Stata code provided at [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) when choosing robust estimation.

As, to our knowledge at the moment, there is no explicit literature covering the estimation of a gravity equation by `bvw` using panel data, we do not recommend to apply this method in this case.

Value

The function returns the summary of the estimated gravity model as an `lm`-object.

References

For more information on gravity models, theoretical foundations and estimation methods in general see

Anderson JE (1979). "A Theoretical Foundation for the Gravity Equation." *The American Economic Review*, **69**(1), 106–116. ISSN 00028282.

Anderson JE, van Wincoop E (2001). "Gravity with Gravitas: A Solution to the Border Puzzle." Working Paper 8079, National Bureau of Economic Research. [doi:10.3386/w8079](https://doi.org/10.3386/w8079).

Anderson JE (2010). “The Gravity Model.” Working Paper 16576, National Bureau of Economic Research. doi:10.3386/w16576.

Baier SL, Bergstrand JH (2009). “Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation.” *Journal of International Economics*, 77(1), 77 - 85. ISSN 0022-1996, doi:10.1016/j.jinteco.2008.10.004.

Baier SL, Bergstrand JH (2010). “The Gravity Model in International Trade: Advances and Applications.” In van Bergeijk PAG, Brakman S (eds.), chapter 4. Cambridge University Press. doi:10.1017/CBO9780511762109.

Feenstra RC (2002). “Border effects and the gravity equation: consistent methods for estimation.” *Scottish Journal of Political Economy*, 49(5), 491–506.

Head K, Mayer T, Ries J (2010). “The erosion of colonial trade linkages after independence.” *Journal of International Economics*, 81(1), 1 - 14. ISSN 0022-1996, doi:10.1016/j.jinteco.2010.01.002.

Head K, Mayer T (2014). “Chapter 3 - Gravity Equations: Workhorse, Toolkit, and Cookbook.” In Gopinath G, Helpman E, Rogoff K (eds.), *Handbook of International Economics*, volume 4 of *Handbook of International Economics*, 131 - 195. Elsevier. doi:10.1016/B9780444543141.000033.

Silva JMCS, Teneyro S (2006). “The Log of Gravity.” *The Review of Economics and Statistics*, 88(4), 641-658. doi:10.1162/rest.88.4.641.

and the citations therein.

See [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) for gravity datasets and Stata code for estimating gravity models.

For estimating gravity equations using panel data see

Egger P, Pfaffermayr M (2003). “The proper panel econometric specification of the gravity equation: A three-way model with bilateral interaction effects.” *Empirical Economics*, 28(3), 571–580. ISSN 1435-8921, doi:10.1007/s001810200146.

Gómez-Herrera E (2013). “Comparing alternative methods to estimate gravity models of bilateral trade.” *Empirical Economics*, 44(3), 1087–1111. ISSN 1435-8921, doi:10.1007/s0018101205762.

and the references therein.

See Also

[lm](#), [coefstest](#), [vcovHC](#)

Examples

```
# Example for CRAN checks:
# Executable in < 5 sec
library(dplyr)
data("gravity_no_zeros")

# Choose 5 countries for testing
countries_chosen <- c("AUS", "CHN", "GBR", "BRA", "CAN")
grav_small <- filter(gravity_no_zeros, iso_o %in% countries_chosen)

fit <- bvw(
  dependent_variable = "flow",
  distance = "distw",
```

```

additional_regressors = c("rta", "comcur", "contig"),
income_origin = "gdp_o",
income_destination = "gdp_d",
code_origin = "iso_o",
code_destination = "iso_d",
robust = FALSE,
data = grav_small
)

```

ddm

Double Demeaning (DDM)

Description

ddm estimates gravity models via double demeaning the left hand side and right hand side of the gravity equation.

Usage

```

ddm(
  dependent_variable,
  distance,
  additional_regressors = NULL,
  code_origin,
  code_destination,
  robust = FALSE,
  data,
  ...
)

```

Arguments

dependent_variable (Type: character) name of the dependent variable. This dependent variable is divided by the product of unilateral incomes such (i.e. `income_origin` and `income_destination`) and logged afterwards.

distance (Type: character) name of the distance variable that should be taken as the key independent variable in the estimation. The distance is logged automatically when the function is executed.

additional_regressors (Type: character) names of the additional regressors to include in the model (e.g. a dummy variable to indicate contiguity). Unilateral metric variables such as GDP should be inserted via the arguments `income_origin` and `income_destination`. As country specific effects are subdued due to demeaning, no further unilateral variables apart from incomes can be added. Write this argument as `c(contiguity, common currency, ...)`. By default this is set to NULL.

code_origin	(Type: character) country of origin variable (e.g. ISO-3 country codes). The variables are grouped using this parameter.
code_destination	(Type: character) country of destination variable (e.g. country ISO-3 codes). The variables are grouped using this parameter.
robust	(Type: logical) whether robust fitting should be used. By default this is set to FALSE.
data	(Type: data.frame) the dataset to be used.
...	Additional arguments to be passed to the function.

Details

ddm is an estimation method for gravity models presented in Head and Mayer (2014).

Country specific effects are subdued due double demeaning. Hence, unilateral income proxies such as GDP cannot be considered as exogenous variables.

Unilateral effect drop out due to double demeaning and therefore cannot be estimated.

ddm is designed to be consistent with the Stata code provided at [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) when choosing robust estimation.

As, to our knowledge at the moment, there is no explicit literature covering the estimation of a gravity equation by ddm using panel data, we do not recommend to apply this method in this case.

Value

The function returns the summary of the estimated gravity model as an `lm`-object.

References

For more information on gravity models, theoretical foundations and estimation methods in general see

Anderson JE (1979). “A Theoretical Foundation for the Gravity Equation.” *The American Economic Review*, **69**(1), 106–116. ISSN 00028282.

Anderson JE, van Wincoop E (2001). “Gravity with Gravitas: A Solution to the Border Puzzle.” Working Paper 8079, National Bureau of Economic Research. [doi:10.3386/w8079](#).

Anderson JE (2010). “The Gravity Model.” Working Paper 16576, National Bureau of Economic Research. [doi:10.3386/w16576](#).

Baier SL, Bergstrand JH (2009). “Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation.” *Journal of International Economics*, **77**(1), 77–85. ISSN 0022-1996, [doi:10.1016/j.jinteco.2008.10.004](#).

Baier SL, Bergstrand JH (2010). “The Gravity Model in International Trade: Advances and Applications.” In van Bergeijk PAG, Brakman S (eds.), chapter 4. Cambridge University Press. [doi:10.1017/CBO9780511762109](#).

Feenstra RC (2002). “Border effects and the gravity equation: consistent methods for estimation.” *Scottish Journal of Political Economy*, **49**(5), 491–506.

Head K, Mayer T, Ries J (2010). “The erosion of colonial trade linkages after independence.” *Journal of International Economics*, **81**(1), 1–14. ISSN 0022-1996, [doi:10.1016/j.jinteco.2010.01.002](#).

Head K, Mayer T (2014). “Chapter 3 - Gravity Equations: Workhorse, Toolkit, and Cookbook.” In Gopinath G, Helpman E, Rogoff K (eds.), *Handbook of International Economics*, volume 4 of *Handbook of International Economics*, 131 - 195. Elsevier. doi:10.1016/B9780444543141.000033.

Silva JMCS, Tenreyro S (2006). “The Log of Gravity.” *The Review of Economics and Statistics*, **88**(4), 641-658. doi:10.1162/rest.88.4.641.

and the citations therein.

See [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) for gravity datasets and Stata code for estimating gravity models.

For estimating gravity equations using panel data see

Egger P, Pfaffermayr M (2003). “The proper panel econometric specification of the gravity equation: A three-way model with bilateral interaction effects.” *Empirical Economics*, **28**(3), 571–580. ISSN 1435-8921, doi:10.1007/s001810200146.

Gómez-Herrera E (2013). “Comparing alternative methods to estimate gravity models of bilateral trade.” *Empirical Economics*, **44**(3), 1087–1111. ISSN 1435-8921, doi:10.1007/s0018101205762.

and the references therein.

See Also

[lm](#), [coefstest](#), [vcovHC](#)

Examples

```
# Example for CRAN checks:
# Executable in < 5 sec
library(dplyr)
data("gravity_no_zeros")

# Choose 5 countries for testing
countries_chosen <- c("AUS", "CHN", "GBR", "BRA", "CAN")
grav_small <- filter(gravity_no_zeros, iso_o %in% countries_chosen)

fit <- ddm(
  dependent_variable = "flow",
  distance = "distw",
  additional_regressors = c("rta", "comcur", "contig"),
  code_origin = "iso_o",
  code_destination = "iso_d",
  robust = FALSE,
  data = grav_small
)
```

Description

discard_unusable drops observations that cannot be used with models that convert columns to log scale, and therefore require non-negative and finite observations.

Consider that some of the functions within this package will drop observations when required and it is not required to be run before fitting a model.

Usage

```
discard_unusable(data, columns)
```

Arguments

`data` (Type: `data.frame`) the dataset to be used.

`columns` The columns to be cleaned (e.g. `c("flow", "distw")`) in the case of `ddm` when used with the example dataset `gravity_zeros`)

Value

The function returns the summary of the estimated gravity model as an `lm`-object.

See Also

[lm](#), [coeftest](#), [vcovHC](#)

Examples

```
discard_unusable(gravity_zeros, "flow")
discard_unusable(gravity_zeros, c("flow", "distw"))
```

ek_tobit

Eaton and Kortum (2001) Tobit model (EK Tobit)

Description

ek_tobit estimates gravity models in their additive form by conducting a censored regression.

Usage

```
ek_tobit(
  dependent_variable,
  distance,
  additional_regressors = NULL,
  code_destination,
  robust = FALSE,
  data,
  ...
)
```

Arguments

dependent_variable	(Type: character) name of the dependent variable. This variable is logged and then used as the dependent variable in the estimation. As the log of zero is not defined, all flows equal to zero are replaced by a left open interval with the logged minimum trade flow of the respective importing country as right border.
distance	(Type: character) name of the distance variable that should be taken as the key independent variable in the estimation. The distance is logged automatically when the function is executed.
additional_regressors	(Type: character) names of the additional regressors to include in the model (e.g. a dummy variable to indicate contiguity). Unilateral metric variables such as GDP should be inserted via the arguments <code>income_origin</code> and <code>income_destination</code> . Write this argument as <code>c(contiguity, common_currency, ...)</code> . By default this is set to NULL.
code_destination	(Type: character) country of destination variable (e.g. country ISO-3 codes). The variables are grouped using this parameter.
robust	(Type: logical) whether robust fitting should be used. By default this is set to FALSE.
data	(Type: data.frame) the dataset to be used.
...	Additional arguments to be passed to the function.

Details

`ek_tobit` represents the Eaton and Kortum (2001) Tobit model where each country is assigned specific censoring bounds.

When taking the log of the gravity equation flows equal to zero constitute a problem as their log is not defined. Therefore, in `ek_tobit` all values of the dependent variable are redefined as intervals.

The positive observations have both interval bounds equal to their original value.

For zero flows the interval is left open. The right border of the interval is set to the log of the minimum positive trade flow of the respective importing country.

The defined data object of class `Surv` is then inserted in `survreg` for the parameter estimation.

`ek_tobit` is designed to be consistent with the Stata code provided at [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) when choosing robust estimation.

For other Tobit functions, see `tobit` for a simple Tobit model where number 1 is added to all observations and `et_tobit` for the Eaton and Tamura (1995) threshold Tobit model where instead of simply adding number 1 to the data the threshold is estimated.

The function is designed for cross-sectional data, but can be extended to panel data using the `survreg` function.

Value

The function returns the summary of the estimated gravity model as a `survreg`-object.

References

For more information on gravity models, theoretical foundations and estimation methods in general see

Anderson JE (1979). “A Theoretical Foundation for the Gravity Equation.” *The American Economic Review*, **69**(1), 106–116. ISSN 00028282.

Anderson JE, van Wincoop E (2001). “Gravity with Gravitas: A Solution to the Border Puzzle.” Working Paper 8079, National Bureau of Economic Research. doi:10.3386/w8079.

Anderson JE (2010). “The Gravity Model.” Working Paper 16576, National Bureau of Economic Research. doi:10.3386/w16576.

Baier SL, Bergstrand JH (2009). “Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation.” *Journal of International Economics*, **77**(1), 77 - 85. ISSN 0022-1996, doi:10.1016/j.jinteco.2008.10.004.

Baier SL, Bergstrand JH (2010). “The Gravity Model in International Trade: Advances and Applications.” In van Bergeijk PAG, Brakman S (eds.), chapter 4. Cambridge University Press. doi:10.1017/CBO9780511762109.

Feenstra RC (2002). “Border effects and the gravity equation: consistent methods for estimation.” *Scottish Journal of Political Economy*, **49**(5), 491–506.

Head K, Mayer T, Ries J (2010). “The erosion of colonial trade linkages after independence.” *Journal of International Economics*, **81**(1), 1 - 14. ISSN 0022-1996, doi:10.1016/j.jinteco.2010.01.002.

Head K, Mayer T (2014). “Chapter 3 - Gravity Equations: Workhorse, Toolkit, and Cookbook.” In Gopinath G, Helpman E, Rogoff K (eds.), *Handbook of International Economics*, volume 4 of *Handbook of International Economics*, 131 - 195. Elsevier. doi:10.1016/B9780444543141.000033.

Silva JMCS, Tenreyro S (2006). “The Log of Gravity.” *The Review of Economics and Statistics*, **88**(4), 641-658. doi:10.1162/rest.88.4.641.

and the citations therein.

See [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) for gravity datasets and Stata code for estimating gravity models.

For estimating gravity equations using panel data see

Egger P, Pfaffermayr M (2003). “The proper panel econometric specification of the gravity equation: A three-way model with bilateral interaction effects.” *Empirical Economics*, **28**(3), 571–580. ISSN 1435-8921, doi:10.1007/s001810200146.

Gómez-Herrera E (2013). “Comparing alternative methods to estimate gravity models of bilateral trade.” *Empirical Economics*, **44**(3), 1087–1111. ISSN 1435-8921, doi:10.1007/s0018101205762.

and the references therein.

See Also

[Surv](#), [survreg](#), [tobit](#)

Examples

```
# Example for CRAN checks:
# Executable in < 5 sec
library(dplyr)
```

```

data("gravity_no_zeros")

# Choose 5 countries for testing
countries_chosen <- c("AUS", "CHN", "GBR", "BRA", "CAN")
grav_small <- filter(gravity_no_zeros, iso_o %in% countries_chosen)

grav_small <- grav_small %>%
  mutate(
    flow = ifelse(flow < 5, 0, flow), # cutoff for testing purposes
    lgdp_o = log(gdp_o),
    lgdp_d = log(gdp_d)
  )

fit <- ek_tobit(
  dependent_variable = "flow",
  distance = "distw",
  additional_regressors = c("distw", "rta", "lgdp_o", "lgdp_d"),
  code_destination = "iso_d",
  robust = FALSE,
  data = grav_small
)

```

et_tobit

Eaton and Tamura (1995) threshold Tobit model (ET Tobit)

Description

et_tobit estimates gravity models in their additive form by conducting a left-censored regression.

Usage

```
et_tobit(dependent_variable, distance, additional_regressors = NULL, data, ...)
```

Arguments

dependent_variable

(Type: character) name of the dependent variable. Following Carson and Sun (2007), the smallest positive flow value is used as an estimate of the threshold, this value is added to the dependent_variable, the result is logged and taken as the dependent variable in the Tobit estimation with lower bound equal to the log of the smallest possible flow value.

distance

(Type: character) name of the distance variable that should be taken as the key independent variable in the estimation. The distance is logged automatically when the function is executed.

additional_regressors

(Type: character) names of the additional regressors to include in the model (e.g. a dummy variable to indicate contiguity). Unilateral metric variables such as GDP should be inserted via the arguments income_origin and income_destination. Write this argument as c(contiguity, common currency, ...). By default this is set to NULL.

data (Type: data.frame) the dataset to be used.
... Additional arguments to be passed to the function.

Details

et_tobit represents the Eaton and Tamura (1995) Tobit model which is often used when several gravity models are compared, instead of adding number 1 to the dependent variable as done in [tobit](#), the constant added to the data is estimated and interpreted as a threshold.

When taking the log of the gravity equation flows equal to zero constitute a problem as their log is not defined. Therefore, a constant is added to the flows.

Compared to the usual ET-Tobit approaches, in this package, the estimation of the threshold is done before the other parameters are estimated.

We follow Carson and Sun (2007), who show that taking the minimum positive flow value as an estimate of the threshold is super-consistent and that using this threshold estimate ensures that the parameter MLE are asymptotically normal with the asymptotic variance identical to the variance achieved when the threshold is known. Hence, first the threshold is estimated as the minimum positive flow. This threshold is added to the flow variable, it is logged afterwards and taken as the dependent variable.

The Tobit estimation is then conducted using the [censReg](#) function and setting the lower bound equal to the log of the minimum positive flow value which was added to all observations.

A Tobit regression represents a combination of a binary and a linear regression. This procedure has to be taken into consideration when interpreting the estimated coefficients.

The marginal effects of an explanatory variable on the expected value of the dependent variable equals the product of both the probability of the latent variable exceeding the threshold and the marginal effect of the explanatory variable of the expected value of the latent variable.

For a more elaborate Tobit function, see [ek_tobit](#) for the Eaton and Kortum (2001) Tobit model where each zero trade volume is assigned a country specific interval with the upper bound equal to the minimum positive trade level of the respective importing country.

The function is designed for cross-sectional data, but can be extended to panel data using the [censReg](#) function.

A robust estimations is not implemented to the present as the [censReg](#) function is not compatible with the [vcovHC](#) function.

Value

The function returns the summary of the estimated gravity model as a [censReg](#)-object.

References

For more information on gravity models, theoretical foundations and estimation methods in general see

Anderson JE (1979). "A Theoretical Foundation for the Gravity Equation." *The American Economic Review*, **69**(1), 106–116. ISSN 00028282.

Anderson JE, van Wincoop E (2001). "Gravity with Gravitas: A Solution to the Border Puzzle." Working Paper 8079, National Bureau of Economic Research. [doi:10.3386/w8079](https://doi.org/10.3386/w8079).

Anderson JE (2010). “The Gravity Model.” Working Paper 16576, National Bureau of Economic Research. doi:10.3386/w16576.

Baier SL, Bergstrand JH (2009). “Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation.” *Journal of International Economics*, 77(1), 77 - 85. ISSN 0022-1996, doi:10.1016/j.jinteco.2008.10.004.

Baier SL, Bergstrand JH (2010). “The Gravity Model in International Trade: Advances and Applications.” In van Bergeijk PAG, Brakman S (eds.), chapter 4. Cambridge University Press. doi:10.1017/CBO9780511762109.

Feenstra RC (2002). “Border effects and the gravity equation: consistent methods for estimation.” *Scottish Journal of Political Economy*, 49(5), 491–506.

Head K, Mayer T, Ries J (2010). “The erosion of colonial trade linkages after independence.” *Journal of International Economics*, 81(1), 1 - 14. ISSN 0022-1996, doi:10.1016/j.jinteco.2010.01.002.

Head K, Mayer T (2014). “Chapter 3 - Gravity Equations: Workhorse, Toolkit, and Cookbook.” In Gopinath G, Helpman E, Rogoff K (eds.), *Handbook of International Economics*, volume 4 of *Handbook of International Economics*, 131 - 195. Elsevier. doi:10.1016/B9780444543141.000033.

Silva JMCS, Teneyro S (2006). “The Log of Gravity.” *The Review of Economics and Statistics*, 88(4), 641-658. doi:10.1162/rest.88.4.641.

and the citations therein.

See [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) for gravity datasets and Stata code for estimating gravity models.

For estimating gravity equations using panel data see

Egger P, Pfaffermayr M (2003). “The proper panel econometric specification of the gravity equation: A three-way model with bilateral interaction effects.” *Empirical Economics*, 28(3), 571–580. ISSN 1435-8921, doi:10.1007/s001810200146.

Gómez-Herrera E (2013). “Comparing alternative methods to estimate gravity models of bilateral trade.” *Empirical Economics*, 44(3), 1087–1111. ISSN 1435-8921, doi:10.1007/s0018101205762.

and the references therein.

See Also

[censReg, et_tobit](#)

Examples

```
# Example for CRAN checks:
# Executable in < 5 sec
library(dplyr)
data("gravity_no_zeros")

# Choose 5 countries for testing
countries_chosen <- c("AUS", "CHN", "GBR", "BRA", "CAN")
grav_small <- filter(gravity_no_zeros, iso_o %in% countries_chosen)

grav_small <- grav_small %>%
  mutate(
    flow = ifelse(flow < 5, 0, flow), # cutoff for testing purposes
```

```

    lgdp_o = log(gdp_o),
    lgdp_d = log(gdp_d)
  )

fit <- et_tobit(
  dependent_variable = "flow",
  distance = "distw",
  additional_regressors = c("rta", "lgdp_o", "lgdp_d"),
  data = grav_small
)

```

fixed_effects

Fixed Effects

Description

fixed_effects estimates gravity models via OLS and fixed effects for the countries of origin and destination.

Usage

```

fixed_effects(
  dependent_variable,
  distance,
  additional_regressors = NULL,
  code_origin,
  code_destination,
  robust = FALSE,
  data,
  ...
)

```

Arguments

dependent_variable	(Type: character) name of the dependent variable. This variable is logged and then used as the dependent variable in the estimation.
distance	(Type: character) name of the distance variable that should be taken as the key independent variable in the estimation. The distance is logged automatically when the function is executed.
additional_regressors	(Type: character) names of the additional regressors to include in the model (e.g. a dummy variable to indicate contiguity). Unilateral metric variables such as GDPs can be added but those variables have to be logged first. Write this argument as <code>c(contiguity, common currency, ...)</code> . By default this is set to NULL.
code_origin	(Type: character) country of origin variable (e.g. ISO-3 country codes). The variables are grouped using this parameter.

<code>code_destination</code>	(Type: character) country of destination variable (e.g. country ISO-3 codes). The variables are grouped using this parameter.
<code>robust</code>	(Type: logical) whether robust fitting should be used. By default this is set to FALSE.
<code>data</code>	(Type: data.frame) the dataset to be used.
<code>...</code>	Additional arguments to be passed to the function.

Details

To account for MR terms, Feenstra (2002) and Feenstra (2015) propose to use importer and exporter fixed effects. Due to the use of these effects, all unilateral influences such as GDPs can no longer be estimated.

A disadvantage of the use of `fixed_effects` is that, when applied to panel data, the number of country-year or country-pair fixed effects can be too high for estimation. In addition, no comparative statistics are possible with `fixed_effects` as the Multilateral Resistance terms are not estimated explicitly. Nevertheless, Head and Mayer (2014) highlight the importance of the use of fixed effects.

By including country specific fixed effects, all monadic effects are captured, including Multilateral Resistance terms. Therefore, no other unilateral variables such as GDP can be included as independent variables in the estimation.

`fixed_effects` estimation can be used for both, cross-sectional as well as panel data.

Nonetheless, the function is designed to be consistent with the Stata code for cross-sectional data provided at the website [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) when choosing robust estimation.

The function `fixed_effects` was therefore tested for cross-sectional data. Its up to the user to ensure that the functions can be applied to panel data.

Also, note that by including bilateral fixed effects such as country-pair effects, the coefficients of time-invariant observables such as distance can no longer be estimated.

Depending on the specific model, the code of the respective function might have to be changed in order to exclude the distance variable from the estimation.

At the very least, the user should take special care with respect to the meaning of the estimated coefficients and variances as well as the decision about which effects to include in the estimation.

When using panel data, the parameter and variance estimation of the models may have to be changed accordingly.

For a comprehensive overview of gravity models for panel data see Egger and Pfaffermayr (2003), Gómez-Herrera (2013) and Head et al. (2010) as well as the references therein.

Value

The function returns the summary of the estimated gravity model as an `lm`-object.

References

For more information on gravity models, theoretical foundations and estimation methods in general see

Anderson JE (1979). “A Theoretical Foundation for the Gravity Equation.” *The American Economic Review*, **69**(1), 106–116. ISSN 00028282.

Anderson JE, van Wincoop E (2001). “Gravity with Gravitas: A Solution to the Border Puzzle.” Working Paper 8079, National Bureau of Economic Research. doi:10.3386/w8079.

Anderson JE (2010). “The Gravity Model.” Working Paper 16576, National Bureau of Economic Research. doi:10.3386/w16576.

Baier SL, Bergstrand JH (2009). “Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation.” *Journal of International Economics*, **77**(1), 77 - 85. ISSN 0022-1996, doi:10.1016/j.jinteco.2008.10.004.

Baier SL, Bergstrand JH (2010). “The Gravity Model in International Trade: Advances and Applications.” In van Bergeijk PAG, Brakman S (eds.), chapter 4. Cambridge University Press. doi:10.1017/CBO9780511762109.

Feenstra RC (2002). “Border effects and the gravity equation: consistent methods for estimation.” *Scottish Journal of Political Economy*, **49**(5), 491–506.

Head K, Mayer T, Ries J (2010). “The erosion of colonial trade linkages after independence.” *Journal of International Economics*, **81**(1), 1 - 14. ISSN 0022-1996, doi:10.1016/j.jinteco.2010.01.002.

Head K, Mayer T (2014). “Chapter 3 - Gravity Equations: Workhorse, Toolkit, and Cookbook.” In Gopinath G, Helpman E, Rogoff K (eds.), *Handbook of International Economics*, volume 4 of *Handbook of International Economics*, 131 - 195. Elsevier. doi:10.1016/B9780444543141.000033.

Silva JMCS, Tenreyro S (2006). “The Log of Gravity.” *The Review of Economics and Statistics*, **88**(4), 641-658. doi:10.1162/rest.88.4.641.

and the citations therein.

See [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) for gravity datasets and Stata code for estimating gravity models.

For estimating gravity equations using panel data see

Egger P, Pfaffermayr M (2003). “The proper panel econometric specification of the gravity equation: A three-way model with bilateral interaction effects.” *Empirical Economics*, **28**(3), 571–580. ISSN 1435-8921, doi:10.1007/s001810200146.

Gómez-Herrera E (2013). “Comparing alternative methods to estimate gravity models of bilateral trade.” *Empirical Economics*, **44**(3), 1087–1111. ISSN 1435-8921, doi:10.1007/s0018101205762.

and the references therein.

See Also

[lm](#), [coefstest](#), [vcovHC](#)

Examples

```
# Example for CRAN checks:
# Executable in < 5 sec
library(dplyr)
data("gravity_no_zeros")

# Choose 5 countries for testing
countries_chosen <- c("AUS", "CHN", "GBR", "BRA", "CAN")
```

```

grav_small <- filter(gravity_no_zeros, iso_o %in% countries_chosen)

fit <- fixed_effects(
  dependent_variable = "flow",
  distance = "distw",
  additional_regressors = c("rta", "comcur", "contig"),
  code_origin = "iso_o",
  code_destination = "iso_d",
  robust = FALSE,
  data = grav_small
)

```

gpml

Gamma Pseudo Maximum Likelihood (GPML)

Description

gpml estimates gravity models in their multiplicative form via Gamma Pseudo Maximum Likelihood.

Usage

```

gpml(
  dependent_variable,
  distance,
  additional_regressors,
  robust = FALSE,
  data,
  ...
)

```

Arguments

dependent_variable	(Type: character) name of the dependent variable. This variable is logged and then used as the dependent variable in the estimation.
distance	(Type: character) name of the distance variable that should be taken as the key independent variable in the estimation. The distance is logged automatically when the function is executed.
additional_regressors	(Type: character) names of the additional regressors to include in the model (e.g. a dummy variable to indicate contiguity). Unilateral metric variables such as GDPs can be added but those variables have to be logged first. Interaction terms can be added. Write this argument as <code>c(contiguity, common currency, ...)</code> . By default this is set to NULL.
robust	(Type: logical) whether robust fitting should be used. By default this is set to FALSE.

data (Type: data.frame) the dataset to be used.
... Additional arguments to be passed to the function.

Details

gpml is an estimation method for gravity models belonging to generalized linear models. It is described in Silva and Tenreyro (2006) and the model is estimated via [glm2](#) using the gamma distribution and a log-link.

For similar functions, utilizing the multiplicative form via the log-link, but different distributions, see [ppml](#), [nls](#), and [nbpml](#).

gpml estimation can be used for both, cross-sectional as well as panel data, but its up to the user to ensure that the functions can be applied to panel data.

Depending on the panel dataset and the variables - specifically the type of fixed effects - included in the model, it may easily occur that the model is not computable.

Also, note that by including bilateral fixed effects such as country-pair effects, the coefficients of time-invariant observables such as distance can no longer be estimated.

Depending on the specific model, the code of the respective function might have to be changed in order to exclude the distance variable from the estimation.

At the very least, the user should take special care with respect to the meaning of the estimated coefficients and variances as well as the decision about which effects to include in the estimation.

When using panel data, the parameter and variance estimation of the models may have to be changed accordingly.

For a comprehensive overview of gravity models for panel data see Egger and Pfaffermayr (2003), Gómez-Herrera (2013) and Head et al. (2010).

Value

The function returns the summary of the estimated gravity model similar to a [glm](#)-object.

References

For more information on gravity models, theoretical foundations and estimation methods in general see

Anderson JE (1979). "A Theoretical Foundation for the Gravity Equation." *The American Economic Review*, **69**(1), 106–116. ISSN 00028282.

Anderson JE, van Wincoop E (2001). "Gravity with Gravitas: A Solution to the Border Puzzle." Working Paper 8079, National Bureau of Economic Research. [doi:10.3386/w8079](#).

Anderson JE (2010). "The Gravity Model." Working Paper 16576, National Bureau of Economic Research. [doi:10.3386/w16576](#).

Baier SL, Bergstrand JH (2009). "Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation." *Journal of International Economics*, **77**(1), 77 - 85. ISSN 0022-1996, [doi:10.1016/j.jinteco.2008.10.004](#).

Baier SL, Bergstrand JH (2010). "The Gravity Model in International Trade: Advances and Applications." In van Bergeijk PAG, Brakman S (eds.), chapter 4. Cambridge University Press. [doi:10.1017/CBO9780511762109](#).

Feenstra RC (2002). “Border effects and the gravity equation: consistent methods for estimation.” *Scottish Journal of Political Economy*, **49**(5), 491–506.

Head K, Mayer T, Ries J (2010). “The erosion of colonial trade linkages after independence.” *Journal of International Economics*, **81**(1), 1 - 14. ISSN 0022-1996, doi:10.1016/j.jinteco.2010.01.002.

Head K, Mayer T (2014). “Chapter 3 - Gravity Equations: Workhorse, Toolkit, and Cookbook.” In Gopinath G, Helpman E, Rogoff K (eds.), *Handbook of International Economics*, volume 4 of *Handbook of International Economics*, 131 - 195. Elsevier. doi:10.1016/B9780444543141.000033.

Silva JMCS, Tenreyro S (2006). “The Log of Gravity.” *The Review of Economics and Statistics*, **88**(4), 641-658. doi:10.1162/rest.88.4.641.

and the citations therein.

See [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) for gravity datasets and Stata code for estimating gravity models.

For estimating gravity equations using panel data see

Egger P, Pfaffermayr M (2003). “The proper panel econometric specification of the gravity equation: A three-way model with bilateral interaction effects.” *Empirical Economics*, **28**(3), 571–580. ISSN 1435-8921, doi:10.1007/s001810200146.

Gómez-Herrera E (2013). “Comparing alternative methods to estimate gravity models of bilateral trade.” *Empirical Economics*, **44**(3), 1087–1111. ISSN 1435-8921, doi:10.1007/s0018101205762.

and the references therein.

See Also

[glm2](#), [coefstest](#), [vcovHC](#)

Examples

```
# Example for CRAN checks:
# Executable in < 5 sec
library(dplyr)
data("gravity_no_zeros")

# Choose 5 countries for testing
countries_chosen <- c("AUS", "CHN", "GBR", "BRA", "CAN")
grav_small <- filter(gravity_no_zeros, iso_o %in% countries_chosen)

grav_small <- grav_small %>%
  mutate(
    lgdp_o = log(gdp_o),
    lgdp_d = log(gdp_d)
  )

fit <- gpml(
  dependent_variable = "flow",
  distance = "distw",
  additional_regressors = c("rta", "iso_o", "iso_d"),
  data = grav_small
)
```

gravity_no_zeros	<i>Gravity dataset without zero trade flows</i>
------------------	---

Description

An edited version of the full gravity dataset: The "square" gravity dataset for all possible pairs of Countries worldwide, 1948-2006, which is used in the article: Head, K., T. Mayer and J. Ries, 2010, "The erosion of colonial linkages after independence". Journal of International Economics, 81(1):1-14 (lead article). Dataset gravity_no_zeros corresponds to the dataset without zero trade flows, gravity_zeros, on the other hand, includes zero trade flows.

Usage

```
data("gravity_no_zeros")
```

Format

A data frame with 17088 observations on the following 10 variables.

iso_o ISO-Code of country of origin
iso_d ISO-Code of country of destination
distw weighted distance
gdp_o GDP of country of origin in million dollars
gdp_d GDP of country of destination in million dollars
rta regional trade agreement dummy
flow trade flow in million dollars
contig contiguity dummy
comlang_off common official language dummy
comcur common currency dummy

Source

<https://sites.google.com/site/hiegravity/data-sources>

References

Head, K. and Mayer, T. (2014). Chapter 3 - gravity equations: Workhorse, toolkit, and cookbook. In Gita Gopinath, E. H. and Rogoff, K., editors, Handbook of International Economics, volume 4 of Handbook of International Economics, pages 131-195. Elsevier. ([Gravity Equations: Workhorse, Toolkit, and Cookbook](#))

Head, K., T. Mayer and J. Ries, 2010, "The erosion of colonial linkages after independence". Journal of International Economics, 81(1):1-14 (lead article).

Examples

```
data(gravity_no_zeros)  
str(gravity_no_zeros)
```

gravity_zeros

Gravity dataset without zero trade flows

Description

An edited version of the full gravity dataset: The "square" gravity dataset for all possible pairs of Countries worldwide, 1948-2006, which is used in the article: Head, K., T. Mayer and J. Ries, 2010, "The erosion of colonial linkages after independence". Journal of International Economics, 81(1):1-14 (lead article). Dataset gravity_no_zeros corresponds to the dataset without zero trade flows, gravity_zeros, on the other hand, includes zero trade flows.

Usage

```
data("gravity_zeros")
```

Format

A data frame with 22588 observations on the following 10 variables.

iso_o ISO-Code of country of origin
iso_d ISO-Code of country of destination
distw weighted distance
gdp_o GDP of country of origin in million dollars
gdp_d GDP of country of destination in million dollars
rta regional trade agreement dummy
flow trade flow in million dollars
contig contiguity dummy
comlang_off common official language dummy
comcur common currency dummy

Source

<https://sites.google.com/site/hiegravity/data-sources>

References

Head, K. and Mayer, T. (2014). Chapter 3 - gravity equations: Workhorse, toolkit, and cookbook. In Gita Gopinath, E. H. and Rogoff, K., editors, Handbook of International Economics, volume 4 of Handbook of International Economics, pages 131-195. Elsevier. ([Gravity Equations: Workhorse, Toolkit, and Cookbook](#))

Head, K., T. Mayer and J. Ries, 2010, "The erosion of colonial linkages after independence". Journal of International Economics, 81(1):1-14 (lead article).

Examples

```
data(gravity_zeros)  
str(gravity_zeros)
```

`hm_summary`*Head and Mayer consistent summary statistics*

Description

Summary of estimates function that, if is used with default options, provides estimation results are consistent with the Stata methods used in Head and Mayer (2014). This function is adapted from the work of [Isidore Beautrelet](#).

Usage

```
hm_summary(model, robust = FALSE, ...)
```

Arguments

<code>model</code>	(Type: <code>lm</code>) Regression object obtained by using the estimation methods from this package or a generic method such as <code>lm</code> or <code>glm</code> . Some particular classes (<code>gpml</code> , <code>nbpml</code> , <code>negbin</code> and <code>nls</code>) don't return R squared and F statistic.
<code>robust</code>	(Type: logical) Determines whether a robust variance-covariance matrix should be used. By default is set to <code>FALSE</code> . If set <code>TRUE</code> the estimation results are consistent with the Stata code provided at the website Gravity Equations: Workhorse, Toolkit, and Cookbook when choosing robust estimation.
<code>...</code>	additional arguments to be passed to <code>tobit</code> .

Value

Summary `lm` object.

Examples

```
# Example for CRAN checks:
# Executable in < 5 sec
library(dplyr)
data("gravity_no_zeros")

# Choose 5 countries for testing
countries_chosen <- c("AUS", "CHN", "GBR", "BRA", "CAN")
grav_small <- filter(gravity_no_zeros, iso_o %in% countries_chosen)

# Using OLS for testing
fit <- ols(
  dependent_variable = "flow",
  distance = "distw",
  additional_regressors = c("rta", "contig", "comcur"),
  income_origin = "gdp_o",
  income_destination = "gdp_d",
  code_origin = "iso_o",
```

```
code_destination = "iso_d",
uie = FALSE,
robust = FALSE,
data = grav_small
)

fit2 <- hm_summary(fit, robust = FALSE)
```

log_distance	<i>Apply logarithm to distance column</i>
--------------	---

Description

log_distance creates a new dist_log column in log scale by taking the original distance column in the data

Usage

```
log_distance(data, distance)
```

Arguments

data (Type: data.frame) the dataset to be used.
distance The distance column

Value

The function returns the summary of the estimated gravity model as an [lm](#)-object.

See Also

[lm](#), [coeftest](#), [vcovHC](#)

Examples

```
log_distance(gravity_zeros, "distw")
```

 nbpml

Negative Binomial Pseudo Maximum Likelihood (NBPML)

Description

nbpml estimates gravity models in their multiplicative form via Negative Binomial Pseudo Maximum Likelihood.

Usage

```
nbpml(
  dependent_variable,
  distance,
  additional_regressors,
  robust = FALSE,
  data,
  ...
)
```

Arguments

dependent_variable	(Type: character) name of the dependent variable. This variable is logged and then used as the dependent variable in the estimation.
distance	(Type: character) name of the distance variable that should be taken as the key independent variable in the estimation. The distance is logged automatically when the function is executed.
additional_regressors	(Type: character) names of the additional regressors to include in the model (e.g. a dummy variable to indicate contiguity). Unilateral metric variables such as GDPs can be added but those variables have to be logged first. Interaction terms can be added. Write this argument as <code>c(contiguity, common currency, ...)</code> . By default this is set to NULL.
robust	(Type: logical) whether robust fitting should be used. By default this is set to FALSE.
data	(Type: data.frame) the dataset to be used.
...	Additional arguments to be passed to the function.

Details

nbpml is an estimation method for gravity models belonging to generalized linear models. It is estimated via [glm.nb](#) using the negative binomial distribution and a log-link.

For similar functions, utilizing the multiplicative form via the log-link, but different distributions, see [nbpml](#), [gpml](#), and [nls](#).

gpml estimation can be used for both, cross-sectional as well as panel data, but its up to the user to ensure that the functions can be applied to panel data.

Depending on the panel dataset and the variables - specifically the type of fixed effects - included in the model, it may easily occur that the model is not computable.

Also, note that by including bilateral fixed effects such as country-pair effects, the coefficients of time-invariant observables such as distance can no longer be estimated.

Depending on the specific model, the code of the respective function may have to be changed in order to exclude the distance variable from the estimation.

At the very least, the user should take special care with respect to the meaning of the estimated coefficients and variances as well as the decision about which effects to include in the estimation. When using panel data, the parameter and variance estimation of the models may have to be changed accordingly.

For a comprehensive overview of gravity models for panel data see Egger and Pfaffermayr (2003), Gómez-Herrera (2013) and Head et al. (2010).

Value

The function returns the summary of the estimated gravity model similar to a `glm`-object.

References

For more information on gravity models, theoretical foundations and estimation methods in general see

Anderson JE (1979). "A Theoretical Foundation for the Gravity Equation." *The American Economic Review*, **69**(1), 106–116. ISSN 00028282.

Anderson JE, van Wincoop E (2001). "Gravity with Gravitas: A Solution to the Border Puzzle." Working Paper 8079, National Bureau of Economic Research. doi:10.3386/w8079.

Anderson JE (2010). "The Gravity Model." Working Paper 16576, National Bureau of Economic Research. doi:10.3386/w16576.

Baier SL, Bergstrand JH (2009). "Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation." *Journal of International Economics*, **77**(1), 77 - 85. ISSN 0022-1996, doi:10.1016/j.jinteco.2008.10.004.

Baier SL, Bergstrand JH (2010). "The Gravity Model in International Trade: Advances and Applications." In van Bergeijk PAG, Brakman S (eds.), chapter 4. Cambridge University Press. doi:10.1017/CBO9780511762109.

Feenstra RC (2002). "Border effects and the gravity equation: consistent methods for estimation." *Scottish Journal of Political Economy*, **49**(5), 491–506.

Head K, Mayer T, Ries J (2010). "The erosion of colonial trade linkages after independence." *Journal of International Economics*, **81**(1), 1 - 14. ISSN 0022-1996, doi:10.1016/j.jinteco.2010.01.002.

Head K, Mayer T (2014). "Chapter 3 - Gravity Equations: Workhorse, Toolkit, and Cookbook." In Gopinath G, Helpman E, Rogoff K (eds.), *Handbook of International Economics*, volume 4 of *Handbook of International Economics*, 131 - 195. Elsevier. doi:10.1016/B9780444543141.000033.

Silva JMCS, Tenreyro S (2006). "The Log of Gravity." *The Review of Economics and Statistics*, **88**(4), 641-658. doi:10.1162/rest.88.4.641.

and the citations therein.

See [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) for gravity datasets and Stata code for estimating gravity models.

For estimating gravity equations using panel data see

Egger P, Pfaffermayr M (2003). “The proper panel econometric specification of the gravity equation: A three-way model with bilateral interaction effects.” *Empirical Economics*, **28**(3), 571–580. ISSN 1435-8921, doi:10.1007/s001810200146.

Gómez-Herrera E (2013). “Comparing alternative methods to estimate gravity models of bilateral trade.” *Empirical Economics*, **44**(3), 1087–1111. ISSN 1435-8921, doi:10.1007/s0018101205762.

and the references therein.

See Also

[glm.nb](#), [coeftest](#), [vcovHC](#)

Examples

```
# Example for CRAN checks:
# Executable in < 5 sec
library(dplyr)
data("gravity_no_zeros")

# Choose 3 countries for testing
countries_chosen <- c("AUS", "GBR", "CAN")
grav_small <- filter(gravity_no_zeros, iso_o %in% countries_chosen)

fit <- nbpml(
  dependent_variable = "flow",
  distance = "distw",
  additional_regressors = c("rta", "iso_o", "iso_d"),
  data = grav_small
)
```

nls

Non-linear Least Squares (NLS)

Description

nls estimates gravity models in their multiplicative form via Nonlinear Least Squares.

Usage

```
nls(dependent_variable, distance, additional_regressors = NULL, data, ...)
```

Arguments

<code>dependent_variable</code>	(Type: character) name of the dependent variable. This variable is logged and then used as the dependent variable in the estimation.
<code>distance</code>	(Type: character) name of the distance variable that should be taken as the key independent variable in the estimation. The distance is logged automatically when the function is executed.
<code>additional_regressors</code>	(Type: character) names of the additional regressors to include in the model (e.g. a dummy variable to indicate contiguity). Unilateral metric variables such as GDPs can be added but those variables have to be logged first. Interaction terms can be added. Write this argument as <code>c(contiguity, common currency, ...)</code> . By default this is set to <code>NULL</code> .
<code>data</code>	(Type: data.frame) the dataset to be used.
<code>...</code>	Additional arguments to be passed to the function.

Details

`nls` is an estimation method for gravity models belonging to generalized linear models. It is estimated via `glm` using the gaussian distribution and a log-link.

As the method may not lead to convergence when poor starting values are used, the linear predictions, fitted values, and estimated coefficients resulting from a `ppml` estimation are used for the arguments `etastart`, `mustart`, and `start`.

For similar functions, utilizing the multiplicative form via the log-link, but different distributions, see `ppml`, `gpml`, and `nbpml`.

`nls` estimation can be used for both, cross-sectional as well as panel data, but its up to the user to ensure that the functions can be applied to panel data.

Depending on the panel dataset and the variables - specifically the type of fixed effects - included in the model, it may easily occur that the model is not computable.

Also, note that by including bilateral fixed effects such as country-pair effects, the coefficients of time-invariant observables such as distance can no longer be estimated.

Depending on the specific model, the code of the respective function may have to be changed in order to exclude the distance variable from the estimation.

At the very least, the user should take special care with respect to the meaning of the estimated coefficients and variances as well as the decision about which effects to include in the estimation. When using panel data, the parameter and variance estimation of the models may have to be changed accordingly.

For a comprehensive overview of gravity models for panel data see Egger and Pfaffermayr (2003), Gómez-Herrera (2013) and Head et al. (2010) as well as the references therein.

Value

The function returns the summary of the estimated gravity model similar to a `glm`-object.

References

For more information on gravity models, theoretical foundations and estimation methods in general see

Anderson JE (1979). “A Theoretical Foundation for the Gravity Equation.” *The American Economic Review*, **69**(1), 106–116. ISSN 00028282.

Anderson JE, van Wincoop E (2001). “Gravity with Gravitas: A Solution to the Border Puzzle.” Working Paper 8079, National Bureau of Economic Research. doi:10.3386/w8079.

Anderson JE (2010). “The Gravity Model.” Working Paper 16576, National Bureau of Economic Research. doi:10.3386/w16576.

Baier SL, Bergstrand JH (2009). “Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation.” *Journal of International Economics*, **77**(1), 77 - 85. ISSN 0022-1996, doi:10.1016/j.jinteco.2008.10.004.

Baier SL, Bergstrand JH (2010). “The Gravity Model in International Trade: Advances and Applications.” In van Bergeijk PAG, Brakman S (eds.), chapter 4. Cambridge University Press. doi:10.1017/CBO9780511762109.

Feenstra RC (2002). “Border effects and the gravity equation: consistent methods for estimation.” *Scottish Journal of Political Economy*, **49**(5), 491–506.

Head K, Mayer T, Ries J (2010). “The erosion of colonial trade linkages after independence.” *Journal of International Economics*, **81**(1), 1 - 14. ISSN 0022-1996, doi:10.1016/j.jinteco.2010.01.002.

Head K, Mayer T (2014). “Chapter 3 - Gravity Equations: Workhorse, Toolkit, and Cookbook.” In Gopinath G, Helpman E, Rogoff K (eds.), *Handbook of International Economics*, volume 4 of *Handbook of International Economics*, 131 - 195. Elsevier. doi:10.1016/B9780444543141.000033.

Silva JMCS, Tenreyro S (2006). “The Log of Gravity.” *The Review of Economics and Statistics*, **88**(4), 641-658. doi:10.1162/rest.88.4.641.

and the citations therein.

See [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) for gravity datasets and Stata code for estimating gravity models.

For estimating gravity equations using panel data see

Egger P, Pfaffermayr M (2003). “The proper panel econometric specification of the gravity equation: A three-way model with bilateral interaction effects.” *Empirical Economics*, **28**(3), 571–580. ISSN 1435-8921, doi:10.1007/s001810200146.

Gómez-Herrera E (2013). “Comparing alternative methods to estimate gravity models of bilateral trade.” *Empirical Economics*, **44**(3), 1087–1111. ISSN 1435-8921, doi:10.1007/s0018101205762.

and the references therein.

See Also

[glm](#), [coefstest](#), [vcovHC](#)

Examples

```
# Example for CRAN checks:
# Executable in < 5 sec
library(dplyr)
```

```

data("gravity_no_zeros")

# Choose 5 countries for testing
countries_chosen <- c("AUS", "CHN", "GBR", "BRA", "CAN")
grav_small <- filter(gravity_no_zeros, iso_o %in% countries_chosen)

grav_small <- grav_small %>%
  mutate(
    lgdp_o = log(gdp_o),
    lgdp_d = log(gdp_d)
  )

fit <- nls(
  dependent_variable = "flow",
  distance = "distw",
  additional_regressors = c("rta", "lgdp_o", "lgdp_d"),
  data = grav_small
)

```

ols

Ordinary Least Squares (OLS)

Description

ols estimates gravity models in their traditional form via Ordinary Least Squares (ols). It does not consider Multilateral Resistance terms.

Usage

```

ols(
  dependent_variable,
  distance,
  additional_regressors = NULL,
  income_origin,
  income_destination,
  code_origin,
  code_destination,
  uie = FALSE,
  robust = FALSE,
  data,
  ...
)

```

Arguments

`dependent_variable`

(Type: character) name of the dependent variable.

If `uie = TRUE` the dependent variable is divided by the product of unilateral incomes (e.g. `income_origin` and `income_destination`) and logged afterwards.

If `uie=FALSE` the dependent variable is logged directly. The transformed variable is then used as the dependent variable and the logged income variables are used as independent variables in the estimation.

<code>distance</code>	(Type: character) name of the distance variable that should be taken as the key independent variable in the estimation. The distance is logged automatically when the function is executed.
<code>additional_regressors</code>	(Type: character) names of the additional regressors to include in the model (e.g. a dummy variable to indicate contiguity). Unilateral metric variables such as GDPs can be added but those variables have to be logged first. Interaction terms can be added. Write this argument as <code>c(contiguity, common currency, ...)</code> . By default this is set to <code>NULL</code> .
<code>income_origin</code>	(Type: character) origin income variable (e.g. GDP) in the dataset.
<code>income_destination</code>	(Type: character) destination income variable (e.g. GDP) in the dataset.
<code>code_origin</code>	(Type: character) country of origin variable (e.g. ISO-3 country codes). The variables are grouped using this parameter.
<code>code_destination</code>	(Type: character) country of destination variable (e.g. country ISO-3 codes). The variables are grouped using this parameter.
<code>uie</code>	(Type: logical) Determines whether the parameters are to be estimated assuming unitary income elasticities. The default value is set to <code>FALSE</code> .
<code>robust</code>	(Type: logical) whether robust fitting should be used. By default this is set to <code>FALSE</code> .
<code>data</code>	(Type: data.frame) the dataset to be used.
<code>...</code>	Additional arguments to be passed to the function.

Details

`ols` estimates gravity models in their traditional, additive, form via Ordinary Least Squares using the `lm` function. Multilateral Resistance terms are not considered by this function.

As the coefficients for the country's incomes were often found to be close to unitary and unitary income elasticities are in line with some theoretical foundations on international trade, it is sometimes assumed that the income elasticities are equal to unity.

In order to allow for the estimation with and without the assumption of unitary income elasticities, the option `uie` is built into `ols` with the default set to `FALSE`.

`ols` estimation can be used for both, cross-sectional and panel data. Nonetheless, the function is designed to be consistent with the Stata code for cross-sectional data provided at the website [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) when choosing robust estimation.

The function `ols` was therefore tested for cross-sectional data. For the use with panel data no tests were performed. Therefore, it is up to the user to ensure that the functions can be applied to panel data.

Depending on the panel dataset and the variables - specifically the type of fixed effects - included in the model, it may easily occur that the model is not computable. Also, note that by including

bilateral fixed effects such as country-pair effects, the coefficients of time-invariant observables such as distance can no longer be estimated.

Depending on the specific model, the code of the respective function may have to be changed in order to exclude the distance variable from the estimation.

At the very least, the user should take special care with respect to the meaning of the estimated coefficients and variances as well as the decision about which effects to include in the estimation. When using panel data, the parameter and variance estimation of the models may have to be changed accordingly.

For a comprehensive overview of gravity models for panel data see Egger and Pfaffermayr (2003), Gómez-Herrera (2013) and Head et al. (2010) as well as the references therein.

Value

The function returns the summary of the estimated gravity model as an `lm`-object.

References

For more information on gravity models, theoretical foundations and estimation methods in general see

Anderson JE (1979). “A Theoretical Foundation for the Gravity Equation.” *The American Economic Review*, **69**(1), 106–116. ISSN 00028282.

Anderson JE, van Wincoop E (2001). “Gravity with Gravitas: A Solution to the Border Puzzle.” Working Paper 8079, National Bureau of Economic Research. doi:10.3386/w8079.

Anderson JE (2010). “The Gravity Model.” Working Paper 16576, National Bureau of Economic Research. doi:10.3386/w16576.

Baier SL, Bergstrand JH (2009). “Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation.” *Journal of International Economics*, **77**(1), 77 - 85. ISSN 0022-1996, doi:10.1016/j.jinteco.2008.10.004.

Baier SL, Bergstrand JH (2010). “The Gravity Model in International Trade: Advances and Applications.” In van Bergeijk PAG, Brakman S (eds.), chapter 4. Cambridge University Press. doi:10.1017/CBO9780511762109.

Feenstra RC (2002). “Border effects and the gravity equation: consistent methods for estimation.” *Scottish Journal of Political Economy*, **49**(5), 491–506.

Head K, Mayer T, Ries J (2010). “The erosion of colonial trade linkages after independence.” *Journal of International Economics*, **81**(1), 1 - 14. ISSN 0022-1996, doi:10.1016/j.jinteco.2010.01.002.

Head K, Mayer T (2014). “Chapter 3 - Gravity Equations: Workhorse, Toolkit, and Cookbook.” In Gopinath G, Helpman E, Rogoff K (eds.), *Handbook of International Economics*, volume 4 of *Handbook of International Economics*, 131 - 195. Elsevier. doi:10.1016/B9780444543141.000033.

Silva JMCS, Teneyro S (2006). “The Log of Gravity.” *The Review of Economics and Statistics*, **88**(4), 641-658. doi:10.1162/rest.88.4.641.

and the citations therein.

See [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) for gravity datasets and Stata code for estimating gravity models.

For estimating gravity equations using panel data see

Egger P, Pfaffermayr M (2003). “The proper panel econometric specification of the gravity equation: A three-way model with bilateral interaction effects.” *Empirical Economics*, **28**(3), 571–580. ISSN 1435-8921, doi:10.1007/s001810200146.

Gómez-Herrera E (2013). “Comparing alternative methods to estimate gravity models of bilateral trade.” *Empirical Economics*, **44**(3), 1087–1111. ISSN 1435-8921, doi:10.1007/s0018101205762. and the references therein.

See Also

[lm](#), [coefstest](#), [vcovHC](#)

Examples

```
# Example for CRAN checks:
# Executable in < 5 sec
library(dplyr)
data("gravity_no_zeros")

# Choose 5 countries for testing
countries_chosen <- c("AUS", "CHN", "GBR", "BRA", "CAN")
grav_small <- filter(gravity_no_zeros, iso_o %in% countries_chosen)

fit <- ols(
  dependent_variable = "flow",
  distance = "distw",
  additional_regressors = c("rta", "contig", "comcur"),
  income_origin = "gdp_o",
  income_destination = "gdp_d",
  code_origin = "iso_o",
  code_destination = "iso_d",
  uie = FALSE,
  robust = FALSE,
  data = grav_small
)
```

ppml

Poisson Pseudo Maximum Likelihood (PPML)

Description

ppml estimates gravity models in their multiplicative form via Poisson Pseudo Maximum Likelihood.

Usage

```
ppml(
  dependent_variable,
  distance,
```

```

    additional_regressors,
    robust = FALSE,
    data,
    ...
)

```

Arguments

`dependent_variable` (Type: character) name of the dependent variable. This variable is used as the dependent variable in the estimation.

`distance` (Type: character) name of the distance variable that should be taken as the key independent variable in the estimation. The distance is logged automatically when the function is executed.

`additional_regressors` (Type: character) names of the additional regressors to include in the model (e.g. a dummy variable to indicate contiguity). Unilateral metric variables such as GDPs can be added but those variables have to be logged first. Interaction terms can be added.
Write this argument as `c(contiguity, common currency, ...)`. By default this is set to `NULL`.

`robust` (Type: logical) whether robust fitting should be used. By default this is set to `FALSE`.

`data` (Type: data.frame) the dataset to be used.

`...` Additional arguments to be passed to the function.

Details

`ppml` is an estimation method for gravity models belonging to generalized linear models. It is estimated via `glm` using the quasipoisson distribution and a log-link. `ppml` is presented in Silva and Tenreyro (2006).

For similar functions, utilizing the multiplicative form via the log-link, but different distributions, see `gpml`, `nls`, and `nbpml`.

`ppml` estimation can be used for both, cross-sectional as well as panel data. The function is designed to be consistent with the results from the Stata function `ppml` written by Silva and Tenreyro (2006).

The function `ols` was therefore tested for cross-sectional data. For the use with panel data no tests were performed. Therefore, it is up to the user to ensure that the functions can be applied to panel data.

Depending on the panel dataset and the variables - specifically the type of fixed effects - included in the model, it may easily occur that the model is not computable. Also, note that by including bilateral fixed effects such as country-pair effects, the coefficients of time-invariant observables such as distance can no longer be estimated.

Depending on the specific model, the code of the respective function may have to be changed in order to exclude the distance variable from the estimation.

At the very least, the user should take special care with respect to the meaning of the estimated coefficients and variances as well as the decision about which effects to include in the estimation.

When using panel data, the parameter and variance estimation of the models may have to be changed accordingly.

For a comprehensive overview of gravity models for panel data see Egger and Pfaffermayr (2003), Gómez-Herrera (2013) and Head et al. (2010) as well as the references therein.

Value

The function returns the summary of the estimated gravity model as an `glm`-object.

References

For more information on gravity models, theoretical foundations and estimation methods in general see

Anderson JE (1979). “A Theoretical Foundation for the Gravity Equation.” *The American Economic Review*, **69**(1), 106–116. ISSN 00028282.

Anderson JE, van Wincoop E (2001). “Gravity with Gravitas: A Solution to the Border Puzzle.” Working Paper 8079, National Bureau of Economic Research. doi:10.3386/w8079.

Anderson JE (2010). “The Gravity Model.” Working Paper 16576, National Bureau of Economic Research. doi:10.3386/w16576.

Baier SL, Bergstrand JH (2009). “Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation.” *Journal of International Economics*, **77**(1), 77 - 85. ISSN 0022-1996, doi:10.1016/j.jinteco.2008.10.004.

Baier SL, Bergstrand JH (2010). “The Gravity Model in International Trade: Advances and Applications.” In van Bergeijk PAG, Brakman S (eds.), chapter 4. Cambridge University Press. doi:10.1017/CBO9780511762109.

Feenstra RC (2002). “Border effects and the gravity equation: consistent methods for estimation.” *Scottish Journal of Political Economy*, **49**(5), 491–506.

Head K, Mayer T, Ries J (2010). “The erosion of colonial trade linkages after independence.” *Journal of International Economics*, **81**(1), 1 - 14. ISSN 0022-1996, doi:10.1016/j.jinteco.2010.01.002.

Head K, Mayer T (2014). “Chapter 3 - Gravity Equations: Workhorse, Toolkit, and Cookbook.” In Gopinath G, Helpman E, Rogoff K (eds.), *Handbook of International Economics*, volume 4 of *Handbook of International Economics*, 131 - 195. Elsevier. doi:10.1016/B9780444543141.000033.

Silva JMCS, Tenreyro S (2006). “The Log of Gravity.” *The Review of Economics and Statistics*, **88**(4), 641-658. doi:10.1162/rest.88.4.641.

and the citations therein.

See [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) for gravity datasets and Stata code for estimating gravity models.

For estimating gravity equations using panel data see

Egger P, Pfaffermayr M (2003). “The proper panel econometric specification of the gravity equation: A three-way model with bilateral interaction effects.” *Empirical Economics*, **28**(3), 571–580. ISSN 1435-8921, doi:10.1007/s001810200146.

Gómez-Herrera E (2013). “Comparing alternative methods to estimate gravity models of bilateral trade.” *Empirical Economics*, **44**(3), 1087–1111. ISSN 1435-8921, doi:10.1007/s0018101205762.

and the references therein.

See Also

[glm](#), [coeftest](#), [vcovHC](#)

Examples

```
# Example for CRAN checks:
# Executable in < 5 sec
library(dplyr)
data("gravity_no_zeros")

# Choose 5 countries for testing
countries_chosen <- c("AUS", "CHN", "GBR", "BRA", "CAN")
grav_small <- filter(gravity_no_zeros, iso_o %in% countries_chosen)

fit <- ppml(
  dependent_variable = "flow",
  distance = "distw",
  additional_regressors = c("rta", "iso_o", "iso_d"),
  data = grav_small
)
```

sils

Structural Iterated Least Squares (SILS)

Description

sils estimates gravity models via Structural Iterated Least Squares and an explicit inclusion of the Multilateral Resistance terms.

Usage

```
sils(
  dependent_variable,
  distance,
  additional_regressors = NULL,
  income_origin,
  income_destination,
  code_origin,
  code_destination,
  maxloop = 100,
  decimal_places = 4,
  robust = FALSE,
  verbose = FALSE,
  data,
  ...
)
```

Arguments

<code>dependent_variable</code>	(Type: character) name of the dependent variable. This dependent variable is divided by the product of unilateral incomes such (i.e. <code>income_origin</code> and <code>income_destination</code>) and logged afterwards.
<code>distance</code>	(Type: character) name of the distance variable that should be taken as the key independent variable in the estimation. The distance is logged automatically when the function is executed.
<code>additional_regressors</code>	(Type: character) names of the additional regressors to include in the model (e.g. a dummy variable to indicate contiguity). Unilateral metric variables such as GDP should be inserted via the arguments <code>income_origin</code> and <code>income_destination</code> . As country specific effects are subdued due to demeaning, no further unilateral variables apart from incomes can be added. Write this argument as <code>c(contiguity, common_currency, ...)</code> . By default this is set to <code>NULL</code> .
<code>income_origin</code>	(Type: character) origin income variable (e.g. GDP) in the dataset.
<code>income_destination</code>	(Type: character) destination income variable (e.g. GDP) in the dataset.
<code>code_origin</code>	(Type: character) country of origin variable (e.g. ISO-3 country codes). The variables are grouped using this parameter.
<code>code_destination</code>	(Type: character) country of destination variable (e.g. country ISO-3 codes). The variables are grouped using this parameter.
<code>maxloop</code>	(Type: numeric) maximum number of outer loop iterations. The default is set to 100. There will be a warning if the iterations did not converge.
<code>decimal_places</code>	(Type: numeric) number of decimal places that should not change after a new iteration for the estimation to stop. The default is set to 4.
<code>robust</code>	(Type: logical) whether robust fitting should be used. By default this is set to <code>FALSE</code> .
<code>verbose</code>	(Type: logical) determines whether the estimated coefficients of each iteration should be printed in the console. The default is set to <code>FALSE</code> .
<code>data</code>	(Type: data.frame) the dataset to be used.
<code>...</code>	Additional arguments to be passed to the function.

Details

`sils` is an estimation method for gravity models developed by Head and Mayer (2014).

The function `sils` utilizes the relationship between the Multilateral Resistance terms and the transaction costs. The parameters are estimated by an iterative procedure. The function executes loops until the parameters stop changing significantly.

`sils` is designed to be consistent with the Stata code provided at [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) when choosing robust estimation.

As, to our knowledge at the moment, there is no explicit literature covering the estimation of a gravity equation by `sils` using panel data, and we do not recommend to apply this method in this case.

Value

The function returns the summary of the estimated gravity model as an `lm`-object. It furthermore returns the resulting coefficients for each iteration.

References

For more information on gravity models, theoretical foundations and estimation methods in general see

Anderson JE (1979). “A Theoretical Foundation for the Gravity Equation.” *The American Economic Review*, **69**(1), 106–116. ISSN 00028282.

Anderson JE, van Wincoop E (2001). “Gravity with Gravitas: A Solution to the Border Puzzle.” Working Paper 8079, National Bureau of Economic Research. doi:10.3386/w8079.

Anderson JE (2010). “The Gravity Model.” Working Paper 16576, National Bureau of Economic Research. doi:10.3386/w16576.

Baier SL, Bergstrand JH (2009). “Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation.” *Journal of International Economics*, **77**(1), 77 - 85. ISSN 0022-1996, doi:10.1016/j.jinteco.2008.10.004.

Baier SL, Bergstrand JH (2010). “The Gravity Model in International Trade: Advances and Applications.” In van Bergeijk PAG, Brakman S (eds.), chapter 4. Cambridge University Press. doi:10.1017/CBO9780511762109.

Feenstra RC (2002). “Border effects and the gravity equation: consistent methods for estimation.” *Scottish Journal of Political Economy*, **49**(5), 491–506.

Head K, Mayer T, Ries J (2010). “The erosion of colonial trade linkages after independence.” *Journal of International Economics*, **81**(1), 1 - 14. ISSN 0022-1996, doi:10.1016/j.jinteco.2010.01.002.

Head K, Mayer T (2014). “Chapter 3 - Gravity Equations: Workhorse, Toolkit, and Cookbook.” In Gopinath G, Helpman E, Rogoff K (eds.), *Handbook of International Economics*, volume 4 of *Handbook of International Economics*, 131 - 195. Elsevier. doi:10.1016/B9780444543141.000033.

Silva JMCS, Tenreyro S (2006). “The Log of Gravity.” *The Review of Economics and Statistics*, **88**(4), 641-658. doi:10.1162/rest.88.4.641.

and the citations therein.

See [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) for gravity datasets and Stata code for estimating gravity models.

For estimating gravity equations using panel data see

Egger P, Pfaffermayr M (2003). “The proper panel econometric specification of the gravity equation: A three-way model with bilateral interaction effects.” *Empirical Economics*, **28**(3), 571–580. ISSN 1435-8921, doi:10.1007/s001810200146.

Gómez-Herrera E (2013). “Comparing alternative methods to estimate gravity models of bilateral trade.” *Empirical Economics*, **44**(3), 1087–1111. ISSN 1435-8921, doi:10.1007/s0018101205762.

and the references therein.

See Also

[lm](#), [coefstest](#), [vcovHC](#)

Examples

```
# Example for CRAN checks:
# Executable in < 5 sec
library(dplyr)
data("gravity_no_zeros")

# Choose 5 countries for testing
countries_chosen <- c("AUS", "CHN", "GBR", "BRA", "CAN")
grav_small <- filter(gravity_no_zeros, iso_o %in% countries_chosen)

fit <- sils(
  dependent_variable = "flow",
  distance = "distw",
  additional_regressors = "rta",
  income_origin = "gdp_o",
  income_destination = "gdp_d",
  code_origin = "iso_o",
  code_destination = "iso_d",
  maxloop = 50,
  dec_places = 3,
  robust = FALSE,
  verbose = FALSE,
  data = grav_small
)
```

tetrads

Tetrads

Description

tetrads estimates gravity models by taking the ratio of the ratio of flows.

Usage

```
tetrads(
  dependent_variable,
  distance,
  additional_regressors,
  code_origin,
  code_destination,
  filter_origin = NULL,
  filter_destination = NULL,
  multiway = FALSE,
  data,
  ...
)
```

Arguments

<code>dependent_variable</code>	(Type: character) name of the dependent variable. This variable is logged and then used as the dependent variable in the estimation.
<code>distance</code>	(Type: character) name of the distance variable that should be taken as the key independent variable in the estimation. The distance is logged automatically when the function is executed.
<code>additional_regressors</code>	(Type: character) names of the additional regressors to include in the model (e.g. a dummy variable to indicate contiguity). Unilateral metric variables such as GDP should be inserted via the arguments <code>income_origin</code> and <code>income_destination</code> . Write this argument as <code>c(contiguity, common currency, ...)</code> . By default this is set to NULL.
<code>code_origin</code>	(Type: character) country of origin variable (e.g. ISO-3 country codes). The variables are grouped using this parameter.
<code>code_destination</code>	(Type: character) country of destination variable (e.g. country ISO-3 codes). The variables are grouped using this parameter.
<code>filter_origin</code>	(Type: character) Reference exporting country.
<code>filter_destination</code>	(Type: character) Reference importing country.
<code>multiway</code>	(Type: logical) in case <code>multiway = TRUE</code> , the <code>cluster.vcov</code> function is used for estimation following Cameron et al. (2011) multi-way clustering of variance-covariance matrices. The default value is set to TRUE.
<code>data</code>	(Type: data.frame) the dataset to be used.
<code>...</code>	Additional arguments to be passed to the function.

Details

`tetrads` is an estimation method for gravity models developed by Head et al. (2010).

The function `tetrads` utilizes the multiplicative form of the gravity equation. After choosing a reference exporter A and importer B one can eliminate importer and exporter fixed effects by taking the ratio of ratios.

Only those exporters trading with the reference importer and importers trading with the reference exporter will remain for the estimation. Therefore, reference countries should preferably be countries which trade with every other country in the dataset.

After restricting the data in this way, `tetrads` estimates the gravity equation in its additive form by OLS.

By taking the ratio of ratios, all monadic effects diminish, hence no unilateral variables such as GDP can be included as independent variables.

`tetrads` estimation can be used for both, cross-sectional as well as panel data. Nonetheless, the function is designed to be consistent with the Stata code for cross-sectional data provided on the website [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) when choosing robust estimation.

The function `tetrads` was therefore tested for cross-sectional data.

If tetrads is used for panel data, the user may have to drop distance as an independent variable as time-invariant effects drop.

For applying tetrads to panel data see Head et al. (2010).

Value

The function returns the summary of the estimated gravity model as an `lm`-object.

References

For more information on gravity models, theoretical foundations and estimation methods in general see

Anderson JE (1979). “A Theoretical Foundation for the Gravity Equation.” *The American Economic Review*, **69**(1), 106–116. ISSN 00028282.

Anderson JE, van Wincoop E (2001). “Gravity with Gravitas: A Solution to the Border Puzzle.” Working Paper 8079, National Bureau of Economic Research. doi:10.3386/w8079.

Anderson JE (2010). “The Gravity Model.” Working Paper 16576, National Bureau of Economic Research. doi:10.3386/w16576.

Baier SL, Bergstrand JH (2009). “Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation.” *Journal of International Economics*, **77**(1), 77 - 85. ISSN 0022-1996, doi:10.1016/j.jinteco.2008.10.004.

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Head K, Mayer T (2014). “Chapter 3 - Gravity Equations: Workhorse, Toolkit, and Cookbook.” In Gopinath G, Helpman E, Rogoff K (eds.), *Handbook of International Economics*, volume 4 of *Handbook of International Economics*, 131 - 195. Elsevier. doi:10.1016/B9780444543141.000033.

Silva JMCS, Tenreyro S (2006). “The Log of Gravity.” *The Review of Economics and Statistics*, **88**(4), 641-658. doi:10.1162/rest.88.4.641.

and the citations therein.

See [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) for gravity datasets and Stata code for estimating gravity models.

For estimating gravity equations using panel data see

Egger P, Pfaffermayr M (2003). “The proper panel econometric specification of the gravity equation: A three-way model with bilateral interaction effects.” *Empirical Economics*, **28**(3), 571–580. ISSN 1435-8921, doi:10.1007/s001810200146.

Gómez-Herrera E (2013). “Comparing alternative methods to estimate gravity models of bilateral trade.” *Empirical Economics*, **44**(3), 1087–1111. ISSN 1435-8921, doi:10.1007/s0018101205762.

and the references therein.

See Also

[lm](#), [coefstest](#),

Examples

```
# Example for CRAN checks:
# Executable in < 5 sec
library(dplyr)
data("gravity_no_zeros")

# Choose 5 countries for testing
countries_chosen <- c("AUS", "CHN", "GBR", "BRA", "CAN")
grav_small <- filter(gravity_no_zeros, iso_o %in% countries_chosen)

fit <- tetrads(
  dependent_variable = "flow",
  distance = "distw",
  additional_regressors = "rta",
  code_origin = "iso_o",
  code_destination = "iso_d",
  filter_origin = countries_chosen[1],
  filter_destination = countries_chosen[2],
  data = grav_small
)
```

tobit

Left-censored Tobit model with known threshold

Description

tobit estimates gravity models in their additive form by conducting a left-censored regression, which, after adding the constant 1 to the dependent variable, utilizes $\log(1) = 0$ as the censoring value.

Usage

```
tobit(
  dependent_variable,
  distance,
  additional_regressors = NULL,
  added_constant = 1,
  data,
  ...
)
```

Arguments

<code>dependent_variable</code>	(Type: character) name of the dependent variable. The number 1 is added and the transformed variable is logged and taken as the dependent variable in the tobit estimation with lower bound equal to 0 as $\log(1) = 0$ represents the smallest flows in the transformed variable.
<code>distance</code>	(Type: character) name of the distance variable that should be taken as the key independent variable in the estimation. The distance is logged automatically when the function is executed.
<code>additional_regressors</code>	(Type: character) names of the additional regressors to include in the model (e.g. a dummy variable to indicate contiguity). Unilateral metric variables such as GDP should be inserted via the arguments <code>income_origin</code> and <code>income_destination</code> . Write this argument as <code>c(contiguity, common currency, ...)</code> . By default this is set to NULL.
<code>added_constant</code>	(Type: numeric) the constant to be added to the dependent variable. The default value is 1. The minimum of $\log(y + \text{added_constant})$ is taken as the left boundary in the Tobit model. In the often used case of <code>added_constant = 1</code> , the dependent variable is left-censored at value 0 as $\log(1) = 0$.
<code>data</code>	(Type: data.frame) the dataset to be used.
<code>...</code>	Additional arguments to be passed to the function.

Details

`tobit` represents the left-censored tobit Tobin (1958) approach utilizing a known censoring threshold which is often used when several gravity models are compared.

When taking the log of the gravity equation flows equal to zero constitute a problem as their log is not defined.

Therefore, in the execution of the function the number 1 is added to all flows and the $\log(\text{flows}+1)$ is taken as the dependent variable.

The tobit estimation is conducted using the `censReg` function and setting the lower bound equal to 0 as $\log(1)=0$ represents the smallest flows in the transformed variable.

A tobit regression represents a combination of a binary and a linear regression.

This procedure has to be taken into consideration when interpreting the estimated coefficients.

The marginal effects of an explanatory variable on the expected value of the dependent variable equals the product of both the probability of the latent variable exceeding the threshold and the marginal effect of the explanatory variable of the expected value of the latent variable.

The function is designed for cross-sectional data, but can be easily extended to panel data using the `censReg` function.

A robust estimations is not implemented to the present as the `censReg` function is not compatible with the `vcovHC` function.

For a more elaborate Tobit function, see `ek_tobit` for the Eaton and Kortum (2001) Tobit model where each zero trade volume is assigned a country specific interval with the upper bound equal to the minimum positive trade level of the respective importing country.

Value

The function returns the summary of the estimated gravity model as a [censReg](#)-object.

References

For more information on gravity models, theoretical foundations and estimation methods in general see

Anderson JE (1979). “A Theoretical Foundation for the Gravity Equation.” *The American Economic Review*, **69**(1), 106–116. ISSN 00028282.

Anderson JE, van Wincoop E (2001). “Gravity with Gravitas: A Solution to the Border Puzzle.” Working Paper 8079, National Bureau of Economic Research. doi:10.3386/w8079.

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Baier SL, Bergstrand JH (2009). “Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation.” *Journal of International Economics*, **77**(1), 77 - 85. ISSN 0022-1996, doi:10.1016/j.jinteco.2008.10.004.

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Silva JMCS, Tenreyro S (2006). “The Log of Gravity.” *The Review of Economics and Statistics*, **88**(4), 641-658. doi:10.1162/rest.88.4.641.

and the citations therein.

See [Gravity Equations: Workhorse, Toolkit, and Cookbook](#) for gravity datasets and Stata code for estimating gravity models.

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Gómez-Herrera E (2013). “Comparing alternative methods to estimate gravity models of bilateral trade.” *Empirical Economics*, **44**(3), 1087–1111. ISSN 1435-8921, doi:10.1007/s0018101205762.

and the references therein.

See Also

[censReg](#)

Examples

```
# Example for CRAN checks:
# Executable in < 5 sec
library(dplyr)
data("gravity_no_zeros")

# Choose 5 countries for testing
countries_chosen <- c("AUS", "CHN", "GBR", "BRA", "CAN")
grav_small <- filter(gravity_no_zeros, iso_o %in% countries_chosen)

grav_small <- grav_small %>%
  mutate(
    lgdp_o = log(gdp_o),
    lgdp_d = log(gdp_d)
  )

fit <- tobit(
  dependent_variable = "flow",
  distance = "distw",
  additional_regressors = c("rta", "lgdp_o", "lgdp_d"),
  added_constant = 1,
  data = grav_small
)
```

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