Package 'gravity'

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Type Package

Title Estimation Methods for Gravity Models

Version 0.8.4

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

URL http://pacha.hk/gravity

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

RdMacros Rdpack

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Suggests knitr, rmarkdown, testthat

VignetteBuilder knitr

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R topics documented:

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bvu   *Bonus vetus OLS (BVU)*

Description

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

Usage

```
bvu(dependent_variable, regressors, incomes, codes, robust = TRUE, data, ...)
```

Arguments

dependent_variable

name (type: character) of the dependent variable in the dataset data (e.g. trade flows).

This dependent variable is divided by the product of unilateral incomes (e.g. GDPs or GNPs of the countries of interest, named inc_o and inc_d in the example datasets) and logged afterwards.

The transformed variable is then used as the dependent variable in the estimation.

regressors   name (type: character) of the regressors to include in the model.

Include the distance variable in the dataset data containing a measure of distance between all pairs of bilateral partners and bilateral variables that should be taken as the independent variables in the estimation.

The distance is logged automatically when the function is executed.

Unilateral metric variables such as GDPs should be inserted via the argument incomes.

As country specific effects are subdued due to demeaning, no further unilateral variables apart from unilateral incomes can be added.

Write this argument as c(distance, contiguity, common curreny, ...).

incomes   variable name (type: character) of the income of the country of origin (e.g. inc_o) and destination (e.g. inc_d) in the dataset data.

The dependent variable dependent_variable is divided by the product of the incomes.

Write this argument as c(income origin, income destination).

codes   variable name (type: character) of the code of the country of origin and destination (e.g. ISO-3 codes from the variables iso_o and iso_d in the example datasets).

The variables are grouped by using iso_o and iso_d to obtain estimates.

Write this argument as c(code origin, code destination).

robust	robust (type: logical) determines whether a robust variance-covariance matrix should be used. By default is set to TRUE.
	If robust = TRUE the estimation results are consistent with the Stata code provided at Gravity Equations: Workhorse, Toolkit, and Cookbook when choosing robust estimation.
data	name of the dataset to be used (type: character).
	To estimate gravity equations you need a square dataset including bilateral flows defined by the argument dependent_variable, ISO codes or similar of type character (e.g. iso_o for the country of origin and iso_d for the destination country), a distance measure defined by the argument distance and other potential influences (e.g. contiguity and common currency) given as a vector in regressors are required.
	All dummy variables should be of type numeric (0/1).
	Make sure the ISO codes are of type "character".
	If an independent variable is defined as a ratio, it should be logged.
	The user should perform some data cleaning beforehand to remove observations that contain entries that can distort estimates.
	The function will remove zero flows and distances.
...	additional arguments to be passed to bvu.

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 bvu 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.

bvu 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 bvu 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 estimating gravity equations via Bonus Vetus OLS see

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.

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." Technical Report 8079, National Bureau of Economic Research. doi: 10.3386/w8079.

Anderson JE (2010). "The Gravity Model." Technical Report 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.

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 series Handbook of International Economics, 131 - 195. Elsevier. doi: 10.1016/B9780444543141.00003-3.

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.

See Also

lm, coeftest, vcovHC

Examples

```
## Not run:
data(gravity_no_zeros)

bvu(dependent_variable = "flow", regressors = c("distw", "rta"),
incomes = c("gdp_o", "gdp_d"), codes = c("iso_o", "iso_d"),
robust = TRUE, data = gravity_no_zeros)

bvu(dependent_variable = "flow", regressors = c("distw", "rta", "contig", "comcur"),
incomes = c("gdp_o", "gdp_d"), codes = c("iso_o", "iso_d"),
robust = TRUE, data = gravity_no_zeros)

## End(Not run)
```

---

bvw *Bonus vetus OLS (BVW)*

Description

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

Usage

```
bvw(dependent_variable, regressors, incomes, codes, robust = TRUE, data, ...)
```

Arguments

dependent_variable

> name (type: character) of the dependent variable in the dataset data (e.g. trade flows).
>
> This dependent variable is divided by the product of unilateral incomes (e.g. GDPs or GNPs of the countries of interest, named inc_o and inc_d in the example datasets) and logged afterwards.
>
> The transformed variable is then used as the dependent variable in the estimation.

regressors

> name (type: character) of the regressors to include in the model.
>
> Include the distance variable in the dataset data containing a measure of distance between all pairs of bilateral partners and bilateral variables that should be taken as the independent variables in the estimation.
>
> The distance is logged automatically when the function is executed.
>
> Unilateral metric variables such as GDPs should be inserted via the argument incomes.
>
> As country specific effects are subdued due to demeaning, no further unilateral variables apart from unilateral incomes can be added.
>
> Write this argument as c(distance, contiguity, common curreny, ...).

incomes

> variable name (type: character) of the income of the country of origin (e.g. inc_o) and destination (e.g. inc_d) in the dataset data.
>
> The dependent variable dependent_variable is divided by the product of the incomes.
>
> Write this argument as c(income origin, income destination).

codes

> variable name (type: character) of the code of the country of origin and destination (e.g. ISO-3 codes from the variables iso_o and iso_d in the example datasets).
>
> The variables are grouped by using iso_o and iso_d to obtain estimates.
>
> Write this argument as c(code origin, code destination).

robust

> robust (type: logical) determines whether a robust variance-covariance matrix should be used. By default is set to TRUE.
>
> If robust = TRUE the estimation results are consistent with the Stata code provided at Gravity Equations: Workhorse, Toolkit, and Cookbook when choosing robust estimation.

data

> name of the dataset to be used (type: character).
>
> To estimate gravity equations you need a square dataset including bilateral flows defined by the argument dependent_variable, ISO codes or similar of type character (e.g. iso_o for the country of origin and iso_d for the destination country), a distance measure defined by the argument distance and other potential influences (e.g. contiguity and common currency) given as a vector in regressors are required.
>
> All dummy variables should be of type numeric (0/1).
>
> Make sure the ISO codes are of type "character".
>
> If an independent variable is defined as a ratio, it should be logged.

	The user should perform some data cleaning beforehand to remove observations that contain entries that can distort estimates.
	The function will remove zero flows and distances.
`...`	additional arguments to be passed to bvw.

Details

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

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 estimating gravity equations via Bonus Vetus OLS see

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.

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." Technical Report 8079, National Bureau of Economic Research. doi: 10.3386/w8079.

Anderson JE (2010). "The Gravity Model." Technical Report 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.

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 series

Handbook of International Economics, 131 - 195. Elsevier. doi: 10.1016/B9780444543141.00003-3.

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.

See Also

lm, coeftest, vcovHC

Examples

```
## Not run:
data(gravity_no_zeros)

bvw(dependent_variable = "flow", regressors = c("distw", "rta"),
incomes = c("gdp_o", "gdp_d"), codes = c("iso_o", "iso_d"),
robust = TRUE, data = gravity_no_zeros)

bvw(dependent_variable = "flow", regressors = c("distw", "rta", "comcur", "contig"),
incomes = c("gdp_o", "gdp_d"), codes = c("iso_o", "iso_d"),
robust = TRUE, data = gravity_no_zeros)

## End(Not run)
```

---

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, regressors, codes, robust = TRUE, data, ...)
```

Arguments

dependent_variable

name (type: character) of the dependent variable in the dataset data (e.g. trade flows).

This variable is logged and then used as the dependent variable in the estimation.

regressors name (type: character) of the regressors to include in the model.

Include the distance variable in the dataset data containing a measure of distance between all pairs of bilateral partners and bilateral variables that should be taken as the independent variables in the estimation.

Write this argument as c(distance, contiguity, common curreny, ...).

codes   variable name (type: character) of the code of the country of origin and desti-
           nation (e.g. ISO-3 codes from the variables iso_o and iso_d) in the example
           datasets).

           The variables are grouped by using iso_o and iso_d to obtain estimates.

           Write this argument as c(code origin, code destination).

robust   robust (type: logical) determines whether a robust variance-covariance matrix
           should be used. By default is set to TRUE.

           If robust = TRUE the estimation results are consistent with the Stata code pro-
           vided at Gravity Equations: Workhorse, Toolkit, and Cookbook when choosing
           robust estimation.

data   name of the dataset to be used (type: character).

           To estimate gravity equations you need a square dataset including bilateral flows
           defined by the argument dependent_variable, ISO codes or similar of type
           character (e.g. iso_o for the country of origin and iso_d for the destination
           country), a distance measure defined by the argument distance and other po-
           tential influences (e.g. contiguity and common currency) given as a vector in
           regressors are required.

           All dummy variables should be of type numeric (0/1).

           Make sure the ISO codes are of type "character".

           If an independent variable is defined as a ratio, it should be logged.

           The user should perform some data cleaning beforehand to remove observations
           that contain entries that can distort estimates.

           The function will remove zero flows and distances.

...   additional arguments to be passed to ddm.

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 Double Demeaning as well as information on gravity models, theoretical
foundations and estimation methods in general see

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 series
Handbook of International Economics, 131 - 195. Elsevier. doi: 10.1016/B9780444543141.00003-
3.

as well as

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." Technical Report 8079, National Bureau of Economic Research. doi: 10.3386/w8079.

Anderson JE (2010). "The Gravity Model." Technical Report 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.

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.

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.

See Also

lm, coeftest, vcovHC

Examples

```
## Not run:
data(gravity_no_zeros)

ddm(dependent_variable = "flow", regressors = c("distw", "rta"),
codes = c("iso_o", "iso_d"),
robust = TRUE, data = gravity_no_zeros)

ddm(dependent_variable = "flow", regressors = c("distw", "rta", "comcur", "contig"),
codes = c("iso_o", "iso_d"),
robust=TRUE, data=gravity_no_zeros)

## End(Not run)
```

---

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.

It follows the Eaton and Kortum (2001) Tobit model where each country is assigned specific censoring bounds.

Usage

```
ek_tobit(dependent_variable, regressors, code_destination, robust = TRUE,
  data, ...)
```

Arguments

dependent_variable

> name (type: character) of the dependent variable in the dataset data (e.g. trade flows).
>
> 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.

regressors   name (type: character) of the regressors to include in the model.

> Include the distance variable in the dataset data containing a measure of distance between all pairs of bilateral partners and bilateral variables that should be taken as the independent variables in the estimation.
>
> Unilateral metric variables such as GDPs should be inserted via the argument incomes.
>
> Interaction terms can be added.
>
> Write this argument as c(distance, contiguity, common curreny, ...).

code_destination

> variable name (type: character) of the label of the country of destination (e.g. ISO-3 code from the iso_d variable in the example datasets). The variables are grouped by using iso_d to obtain estimates.

robust   robust (type: logical) determines whether a robust variance-covariance matrix should be used. By default is set to TRUE.

> If robust = TRUE the estimation results are consistent with the Stata code provided at Gravity Equations: Workhorse, Toolkit, and Cookbook when choosing robust estimation.

data   name of the dataset to be used (type: character).

> To estimate gravity equations you need a square dataset including bilateral flows defined by the argument dependent_variable, ISO codes or similar of type character (e.g. iso_o for the country of origin and iso_d for the destination country), a distance measure defined by the argument distance and other potential influences (e.g. contiguity and common currency) given as a vector in regressors are required.
>
> All dummy variables should be of type numeric (0/1).
>
> Make sure the ISO codes are of type "character".
>
> If an independent variable is defined as a ratio, it should be logged.
>
> The user should perform some data cleaning beforehand to remove observations that contain entries that can distort estimates.
>
> The function allows zero flows but will remove zero distances.

...   additional arguments to be passed to ek_tobit.

Details

ek_tobit represents the Eaton and Kortum (2001) Tobit model.

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 (1994) 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." Technical Report 8079, National Bureau of Economic Research. doi: 10.3386/w8079.

Anderson JE (2010). "The Gravity Model." Technical Report 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.

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.

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.

Especially for Tobit models see

Tobin J (1958). "Estimation of Relationships for Limited Dependent Variables." *Econometrica*, **26**(1), 24–36. ISSN 14680262.

Eaton J, Tamura A (1995). "Bilateralism and Regionalism in Japanese and U.S. Trade and Direct Foreign Investment Patterns." Technical Report 4758, National Bureau of Economic Research. doi: 10.3386/w4758.

Eaton J, Kortum S (2001). "Trade in Capital Goods." Technical Report 8070, National Bureau of Economic Research. doi: 10.3386/w8070, http://www.nber.org/papers/w8070.

Carson RT, Sun Y (2007). "The Tobit model with a non-zero threshold." *The Econometrics Journal*, **10**(3), 488-502. doi: 10.1111/j.1368423X.2007.00218.x.

See Gravity Equations: Workhorse, Toolkit, and Cookbook for gravity datasets and Stata code for estimating gravity models.

See Also

Surv, survreg

Examples

```
## Not run:
# Example for data with zero trade flows
data(gravity_zeros)

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

ek_tobit(dependent_variable = "flow", regressors = c("distw", "rta","lgdp_o","lgdp_d"),
code_destination = "iso_d",
robust = TRUE, data = gravity_zeros)

## End(Not run)
```

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.

It follows the Eaton and Tamura (1995) Tobit model, also called threshold Tobit model, where, 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.

For estimating this threshold, we follow Carson and Sun (2007).

Usage

```
et_tobit(dependent_variable, regressors, data, ...)
```

Arguments

dependent_variable

name (type: character) of the dependent variable in the dataset data, e.g. trade flows.

Following Carson and Sun (2007), the smallest positive flow value is used as an estimate of the threshold, this value is 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.

regressors   name (type: character) of the regressors to include in the model.

Include the distance variable in the dataset data containing a measure of distance between all pairs of bilateral partners and bilateral variables that should be taken as the independent variables in the estimation.

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(distance, contiguity, common curreny, ...).

data   name of the dataset to be used (type: character).

To estimate gravity equations you need a square dataset including bilateral flows defined by the argument dependent_variable, ISO codes or similar of type character (e.g. iso_o for the country of origin and iso_d for the destination country), a distance measure defined by the argument distance and other potential influences (e.g. contiguity and common currency) given as a vector in regressors are required.

All dummy variables should be of type numeric (0/1).

Make sure the ISO codes are of type "character".

If an independent variable is defined as a ratio, it should be logged.

The user should perform some data cleaning beforehand to remove observations that contain entries that can distort estimates.

The function allows zero flows but will remove zero distances.

...   additional arguments to be passed to et_tobit.

Details

et_tobit represents the Eaton and Tamura (1995) Tobit model 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, a constant is added to the flows.

This constant, opposed to [tobit](), is estimated. 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." Technical Report 8079, National Bureau of Economic Research. doi: 10.3386/w8079.

Anderson JE (2010). "The Gravity Model." Technical Report 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.

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.

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.

Especially for Tobit models see

Tobin J (1958). "Estimation of Relationships for Limited Dependent Variables." *Econometrica*, **26**(1), 24–36. ISSN 14680262.

Eaton J, Tamura A (1995). "Bilateralism and Regionalism in Japanese and U.S. Trade and Direct Foreign Investment Patterns." Technical Report 4758, National Bureau of Economic Research. doi: 10.3386/w4758.

Eaton J, Kortum S (2001). "Trade in Capital Goods." Technical Report 8070, National Bureau of Economic Research. doi: 10.3386/w8070, http://www.nber.org/papers/w8070.

Carson RT, Sun Y (2007). "The Tobit model with a non-zero threshold." *The Econometrics Journal*, **10**(3), 488-502. doi: 10.1111/j.1368423X.2007.00218.x.

See Gravity Equations: Workhorse, Toolkit, and Cookbook for gravity datasets and Stata code for estimating gravity models.

See Also

censReg

Examples

```
## Not run:
# Example for data with zero trade flows
data(gravity_zeros)

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

et_tobit(dependent_variable = "flow", regressors = c("distw", "rta","lgdp_o","lgdp_d"),
data = gravity_zeros)

## End(Not run)
```

---

fixed_effects   *Fixed Effects*

Description

`fixed_effects` estimates gravity models via OLS and fixed effects for the countries of origin and destination. These effects catch country specific effects.

Usage

```
fixed_effects(dependent_variable, regressors, codes = c("iso_o", "iso_d"),
  robust = TRUE, data, ...)
```

Arguments

dependent_variable

name (type: character) of the dependent variable in the dataset data (e.g. trade flows).

This variable is logged and then used as the dependent variable in the estimation.

regressors   name (type: character) of the regressors to include in the model.

Include the distance variable in the dataset data containing a measure of distance between all pairs of bilateral partners and bilateral variables that should be taken as the independent variables in the estimation.

The distance is logged automatically when the function is executed.

Fixed effects catch all unilateral effects. Therefore, no other unilateral variables such as GDP can be included as independent variables in the estimation.

Write this argument as c(distance, contiguity, common curreny, ...).

codes   variable name (type: character) of the code of the country of origin and destination (e.g. ISO-3 codes from the variables iso_o and iso_d) in the example datasets).

The variables are grouped by using iso_o and iso_d to obtain estimates.

Write this argument as c(code origin, code destination).

robust   robust (type: logical) determines whether a robust variance-covariance matrix
                should be used. By default is set to TRUE.

                If robust = TRUE the estimation results are consistent with the Stata code pro-
                vided at Gravity Equations: Workhorse, Toolkit, and Cookbook when choosing
                robust estimation.

data   name of the dataset to be used (type: character).

                To estimate gravity equations you need a square dataset including bilateral flows
                defined by the argument dependent_variable, ISO codes or similar of type
                character (e.g. iso_o for the country of origin and iso_d for the destination
                country), a distance measure defined by the argument distance and other po-
                tential influences (e.g. contiguity and common currency) given as a vector in
                regressors are required.

                All dummy variables should be of type numeric (0/1).

                Make sure the ISO codes are of type "character".

                If an independent variable is defined as a ratio, it should be logged.

                The user should perform some data cleaning beforehand to remove observations
                that contain entries that can distort estimates.

                When using panel data, a variable for the time may be included in the dataset.
                Note that the variable for the time dimension should be of type factor.

                The time variable can be used as a single dependent variable or interaction term
                with other variables such as country identifiers by inserting it into regressors
                or as an optional parameter.

                The function will remove zero flows and distances.

...   additional arguments to be passed to fixed_effects.

Details

To account for MR terms, Feenstra (2002) and Feenstra (2004) 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 Multilat-
eral 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.

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 has 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), GÃ³mez-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 fixed effects as well as informaton on gravity models, theoretical foundations and suitable 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." Technical Report 8079, National Bureau of Economic Research. doi: 10.3386/w8079.

Anderson JE (2010). "The Gravity Model." Technical Report 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.

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 series Handbook of International Economics, 131 - 195. Elsevier. doi: 10.1016/B9780444543141.00003-3.

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.

GÃ³mez-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`, `coeftest`, `vcovHC`

Examples

```
## Not run:
data(gravity_no_zeros)

fixed_effects(dependent_variable = "flow",
regressors = c("distw", "rta"), codes = c("iso_o", "iso_d"),
robust = TRUE, data = gravity_no_zeros)

fixed_effects(dependent_variable = "flow",
regressors = c("distw", "rta", "comcur", "contig"),
codes = c("iso_o", "iso_d"), robust = TRUE, data = gravity_no_zeros)

## End(Not run)
```

---

gpml   *Gamma Pseudo Maximum Likelihood (GPML)*

Description

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

Usage

```
gpml(dependent_variable, regressors, robust = TRUE, data, ...)
```

Arguments

dependent_variable

> name (type: character) of the dependent variable in the dataset data (e.g. trade flows).

regressors   name (type: character) of the regressors to include in the model.

> Include the distance variable in the dataset data containing a measure of distance between all pairs of bilateral partners and bilateral variables that should be taken as the independent variables in the estimation.

> The distance is logged automatically when the function is executed.

> 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(distance, contiguity, common curreny, ...).

robust   robust (type: logical) determines whether a robust variance-covariance matrix should be used. By default is set to TRUE.

data   name of the dataset to be used (type: character).

> To estimate gravity equations you need a square dataset including bilateral flows defined by the argument dependent_variable, ISO codes or similar of type character (e.g. iso_o for the country of origin and iso_d for the destination

country), a distance measure defined by the argument `distance` and other potential influences (e.g. contiguity and common currency) given as a vector in `regressors` are required.

All dummy variables should be of type numeric (0/1).

Make sure the ISO codes are of type "character".

If an independent variable is defined as a ratio, it should be logged.

The user should perform some data cleaning beforehand to remove observations that contain entries that can distort estimates.

When using panel data, a variable for the time may be included in the dataset. Note that the variable for the time dimension should be of type factor.

The function will remove zero flows and distances.

...   additional arguments to be passed to functions used by `gpml`.

Details

`gpml` is an estimation method for gravity models belonging to generalized linear models.

It 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.

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 has 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), GÃ³mez-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 the estimation of gravity equations via Gamma Pseudo maximum Likelihood see

Santos-Silva, J. M. C. and Tenreyro, S. (2006) <DOI:10.1162/rest.88.4.641>

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." Technical Report 8079, National Bureau of Economic Research. doi: 10.3386/w8079.

Anderson JE (2010). "The Gravity Model." Technical Report 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.

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 series Handbook of International Economics, 131 - 195. Elsevier. doi: 10.1016/B9780444543141.00003-3.

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.

GÃ³mez-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, coeftest, vcovHC

Examples

```
## Not run:
data(gravity_no_zeros)

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

gpml(dependent_variable = "flow", regressors = c("distw", "rta", "lgdp_o", "lgdp_d"),
robust = TRUE, data = gravity_no_zeros)

## End(Not run)
```

---

gravity_no_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_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

gdp_d GDP of country of destination

rta regional trade agreement

flow trade flow

contig contiguity

comlang_off common official language

comcur common currency

Source

<http://econ.sciences-po.fr/node/131> <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 od 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

gdp_d GDP of country of destination

rta regional trade agreement

flow trade flow

contig contiguity

comlang_off common official language

comcur common currency

Source

<http://econ.sciences-po.fr/node/131> <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 od colonial linkages after independence". Journal of International Economics, 81(1):1-14 (lead article).

Examples

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

---

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, regressors, robust = TRUE, data, ...)
```

Arguments

dependent_variable

> name (type: character) of the dependent variable in the dataset data (e.g. trade flows).

regressors   name (type: character) of the regressors to include in the model.

> Include the distance variable in the dataset data containing a measure of distance between all pairs of bilateral partners and bilateral variables that should be taken as the independent variables in the estimation.

> The distance is logged automatically when the function is executed.

> 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(distance, contiguity, common curreny, ...).

robust   robust (type: logical) determines whether a robust variance-covariance matrix should be used. By default is set to TRUE.

data   name of the dataset to be used (type: character).

> To estimate gravity equations you need a square dataset including bilateral flows defined by the argument dependent_variable, ISO codes or similar of type character (e.g. iso_o for the country of origin and iso_d for the destination country), a distance measure defined by the argument distance and other potential influences (e.g. contiguity and common currency) given as a vector in regressors are required.

> All dummy variables should be of type numeric (0/1).

> Make sure the ISO codes are of type "character".

> If an independent variable is defined as a ratio, it should be logged.

> The user should perform some data cleaning beforehand to remove observations that contain entries that can distort estimates.

> When using panel data, a variable for the time may be included in the dataset. Note that the variable for the time dimension should be of type factor.

> The function allows zero flows but will remove zero distances.

...   additional arguments to be passed to functions used by nbpml.

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.

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

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 has 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), GÃ³mez-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." Technical Report 8079, National Bureau of Economic Research. doi: 10.3386/w8079.

Anderson JE (2010). "The Gravity Model." Technical Report 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.

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 series Handbook of International Economics, 131 - 195. Elsevier. doi: 10.1016/B9780444543141.00003-3.

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.

GÃ³mez-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

```
## Not run:
# Example for data with zero trade flows
data(gravity_zeros)

nbpml(dependent_variable = "flow", regressors = c("distw", "rta","iso_o","iso_d"),
robust = TRUE, data = gravity_zeros)

# Example for data without zero trade flows
data(gravity_no_zeros)

gravity_no_zeros$lgdp_o <- log(gravity_no_zeros$gdp_o)
gravity_no_zeros$lgdp_d <- log(gravity_no_zeros$gdp_d)

nbpml(dependent_variable = "flow", regressors = c("distw","rta","lgdp_o","lgdp_d"),
robust = TRUE, data = gravity_no_zeros)

## End(Not run)
```

---

nls *Non-linear Least Squares (NLS)*

Description

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

Usage

```
nls(dependent_variable, regressors, robust = TRUE, data, ...)
```

Arguments

dependent_variable

        name (type: character) of the dependent variable in the dataset data (e.g. trade flows).

regressors   name (type: character) of the regressors to include in the model.

        Include the distance variable in the dataset data containing a measure of distance between all pairs of bilateral partners and bilateral variables that should be taken as the independent variables in the estimation.

        The distance is logged automatically when the function is executed.

        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(distance, contiguity, common curreny, ...).

robust   robust (type: logical) determines whether a robust variance-covariance matrix should be used. By default is set to TRUE.

data   name of the dataset to be used (type: character).

        To estimate gravity equations you need a square dataset including bilateral flows defined by the argument dependent_variable, ISO codes or similar of type character (e.g. iso_o for the country of origin and iso_d for the destination country), a distance measure defined by the argument distance and other potential influences (e.g. contiguity and common currency) given as a vector in regressors are required.

        All dummy variables should be of type numeric (0/1).

        Make sure the ISO codes are of type "character".

        If an independent variable is defined as a ratio, it should be logged.

        The user should perform some data cleaning beforehand to remove observations that contain entries that can distort estimates.

        When using panel data, a variable for the time may be included in the dataset. Note that the variable for the time dimension should be of type factor.

        The function allows zero flows but will remove zero distances.

...   additional arguments to be passed to functions used by nls.

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.

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 has 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), GÃ³mez-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." Technical Report 8079, National Bureau of Economic Research. doi: 10.3386/w8079.

Anderson JE (2010). "The Gravity Model." Technical Report 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.

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 series Handbook of International Economics, 131 - 195. Elsevier. doi: 10.1016/B9780444543141.00003-3.

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.

GÃ³mez-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

```
## Not run:
# Example for data without zero trade flows
data(gravity_no_zeros)

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

nls(dependent_variable = "flow", regressors = c("distw", "rta", "lgdp_o", "lgdp_d"),
robust = TRUE, data = gravity_no_zeros)

## End(Not run)
```

---

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, regressors, incomes, codes, uie = FALSE,
  robust = TRUE, data, ...)
```

Arguments

dependent_variable

> name (type: character) of the dependent variable in the dataset `data` (e.g. trade flows).
>
> This variable is logged and then used as the dependent variable in the estimation.
>
> If `uie = TRUE` the dependent variable is divided by the product of unilateral incomes (e.g. GDP variables `inc_o` and `inc_d` in the example datasets) of the countries of interest 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.

regressors   name (type: character) of the regressors to include in the model.

> Include the distance variable in the dataset `data` containing a measure of distance between all pairs of bilateral partners and bilateral variables that should be taken as the independent variables in the estimation.

> The distance is logged automatically when the function is executed.
>
> 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(distance, contiguity, common curreny, ...).

incomes
: variable name (type: character) of the income of the country of origin (e.g. inc_o) and destination (e.g. inc_d) in the dataset data.

  The dependent variable dependent_variable is divided by the product of the incomes.

  Write this argument as c(income origin, income destination).

codes
: variable name (type: character) of the code of the country of origin and destination (e.g. ISO-3 codes from the variables iso_o and iso_d) in the example datasets).

  The variables are grouped by using iso_o and iso_d to obtain estimates.

  Write this argument as c(code origin, code destination).

uie
: Unitary Income Elasticities (type: logic) determines whether the parameters are to be estimated assuming unitary income elasticities. The default value is set to FALSE.

  If uie is set TRUE, the flows in the dependent variable y are divided by the product of the country pairs' incomes before the estimation.

  If uie is set to FALSE, the income variables are logged and taken as independent variables in the estimation. The variable names for the incomes should be included (e.g. inc_o and inc_d in the example datasets).

robust
: robust (type: logical) determines whether a robust variance-covariance matrix should be used. By default is set to TRUE.

  If robust = TRUE the estimation results are consistent with the Stata code provided at Gravity Equations: Workhorse, Toolkit, and Cookbook when choosing robust estimation.

data
: name of the dataset to be used (type: character).

  To estimate gravity equations you need a square dataset including bilateral flows defined by the argument dependent_variable, ISO codes or similar of type character (e.g. iso_o for the country of origin and iso_d for the destination country), a distance measure defined by the argument distance and other potential influences (e.g. contiguity and common currency) given as a vector in regressors are required.

  All dummy variables should be of type numeric (0/1).

  Make sure the ISO codes are of type "character".

  If an independent variable is defined as a ratio, it should be logged.

  The user should perform some data cleaning beforehand to remove observations that contain entries that can distort estimates.

  When using panel data, a variable for the time may be included in the dataset. Note that the variable for the time dimension should be of type factor.

  The function will remove zero flows and distances.

...
: additional arguments to be passed to ols.

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 has 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), GÃ³mez-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." Technical Report 8079, National Bureau of Economic Research. doi: 10.3386/w8079.

Anderson JE (2010). "The Gravity Model." Technical Report 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.

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 series

Handbook of International Economics, 131 - 195. Elsevier. doi: 10.1016/B9780444543141.00003-3.

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.

GÃ³mez-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, coeftest, vcovHC

Examples

```
## Not run:
data(gravity_no_zeros)

ols(dependent_variable = "flow", regressors = c("distw", "rta", "contig", "comcur"),
incomes = c("gdp_o", "gdp_d"), codes = c("iso_o", "iso_d"),
uie = TRUE, robust = TRUE, data = gravity_no_zeros)

## End(Not run)
```

---

ppml   *Poisson Pseudo Maximum Likelihood (PPML)*

Description

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

Usage

```
ppml(dependent_variable, regressors, robust = TRUE, data, ...)
```

Arguments

dependent_variable

> name (type: character) of the dependent variable in the dataset data (e.g. trade flows)

regressors   name (type: character) of the regressors to include in the model.

> Include the distance variable in the dataset data containing a measure of distance between all pairs of bilateral partners and bilateral variables that should be taken as the independent variables in the estimation.
>
> The distance is logged automatically when the function is executed.
>
> 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(distance, contiguity, common curreny, ...).

robust   robust (type: logical) determines whether a robust variance-covariance matrix should be used. By default is set to TRUE.

> If robust = TRUE the estimation results are consistent with the Stata code provided at Gravity Equations: Workhorse, Toolkit, and Cookbook when choosing robust estimation.

data   name of the dataset to be used (type: character).

> To estimate gravity equations you need a square dataset including bilateral flows defined by the argument dependent_variable, ISO codes or similar of type character (e.g. iso_o for the country of origin and iso_d for the destination country), a distance measure defined by the argument distance and other potential influences (e.g. contiguity and common currency) given as a vector in regressors are required.
>
> All dummy variables should be of type numeric (0/1).
>
> Make sure the ISO codes are of type "character".
>
> If an independent variable is defined as a ratio, it should be logged.
>
> The user should perform some data cleaning beforehand to remove observations that contain entries that can distort estimates.
>
> The function allows zero flows but will remove zero distances.

...   additional arguments to be passed to functions used by ppml.

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 has 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), GÃ³mez-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." Technical Report 8079, National Bureau of Economic Research. doi: 10.3386/w8079.

Anderson JE (2010). "The Gravity Model." Technical Report 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.

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 series Handbook of International Economics, 131 - 195. Elsevier. doi: 10.1016/B9780444543141.00003-3.

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.

GÃ³mez-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

```
## Not run:
# Example for data with zero trade flows
data(gravity_zeros)

ppml(dependent_variable = "flow", regressors = c("distw", "rta","iso_o","iso_d"),
robust = TRUE, data = gravity_zeros)

# Example for data without zero trade flows
data(gravity_no_zeros)

gravity_no_zeros$lgdp_o <- log(gravity_no_zeros$gdp_o)
gravity_no_zeros$lgdp_d <- log(gravity_no_zeros$gdp_d)

ppml(dependent_variable = "flow", regressors = c("distw","rta","lgdp_o","lgdp_d"),
robust = TRUE, data = gravity_no_zeros)

## End(Not run)
```

---

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, regressors, incomes, maxloop = 50,
  decimal_places = 4, robust = TRUE, verbose = FALSE, data, ...)
```

Arguments

dependent_variable

> name (type: character) of the dependent variable in the dataset data (e.g. trade flows).
>
> This dependent variable is divided by the product of unilateral incomes (e.g. GDPs or GNPs of the countries of interest, named inc_o and inc_d in the example datasets) and logged afterwards.
>
> The transformed variable is then used as the dependent variable in the estimation.

regressors   name (type: character) of the regressors to include in the model.

> Include the distance variable in the dataset data containing a measure of distance between all pairs of bilateral partners and bilateral variables that should be taken as the independent variables in the estimation.

> The distance is logged automatically when the function is executed.

> Unilateral metric variables such as GDPs should be inserted via the argument incomes.

> As country specific effects are subdued due to demeaning, no further unilateral variables apart from unilateral incomes can be added.

> Write this argument as c(distance, contiguity, common curreny, ...).

incomes   variable name (type: character) of the income of the country of origin (e.g. inc_o) and destination (e.g. inc_d) in the dataset data.

> The dependent variable dependent_variable is divided by the product of the incomes.

> Write this argument as c(income origin, income destination).

maxloop   maximum number of outer loop iterations. The default is set to 100. There will be a warning if the iterations did not converge.

decimal_places   number of decimal places that should not change after a new iteration for the estimation to stop. The default is set to 4.

robust   robust (type: logic) determines whether a robust variance-covariance matrix should be used. The default is set to TRUE.

> If set TRUE the estimation results are consistent with the Stata code provided at the website Gravity Equations: Workhorse, Toolkit, and Cookbook when choosing robust estimation.

verbose   (type: logic) determines whether the estimated coefficients of each iteration should be printed in the console. The default is set to FALSE.

data   name of the dataset to be used (type: character).

> To estimate gravity equations you need a square dataset including bilateral flows defined by the argument dependent_variable, ISO codes or similar of type character (e.g. iso_o for the country of origin and iso_d for the destination country), a distance measure defined by the argument distance and other potential influences (e.g. contiguity and common currency) given as a vector in regressors are required.

> All dummy variables should be of type numeric (0/1).

> Make sure the ISO codes are of type "character".

> If an independent variable is defined as a ratio, it should be logged.

> The user should perform some data cleaning beforehand to remove observations that contain entries that can distort estimates.

> The function will remove zero flows and distances.

...   additional arguments to be passed to functions used by sils.

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, 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 information on sils as well as more information on gravity models, theoretical foundations and suitable estimation methods in general see

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 series Handbook of International Economics, 131 - 195. Elsevier. doi: 10.1016/B9780444543141.00003-3.

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

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 (2010). "The Gravity Model." Technical Report 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.

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.

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.

See Also

lm, coeftest, vcovHC

Examples

```
## Not run:
data(gravity_no_zeros)

sils(dependent_variable = "flow", regressors = c("distw", "rta"),
```

```
incomes = c("gdp_o", "gdp_d"),
maxloop = 100, dec_places = 4, robust = TRUE, verbose = FALSE,
data = gravity_no_zeros)

sils(dependent_variable = "flow", regressors = c("distw", "rta", "comcur", "contig"),
incomes = c("gdp_o", "gdp_d"),
maxloop = 100, dec_places = 4, robust = TRUE, verbose = FALSE,
data = gravity_no_zeros)

## End(Not run)
```

---

tetrads	*Tetrads*

Description

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

Usage

```
tetrads(dependent_variable, regressors, codes, reference_countries = c("JPN",
  "USA"), multiway = TRUE, data, ...)
```

Arguments

dependent_variable

name (type: character) of the dependent variable in the dataset data (e.g. trade flows).

This variable is logged and then used as the dependent variable in the estimation.

regressors   name (type: character) of the regressors to include in the model.

Include the distance variable in the dataset data containing a measure of distance between all pairs of bilateral partners and bilateral variables that should be taken as the independent variables in the estimation.

The distance is logged automatically when the function is executed.

Unilateral effects drop as the ratio of ratios is taken.

Write this argument as c(distance, contiguity, common curreny, ...).

codes   variable name (type: character) of the code of the country of origin and destination (e.g. ISO-3 codes from the variables iso_o and iso_d) in the example datasets).

The variables are grouped by using iso_o and iso_d to obtain estimates.

Write this argument as c(code origin, code destination).

reference_countries

reference exporting and importing country, default is set to c("JPN", "USA")

Write this argument as c(importing country, exporting country).

multiway   (type: logic) In case multiway = TRUE, the cluster.vcov function is used for estimation following Cameron et al. (2011) multi-way clustering of variance-covariance matrices.

The default value is set to TRUE.

data   name of the dataset to be used (type: character).

To estimate gravity equations you need a square dataset including bilateral flows defined by the argument dependent_variable, ISO codes or similar of type character (e.g. iso_o for the country of origin and iso_d for the destination country), a distance measure defined by the argument distance and other potential influences (e.g. contiguity and common currency) given as a vector in regressors are required.

All dummy variables should be of type numeric (0/1).

Make sure the ISO codes are of type "character".

If an independent variable is defined as a ratio, it should be logged.

The user should perform some data cleaning beforehand to remove observations that contain entries that can distort estimates.

When using panel data, a variable for the time may be included in the dataset. Note that the variable for the time dimension should be of type factor.

The time variable can be used as a single dependent variable or interaction term with other variables such as country identifiers by inserting it into regressors or as an optional parameter.

The function will remove zero flows and distances.

...   additional arguments to be passed to functions used by tetrads.

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 information on tetrads see

Cameron AC, Gelbach JB, Miller DL (2011). "Robust Inference With Multiway Clustering." *Journal of Business & Economic Statistics*, **29**(2), 238–249. ISSN 07350015.

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.

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." Technical Report 8079, National Bureau of Economic Research. doi: 10.3386/w8079.

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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.

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.

GÃ³mez-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, coeftest, cluster.vcov

Examples

```
## Not run:
data(gravity_no_zeros)

tetrads(dependent_variable = "flow", regressors = c("distw", "rta"),
codes = c("iso_o", "iso_d"), reference_countries = c("JPN", "USA"),
multiway = TRUE, data = gravity_no_zeros)

tetrads(dependent_variable = "flow", regressors = c("distw", "rta", "comcur", "contig"),
codes = c("iso_o", "iso_d"), reference_countries = c("JPN", "USA"),
multiway = FALSE, data = gravity_no_zeros)

## End(Not run)
```

---

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, regressors, added_constant = 1, data, ...)
```

Arguments

dependent_variable

> name (type: character) of the dependent variable in the dataset data (e.g. trade flows).
>
> 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.

regressors   name (type: character) of the regressors to include in the model.

> Include the distance variable in the dataset data containing a measure of distance between all pairs of bilateral partners and bilateral variables that should be taken as the independent variables in the estimation.
>
> The distance is logged automatically when the function is executed.
>
> 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(distance, contiguity, common curreny, ...).

added_constant   scalar (type: numeric); represents the constant to be added to the dependent variable. The default value is 1.

> The minimum of log(y + added_constant) is taken as the left boundary in the Tobit model.
>
> In the often used case of added_constant = 1, the dependent variable is left-censored at value 0 as log(1) = 0.

data   name of the dataset to be used (type: character).

> To estimate gravity equations you need a square dataset including bilateral flows defined by the argument dependent_variable, ISO codes or similar of type character (e.g. iso_o for the country of origin and iso_d for the destination country), a distance measure defined by the argument distance and other potential influences (e.g. contiguity and common currency) given as a vector in regressors are required.
>
> All dummy variables should be of type numeric (0/1).
>
> Make sure the ISO codes are of type "character".
>
> If an independent variable is defined as a ratio, it should be logged.

The user should perform some data cleaning beforehand to remove observations that contain entries that can distort estimates.

The function allows zero flows but will remove zero distances.

...   additional arguments to be passed to `tobit`.

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(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.

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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](#).

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.

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.

Especially for Tobit models see

Tobin J (1958). "Estimation of Relationships for Limited Dependent Variables." *Econometrica*, **26**(1), 24–36. ISSN 14680262.

Eaton J, Tamura A (1995). "Bilateralism and Regionalism in Japanese and U.S. Trade and Direct Foreign Investment Patterns." Technical Report 4758, National Bureau of Economic Research. doi: 10.3386/w4758.

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Carson RT, Sun Y (2007). "The Tobit model with a non-zero threshold." *The Econometrics Journal*, **10**(3), 488-502. doi: 10.1111/j.1368423X.2007.00218.x.

See Gravity Equations: Workhorse, Toolkit, and Cookbook for gravity datasets and Stata code for estimating gravity models.

See Also

censReg

Examples

```
## Not run:
# Example for data with zero trade flows
data(gravity_zeros)

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

tobit(dependent_variable = "flow", regressors = c("distw", "rta", "lgdp_o", "lgdp_d"),
added_constant = 1, data = gravity_zeros)

## End(Not run)
```

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