Package ‘DPTM’

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Type Package

Title Dynamic Panel Multiple Threshold Model with Fixed Effects

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Description Compute the fixed effects dynamic panel threshold model suggested by Ramírez-Rondán (2020) <doi:10.1080/07474938.2019.1624401>, and dynamic panel linear model suggested by Hsiao et al. (2002) <doi:10.1016/S0304-4076(01)00143-9>, where maximum likelihood type estimators are used. Multiple thresholds estimation based on Markov Chain Monte Carlo (MCMC) is allowed, and model selection of linear model, threshold model and multiple threshold model is also allowed.

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URL https://github.com/HujieBai/DPTM

Encoding UTF-8

Imports Rcpp (>= 1.0.12),R6,BayesianTools, purrr, MASS,stats,coda,parabar,utils

LinkingTo Rcpp,RcppEigen

RoxygenNote 7.3.2

Depends R (>= 4.3.0)

LazyData true

BugReports https://github.com/HujieBai/DPTM/issues

NeedsCompilation yes

Author Bai Hujie [aut, cre, cph] (ORCID: <https://orcid.org/0009-0004-2060-4351>)

Maintainer Bai Hujie <hujiebai@163.com>

Repository CRAN

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Contents

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d1 *Example Dataset d1*

Description

A simulated dataset for demonstrating the package

Usage

```
d1
```

Format

'd1' A data.frame with 1000 rows and 7 columns:

id individuals

year periods

y dependent variable

y1 the first lag of y

q threshold variable

x regressor with threshold effects

z regressor without threshold effects

Source

Simulated data with two thresholds

DPML *Dynamic panel model with fixed effects.*

Description

Use a MLE procedure to estimate the dynamic panel model with fixed effects.

Usage

```
DPML(formula, data, index=NULL, timeFE = FALSE, y1 = NULL,...)

## S6 method for class 'DPTM'
#print(...)
```

Arguments

`formula`	formula of the covariates with threshold effects.
`data`	data frame of the observed data.
`index`	variable names of individuals and period; If a setting is not provided, defaults (the first variables in data will be as "id", while the second will be "year") will be used. Defaults to ‘NULL‘.
`timeFE`	logicals. If TRUE the time fixed effects will be allowed. Defaults to ‘FALSE‘.
`y1`	lags of dependent variables; If a setting is not provided, defaults (the first-order lag) will be used. Defaults to ‘NULL‘.
`...`	additional arguments, see`stats::nlm`.

Details

`DPML` can fit the dynamic panel model with fixed effects proposed by Hsiao et al. (2002), which is based on the first difference and the maximum likelihood (MLE) method.

For a classical dynamic panel model with fixed effects having following form:

$$y_{it} = \rho y_{it-1} + \beta_1 x_{1,it} + \beta_2 x_{2,it} + \alpha_i + u_{it}$$

, can use `y~x1+x2`.

For a special dynamic panel model with fixed effects having the following form:

$$\Delta y_{it} = \rho y_{it-1} + \beta_1 x_{1,it} + \beta_2 x_{2,it} + \alpha_i + u_{it}$$

, can use `dy~x1+x2` with `y1`= y_{it-1}.

We assume the exogenous regressor x is weakly exogenous, and thus the first period after difference is given by

$$\Delta y_{i1} = \delta_0 + \boldsymbol{\delta}_1' \Delta \mathbf{x}_{i1} + v_{i1},$$

where $E(v_{i1}|\Delta \mathbf{x}_{i1}) = 0$. $E(v_{i1}^2) = \sigma_v^2$, $E(v_{i1}\Delta u_{i2}) = -\sigma_u^2$ and $E(v_{i1}\Delta u_{it}) = 0$ for $t = 3, 4, ..., T$ and $i = 1, ..., N$. For more details, see Hsiao et al. (2002).

In addition, we solve the log-likelihood function by `stats::nlm` who uses `iterlim` to set the maximum number of iterations, and thus `iterlim` is allowed by `...` in `DPML`.

Value

DPML returns an object of class "DPTM". The function `print` are used to obtain and print a print of the results. An object of class "DPTM" is a list containing at least the following components:

- `coefficients` a named vector of coefficients
- `NNLL` the negative log-likelihood function value
- `Zvalues` a vector of t statistics
- `Ses` a vector of standard errors
- `covariance_matrix` a covariance matrix
- `Th` the number of thresholds
- `thresholds` a named vector of thresholds

Author(s)

Hujie Bai

References

Hsiao, C., Pesaran, M. H., & Tahmiscioglu, A. K. (2002). Maximum likelihood estimation of fixed effects dynamic panel data models covering short time periods. Journal of econometrics, 109(1), 107-150.

Examples

```
data(d1)

# No time fixed effects
model1 <- DPML(y~x+z, data = d1)
print(model1)

# With time fixed effects
model2 <- DPML(y~x+z, data = d1, timeFE = TRUE)
print(model2)
```

DPTS — *Dynamic panel multiple threshold model with fixed effects.*

Description

Use a MCMC-MLE based on two-step procedure to estimate the dynamic panel multiple threshold model with fixed effects.

Usage

```
DPTS(formula = NULL, formula_cv = NULL, data, index=NULL, Th = 1, q, timeFE = FALSE,
NoY = FALSE, y1 = NULL, iterations = 2000, sro = 0.1, r0x = NULL, r1x = NULL,
...)

## S6 method for class 'DPTM'
#print(...)
```

Arguments

formula	formula of the covariates with threshold effects; If a setting is not provided, defaults (no covariates with threshold effects) will be used. Defaults to ‘NULL‘.
formula_cv	formula of the covariates without threshold effects; If a setting is not provided, defaults (no covariates without threshold effects) will be used. Defaults to ‘NULL‘.
data	data frame of the observed data.
index	variable names of individuals and period; If a setting is not provided, defaults (the first variables in data will be as "id", while the second will be "year") will be used.Defaults to ‘NULL‘.
Th	number of thresholds; Defaults to ‘1‘.
q	threshold variable.
timeFE	logicals. If TRUE the time fixed effects will be allowed. Defaults to ‘FALSE‘.
NoY	logicals. If TRUE the lags of dependent variables will be without threshold effects. Defaults to ‘FALSE‘.
y1	lags of dependent variables; If a setting is not provided, defaults (the first-order lag) will be used. Defaults to ‘NULL‘.
iterations	MCMC iterations (50% used for burnining). Defaults to ‘2000‘.
sro	regime (subsample) proportion; If a setting is not provided, defaults (10%) will be used. Defaults to ‘0.1‘.
r0x	lower bound of threshold parameter space; If a setting is not provided, defaults (15% quantile of threshold variable) will be used.
r1x	upper bound of threshold parameter space; If a setting is not provided, defaults (85% quantile of threshold variable) will be used.
...	additional arguments to be passed to the settings of MCMC (see BayesianTools::applySettingsDefault)

Details

DPTS can fit the dynamic panel threshold model with fixed effects proposed by Ramírez-Rondán (2020), and also allow a multiple threshold model by setting Th > 1.

Given the diverse forms and versatile applications of threshold models, we advocate for aligning model selection with specific research objectives, thereby granting users autonomy in specifying the model structure.

Take the model with one threshold (Ramírez-Rondán, 2020) as example.

For a standard threshold model

$$y_{it} = (\rho_1 y_{it-1} + \beta_1 x_{it}) I (q_{it} \leq \gamma) + (\rho_2 y_{it-1} + \beta_2 x_{it}) I (q_{it} > \gamma) \\ + \alpha_i + u_{it},$$

, can use `DPTS(y~x,data = data, q = q, Th = 1)`.

For a threshold model who has regressors with threshold effects (x) and regressors without threshold effects (z)

$$y_{it} = (\rho_1 y_{it-1} + \beta_1 x_{it}) I (q_{it} \leq \gamma) + (\rho_2 y_{it-1} + \beta_2 x_{it}) I (q_{it} > \gamma) \\ + \theta z_{it} + \alpha_i + u_{it},$$

, can use `DPTS(y~x,y~z,data = data, q = q, Th = 1)`.

If user only cares about the regressors with threshold effects (thus hopes there is no threshold effects in the lag of dependent variable y_1), like

$$y_{it} = \rho y_{it-1} + \beta_1 x_{it} I (q_{it} \leq \gamma) + \beta_2 x_{it} I (q_{it} > \gamma) \\ + \theta z_{it} + \alpha_i + u_{it},$$

, can use `DPTS(y~x,y~z,data = data, q = q, Th = 1, NoY = TRUE)`.

And, the threshold model with the following form

$$y_{it} = \rho_1 y_{it-1} I (q_{it} \leq \gamma) + \rho_2 y_{it-1} I (q_{it} > \gamma) + \beta x_{it} \\ + \theta z_{it} + \alpha_i + u_{it},$$

, is also allowed by `DPTS(NULL,y~x+z,data = data, q = q, Th = 1)`.

In addition, a special threshold model having the following form

$$\Delta y_{it} = (\rho_1 y_{it-1} + \beta_1 x_{it}) I (q_{it} \leq \gamma) + (\rho_2 y_{it-1} + \beta_2 x_{it}) I (q_{it} > \gamma) \\ + \theta z_{it} + \alpha_i + u_{it},$$

, can use `DPTS(dy~x,dy~z,data = data, q = q, Th = 1)` with `y1`$= y_{it-1}$.

The MCMC we used is based on **BayesianTools**, and the default method is "DREAMzs" (see Vrugt et al., 2009). If user wants to use other MCMC, can use `...` (see BayesianTools::applySettingsDefault). As for the length of iterations, it can be set by `iterations` (50% used for burnining) and default length is 2000. The trace plot and the Gelman and Rubin's convergence diagnostic are supplied by `DPTS` (`print`) to test the convergence of MCMC sample.

Additionally, we assume the exogenous regressor x is weakly exogenous, and thus the first period after difference is given by

$$\Delta y_{i1} = \delta_0 + \boldsymbol{\delta}_1' \Delta \mathbf{x}_{i1} + v_{i1},$$

where $E(v_{i1}|\Delta \mathbf{x}_{i1}) = 0$. $E(v_{i1}^2) = \sigma_v^2$, $E(v_{i1}\Delta u_{i2}) = -\sigma_u^2$ and $E(v_{i1}\Delta u_{it}) = 0$ for $t = 3, 4, ..., T$ and $i = 1, ..., N$. For more details, see Hsiao et al. (2002).

Finally, we solve the log-likelihood function by `stats::nlm` who uses `iterlim` to set the maximum number of iterations, and thus `iterlim` is allowed by `...` in `DPTS`.

Value

DPTS returns an object of class "DPTM". The function `print` are used to obtain and print a print of the results. An object of class "DPTM" is a list containing at least the following components:

- `coefficients` a named vector of coefficients
- `NNLL` the negative log-likelihood function value
- `Zvalues` a vector of t statistics
- `Ses` a vector of standard errors
- `covariance_matrix` a covariance matrix
- `Th` the number of thresholds
- `thresholds` a named vector of thresholds

Author(s)

Hujie Bai

References

Ramírez-Rondán, N. R. (2020). Maximum likelihood estimation of dynamic panel threshold models. Econometric Reviews, 39(3), 260-276.

Vrugt, Jasper A., et al. (2009)."Accelerating Markov chain Monte Carlo simulation by differential evolution with self-adaptive randomized subspace sampling." International Journal of Nonlinear Sciences and Numerical Simulation 10.3: 273-290.

Hsiao, C., Pesaran, M. H., & Tahmiscioglu, A. K. (2002). Maximum likelihood estimation of fixed effects dynamic panel data models covering short time periods. Journal of econometrics, 109(1), 107-150.

Examples

```
data(d1)

# single threshold

## standard form
#Model1_1 <- DPTS(y~x,data = d1, index = c('id','year'), q = d1$q, Th = 1,
#iterations = 1000)
#print(Model1_1)


### Examples elapsed time > 15s
## with x \& z
#Model2_1 <- DPTS(y~x,y~z,data = d1, index = c('id','year'), q = d1$q, Th = 1,
#iterations = 1000)
#print(Model2_1)

## with x \& z (y1 no threshold effects)
#Model3_1 <- DPTS(y~x,y~z,data = d1, index = c('id','year'), q = d1$q, Th = 1,
```

```
#NoY = TRUE, iterations = 1000)
#print(Model3_1)

## only y1 with threshold effects
#Model4_1 <- DPTS(NULL,y~x+z,data = d1, index = c('id','year'), q = d1$q, Th = 1,
#iterations = 1000)
#print(Model4_1)

# two thresholds (Th = 2)
## with x \& z
#Model2_2 <- DPTS(y~x,y~z,data = d1, index = c('id','year'), q = d1$q, Th = 2,
#iterations = 1000)
#print(Model2_2)

# Adding time fixed effects (timeFE = TRUE)
#Model2_2T <- DPTS(y~x,y~z,data = d1, index = c('id','year'), q = d1$q, Th = 2,
#timeFE = TRUE, iterations = 1000)
#print(Model2_2T)
```

Growth_Inflation *Example Dataset Growth_Inflation*

Description

A dataset for economic growth of 74 countries from 1961 to 2015 (five-year average).

Usage

```
Growth_Inflation
```

Format

‘Growth_Inflation‘ A data.frame with 814 rows and 15 columns:

ncountry country id

countryname country name

code country code

Period Period

years years

GDP per capita growth the difference of ln(GDP per capita)

Inflation rate-semilog the semi-log of Inflation rate

Transitional convergence the lag of ln(GDP per capita)

Human capital Human capital

Financial depth Financial depth

Governance Governance

Public infrastructure Public infrastructure

Trade openness Trade openness

Economic instability Economic instability

Inflation rate Inflation rate

Source

https://doi.org/10.1080/07474938.2019.1624401

`Threshold_Test` *Tests for multiple thresholds.*

Description

Tests for models with different thresholds, using bootstrap method.

Usage

```
Threshold_Test(formula = NULL, formula_cv = NULL, data, index=NULL, Th = 1, q,
timeFE = FALSE, bt = 100,NoY = FALSE, y1 = NULL, iterations = 2000, sro = 0.1,
r0x = NULL, r1x = NULL, parallel=TRUE, seed = NULL,...)
```

Arguments

`formula`	formula of the covariates with threshold effects; If a setting is not provided, defaults (no covariates with threshold effects) will be used. Defaults to ‘NULL‘.
`formula_cv`	formula of the covariates without threshold effects; If a setting is not provided, defaults (no covariates without threshold effects) will be used. Defaults to ‘NULL‘.
`data`	data frame of the observed data.
`index`	variable names of individuals and period; If a setting is not provided, defaults (the first variables in data will be as "id", while the second will be "year") will be used.Defaults to ‘NULL‘.
`q`	threshold variable.
`timeFE`	logicals. If TRUE the time fixed effects will be allowed. Defaults to ‘FALSE‘.
`bt`	the number of bootstrap; If a setting is not provided, defaults (bt = 100) will be used. Defaults to ‘100‘.
`NoY`	logicals. If TRUE the lags of dependent variables will be without threshold effects. Defaults to ‘FALSE‘.
`y1`	lags of dependent variables; If a setting is not provided, defaults (the first-order lag) will be used. Defaults to ‘NULL‘.
`iterations`	MCMC iterations (50% used for burnining). Defaults to ‘2000‘.
`sro`	regime (subsample) proportion; If a setting is not provided, defaults (10%) will be used. Defaults to ‘0.1‘.

r0x	lower bound of threshold parameter space; If a setting is not provided, defaults (15% quantile of threshold variable) will be used.
r1x	upper bound of threshold parameter space; If a setting is not provided, defaults (85% quantile of threshold variable) will be used.
parallel	logicals. If TRUE test will run in parallel for saving time. Defaults to ‘TRUE‘.
seed	set seeds to guarantee the replication the test (see set.seed);
...	additional arguments to be passed to the settings of MCMC (see BayesianTools::applySettingsDefault)
Th	number of thresholds; Defaults to ‘1‘.

Details

Threshold_Test can run the Test for multiple thresholds (Th is H1). The statistic is

$$F_s = \frac{S\left(\hat{\gamma}_{s-1}\right) - S\left(\hat{\gamma}_s\right)}{S\left(\hat{\gamma}_s\right)/N(T-1)},$$

where s is the number of thresholds in H1, $S\left(\hat{\gamma}_{s-1}\right) = -\ln L\left(\hat{\gamma}_{s-1}\right)$ and $S\left(\hat{\gamma}_s\right) = -\ln L\left(\left(\hat{\gamma}'_{s-1}, \hat{\gamma}_s\right)'\right)$. And the p-value is computed by bootstrap method (see Ramírez-Rondán, 2020).

Take the two threshold model as example. User must set Th = 1 firstly to reject the null hypothesis of no threshold effects; Then he should set Th = 2 to reject the null hypothesis of only one threshold; Lastly, set Th = 3 to accept the null hypothesis of two thresholds. In other words, p-values of the first test (Th = 1) and the second test (Th = 1) should be less than significant level while the third test (Th = 3) is not.

Threshold_Test contains all augments in DPTS, but with three new augments: bt, parallel and seed. bt is the number of bootstrap (by default is 100); parallel can allow user to run test in parallel to save time; seed is used to guarantee the replication of tests.

It is worthy noting that the test shrinks to the so-called threshold existence test when Th = 1.

Value

A list with class "htest" containing the following components:

statistic	the value of the F-statistic.
parameter	the degrees of freedom for the F-statistic.
p.value	the p-value for the test.
null.value	the specified hypothesized value of the null hypothesis.
alternative	a character string describing the alternative hypothesis.
method	a character string indicating what type of test was performed.
data.name	a character string giving the name(s) of the data.
estimate	the critical value of the statistic (5% significance level).
LRs	a vector of statistics from bootstrap.

Author(s)

Hujie Bai

References

Ramírez-Rondán, N. R. (2020). Maximum likelihood estimation of dynamic panel threshold models. Econometric Reviews, 39(3), 260-276.

Examples

```
### Examples elapsed time > 15s

#data(d1)

# H0: no threshold effects (no threshold)
#test0 <- Threshold_Test(y~x,y~z,data = d1, index = c('id','year'), q = d1$q, Th = 1,
#bt = 50, iterations = 500)
#test0

# H0: one threshold
#test1 <- Threshold_Test(y~x,y~z,data = d1, index = c('id','year'), q = d1$q, Th = 2,
#bt = 50, iterations = 500)
#test1

# H0: two threshold
#test2 <- Threshold_Test(y~x,y~z,data = d1, index = c('id','year'), q = d1$q, Th = 3,
#bt = 50, iterations = 500)
#test2
```

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