Package 'mbreaks'

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Type Package

Title Estimation and Inference for Structural Breaks in Linear Regression Models

Version 1.0.0

Description
Functions provide comprehensive treatments for estimating, inferring, testing and model selecting in linear regression models with structural breaks. The tests, estimation methods, inference and information criteria implemented are discussed in Bai and Perron (1998) ``Estimating and Testing Linear Models with Multiple Structural Changes" <doi:10.2307/2998540>.

URL https://github.com/RoDivinity/mbreaks

BugReports https://github.com/RoDivinity/mbreaks/issues

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NeedsCompilation no

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R topics documented:

`compile_model` *Format output of n break model*

Description

`compile_model()` compiles the information of `model` class object `x` into 3 main tables:

- `date_tab` Table for estimated break date in the model with 90% and 95% confidence intervals based on `robust`,`hetomega`, `hetq` options for errors and `prewhit` option
- `RS_tab` Table for estimated coefficients for `z` regressors with corrected standard errors based on `robust`,`hetdat`,`hetvar` options for errors and `prewhit` option
- `FS_tab` Table for estimated coefficients for `x` regressors with corrected standard errors based on `robust`,`hetdat`,`hetvar` options for errors and `prewhit` option

Usage

```
compile_model(x, digits = 3)
```

Arguments

x	the model class to format
digits	number of digits displayed in console. Default value is 3

Value

x The input list of model class contains the following tables:

- date_tab A data frame storing the break date estimated by the model, and their corresponding confidence intervals
- RS_tab A data frame storing the estimated coefficients which allowed to change across regimes with corrected standard errors
- FS_tab A data frame storing the estimated coefficients which is constant across regimes with corrected standard errors

Note

- If x returns 0 number of estimated break, the function will return NULL value instead of the list in Value.
- If x is a pure structural break, the FS_tab will return NULL in Value

---

compile_sbtests *Compile the output of Sup Wald test*

Description

compile_sbtests formats the output of the sbtests into 2 tables

- supF1 table containing Sup F tests of 0 versus 1 to m breaks with critical values of the corresponding tests
-

Usage

```
compile_sbtests(x, digits = 3)
```

Arguments

x	sbtests class object
digits	number of decimal places displayed

Value

class sbtests x with appended 2 data frames:

- supF1 A data frame contains SupF tests statistics of 0 versus m breaks, where m is maximum number of breaks considered in x with critical values at {10%,5%,2.5%,1%} level
- UDMax A data frame contains Double Max test statistics with with critical values at {10%,5%,2.5%,1%} level

---

compile_seqtests *Compile the output of sequential Sup Wald test*

Description

compile_seqtests formats the output of the seqtests class object to 1 table

- sfl table containing sequential sup F tests statistics of l versus l+1 for l in 1 to m breaks with critical values of the corresponding tests at {1%, 2.5%, 5%, 10%} significance levels

Usage

```
compile_seqtests(x)
```

Arguments

x	seqtests class object

Value

class seqtests list x with appended data frame sfl containing the sequential SupF test statistics with critical values at {10%,5%,2.5%,1%} level

---

correct *Heteroskedasticy and autocorrelation consistency correction for residuals*

Description

hac() corrects the estimated errors based on options of prewhitening using a AR(1) process estimation of error terms to obtain heteroskedasticy and autocorrelation consistency (HAC) errors with automatic bandwith and kernel similar to Andrews, 1994

Usage

```
correct(reg, res, prewhit)
```

Arguments

reg	matrix of regressors
res	matrix of estimated residuals
prewhit	Option of using prewhitening process. If 1, an AR(1) process will be used to filter. If 0, skipped the filtering process

Value

hac Heteroskedasticy and autocorrelation consistent errors

---

dating *Computation of global minimizer for pure structural change model*

Description

dating() computes break points that globally minimizes SSR via dynamic programming approach. To avoid recursion depth increases as number of breaks in the model increases, a temporary array is used to store optimal partition with corresponding SSR for all permissible subsamples for all 1:m-1 breaks. For the m-th break, the problem becomes finding where to insert the last feasible m+1-th segment into the sample partitioned by m-1 breaks to obtain minimum SSR over the sample

Usage

```
dating(y, z, h, m, q, bigT)
```

Arguments

y	matrix of dependent variable
z	matrix of regressors with coefficients allowed to change across regimes
h	minimum length of segment
m	maximum number of breaks
q	number of z regressors
bigT	sample period T

Value

A list containing the following components:

glb	minimum global SSR
datevec	Vector of dates (optimal minimizers)
bigvec	Associated SSRs

diag_par *Diagonal partition given break dates*

Description

diag_par() partition the matrix of z regressors which coefficients are changed based on the provided break dates

Usage

```
diag_par(input, m, date)
```

Arguments

input	matrix of independent variables z with coefficients allowed to change overtime
m	number of breaks in the series
date	vector of break dates

Value

output: matrix of partitioned variables corresponds to break dates

Examples

```
z = matrix(c(1:100),50,2)
m = 2  #2 breaks
date = matrix(c(15,30),2,1) #first break at t = 15; second break at t = 30
diag_par(z,m,date)
```

dofix *Estimate a model with pre-specified number of breaks*

Description

dofix() compute a structural change model with pre-specified number of breaks.

Usage

```
dofix(
  y_name,
  z_name = NULL,
  x_name = NULL,
  data,
  fixn = 5,
  eps = 1e-05,
```

```
  eps1 = 0.15,
  maxi = 10,
  fixb = 0,
  betaini = 0,
  printd = 0,
  prewhit = 1,
  robust = 1,
  hetdat = 1,
  hetvar = 1,
  hetq = 1,
  hetomega = 1,
  const = 1,
  h = NULL
)
```

Arguments

y_name	name of dependent variable in the data set
z_name	name of independent variables in the data set which coefficients are allowed to change across regimes. default is vector of 1 (Mean-shift model)
x_name	name of independent variables in the data set which coefficients are constant across regimes. default is NULL
data	name of data set used
fixn	number of breaks specified
eps	convergence criterion for iterative recursive computation
eps1	value of trimming (in percentage) for the construction and critical values. Minimal segment length h will be set at default = int(eps1*T) (T is total sample size). • eps1=0.05 Maximal value of m = 10 • eps1=0.10 Maximal value of m = 8 • eps1=.15 Maximal value of m = 5 • eps1=.20 Maximal value of m = 3 • eps1=.25 Maximal value of m = 2 • eps1=0 This option allows users to explicitly specify minimum segment length h parameters
maxi	maximum number of iterations
fixb	option to use fixed initial input β. If 1, the model will use values given in betaini. If 0, betaini is skipped
betaini	Initial $beta_0$ to use in estimation
printd	Print option for model estimation. default = 0, to suppress intermediate outputs printing to console
prewhit	set to 1 to apply AR(1) prewhitening prior to estimating the long run covariance matrix.

robust	set to 1 to allow for heterogeneity and autocorrelation in the residuals, 0 otherwise. The method used is *Andrews(1991)* automatic bandwidth with AR(1) approximation with quadratic kernel. Note: Do not set to 1 if lagged dependent variables are included as regressors.
hetdat	option for the construction of the F tests. Set to 1 if want to allow different moment matrices of the regressors across segments. If hetdat = 0, the same moment matrices are assumed for each segment and estimated from the ful sample. It is recommended to set hetdat=1 if number of regressors x > 0.
hetvar	option for the construction of the F tests.Set to 1 if users want to allow for the variance of the residuals to be different across segments. If hetvar=0, the variance of the residuals is assumed constant across segments and constructed from the full sample. hetvar=1 when robust =1)
hetq	used in the construction of the confidence intervals for the break dates. If hetq=0, the moment matrix of the data is assumed identical across segments
hetomega	used in the construction of the confidence intervals for the break dates. If hetomega=0, the long run covariance matrix of zu is assumed identical across segments (the variance of the errors u if robust=0)
const	indicates whether the regression model include an intercept changing across regimes. Default value is 1
h	Minimum segment length of regime considered in estimation. If users want to specify a particular value, please set eps1=0

Value

out A list of class model contains all information about the estimated structural change model with fixn breaks

Examples

```
dofix('rate',data=real,fixn=3)
```

---

doglob *Global SSR minimizer for structural change model*

Description

doglob() identify if the structural change model is i) pure or ii) partial change model. The procedure then calls appropriate functions dating to estimate the pure change model and nldat to estimate the partial change model.

Usage

```
doglob(y, z, x, m, eps, h, maxi, fixb, betaini, printd, eps1)
```

Arguments

y	matrix of dependent variable
z	matrix of independent variables with coefficients allowed to change across regimes
x	matrix of independent variables with coefficients constant across regimes
m	number of breaks in the structural change model
eps	convergence criterion for iterative recursive computation. (For partial change model ONLY)
h	Minimum segment length of regime considered in estimation. If users want to specify a particular value, please set `eps1=0`
maxi	maximum number of iterations. (For partial change model ONLY)
fixb	option to use fixed initial input β. If `1`, the model will use values given in `betaini`. If `0`, betaini is skipped
betaini	Initial $beta_0$ to use in estimation (Must be a `p x 1` matrix, where p is number of x variables)
printd	Print option for model estimation. `default` = 0, to suppress intermediate outputs printing to console
eps1	trimming level

Value

A list containing the following components:

- glb Minimum global SSR
- datevec Vector of dates (optimal minimizers)
- bigvec Associated SSRs with possible break dates combination

---

`doorder` *Estimating number of breaks via information criterion*

Description

`doorder()` estimates the number of breaks using one of the following information criteria:

- modified Bayesian information criterion by Kurozumi and Tuvaandorj, 2011,
- modified Schwarz information criterion by Liu, Wu and Zidek, 1997,
- Bayesian information criterion by Yao, 1988

and the structural break model corresponding to estimated number of breaks

Usage

```
doorder(
  y_name,
  z_name = NULL,
  x_name = NULL,
  data,
  m = 5,
  eps = 1e-05,
  eps1 = 0.15,
  maxi = 10,
  fixb = 0,
  betaini = 0,
  printd = 0,
  ic = "KT",
  const = 1,
  h = NULL,
  prewhit = 1,
  hetdat = 1,
  hetq = 1,
  hetomega = 1,
  hetvar = 1,
  robust = 1
)
```

Arguments

y_name	name of dependent variable in the data set
z_name	name of independent variables in the data set which coefficients are allowed to change across regimes. default is vector of 1 (Mean-shift model)
x_name	name of independent variables in the data set which coefficients are constant across regimes. default is NULL
data	name of data set used
m	maximum number of breaks
eps	convergence criterion for iterative recursive computation
eps1	value of trimming (in percentage) for the construction and critical values. Minimal segment length h will be set at default = int(eps1*T) (T is total sample size). • eps1=0.05 Maximal value of m = 10 • eps1=0.10 Maximal value of m = 8 • eps1=.15 Maximal value of m = 5 • eps1=.20 Maximal value of m = 3 • eps1=.25 Maximal value of m = 2 • eps1=0 This option allows users to explicitly specify minimum segment length h parameters
maxi	maximum number of iterations

fixb	option to use fixed initial input β. If 1, the model will use values given in betaini. If 0, betaini is skipped
betaini	Initial $beta_0$ to use in estimation
printd	Print option for model estimation. default = 0, to suppress intermediate outputs printing to console
ic	indicator which information criterion is used in selecting number of breaks: {'KT','BIC','LWZ'}. The default value is 'KT'
const	indicates whether the regression model include an intercept changing across regimes. Default value is 1
h	Minimum segment length of regime considered in estimation. If users want to specify a particular value, please set eps1=0
prewhit	set to 1 to apply AR(1) prewhitening prior to estimating the long run covariance matrix.
hetdat	option for the construction of the F tests. Set to 1 if want to allow different moment matrices of the regressors across segments. If hetdat = 0, the same moment matrices are assumed for each segment and estimated from the ful sample. It is recommended to set hetdat=1 if number of regressors x > 0.
hetq	used in the construction of the confidence intervals for the break dates. If hetq=0, the moment matrix of the data is assumed identical across segments
hetomega	used in the construction of the confidence intervals for the break dates. If hetomega=0, the long run covariance matrix of zu is assumed identical across segments (the variance of the errors u if robust=0)
hetvar	option for the construction of the F tests.Set to 1 if users want to allow for the variance of the residuals to be different across segments. If hetvar=0, the variance of the residuals is assumed constant across segments and constructed from the full sample. hetvar=1 when robust =1)
robust	set to 1 to allow for heterogeneity and autocorrelation in the residuals, 0 otherwise. The method used is *Andrews(1991)* automatic bandwidth with AR(1) approximation with quadratic kernel. Note: Do not set to 1 if lagged dependent variables are included as regressors.

Value

A list of class model that contains one of the following:

mBIC	change model with number of breaks selected by BIC
mLWZ	change model with number of breaks selected by LWZ
mKT	change model with number of breaks selected by KT

References

Liu J, Wu S, Zidek JV (1997). *"On Segmented Multivariate Regressions"*, Statistica Sinica, 7, 497-525. Yao YC (1988). *"Estimating the Number of Change-points via Schwartz Criterion"*, Statistics and Probability Letters, 6, 181-189. Kurozumi E, Tuvaandorj P (2011). *"Model Selection Criteria in Multivariate Models with Multiple Structural Changes"*, Journal of Econometrics 164, 218-238.

Examples

```
doorder('rate',data=real,ic=c('BIC'))
```

`dorepart` *Estimating number of breaks using repartition procedure*

Description

`dorepart()` computes the repartition estimates of the breaks obtained by the sequential method by Bai, 1995.. It alows estimates that have the same asymptotic distribution as those obtained by global minimization. Otherwise, the output from the procedure "estim" below do not deliver asymptotically correct confidence intervals for the break dates.

Usage

```
dorepart(
  y_name,
  z_name = NULL,
  x_name = NULL,
  data,
  m = 5,
  eps = 1e-05,
  eps1 = 0.15,
  maxi = 10,
  fixb = 0,
  betaini = 0,
  printd = 0,
  prewhit = 1,
  robust = 1,
  hetdat = 1,
  hetvar = 1,
  const = 1,
  signif = 2
)
```

Arguments

`y_name`	name of dependent variable in the data set
`z_name`	name of independent variables in the data set which coefficients are allowed to change across regimes. `default` is vector of 1 (Mean-shift model)
`x_name`	name of independent variables in the data set which coefficients are constant across regimes. `default` is `NULL`
`data`	name of data set used
`m`	Maximum number of structural changes allowed. If not specify, m will be set to `default` value matching `eps1` input

eps	convergence criterion for iterative recursive computation
eps1	value of trimming (in percentage) for the construction and critical values. Minimal segment length h will be set at default = int(eps1*T) (T is total sample size). • • eps1=0.05 Maximal value of m = 10 • eps1=0.10 Maximal value of m = 8 • eps1=.15 Maximal value of m = 5 • eps1=.20 Maximal value of m = 3 • eps1=.25 Maximal value of m = 2 • eps1=0 This option is not allowed
maxi	maximum number of iterations
fixb	option to use fixed initial input β. If 1, the model will use values given in betaini. If 0, betaini is skipped
betaini	Initial $beta_0$ to use in estimation
printd	Print option for model estimation. default = 0, to suppress intermediate outputs printing to console
prewhit	set to 1 to apply AR(1) prewhitening prior to estimating the long run covariance matrix.
robust	set to 1 to allow for heterogeneity and autocorrelation in the residuals, 0 otherwise. The method used is *Andrews(1991)* automatic bandwidth with AR(1) approximation with quadratic kernel. Note: Do not set to 1 if lagged dependent variables are included as regressors.
hetdat	option for the construction of the F tests. Set to 1 if want to allow different moment matrices of the regressors across segments. If hetdat = 0, the same moment matrices are assumed for each segment and estimated from the ful sample. It is recommended to set hetdat=1 if number of regressors x > 0.
hetvar	option for the construction of the F tests.Set to 1 if users want to allow for the variance of the residuals to be different across segments. If hetvar=0, the variance of the residuals is assumed constant across segments and constructed from the full sample. hetvar=1 when robust =1)
const	indicates whether the regression model include an intercept changing across regimes. Default value is 1
signif	significance level used to sequential test to select number of breaks. • 4: 1% level • 3: 2.5% level • 2: 5% level • 1: 10% level

Value

out A list of model class for structural break model estimating by repartition procedure

References

Bai, J. 1995, *"Estimating Breaks one at a time"*, Econometric Theory, 13, 315-352

Examples

```
dorepart('inf','inflag','inffut',data=nkpc)
```

`doseqtests` *Sequential Sup F tests*

Description

`doseqtests()` computes the sequential sup F tests of l versus l+1 for l from 1 to m with each corresponding null hypothesis of maximum number of break is l and alternative hypothesis is l+1. The l breaks under the null hypothesis are taken from the global minimization estimation

Usage

```
doseqtests(
  y_name,
  z_name = NULL,
  x_name = NULL,
  data,
  m = 5,
  eps = 1e-05,
  eps1 = 0.15,
  maxi = 10,
  fixb = 0,
  betaini = 0,
  printd = 0,
  prewhit = 1,
  robust = 1,
  hetdat = 1,
  hetvar = 1,
  hetq = 1,
  hetomega = 1,
  const = 1
)
```

Arguments

`y_name`	name of dependent variable in the data set
`z_name`	name of independent variables in the data set which coefficients are allowed to change across regimes. `default` is vector of 1 (Mean-shift model)
`x_name`	name of independent variables in the data set which coefficients are constant across regimes. `default` is `NULL`

`data` name of data set used

`m` maximum number of breaks

`eps` convergence criterion for recursive calculations (For partial change model ONLY)

`eps1` value of trimming (in percentage) for the construction and critical values. Minimal segment length `h` will be set at `default` = int(`eps1`*T) (T is total sample size). There are five options:

- `eps1=0.05` Maximal value of `m` = 10
- `eps1=0.10` Maximal value of `m` = 8
- `eps1=.15` Maximal value of `m` = 5
- `eps1=.20` Maximal value of `m` = 3
- `eps1=.25` Maximal value of `m` = 2
- `eps1=0` is not allowed. The test is undefined for no trimming level

`maxi` number of maximum iterations for recursive calculations of finding global minimizers.`default` = 10 (For partial change model ONLY)

`fixb` option to use fixed initial input β. If `1`, the model will use values given in `betaini`. If `0`, betaini is skipped

`betaini` Initial $beta_0$ to use in estimation (Must be a `p x 1` matrix, where p is number of x variables)

`printd` Print option for model estimation. `default` = 0, to suppress intermediate outputs printing to console

`prewhit` set to `1` to apply AR(1) prewhitening prior to estimating the long run covariance matrix.

`robust` set to `1` to allow for heterogeneity and autocorrelation in the residuals, `0` otherwise. The method used is *Andrews(1991)* automatic bandwidth with AR(1) approximation with quadratic kernel. Note: Do not set to `1` if lagged dependent variables are included as regressors.

`hetdat` option for the construction of the F tests. Set to 1 if want to allow different moment matrices of the regressors across segments. If `hetdat = 0`, the same moment matrices are assumed for each segment and estimated from the ful sample. It is recommended to set `hetdat=1` if number of regressors `x > 0`.

`hetvar` option for the construction of the F tests.Set to `1` if users want to allow for the variance of the residuals to be different across segments. If `hetvar=0`, the variance of the residuals is assumed constant across segments and constructed from the full sample. `hetvar=1` when `robust =1`)

`hetq` used in the construction of the confidence intervals for the break dates. If `hetq=0`, the moment matrix of the data is assumed identical across segments

`hetomega` used in the construction of the confidence intervals for the break dates. If `hetomega=0`, the long run covariance matrix of zu is assumed identical across segments (the variance of the errors u if `robust=0`)

`const` indicates whether the regression model include an intercept changing across regimes. Default value is 1

Value

A list that contains following:

- supfl: SupF(l+1|l) test statistics
- cv: Critical values for SupF(l+1|l) test

Examples

```
doseqtests('inf',c('inflag','lbs','inffut'),data=nkpc,prewhit=0)
```

---

dosequa *Estimating number of breaks using sequential tests*

Description

`dosequa()` sequentially increases the number of breaks from `1` to `m` until the sequential tests reject and estimate the structural change model with corresponding estimated breaks. The procedure is proposed by Bai and Perron, 1998

Usage

```
dosequa(
  y_name,
  z_name = NULL,
  x_name = NULL,
  data,
  m = 5,
  eps = 1e-05,
  eps1 = 0.15,
  maxi = 10,
  fixb = 0,
  betaini = 0,
  printd = 0,
  prewhit = 1,
  robust = 1,
  hetdat = 1,
  hetvar = 1,
  hetq = 1,
  hetomega = 1,
  const = 1,
  signif = 2
)
```

Arguments

y_name	name of dependent variable in the data set
z_name	name of independent variables in the data set which coefficients are allowed to change across regimes. default is vector of 1 (Mean-shift model)
x_name	name of independent variables in the data set which coefficients are constant across regimes. default is NULL
data	name of data set used
m	Maximum number of structural changes allowed. If not specify, m will be set to default value matching eps1 input
eps	convergence criterion for iterative recursive computation
eps1	value of trimming (in percentage) for the construction and critical values. Minimal segment length h will be set at default = int(eps1*T) (T is total sample size). • • eps1=0.05 Maximal value of m = 10 • eps1=0.10 Maximal value of m = 8 • eps1=.15 Maximal value of m = 5 • eps1=.20 Maximal value of m = 3 • eps1=.25 Maximal value of m = 2 • eps1=0 This option is not allowed
maxi	maximum number of iterations
fixb	option to use fixed initial input β. If 1, the model will use values given in betaini. If 0, betaini is skipped
betaini	Initial $beta_0$ to use in estimation
printd	Print option for model estimation. default = 0, to suppress intermediate outputs printing to console
prewhit	set to 1 to apply AR(1) prewhitening prior to estimating the long run covariance matrix.
robust	set to 1 to allow for heterogeneity and autocorrelation in the residuals, 0 otherwise. The method used is *Andrews(1991)* automatic bandwidth with AR(1) approximation with quadratic kernel. Note: Do not set to 1 if lagged dependent variables are included as regressors.
hetdat	option for the construction of the F tests. Set to 1 if want to allow different moment matrices of the regressors across segments. If hetdat = 0, the same moment matrices are assumed for each segment and estimated from the ful sample. It is recommended to set hetdat=1 if number of regressors x > 0.
hetvar	option for the construction of the F tests.Set to 1 if users want to allow for the variance of the residuals to be different across segments. If hetvar=0, the variance of the residuals is assumed constant across segments and constructed from the full sample. hetvar=1 when robust =1)
hetq	used in the construction of the confidence intervals for the break dates. If hetq=0, the moment matrix of the data is assumed identical across segments

`hetomega`	used in the construction of the confidence intervals for the break dates. If `hetomega=0`, the long run covariance matrix of zu is assumed identical across segments (the variance of the errors u if `robust=0`)
`const`	indicates whether the regression model include an intercept changing across regimes. Default value is 1
`signif`	significance level used to sequential test to select number of breaks. • 4: 1% level • 3: 2.5% level • 2: 5% level • 1: 10% level

Value

out A list of `model` class with number of breaks selected by sequential tests

Examples

```
dosequa('rate',data=real,signif=1)
```

`dotest` *SupF, UDMax & WDMax testing procedure*

Description

`dotest()` compute the test statistics and report the critical values of the 2 main supF tests below:

- SupF test of 0 vs m breaks
- Double Max test proposed by Perron and Bai, 1998

Usage

```
dotest(
  y_name,
  z_name = NULL,
  x_name = NULL,
  data,
  m = 5,
  eps = 1e-05,
  eps1 = 0.15,
  maxi = 10,
  fixb = 0,
  betaini = 0,
  printd = 0,
  prewhit = 1,
  robust = 1,
  hetdat = 1,
```

```
  hetvar = 1,
  hetq = 1,
  hetomega = 1,
  const = 1
)
```

Arguments

y_name	matrix of dependent variable
z_name	matrix of regressors which coefficients are allowed to change across regimes.
x_name	matrix of regressors which coefficients are constant across regimes.
data	the data set for estimation
m	maximum number of breaks
eps	convergence criterion for iterative recursive computation
eps1	trimming level
maxi	maximum number of iterations
fixb	option to use fixed initial input β. If 1, the model will use values given in betaini. If 0, betaini is skipped
betaini	Initial $beta_0$ to use in estimation (Must be a p x 1 matrix, where p is number of x variables)
printd	Print option for model estimation. default = 0, to suppress intermediate outputs printing to console
prewhit	option to use AR(1) for prewhitening
robust	set to 1 to allow for heterogeneity and autocorrelation in the residuals, 0 otherwise. The method used is *Andrews(1991)* automatic bandwidth with AR(1) approximation with quadratic kernel. Note: Do not set to 1 if lagged dependent variables are included as regressors.
hetdat	option for the construction of the F tests. Set to 1 if want to allow different moment matrices of the regressors across segments. If hetdat = 0, the same moment matrices are assumed for each segment and estimated from the ful sample. It is recommended to set hetdat=1 if number of regressors x > 0.
hetvar	option for the construction of the F tests.Set to 1 if users want to allow for the variance of the residuals to be different across segments. If hetvar=0, the variance of the residuals is assumed constant across segments and constructed from the full sample. hetvar=1 when robust =1)
hetq	used in the construction of the confidence intervals for the break dates. If hetq=0, the moment matrix of the data is assumed identical across segments
hetomega	used in the construction of the confidence intervals for the break dates. If hetomega=0, the long run covariance matrix of zu is assumed identical across segments (the variance of the errors u if robust=0)
const	indicates whether the regression model include an intercept changing across regimes. Default value is 1

Value

A list that contains following:

- ftest: SupF test of 0 vs m (1 to maximum) breaks statistics
- cv_supF: Critical values for Sup F test
- cv_Dmax: Critical values for Double Max test
- supF1: table summarizing the SupF test (for viewing purposes)
- UDMax: table summarizing the Double Max test (including UDMax statistics and CVs)

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estim *Structural change model estimation*

Description

`estim()` estimates the structural change model by OLS given specified vector of break dates It also computes and reports confidence intervals for the break dates based on asymptotic distributions of break date and corrected standard errors of coefficients estimates given the structure of covariance matrix for model errors by specifying error options `robust`, `hetomega`, `hetq`, `hetdat` and `hetvar`

Usage

```
estim(m, q, z, y, b, robust, prewhit, hetomega, hetq, x, p, hetdat, hetvar)
```

Arguments

`m`	number of breaks
`q`	number of z regressors z
`z`	matrix of regressors with coefficients are allowed to change across regimes
`y`	matrix of dependent variable
`b`	vector of break dates
`robust, hetomega, hetq, hetdat, hetvar`	options for assumptions on the error terms. For more details, please refer to `mdl()`.
`prewhit`	option to use prewhitening process based on AR(1) approximation
`x`	matrix of regressors with coefficients are constant across regimes
`p`	number of regressors x

Value

A list containing the following components:

- date List of estimated breaks
- CI List of Confidence Intervals for each corresponding break
- beta Estimated coefficients of the regression. The first (m+1)*q are coefficients of q variables z that change across regimes. The last p are coefficients of p variables x that are constant across regimes
- SE Corrected standard errors for the coefficients' estimates

`interval` *Estimatd break confidence interval*

Description

`interval()` computes confidence intervals for the break dates based on approximating the limiting distribution of the break date following the "shrinking shifts" asymptotic framework

Usage

```
interval(y, z, zbar, b, q, m, robust, prewhit, hetomega, hetq, x, p)
```

Arguments

`y`	matrix of dependent variable
`z`	matrix of independent variables with coefficients allowed to change across regimes
`zbar`	partitioned matrix of independent variables with coefficients allowed to change across regimes according to break date vector `b`
`b`	vector of break breaks
`q`	number of `z` regressors
`m`	maximum number of breaks
`robust`	set to `1` to allow for heterogeneity and autocorrelation in the residuals, `0` otherwise. The method used is Andrews(1991) automatic bandwidth with AR(1) approximation with quadratic kernel. Note: Do not set to `1` if lagged dependent variables are included as regressors.
`prewhit`	Option of using prewhitening process. If `1`, an AR(1) process will be used to filter. If `0`, skipped the filtering process
`hetomega, hetq`	options for assumptions of error terms structure. For more details, refers to `mdl()`
`x`	matrix of independent variables with coefficients constant across regimes
`p`	number of `x` regressors

Value

bound Confidence intervals of break date in `90%` and `95%` significant level

mdl *Comprehensive structural change estimation and testing*

Description

`mdl()` calls main functions of the `mbreaks` package to execute the following estimation procedures:

- `dotest()` conducts Sup F tests of `0` versus `m` breaks and Double Max tests
- `doseqtests()` conducts the sequential Sup F tests of l versus l+1 breaks
- `doorder()` conducts the number of breaks selection from `1` to `m` breaks using information critera: `{'KT','BIC','LWZ'}`
- `dosequa()` conducts the number of breaks selection by sequential tests from `1` to `m` breaks using sequential Sup F tests
- `dofix()` conducts structural break model estimation with `fixn` breaks

All the procedures automatically identify if the `model` is either i) pure structural breaks model or ii) partial structural breaks model

Usage

```
mdl(
  y_name,
  z_name = NULL,
  x_name = NULL,
  data,
  eps1 = 0.15,
  m = 5,
  prewhit = 1,
  robust = 1,
  hetdat = 1,
  hetvar = 1,
  hetomega = 1,
  hetq = 1,
  maxi = 10,
  eps = 1e-05,
  fixn = -1,
  fixb = 0,
  betaini = 0,
  printd = 0,
  const = 1,
  signif = 2,
  h = NULL
)
```

Arguments

y_name	name of dependent variable in the data set
z_name	name of independent variables in the data set which coefficients are allowed to change across regimes. default is vector of 1 (Mean-shift model)
x_name	name of independent variables in the data set which coefficients are constant across regimes. default is NULL
data	the data set for estimation
eps1	value of trimming (in percentage) for the construction and critical values. Minimal segment length h will be set at default = int(eps1*T) (T is total sample size). • eps1=0.05 Maximal value of m = 10 • eps1=0.10 Maximal value of m = 8 • eps1=.15 Maximal value of m = 5 • eps1=.20 Maximal value of m = 3 • eps1=.25 Maximal value of m = 2 • eps1=0 This option allows users to explicitly specify minimum segment length h parameters. However, this option will not be allowed for testing and testing related functions The default value is set at 0.15
m	Maximum number of structural changes allowed. If not specify, m will be set to default value matching eps1 input
prewhit	set to 1 to apply AR(1) prewhitening prior to estimating the long run covariance matrix.
robust	set to 1 to allow for heterogeneity and autocorrelation in the residuals, 0 otherwise. The method used is Andrews(1991) automatic bandwidth with AR(1) approximation with quadratic kernel. Note: Do not set to 1 if lagged dependent variables are included as regressors.
hetdat	option for the construction of the F tests. Set to 1 if want to allow different moment matrices of the regressors across segments. If hetdat = 0, the same moment matrices are assumed for each segment and estimated from the ful sample. It is recommended to set hetdat=1 if number of regressors x > 0.
hetvar	option for the construction of the F tests.Set to 1 if users want to allow for the variance of the residuals to be different across segments. If hetvar=0, the variance of the residuals is assumed constant across segments and constructed from the full sample. hetvar=1 when robust =1)
hetomega	used in the construction of the confidence intervals for the break dates. If hetomega=0, the long run covariance matrix of zu is assumed identical across segments (the variance of the errors u if robust=0)
hetq	used in the construction of the confidence intervals for the break dates. If hetq=0, the moment matrix of the data is assumed identical across segments
maxi	number of maximum iterations for recursive calculations of finding global minimizers.default = 10 (For partial change model ONLY)
eps	convergence criterion for recursive calculations (For partial change model ONLY)

`fixn`	number of pre-specified breaks. `default` = -1. It will be replaced automatically to 2 if no specification is given (For partial change model ONLY)
`fixb`	option to use fixed initial input β. If `1`, the model will use values given in `betaini`. If `0`, betaini is skipped
`betaini`	Initial $beta_0$ to use in estimation (Must be a `p x 1` matrix, where p is number of x variables)
`printd`	Print option for model estimation. `default` = 0, to suppress intermediate outputs printing to console
`const`	indicates whether the regression model include an intercept changing across regimes. Default value is 1
`signif`	significance level used to sequential test to select number of breaks. • 4: 1% level • 3: 2.5% level • 2: 5% level • 1: 10% level
`h`	Minimum segment length of regime considered in estimation. If users want to specify a particular value, please set `eps1=0`

Value

A list that contains the following:

- sbtests: class `sbtests` of Sup F tests of 0 versus m breaks and Double Max tests
- seqtests: class `seqtests` of sequential Sup F test of l versus l+1 breaks
- BIC: class `model` of structural break model with estimated number of breaks by BIC criterion
- LWZ: class `model` of structural break model with estimated number of breaks by LWZ criterion
- KT: class `model` of structural break model with estimated number of breaks by KT criterion
- sequa: class `model` of structural break model with estimated number of breaks by sequential tests
- fix: class `model` of structural break model with pre-specified `fixn` number of breaks

Note: All `default` values of error assumptions (`robust`, `hetdat`, `hetvar`, `hetq`) are set to 1. The implications on the structure of model's errors related to individual settings are explained within the arguments section for each option.

See Also

`dotest()`, `doseqtests()`, `doorder()`, `dosequa()`, and `dofix()` which are functions called by `mdl()`.

Examples

```
US_rate = mdl('rate',data=real)
nkpc_lbs = mdl('inf',c('inflag','lbs','inffut'),data=nkpc,prewhit = 0)
```

nkpc *New Keynesian Phillips curve data*

Description

Data set from inflation and other macroeconomic variables

Usage

```
nkpc
```

Format

nkpc**:**

A data frame with 151 rows and 12 columns:

year Current period year

quarter Quarter in current period year

inf Inflation rate

inflag Inflation rate in previous period

inffut Expected inflation rate, taken as value of inflation rate of next period

ygap Productivity output gap

lbs

lbslag

spreadlag

dwlag

dcplag

Source

Perron, P. and Yamamoto, Y., 2015. "Using ols to estimate and test for structural changes in models with endogenous regressors." Journal of Applied Econometrics 30, 119–144.

nldat *Computation of global minimizer for partial structural change model*

Description

`nldat()` computes the break dates of a partial structural change model for a pre-specified number of breaks `m`. The procedure iterates between estimating the invariant and changing coefficients of `x` and `z` regressors until convergence, by noting that the residuals from linear regression model between `y` and `x` regressors is a pure structural change model, while the residuals from pure structural change model between `y` and `z` regressors is a linear regression

Usage

```
nldat(y, z, x, h, m, p, q, bigT, fixb, eps, maxi, betaini, printd)
```

Arguments

y	dependent variable in matrix form
z	matrix of regressors which coefficients are allowed to change across regimes
x	matrix of regressors which coefficients are constant across regime
h	minimum segment length
m	number of breaks
p	number of z regressors
q	number of x regressors
bigT	the sample size T
fixb	option to use initial β If 1, procedure requires betaini. If 0, procedure will not use initial beta values
eps	Convergence criterion (For partial change model ONLY)
maxi	Maximum number of iterations (For partial change model ONLY)
betaini	initial beta values. Required when use with option fixb
printd	option to print output from iterated estimations. If 1, the results for each iteration will be printed in console log. If 0, no output will be printed

Value

A list containing the following components:

glb	minimum global SSR
datevec	Vector of dates (optimal minimizers)
bigvec	Associated SSRs

References

Bai J, Perron P (1998). *"Estimating and Testing Linear Models with Multiple Structural Changes"* Econometrica, 66, 47-78. Bai J, Perron P (2003). *"Computation and Analysis of Multiple Structural Change Models"* Journal of Applied Econometrics 18, 1-22

pftest *SupF test for 0 vs i breaks*

Description

Function compute the supF test statistics of testing procedure with null hypothesis: no break versus alternative hypothesis: `i` breaks.

Function compute the supF test statistics of testing procedure with null hypothesis: no break versus alternative hypothesis: `i` breaks.

Usage

```
pftest(y, z, i, q, bigT, datevec, prewhit, robust, x, p, hetdat, hetvar)

pftest(y, z, i, q, bigT, datevec, prewhit, robust, x, p, hetdat, hetvar)
```

Arguments

`y`	dependent variables
`z`	independent variables with coefficients are allowed to change across regimes
`i`	number of breaks in the model
`q`	number of `z` regressors
`bigT`	sample period T
`datevec`	`i` estimated dates from the model
`prewhit`	Options for prewhitening process
`robust, hetdat, hetvar`	options for assumptions on error terms
`x`	independent variables with constant coefficients across regimes
`p`	number of `x` regressors

Value

ftest SupF test results

ftest SupF test results

plambda *Construct diagonal matrix according to break date*

Description

Function constructs a diagonal matrix of dimension (m+1) by (m+1) matrix with i-th entry $\frac{T_i - T_{i-1}}{T}$

Usage

```
plambda(b, m, bigT)
```

Arguments

b	Estimated date of changes
m	Number of breaks
bigT	The sample size T

Value

lambda (m+1) by (m+1) diagonal matrix with i-th entry $\frac{T_i - T_{i-1}}{T}$

plot_model *Plot structural change model*

Description

`plot_model()` visualizes any object of class `model` with comparison between real, fitted values between model of `m` breaks and null model of `0` breaks with options for confidence interval of break date.

Usage

```
plot_model(model, CI = 0.95, title = NULL)
```

Arguments

model	object of class `model` in `mbreaks` package
CI	confidence intervals for break date and coefficient estimates visualize in terms of fitted values
title	title of the graph

Value

No return value, called for plotting class `model` object. For more details on `model` class, see compile_model

Examples

```
rate = dofix('rate',data=real,fixn=2)
plot_model(rate,title='Ex-post US exchange rate')
```

---

print.mdl *Print information of* mbreaks *comprehensive procedure*

Description

print prints the class mdl object with default showing only certain procedures called by mdl() function including: seqtests class object, sbtests class object, and model class object using KT information criterion

Usage

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

Arguments

x	class mdl object
...	further arguments passed to or from other methods

Value

No return value, only for printing model, sbtests and seqtests class objects invoked during mdl().

Examples

```
rate = mdl('rate',data=real)
print(rate)
```

---

print.model *Summary output of a structural breaks* model

Description

print the output of the S3 class model with all relevant information:

- name of procedure used to obtain number of breaks in the model
- print a table summarizing the break date estimation (including confidence interval for the estimated date)
- print a table summarizing the estimated coefficients for z regressors
- print a table summarizing the estimated coefficients for x regressors (if any)

Usage

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

Arguments

x	object of S3 class model
...	further arguments passed to or from other methods.

Value

No return value, called for printing to console the following information in x:

- Basic details of the model: name of prodecures invoked, number of estimated breaks, pure/partial structural change model,global min SSR
- date_tab summarizes estimated break dates, see compile_model
- RS_tab summarizes estimated coefficients allowed to change across regimes, see compile_model
- FS_tab summarizes estimated coefficients constant across regimes, see compile_model

---

print.sbtests *Print Sup F and UDMax tests*

Description

print prints the following information from a sbtests class object:

- table supF1 reporting sup F tests of 0 versus 1 upto m breaks with critical values for {1%, 2.5%, 5%, 10%} significance levels
- table UDmax reporting Double Max tests with critical values for {1%, 2.5%, 5%, 10%} significance levels.

Usage

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

Arguments

x	class sbtests object
...	further arguments passed to or from other methods

Value

No return value, only for printing formatted sbtests class object to console

Examples

```
supF = dotest('inf','inflag',data=nkpc)
print(supF)
```

`print.seqtests` *Print sequential SupF tests*

Description

`print` prints the object of class `seqtests` with the following information

- Maximum number of breaks `m` in the tests
- `sfl` table with sequential sup F tests statistics of l versus l+1 breaks up to `m` breaks

Usage

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

Arguments

`x`	`seqtests` class object.
`...`	further arguments passed to or from other methods.

Value

No return value, only for printing formatted `seqtests` class object to console

Examples

```
seq_supF = doseqtests('inf','inflag',data=nkpc)
print(seq_supF)
```

`psigmq` *Construct diagonal matrix of estimated variance*

Description

Function computes a diagonal matrix of dimension m+1 by m+1 with i-th entry is the estimated variance of residuals of segment i

Usage

```
psigmq(res, b, q, m, nt)
```

Arguments

res	big residual vector of the model
b	Estimated date of changes
q	Number of z regressors
m	Number of breaks
nt	The size of z regressors

Value

sigmat (m+1)x(m+1) diagonal matrix with i-th entry equal to estimated variance of regime i

---

real *World Health Organization TB data*

Description

Data set from the Garcia and Perron study's of ex-post exchange rate.

Usage

```
real
```

Format

real**:**

A data frame with 103 rows and 1 column:

rate Real exchange rate

Source

Garcia, R. and Perron, P., 1996. "An analysis of the real interest rate under regime shifts." Review of Economics and Statistics 111–125.

spflp1 *SupF(l+1|l) test*

Description

Function computes the test statistics of supF(l+1|l) test with null hypothesis is l=nseg-1 and alternative hypothesis is l+1. The l breaks under the null hypothesis are taken from the global minimization.

spflp1 computes the test statistics of supF(l+1|l) test with null hypothesis is l=nseg-1 and alternative hypothesis is l+1. The l breaks under the null hypothesis are taken from the global minimization.

Usage

```
spflp1(bigvec, dt, nseg, y, z, h, q, prewhit, robust, x, p, hetdat, hetvar)

spflp1(bigvec, dt, nseg, y, z, h, q, prewhit, robust, x, p, hetdat, hetvar)
```

Arguments

bigvec	associated SSR of estimated break date under H0
dt	vector of estimated date under H0
nseg	number of segment under H1
y	matrix of dependent variable
z	matrix of variables with coefficients are allowed to change across regimes
h	minimum segment length
q	number of z regressors
prewhit, robust, hetdat, hetvar	options on residuals/errors. For more details, please refer to mdl()
x	matrix of variables with constant coefficients across regimes
p	number of x regressors

Value

A list that contains the following:

- maxfMaximum value of test
- newdAdditional date in alternative hypothesis

A list that contains the following:

- maxfMaximum value of test
- newdAdditional date in alternative hypothesis

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