# Package 'mosumvar'

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**Type** Package

**Title** Multiple Change Point Analysis for Vector Autoregressions via MOSUM Statistics

**Version** 0.1.0

**Date** 2021-03-23

**Description** A variety of methods for the analysis of multiple change points in time series data. All methods use Moving Sum (MOSUM) statistics for segmentation, and dependence properties are extracted with Vector Autoregression (VAR) models.

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**Imports** Rcpp (>= 1.0.4.6)

**LinkingTo** Rcpp, RcppArmadillo

**RoxygenNote** 7.1.0

**Depends** R (>= 2.10)

**NeedsCompilation** yes

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## R topics documented:

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`fit_out_model` *Fit piecewise VAR model to data*

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## Description

Fit piecewise VAR model to data

## Usage

```
fit_out_model(x, cps, p = NULL, pen = log(nrow(x))^1.01)
```

## Arguments

| | |
|---|---|
| `x` | data matrix |
| `cps` | change point vector |
| `p` | integer VAR model order (optional, uses AIC otherwise) |
| `pen` | penalty scalarl; defaults to sSIC with exponent 1.01 |

## Value

list of model list and cost

## Examples

```
data(voldata)
run_mosum <- mosumvar(voldata[,2:5], 1, 250)
fit_out_model(voldata[,2:5],run_mosum$cps, p=1)
```

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`MFA` *MOSUM procedure for multiple time series at multiple scales*

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## Description

MOSUM procedure for multiple time series at multiple scales

## Usage

```
MFA(
  x,
  p,
  Gset,
  method = c("Wald", "Score")[1],
  estim = c("DiagC", "DiagH")[1],
  alpha = 0.05
)
```

### Arguments

| | |
|---|---|
| x | data matrix |
| p | integer VAR model order |
| Gset | integer vector of MOSUM bandwidths |
| method | string indicating which of ‘Wald‘ or ‘Score‘ to use |
| estim | string estimation method |
| alpha | Numeric significance level |

### Value

list containing Boolean test outcome ‘Reject‘, Numeric rejection threshold ‘Threshold‘, Numeric vector of test statistic ‘mosum‘, Integer vector of estimated changepoints ‘cps‘, Plot ‘plot‘, String of input estimator ‘estim‘

### Examples

```
data(voldata)
MFA(voldata[1:3000,2:4], 1, c(100, 250, 400) )
```

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## MOSUMBS *MOSUM Binary Segmentation procedure for multiple time series*

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### Description

MOSUM Binary Segmentation procedure for multiple time series

### Usage

```
MOSUMBS(
  x,
  p,
  G,
  estim = c("DiagC", "DiagH")[1],
  varEstim = c("Local", "Global")[1],
  alpha = 0.05,
  criterion = c("eps", "eta")[1],
  nu = 0.25
)
```

### Arguments

| | |
|---|---|
| x | data matrix |
| p | integer VAR model order |
| G | integer MOSUM bandwidth |
| estim | string estimation method |

| | |
|---|---|
| varEstim | string variance estimation method |
| alpha | Numeric significance level |
| criterion | string location procedure |
| nu | Numeric location procedure hyperparameter |

## Value

list containing Boolean test outcome ‘Reject‘, Numeric rejection threshold ‘Threshold‘, Numeric vector of test statistic ‘mosum‘, Integer vector of estimated change points ‘cps‘, Plot ‘plot‘, String of input estimator ‘estim‘

## Examples

```
data(voldata)
mosum_sub(voldata[,2:5], 1, 250)
```

---

# mosumvar *MOSUM procedure for multiple time series*

---

## Description

MOSUM procedure for multiple time series

## Usage

```
mosumvar(
  x,
  p,
  G,
  method = c("Wald", "Score")[1],
  estim = c("DiagC", "DiagH")[1],
  varEstim = c("Local", "Global")[1],
  alpha = 0.05,
  criterion = c("eps", "eta")[1],
  nu = 0.25,
  do_bootstrap = c(F, "multiplier", "regression")[1],
  M = 1000
)
```

## Arguments

| | |
|---|---|
| x | data matrix |
| p | integer VAR model order |
| G | integer MOSUM bandwidth |
| method | string indicating which of ‘Wald‘ or ‘Score‘ to use |
| estim | string estimation method |

| | |
|---|---|
| varEstim | string variance estimation method |
| alpha | Numeric significance level |
| criterion | string location procedure |
| nu | Numeric location procedure hyperparameter |
| do_bootstrap | Bootstrap procedure to use (For Score procedure only) |
| M | Integer; number of bootstrap replicates |

## Value

list containing Boolean test outcome ‘Reject‘, Numeric rejection threshold ‘Threshold‘, Numeric vector of test statistic ‘mosum‘, Integer vector of estimated changepoints ‘cps‘, Plot ‘plot‘, String of input estimator ‘estim‘

## Examples

```
data(voldata)
mosumvar(voldata[,2:5], 1, 250)
```

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# mosum_lm *MOSUM procedure for multivariate regression*

---

## Description

MOSUM procedure for multivariate regression

## Usage

```
mosum_lm(
  X,
  G,
  method = c("Wald", "Score")[1],
  alpha = 0.05,
  criterion = c("eps", "eta")[1],
  nu = 0.25
)
```

## Arguments

| | |
|---|---|
| X | data matrix with response in column 1, and intercept in any other column |
| G | integer MOSUM bandwidth |
| method | string indicating which of ‘Wald‘ or ‘Score‘ to use |
| alpha | Numeric significance level |
| criterion | string location procedure |
| nu | Numeric location procedure hyperparameter |

## Value

list containing Boolean test outcome ‘Reject‘, Numeric rejection threshold ‘Threshold‘, Numeric vector of test statistic ‘mosum‘, Integer vector of estimated change points ‘cps‘, Plot ‘plot‘,

## Examples

```
data(X0df)
mosum_lm(X0df, 200)
data(X1df)
mosum_lm(X1df, 200)
```

---

`mosum_lm_bs` *MOSUM Binary Segmentation procedure for multivariate regression*

---

## Description

MOSUM Binary Segmentation procedure for multivariate regression

## Usage

```
mosum_lm_bs(X, G, alpha = 0.05, max_iter = 10)
```

## Arguments

| | |
|---|---|
| `X` | data matrix with response in column 1, and intercept in any other column |
| `G` | integer MOSUM bandwidth |
| `alpha` | Numeric significance level |
| `max_iter` | Integer maximum number of Binary Segmentation recursions to allow |

## Value

list containing Boolean test outcome ‘Reject‘, Numeric rejection threshold ‘Threshold‘, Numeric vector of test statistic ‘mosum‘, Integer vector of estimated change points ‘cps‘, Plot ‘plot‘,

## Examples

```
data(X1df)
mosum_lm_bs(X1df, 200)
```

mosum_lm_sub *MOSUM subsampling procedure for multivariate regression*

## Description

MOSUM subsampling procedure for multivariate regression

## Usage

```
mosum_lm_sub(
  X,
  G,
  method = c("Wald", "Score")[1],
  kap = 0.1,
  alpha = 0.05,
  criterion = c("eps", "eta")[1],
  nu = 0.25
)
```

## Arguments

| | |
|---|---|
| X | data matrix with response in column 1, and intercept in any other column |
| G | integer MOSUM bandwidth |
| method | string indicating which of 'Wald' or 'Score' to use |
| kap | Numeric sampling resolution constant |
| alpha | Numeric significance level |
| criterion | string location procedure |
| nu | Numeric location procedure hyperparameter |

## Value

list containing Boolean test outcome 'Reject', Numeric rejection threshold 'Threshold', Numeric vector of test statistic 'mosum', Integer vector of estimated change points 'cps', Plot 'plot',

## Examples

```
data(X0df)
mosum_lm_sub(X0df, 200, kap = 1)
data(X1df)
mosum_lm_sub(X1df, 200, kap = 1)
```

mosum_sub *MOSUM subsampling procedure for multiple time series*

## Description

MOSUM subsampling procedure for multiple time series

## Usage

```
mosum_sub(
  x,
  p,
  G,
  method = c("Wald", "Score")[1],
  estim = c("DiagC", "DiagH")[1],
  varEstim = c("Local", "Global")[1],
  kap = 1,
  alpha = 0.05,
  criterion = c("eps", "eta")[1],
  nu = 0.25
)
```

## Arguments

| | |
|---|---|
| x | data matrix |
| p | integer VAR model order |
| G | integer MOSUM bandwidth |
| method | string indicating which of 'Wald' or 'Score' to use |
| estim | string estimation method |
| varEstim | string variance estimation method |
| kap | Numeric subsampling resolution constant |
| alpha | Numeric significance level |
| criterion | string location procedure |
| nu | Numeric location procedure hyperparameter |

## Value

list containing Boolean test outcome 'Reject', Numeric rejection threshold 'Threshold', Numeric vector of test statistic 'mosum', Integer vector of estimated changepoints 'cps', Plot 'plot', String of input estimator 'estim'

## Examples

```
data(voldata)
mosum_sub(voldata[,2:5], 1, 250)
```

mosum_univ *MOSUM procedure using dimension reduction*

## Description

MOSUM procedure using dimension reduction

## Usage

```
mosum_univ(
  x,
  p,
  G,
  method = c("Wald", "Score")[1],
  estim = c("DiagC", "DiagH")[1],
  varEstim = c("Local", "Global")[1],
  alpha = 0.05,
  criterion = c("eps", "eta")[1],
  nu = 0.25,
  rm_cross_terms = F,
  do_bootstrap = c(F, "multiplier", "regression")[1],
  M = 1000,
  global_resids = F
)
```

## Arguments

| | |
|---|---|
| x | data matrix |
| p | integer VAR model order |
| G | integer MOSUM bandwidth |
| method | string indicating which of ‘Wald‘ or ‘Score‘ to use |
| estim | string estimation method |
| varEstim | string variance estimation method |
| alpha | Numeric significance level |
| criterion | string location procedure |
| nu | Numeric location procedure hyperparameter |
| rm_cross_terms | Boolean perform dimension reduction |
| do_bootstrap | string threshold bootstrap method, ‘multiplier‘ |
| M | integer number of simulations for ‘do_bootstrap‘ |
| global_resids | Boolean use |

## Value

list containing Boolean test outcome ‘Reject‘, Numeric rejection threshold ‘Threshold‘, Numeric vector of test statistic ‘mosum‘, Integer vector of estimated change points ‘cps‘, Plot ‘plot‘, String of input estimator ‘estim‘

## Examples

```
data(voldata)
mosum_univ(voldata[,2:5], 1, 250)
```

---

`VAR.sim` *Simulate multiple time series from a VAR model*

---

## Description

Simulate multiple time series from a VAR model

## Usage

```
VAR.sim(
  n,
  mu = NULL,
  Sigma = NULL,
  coeffs,
  error_dist = c("normal", "t", "garch")[1],
  P1 = NULL,
  Q1 = NULL,
  df = 1
)
```

## Arguments

| | |
|---|---|
| `n` | integer data length |
| `mu` | Numeric vector of means, defaults to zero |
| `Sigma` | error covariance matrix, defaults to identity |
| `coeffs` | list or matrix of VAR coefficients; dimension ‘d‘ and lag ‘p‘ are inferred from this |
| `error_dist` | string of error distribution |
| `P1` | Matrix for BEKK |
| `Q1` | Matrix for BEKK |
| `df` | Integer t-distribution degrees of freedom |

## Value

data frame of time series

## Examples

```
A <- diag(0.7,4)
data <- VAR.sim(100, coeffs=A)
plot.ts(data)
```

---

`voldata` *Volatility data of five technology assets (IBM, AAPL, INTC, MSFT, ORCL), the S&P technology sector (XLK), and the S&P index (SP)*

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## Description

Volatility data of five technology assets (IBM, AAPL, INTC, MSFT, ORCL), the S&P technology sector (XLK), and the S&P index (SP)

## Usage

```
data(voldata)
```

---

`X0df` *Simulated data from a regression model without change points*

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## Description

Simulated data from a regression model without change points

## Usage

```
data(X0df)
```

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`X1df` *Simulated data from a regression model with change points at 400, 1000, and 1600*

---

## Description

Simulated data from a regression model with change points at 400, 1000, and 1600

## Usage

```
data(X1df)
```

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