Package 'BayesSplineUR'

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Type Package

Title Bayesian Unit Root Test for AR(1) Model with Trend Approximated by Linear Spline Function

Version 0.1.0

Description Performs Bayesian unit root testing for autoregressive time series models with nonlinear trend components approximated by linear spline functions, as proposed by Kumar et al. (2020) <doi:10.19139/soic-2310-5070-786>. The package 'BayesSplineUR' computes posterior odds ratios, Bayes factors, and posterior probabilities for the unit root hypothesis against trend-stationary alternatives in models with linear spline trends or maintained polynomial trends as developed by Chaturvedi and Kumar (2005) <doi:10.1016/j.spl.2005.04.044>. Includes automatic knot selection using information criteria (AIC/BIC) and theoretical foundations for Bayesian unit root testing under structural breaks and maintained trends drawing from Schotman and van Dijk (1991) <doi:10.1016/0304-4076(91)90038-F>, Phillips and Perron (1988) <doi:10.1093/biomet/75.2.335>, Ouliaris et al. (1988) <doi:10.1007/978-94-009-2953-1_10>, and Perron (1989) <doi:10.2307/1913683>.

License GPL (>= 3)

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Depends R (>= 3.5.0)

Imports stats, graphics

Suggests knitr, rmarkdown, testthat (>= 3.0.0)

VignetteBuilder knitr

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Contents

`arf_imports` *Monthly Import Series of ASEAN Regional Forum (ARF) Countries*

Description

Monthly import data (in Billion US Dollars) for 14 selected ASEAN Regional Forum (ARF) countries covering the period April 2012 to August 2018 (77 monthly observations). Analyzed in Section 5 of Kumar et al. (2020) for empirical illustration of the Bayesian unit root test with linear spline trend.

Usage

```
arf_imports
```

Format

A data frame with 77 rows and 15 variables:

Date Date of observation (monthly, April 2012 to August 2018).

Australia Monthly imports for Australia (Billion USD).

Hong_Kong Monthly imports for Hong Kong (Billion USD).

Japan Monthly imports for Japan (Billion USD).

South_Korea Monthly imports for South Korea (Billion USD).

New_Zealand Monthly imports for New Zealand (Billion USD).

Taiwan Monthly imports for Taiwan (Billion USD).

China Monthly imports for China (Billion USD).

India Monthly imports for India (Billion USD).

Indonesia Monthly imports for Indonesia (Billion USD).

Malaysia Monthly imports for Malaysia (Billion USD).

Philippines Monthly imports for Philippines (Billion USD).

Singapore Monthly imports for Singapore (Billion USD).

Thailand Monthly imports for Thailand (Billion USD).

Viet_Nam Monthly imports for Viet Nam (Billion USD).

Source

International Monetary Fund (IMF) and International Financial Statistics (IFS) data portal.

References

Kumar, J., Agiwal, V., Kumar, D., & Chaturvedi, A. (2020). Bayesian unit root test for AR(1) model with trend approximated by linear spline function. *Statistics, Optimization & Information Computing*, 8(2), 425–461. doi:10.19139/soic23105070786

Examples

```
data(arf_imports)
india_imports <- arf_imports$India
res <- bayes_ur_spline_test(india_imports, knots = c(14, 32, 52))
print(res)
```

`bayes_ur_spline_test` *Bayesian Unit Root Test for AR(1) Model with Linear Spline Trend*

Description

Computes the posterior odds ratio, Bayes factor, and posterior probability for testing the unit root hypothesis (H0: rho = 1) against the trend-stationary alternative (H1: rho in (a, 1)) in an autoregressive AR(1) model where the non-linear time trend is approximated by a linear spline function, as derived by Kumar et al. (2020).

Usage

```
bayes_ur_spline_test(
  y,
  knots = NULL,
  r = 1,
  a = 0,
  p0 = 0.5,
  vartheta = 1,
  Omega = NULL,
  psi0 = NULL,
  y0 = NULL,
  n_grid = 500
)

kumar_spline_test(
  y,
  knots = NULL,
  r = 1,
  a = 0,
  p0 = 0.5,
```

```
  vartheta = 1,
  Omega = NULL,
  psi0 = NULL,
  y0 = NULL,
  n_grid = 500
)
```

Arguments

y	A numeric vector or univariate time series.
knots	Optional numeric vector of knot locations (indices 1 < t1 < ... < tr < T). If NULL, knot locations are automatically selected using select_knots.
r	Positive integer specifying the number of spline knots if knots = NULL (default is 1).
a	Lower bound of the prior interval (a, 1) for autoregressive parameter rho under H1 (default is 0). Must satisfy -1 < a < 1.
p0	Prior probability of the unit root hypothesis H0 (default is 0.5). Must satisfy 0 < p0 < 1.
vartheta	Prior hyperparameter scaling parameter for trend precision (default is 1.0). Must be positive.
Omega	Optional prior precision matrix (r x r) for spline coefficients (default is identity matrix I_r).
psi0	Optional prior mean vector (r x 1) for spline coefficients (default is column means of spline design matrix).
y0	Optional initial observation value y_0 (default is y[1]).
n_grid	Integer specifying the number of evaluation grid points for rho (default is 500).

Value

An object of class "bayes_ur_test" and "htest" containing:

statistic	The posterior odds ratio (B01) in favor of the unit root hypothesis H0.
p.value	The posterior probability P(H0|y) of the unit root hypothesis.
bayes_factor	The Bayes factor (BF01) in favor of H0 relative to H1.
posterior_h0	Posterior probability of the unit root hypothesis H0.
posterior_h1	Posterior probability of the stationary alternative hypothesis H1.
rho_summary	Vector of summary statistics for rho under H1 (mean, sd, median, 2.5%, 97.5% quantiles).
rho_grid	Vector of evaluation grid points for rho in (a, 1).
rho_density	Vector of normalized posterior density values for rho under H1.
parameter	Named vector of test settings (r, knots, a, p0).
method	Character string describing the test method.
data.name	Character string providing the data name.
estimates	Named vector of estimated parameter values.

References

Kumar, J., Agiwal, V., Kumar, D., & Chaturvedi, A. (2020). Bayesian unit root test for AR(1) model with trend approximated by linear spline function. *Statistics, Optimization & Information Computing*, 8(2), 425–461. doi:10.19139/soic23105070786

Schotman, P., & van Dijk, H. K. (1991). A Bayesian analysis of the unit root in real exchange rates. *Journal of Econometrics*, 49(1-2), 195–238. doi:10.1016/03044076(91)90038F

Phillips, P. C. B., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, 75(2), 335–346. doi:10.1093/biomet/75.2.335

Examples

```
set.seed(123)
# Simulated AR(1) time series with linear spline trend
t_vec <- 1:60
y_sim <- 5 + 0.1 * t_vec + pmax(0, t_vec - 30) * 0.4 + rnorm(60)
res <- bayes_ur_spline_test(y_sim, knots = c(30))
print(res)
summary(res)
```

`bayes_ur_test` *Master Function for Bayesian Unit Root Test*

Description

Computes the posterior odds ratio, Bayes factor, and posterior probabilities for testing the unit root hypothesis (H0: rho = 1) in autoregressive time series models with non-linear linear spline trends (Kumar et al., 2020) or maintained polynomial trends (Chaturvedi & Kumar, 2005).

Usage

```
bayes_ur_test(
  y,
  trend_type = c("spline", "polynomial"),
  knots = NULL,
  r = 1,
  p = 1,
  k = 1,
  a = 0,
  p0 = 0.5,
  vartheta = 1,
  V = NULL,
  n_grid = 500,
  ...
)

chaturvedi_test(y, p = 1, k = 1, a = 0, p0 = 0.5, V = NULL, n_grid = 500)
```

Arguments

y	A numeric vector or univariate time series.
trend_type	Character string specifying the trend model: "spline" (default, Kumar et al., 2020) or "polynomial" (Chaturvedi & Kumar, 2005).
knots	Optional numeric vector of knot locations for linear spline trend. If NULL and trend_type = "spline", knots are selected automatically.
r	Positive integer specifying the number of spline knots when knots = NULL (default is 1).
p	Degree of polynomial trend when trend_type = "polynomial" (default is 1).
k	Lag augmentation order when trend_type = "polynomial" (default is 1).
a	Lower bound of prior interval (a, 1) for rho under H1 (default is 0). Must satisfy -1 < a < 1.
p0	Prior probability of unit root hypothesis H0 (default is 0.5). Must satisfy 0 < p0 < 1.
vartheta	Prior hyperparameter scaling parameter for trend precision (default is 1.0).
V	Optional prior precision matrix for polynomial trend coefficients or scaling factor.
n_grid	Number of evaluation grid points for rho (default is 500).
...	Additional arguments passed to bayes_ur_spline_test.

Value

An object of class "bayes_ur_test" and "htest".

References

Kumar, J., Agiwal, V., Kumar, D., & Chaturvedi, A. (2020). Bayesian unit root test for AR(1) model with trend approximated by linear spline function. *Statistics, Optimization & Information Computing*, 8(2), 425–461. doi:10.19139/soic23105070786

Chaturvedi, A., & Kumar, J. (2005). Bayesian unit root test for model with maintained trend. *Statistics & Probability Letters*, 74(1), 109–115. doi:10.1016/j.spl.2005.04.044

Examples

```
set.seed(123)
y_sim <- cumsum(rnorm(50))
# Spline trend unit root test (Kumar et al., 2020)
res_spline <- bayes_ur_test(y_sim, trend_type = "spline", r = 1)
print(res_spline)

# Polynomial trend unit root test (Chaturvedi & Kumar, 2005)
res_poly <- bayes_ur_test(y_sim, trend_type = "polynomial", p = 1, k = 1)
print(res_poly)
```

macro_data *Simulated Macroeconomic Time Series Data*

Description

A simulated univariate time series vector containing 100 observations exhibiting a random walk with drift, suitable for demonstrating unit root testing.

Usage

```
macro_data
```

Format

A numeric vector of length 100.

Source

Simulated dataset generated for package documentation and examples.

Examples

```
data(macro_data)
res <- bayes_ur_test(macro_data, trend_type = "spline", r = 1)
print(res)
```

plot.bayes_ur_test *Plot Method for Bayesian Unit Root Test*

Description

Plots the posterior density of the autoregressive parameter rho under H1 along with prior density and unit root probability point mass.

Usage

```
## S3 method for class 'bayes_ur_test'
plot(x, ...)
```

Arguments

x	An object of class "bayes_ur_test".
...	Further graphical arguments.

Value

No return value, called for side effects (plotting).

print.bayes_ur_test *Print Method for Bayesian Unit Root Test*

Description

Prints a concise summary of the Bayesian unit root test results.

Usage

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

Arguments

x	An object of class "bayes_ur_test".
...	Further arguments passed to or from other methods.

Value

Invisibly returns the input object x.

select_knots *Knot Selection for Linear Spline Trend Model*

Description

Identifies the optimal number and locations of join points (knots) in a time series with a linear spline trend based on Akaike Information Criterion (AIC) or Bayesian Information Criterion (BIC), as described in Section 5 of Kumar et al. (2020).

Usage

```
select_knots(y, max_r = 3, criterion = c("AIC", "BIC"), min_gap = 5)
```

Arguments

y	A numeric vector or univariate time series.
max_r	Positive integer specifying the maximum number of knots to evaluate (default is 3).
criterion	Character string specifying the selection criterion: "AIC" (default) or "BIC".
min_gap	Positive integer specifying minimum observations between consecutive knots (default is 5).

Value

A list containing:

`r`	Selected optimal number of knots.
`knots`	Vector of selected optimal knot locations (indices).
`aic`	Minimum AIC value achieved.
`bic`	Minimum BIC value achieved.
`model_summary`	Data frame summarizing evaluated models across different knot configurations.

References

Kumar, J., Agiwal, V., Kumar, D., & Chaturvedi, A. (2020). Bayesian unit root test for AR(1) model with trend approximated by linear spline function. *Statistics, Optimization & Information Computing*, 8(2), 425–461. doi:10.19139/soic23105070786

Examples

```
set.seed(123)
t_vec <- 1:60
y_sim <- 10 + 0.2 * t_vec + pmax(0, t_vec - 25) * 0.5 + rnorm(60)
res_knots <- select_knots(y_sim, max_r = 2, criterion = "AIC")
print(res_knots$knots)
```

`summary.bayes_ur_test` *Summary Method for Bayesian Unit Root Test*

Description

Provides detailed summary output for a Bayesian unit root test object.

Usage

```
## S3 method for class 'bayes_ur_test'
summary(object, ...)
```

Arguments

`object`	An object of class `"bayes_ur_test"`.
`...`	Further arguments passed to or from other methods.

Value

Invisibly returns the input object `object`.

Index