Package 'BAYSTAR'

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Title On Bayesian Analysis of Threshold Autoregressive Models

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Description
Fit two-regime threshold autoregressive (TAR) models by Markov chain Monte Carlo methods.

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R topics documented:

| BAYSTAR | *Threshold Autoregressive model: Bayesian approach* |

Description

Bayesian estimation and one-step-ahead forecasting for two-regime TAR model, as well as monitoring MCMC convergence. One may want to allow for higher-order AR models in the different regimes. Parsimonious subset AR could be assigned in each regime in the BAYSTAR function rather than a full AR model (i.e. the autoregressive orders could be not a continuous series).

Usage

```
BAYSTAR(x, lagp1, lagp2, Iteration, Burnin, constant, d0,
        step.thv, thresVar, mu01, v01, mu02, v02, v0, lambda0, refresh,tplot)
```

Arguments

x	A vector of time series.
lagp1	A vector of non-zero autoregressive lags for the lower regime (regime one). For example, an AR model with p1=3 in lags 1,3, and 5 would be set as lagp1<-c(1,3,5).
lagp2	A vector of non-zero autoregressive lags for the upper regime (regime two).
Iteration	The number of MCMC iterations.
Burnin	The number of burn-in iterations for the sampler.
constant	The intercepts include in the model for each regime, if constant=1. Otherwise, if constant=0. (Default: constant=1)
d0	The maximum delay lag considered. (Default: d0 = 3)
step.thv	Step size of tuning parameter for the Metropolis-Hasting algorithm.
thresVar	A vector of time series for the threshold variable. (if missing, the series x is used.)
mu01	The prior mean of ϕ in regime one. This setting can be a scalar or a column vector with dimension equal to the number of ϕ. If this sets a scalar value, then the prior mean for all of ϕ are this value. (Default: a vector of zeros)
v01	The prior covariance matrix of ϕ in regime one. This setting can either be a scalar or a square matrix with dimensions equal to the number of ϕ. If this sets a scalar value, then prior covariance matrix of ϕ is that value times an identity matrix. (Default: a diagonal matrix are set to 0.1)
mu02	The prior mean of ϕ in regime two. This setting can be a scalar or a column vector with dimension equal to the number of ϕ. If this sets a scalar value, then the prior mean for all of ϕ are this value. (Default: a vector of zeros)

v02	The prior covariance matrix of ϕ in regime two. This setting can either be a scalar or a square matrix with dimensions equal to the number of ϕ. If this sets a scalar value, then prior covariance matrix of ϕ is that value times an identity matrix. (Default: a diagonal matrix are set to 0.1)
v0	v0/2 is the shape parameter for Inverse-Gamma prior of σ^2. (Default: v0 = 3)
lambda0	lambda0*v0/2 is the scale parameter for Inverse-Gamma prior of σ^2. (Default: lambda0 = the residual mean squared error of fitting an AR(p1) model to the data.)
refresh	Each refresh iteration for monitoring MCMC output. (Default: refresh=Iteration/2)
tplot	Trace plots and ACF plots for all parameter estimates. (Default: tplot=FALSE)

Details

Given the maximum AR orders p1 and p2, the two-regime SETAR(2:p1;p2) model is specified as:

$$x_t = (\phi_0^{(1)} + \phi_1^{(1)} x_{t-1} + \ldots + \phi_{p1}^{(1)} x_{t-p1} + a_t^{(1)}) I(z_{t-d} <= th) + (\phi_0^{(2)} + \phi_1^{(2)} x_{t-1} + \ldots + \phi_{p2}^{(2)} x_{t-p2} + a_t^{(2)} I(z_{t-d} > th)$$

where th is the threshold value for regime switching; z_t is the threshold variable; d is the delay lag of threshold variable; and the error term $a_t^{(j)}$, $j, (j = 1, 2)$, for each regime is assumed to be an i.i.d. Gaussian white noise process with mean zero and variance $sigma_j^2, j = 1, 2$. I(A) is an indicator function. Event A will occur if I(A)=1 and otherwise if I(A)=0. One may want to allow parsimonious subset AR model in each regime rather than a full AR model.

Value

A list of output with containing the following components:

mcmc	All MCMC iterations.
posterior	The initial Burnin iterations are discarded as a burn-in sample, the final sample of (Iteration-Burnin) iterates is used for posterior inference.
coef	Summary Statistics of parameter estimation based on the final sample of (Iteration-Burnin) iterates.
residual	Residuals from the estimated model.
lagd	The mode of time delay lag of the threshold variable.
DIC	The deviance information criterion (DIC); a Bayesian method for model comparison (Spiegelhalter et al, 2002)

Author(s)

Cathy W. S. Chen, Edward M.H. Lin, F.C. Liu, and Richard Gerlach

Examples

```
set.seed(989981)
## Set the true values of all parameters
nob<- 200              ## No. of observations
lagd<- 1                ## delay lag of threshold variable
r<- 0.4                 ## r is the threshold value
sig.1<- 0.8; sig.2<- 0.5  ## variances of error distributions for two regimes
p1<- 2; p2<- 1          ## No. of covariate in two regimes
ph.1<- c(0.1,-0.4,0.3)    ## mean coefficients for regime 1
ph.2<- c(0.2,0.6)    ## mean coefficients for regime 2
lagp1<-1:2
lagp2<-1:1

yt<- TAR.simu(nob,p1,p2,ph.1,ph.2,sig.1,sig.2,lagd,r,lagp1,lagp2)


## Total MCMC iterations and burn-in iterations
Iteration <- 500
Burnin    <- 200


## A RW (random walk) MH algorithm is used in simulating the threshold value
## Step size for the RW MH
step.thv<- 0.08

out <- BAYSTAR(yt,lagp1,lagp2,Iteration,Burnin,constant=1,step.thv=step.thv,tplot=TRUE)
```

TAR.coeff   *Estimate AR coefficients*

Description

We assume a normal prior for the AR coefficients and draw AR coefficients from a multivariate normal posterior distribution. Parsimonious subset AR could be assigned in each regime in the BAYSTAR function rather than a full AR model.

Usage

```
TAR.coeff(reg, ay, p1, p2, sig, lagd,
          thres, mu0, v0, lagp1, lagp2, constant = 1, thresVar)
```

Arguments

	A list containing:
	The regime is assigned. (equal to one or two)
reg ay	The real data set. (input)
p1	Number of AR coefficients in regime one.

p2	Number of AR coefficients in regime two.
sig	The error terms of TAR model.
lagd	The delay lag parameter.
thres	The threshold parameter.
mu0	Mean vector of conditional prior distribution in mean equation.
v0	Covariance matrix of conditional prior distribution in mean equation.
lagp1	The vector of non-zero autoregressive lags for the lower regime. (regime one); e.g. An AR model with p1=3, it could be non-zero lags 1,3, and 5 would set lagp1<-c(1,3,5).
lagp2	The vector of non-zero autoregressive lags for the upper regime. (regime two)
constant	Use the CONSTANT option to fit a model with/without a constant term (1/0). By default CONSTANT=1.
thresVar	Exogenous threshold variable. (if missing, the self series are used)

Author(s)

Cathy W.S. Chen, F.C. Liu

TAR.lagd	*Identification of lag order of threshold variable*

Description

The delay d has a discrete uniform prior over the integers: 1,2,..., d0, where d0 is a set maximum delay. We draw the delay lag of threshold variable from a multinomial distribution.

Usage

```
TAR.lagd(ay, p1, p2, ph.1, ph.2, sig.1, sig.2,
        thres, lagp1, lagp2, constant = 1, d0, thresVar)
```

Arguments

	A list containing:
	The real data set. (input)
p1̶y̶	Number of AR coefficients in regime one.
p2	Number of AR coefficients in regime two.
ph.1	The vector of AR parameters in regime one.
ph.2	The vector of AR parameters in regime two.
sig.1	The error terms of AR model in the regime one.
sig.2	The error terms of AR model in the regime two.
thres	The threshold parameter.

lagp1	The vector of non-zero autoregressive lags for the lower regime. (regime one); e.g. An AR model with p1=3, it could be non-zero lags 1,3, and 5 would set lagp1<-c(1,3,5).
lagp2	The vector of non-zero autoregressive lags for the upper regime. (regime two)
constant	Use the CONSTANT option to fit a model with/without a constant term (1/0). By default CONSTANT=1.
d0	The maximum delay lag could be selected.
thresVar	Exogenous threshold variable. (if missing, the series x is used)

Author(s)

Cathy W.S. Chen, Edward Lin

TAR.lik   *Log-likelihood function*

Description

To calculate the model log-likelihood function.

Usage

```
TAR.lik(ay, p1, p2, ph.1, ph.2, sig.1, sig.2,
        lagd, thres, lagp1, lagp2, constant = 1, thresVar)
```

Arguments

	A list containing:
	The real data set. (input)
p1	Number of AR coefficients in regime one.
p2	Number of AR coefficients in regime two.
ph.1	The vector of AR parameters in regime one.
ph.2	The vector of AR parameters in regime two.
sig.1	The error terms of AR model in the regime one.
sig.2	The error terms of AR model in the regime two.
lagd	The delay lag parameter.
thres	The threshold parameter.
lagp1	The vector of non-zero autoregressive lags for the lower regime. (regime one); e.g. An AR model with p1=3, it could be non-zero lags 1,3, and 5 would set lagp1<-c(1,3,5).
lagp2	The vector of non-zero autoregressive lags for the upper regime. (regime two)
constant	Use the CONSTANT option to fit a model with/without a constant term (1/0). By default CONSTANT=1.
thresVar	Exogenous threshold variable. (if missing, the series x is used)

Author(s)

Cathy W.S. Chen, F.C. Liu

TAR.sigma   *To draw the variance of error distribution.*

Description

We employ a conjugate prior, Inverse-Gamma distribution, for sigma squared in regime j, j=1,2. To draw the variance of error distribution from an Inverse-Gamma posterior distribution.

Usage

```
TAR.sigma(reg, ay, thres, lagd, p1, p2, ph, v,
         lambda, lagp1, lagp2, constant = 1, thresVar)
```

Arguments

	A list containing:
	The regime is assigned. (equal to one or two)
reg thres	The threshold parameter.
lagd	The delay lag parameter.
p1	Number of AR coefficient in regime one.
p2	Number of AR coefficient in regime two.
ph	The vector of AR parameters in regime reg.
ay	The real data set. (input)
v, lambda	The hyper-parameter of Inverse Gamma distribution for priors of variance. (i.e. IG(v/2,lambda/2))
lagp1	The vector of non-zero autoregressive lags for the lower regime. (regime one); e.g. An AR model with p1=3, it could be non-zero lags 1,3, and 5 would set lagp1<-c(1,3,5).
lagp2	The vector of non-zero autoregressive lags for the upper regime. (regime two)
constant	Use the CONSTANT option to fit a model with/without a constant term (1/0). By default CONSTANT=1.
thresVar	Exogenous threshold variable. (if missing, the series x is used)

Author(s)

Cathy W.S. Chen, Edward Lin

TAR.simu   *Simulated data from TAR model*

Description

To generate the simulated data from TAR(2;p1,p2) model.

Usage

```
TAR.simu(nob, p1, p2, ph.1, ph.2, sig.1, sig.2, lagd, thres, lagp1, lagp2)
```

Arguments

nob	Number of observations that we want to simulate.
p1	Number of AR coefficient in regime one.
p2	Number of AR coefficient in regime two.
ph.1	The vector of AR parameters in regime one.
ph.2	The vector of AR parameters in regime two.
sig.1	The error terms in regime one.
sig.2	The error terms in regime two.
lagd	The delay lag parameter.
thres	The threshold parameter.
lagp1	The vector of non-zero autoregressive lags for the lower regime. (regime one); e.g. An AR model with p1=3, it could be non-zero lags 1,3, and 5 would set lagp1<-c(1,3,5).
lagp2	The vector of non-zero autoregressive lags for the upper regime. (regime two)

Author(s)

Cathy W.S. Chen, Edward Lin

Examples

```
## Set the true values of all parameters
nob<- 2000               ## No. of observations
lagd<- 1                 ## delay lag of threshold variable
r<- 0.4                  ## r is the threshold value
sig.1<- 0.8; sig.2<- 0.5 ## variances of error distributions for two regimes
p1<- 2; p2<- 2           ## No. of covariate in two regimes
ph.1<- c(0.1,-0.4,0.3)   ## mean coefficients for regime 1
ph.2<- c(0.2,0.3,0.3)    ## mean coefficients for regime 2
lagp1<-1:2
lagp2<-1:2


yt<- TAR.simu(nob,p1,p2,ph.1,ph.2,sig.1,sig.2,lagd,r,lagp1,lagp2)
```

`TAR.summary`   *Calculate summary statistics for all parameters*

Description

A summary of the MCMC output can be obtained via the function `TAR.summary`. `TAR.summary` returns the posterior mean, median, standard deviation and the lower and upper bound of the 95% Bayes posterior interval for all parameters, all botained from the sampling period only, after burn-in.

Usage

```
TAR.summary(x, lagp1, lagp2, constant = 1)
```

Arguments

	A list containing:
	A matrix of the MCMC output of estimater parameters.
`lagp1`	The vector of non-zero autoregressive lags for the lower regime. (regime one); e.g. An AR model with p1=3, it could be non-zero lags 1,3, and 5 would set lagp1<-c(1,3,5).
`lagp2`	The vector of non-zero autoregressive lags for the upper regime. (regime two)
`constant`	Use the CONSTANT option to fit a model with/without a constant term (1/0). By default CONSTANT=1.

Author(s)

Cathy W.S. Chen, F.C. Liu

`TAR.thres`   *To draw a threshold value.*

Description

The prior for the threshold parameter $thres$, follows a uniform prior on a range (l,u), where l and u can be set as relevant percentiles of the observed threshold variable. This prior could be considered to correspond to an empirical Bayes approach, rather than a fully Bayesian one. The posterior distribution of $thres$ is not of a standard distributional form, thus requiring us to use the Metropolis-Hastings (MH) method to achieve the desired sample for $thres$.

Usage

```
TAR.thres(ay, p1, p2, ph.1, ph.2, sig.1, sig.2, lagd, thres,
          step.r = 0.02, bound, lagp1, lagp2, constant = 1, thresVar)
```

Arguments

	A list containing:
	The real data set. (input)
p1	Number of AR coefficients in regime one.
p2	Number of AR coefficients in regime two.
ph.1	The vector of AR parameters in regime one.
ph.2	The vector of AR parameters in regime two.
sig.1	The error terms of AR model in the regime one.
sig.2	The error terms of AR model in the regime two.
lagd	The delay lag parameter.
thres	The threshold parameter.
step.r	Step size of threshold variable for the MH algorithm are controlled the proposal variance.
bound	The bound of threshold parameter.
lagp1	The vector of non-zero autoregressive lags for the lower regime. (regime one); e.g. An AR model with p1=3, it could be non-zero lags 1,3, and 5 would set lagp1<-c(1,3,5).
lagp2	The vector of non-zero autoregressive lags for the upper regime. (regime two)
constant	Use the CONSTANT option to fit a model with/without a constant term (1/0). By default CONSTANT=1.
thresVar	Exogenous threshold variable. (if missing, the series x is used)

Author(s)

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unemployrate	*U.S. monthly civilian unemployment rate*

Description

U.S. monthly civilian unemployment rate, seasonally adjusted and measured in percentage, from January 1948 to March 2004. The data set is available in Tsay (2005).

Usage

```
data(unemployrate)
```

Format

unemployrate is a data frame with 675 observations

Source

The data are obtained from the Bureau of Labor statistics, Department of Labor.

References

Tsay, R.S. (2005) Analysis of Financial Time Series. Second ed. Wiley, Hoboken.

Examples

```
data(unemployrate)
plot.ts(unemployrate)
```

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