Package ‘FAVAR’

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Title Bayesian Analysis of a FAVAR Model

Version 0.1.3

Description
Estimate a FAVAR model by a Bayesian method, based on Bernanke et al. (2005) <DOI:10.1162/0033553053327452>.

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LazyData true

RoxygenNote 7.1.2

Imports ggplot2, bvartools, foreach, magrittr, MCMCpack, coda, dplyr, doParallel, Matrix

Depends R (>= 3.5.0)

Suggests testthat, vars, patchwork

NeedsCompilation no

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Contents

`ar2ma` *ar2ma*

Description

Convert auto regression (AR) coefficients to moving average (MA) coefficients

Usage

```
ar2ma(ar, p, n = 11, CharValue = TRUE)
```

Arguments

`ar`	AR coefficients matrix which is k x kp dimension, k is numbers of variables, and no constant.
`p`	lags orders of AR.
`n`	lags orders of MA generated.
`CharValue`	logical value, whether compute character value.

Details

the formula is,

$$A_s = F_1 * A_{s-1} + F_2 * A_{s-2} + ... + F_p * A_{s-p}$$

where A is MA coefficients, F is AR coefficients.

Value

a matrix which is MA coefficients.

Examples

```
require(vars)
data(Canada)
ar <- Bcoef(VAR(Canada, p = 2, type = "none"))
ar
ar2ma(ar, p = 2)
```

BGM *Separate R From X*

Description

X may include some information related with R. The function extract factors from `X` which is not related with `R` by iteration based on Boivin et al. (2009).

Usage

```
BGM(X, R, K = 2, tolerance = 0.001, nmax = 100)
```

Arguments

`X`	a large matrix from which principle components are extracted.
`R`	a numeric vector which we are interesting in, for example interest rates.
`K`	the number of extracted principle components.
`tolerance`	the difference between factors when iterating.
`nmax`	the max iterations, see details.

Details

The algorithm is as follows:

1. Extract the first K principal components noted $F_t^{(0)}$ from `X`.
2. Regress `X` on $F_t^{(0)}$ and R_t, and get regression coefficients $\beta_R^{(0)}$ of R_t.
3. compute $X_0^{(0)} = X_t - R_t\beta_R$.
4. Extract the first K principal components noted $F_t^{(1)}$ from `X_t^{(0)}`.
5. repeat step 2 - step 4 until precision you want.

Value

the first K principle components, i.e. $F_t^{(n)}$, not containing the information `R`.

References

Boivin, J., M.P. Giannoni and I. Mihov, Sticky Prices and Monetary Policy: Evidence from Disaggregated US Data. American Economic Review, 2009. 99(1): p. 350-384.

Examples

```
data('regdata')
BGM(X = regdata[,1:115],R = regdata[,ncol(regdata)], K = 2)
```

BVAR *Bayesian Estimation of VAR*

Description

Estimate a VAR base on Bayesian method

Usage

```
BVAR(
  data,
  plag = 2,
  iter = 10000,
  burnin = 5000,
  prior = list(b0 = 0, vb0 = 0, nu0 = 0, s0 = 0, mn = list(kappa0 = NULL, kappa1 =
    NULL)),
  ncores = 1
)
```

Arguments

`data`	a `ts` object which include all endogenous variables in VAR
`plag`	a lag order in VAR
`iter`	iterations of the MCMC
`burnin`	the first random draws discarded in MCMC
`prior`	a list whose elements is named. `b0` is the prior of mean of β, and `vb0` is the prior of the variance of β. `nu0` is the degree of freedom of Wishart distribution for Σ^{-1}, i.e., a shape parameter, and `s0^{-1}` is scale parameters for the Wishart distribution. `mn` sets the Minnesota prior. If `prior$mn$kappa0` is not `NULL`, `b0,vb0` is neglected.
`ncores`	the number of CPU cores in parallel computations.

Value

a list:

- `A`, the samples drawn for the coefficients of VAR
- `sigma`, the samples drawn for the variance-covariance of the coefficients of VAR
- `sumrlt`, a list include `varcoef, varse, q25, q975` which are means, standard errors, 0.25 quantiles and 0.975 quantiles of `A`.

`coef.favar` *Extract Coefficients of a FAVAR Model*

Description

Extract Coefficients of a FAVAR Model

Usage

```
## S3 method for class 'favar'
coef(object, ...)
```

Arguments

`object`	a class 'favar'.
`...`	additional arguments affecting the coefficients produced.

Value

A list

fct_loading Factor loading matrix in a factor equation.

varcoef regression coefficients in VAR equations.

`FAVAR` *FAVAR*

Description

Estimate a FAVAR model by Bernanke et al. (2005).

Usage

```
FAVAR(
  Y,
  X,
  fctmethod = "BBE",
  slowcode,
  K = 2,
  plag = 2,
  factorprior = list(b0 = 0, vb0 = NULL, c0 = 0.01, d0 = 0.01),
 varprior = list(b0 = 0, vb0 = 0, nu0 = 0, s0 = 0, mn = list(kappa0 = NULL, kappa1 =
    NULL)),
  nburn = 5000,
  nrep = 15000,
  standardize = TRUE,
  ncores = 1
)
```

Arguments

- `Y` — a matrix. Observable economic variables assumed to drive the dynamics of the economy.
- `X` — a matrix. A large macro data set. The meanings of `X` and `Y` is same as ones of Bernanke et al. (2005).
- `fctmethod` — `'BBE'` or `'BGM'`. `'BBE'`(default) means the factors extracted method by Bernanke et al. (2005), and `'BGM'` means the factors extracted method by Boivin et al. (2009).
- `slowcode` — a logical vector that identifies which columns of X are slow moving. Only when `fctmethod` is set as `'BBE'`, `slowcode` is valid.
- `K` — the number of factors extracted from `X`.
- `plag` — the lag order in the VAR equation.
- `factorprior` — A list whose elements is named sets the prior for the factor equation. `b0` is the prior of mean of regression coefficients β,and `vb0` is the prior of the variance of β, and `c0/2` and `d0/2` are prior parameters of the variance of the error σ^{-2}, and they are the shape and scale parameters of Gamma distribution, respectively.
- `varprior` — A list whose elements is named sets the prior of VAR equations. `b0` is the prior of mean of VAR coefficients β, and `vb0` is the prior of the variance of β, it's a scalar that means priors of variance is same, or a vector whose length equals the length of β. `nu0` is the degree of freedom of Wishart distribution for Σ^{-1}, i.e., a shape parameter, and `s0` is a inverse scale parameter for the Wishart distribution, and it's a matrix with `ncol(s0)=nrow(s0)=`the number of endogenous variables in VAR. If it's a scalar, it means the entry of the matrix is same. `mn` sets the Minnesota prior. If `varprior$mn$kappa0` is not `NULL`, `b0,vb0` is neglected. `mn`'s element `kappa0` controls the tightness of the prior variance for self-variables lag coefficients, the prior variance is κ_0/lag^2, another element `kappa1` controls the cross-variables lag coefficients spread, the prior variance is $\frac{\kappa_0\kappa_1}{lag^2}\frac{\sigma_m^2}{\sigma_n^2}, m \neq n$. See details.
- `nburn` — the number of the first random draws discarded in MCMC.
- `nrep` — the number of the saved draws in MCMC.
- `standardize` — Whether standardize? We suggest it does, because in the function VAR equation and factor equation both don't include intercept.
- `ncores` — the number of CPU cores in parallel computations.

Details

Here we simply state the prior distribution setting of VAR. VAR could be written by (Koop and Korobilis, 2010),

$$y_t = Z_t\beta + \varepsilon_t, \varepsilon_t \sim N(0, \Sigma)$$

You can write down it according to data matrix,

$$Y = Z\beta + \varepsilon, \varepsilon \sim N(0, I \otimes \Sigma)$$

where $Y = (y_1, y_2, \cdots, y_T)', Z = (Z_, Z_2, \cdots, Z_T)', \varepsilon = (\varepsilon_1, \varepsilon_2, \cdots, \varepsilon_T)$. We assume that prior distribution of β and Σ^{-1} is,

$$\beta \sim N(b0, V_{b0}), \Sigma^{-1} \sim W(S_0^{-1}, \nu_0)$$

Or you can set the Minnesota prior for variance of β, for example, for the mth equation in $y_t = Z_t\beta + \varepsilon_t$,

- $\frac{\kappa_0}{l^2}, l$ is lag order, for won lags of endogenous variables
- $\frac{\kappa_0\kappa_1}{l^2}\frac{\sigma_m^2}{\sigma_n^2}, m \neq n$,for lags of other endogenous variables in the mth equation, where σ_m is the standard error for residuals of the mth equation.

Based on the priors, you could get corresponding post distribution for the parameters by Markov Chain Monte Carlo (MCMC) algorithm. More details, see Koop and Korobilis (2010).

Value

An object of class "favar" containing the following components:

varrlt A list. The estimation results of VAR including estimated coefficients `A`, their variance-covariance matrix `sigma`, and other statistical summary for `A`.

Lamb A array with 3 dimension. and `Lamb[i,,]` is factor loading matrix for factor equations in the ith sample of MCMC.

factorx Extracted factors from `X`.

model_info Model information containing `nburn,nrep,X,Y` and `p`, the number of endogenous variables in the VAR.

References

1. Bernanke, B.S., J. Boivin and P. Eliasz, Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR) Approach. Quarterly Journal of Economics, 2005. 120(1): p. 387-422.
2. Boivin, J., M.P. Giannoni and I. Mihov, Sticky Prices and Monetary Policy: Evidence from Disaggregated US Data. American Economic Review, 2009. 99(1): p. 350-384.
3. Koop, G. and D. Korobilis, Bayesian Multivariate Time Series Methods for Empirical Macroeconomics. 2010: Now Publishers.

See Also

`summary.favar`, `coef.favar` and `irf`. All of them are S3 methods of the "favar" object, and `summary.favar` that prints the estimation results of a FAVAR model, and `coef.favar` that extracts the coefficients in a FAVAR model, and `irf` that computes the impulse response in a FAVAR model.

Examples

```
# data('regdata')
# fit <- FAVAR(Y = regdata[,c("Inflation","Unemployment","Fed_funds")],
#              X = regdata[,1:115], slowcode = slowcode,fctmethod = 'BBE',
#              factorprior = list(b0 = 0, vb0 = NULL, c0 = 0.01, d0 = 0.01),
```

```
#              varprior = list(b0 = 0,vb0 = 10, nu0 = 0, s0 = 0),
#              nrep = 15000, nburn = 5000, K = 2, plag = 2)
##---- print FAVAR estimation results------
# summary(fit,xvar = c(3,5))
##---- or extract coefficients------
# coef(fit)
##---- plot impulse response figure------
# library(patchwork)
# dt_irf <- irf(fit,resvar = c(2,9,10))
```

GI *Generalized Impulse Response Function (GIRF)*

Description

Compute GIRF of linear VAR by Koop et al. (1996)

Usage

```
GI(ma, sig_u, imp_var = 1, unit = "sd")
```

Arguments

ma	a list, it's MA coefficients from `ar2ma`
sig_u	a covariance matrix from VAR models. Note the order of variables in `sig_u` is same with one of `ma[[i]]`.
imp_var	a numerical scalar which specifies the impulse variable.
unit	`'sd'` is one standard deviation shock which is default, and `'one'` is one unit shock.

Value

a data frame, its row is variables and its column is horizons.

References

Koop, G., M.H. Pesaran and S. Potter, Impulse Response Analysis in Nonlinear Multivariate Models. Journal of Econometrics, 1996. 74: p. 119-147.

irf — *Impulse Response Function for FAVAR*

Description

Based on a shock to one standard deviation, compute the IRF.

Usage

```
irf(
  fit,
  irftype = "orth",
  tcode = "level",
  resvar = 1,
  impvar = NULL,
  nhor = 10,
  ci = 0.8,
  showplot = TRUE
)
```

Arguments

`fit`	a "favar" object.
`irftype`	`'orth'` is orthogonal IRF, and `'gen'` is generalized IRF.
`tcode`	a scalar `'level'` or a vector whose length equal `ncol(X)+ncol(Y)`. `X,Y` is the parameters of the `FAVAR` function. If the variable is taken the logarithm(`'ln'`) or the first difference of logarithm(`'Dln'`), the IRF needs to return to its level value, and you can set the parameters. Default is `'level'`.
`resvar`	It's column indexes in `cbind(XY)` that specify response variables. It's a scalar or a vector. A change variable cause a change of another variable, and the former is viewed as impulse variable, the latter is viewed as response variable.
`impvar`	Specify a impulse variable. A numeric scalar which is position of variables in VAR equation. If it's `NULL` that is default, its position is the last.
`nhor`	IRF horizon, default is `10`.
`ci`	confidence interval, default is 0.8.
`showplot`	whether show figure. `TRUE` is default. If multiple pictures would be printed, the package `patchwork` is needed to be loaded.

Value

A list containing 2 elements. The first element is a object from `ggplot2::ggplot`, the second element is raw data for IRF.

Examples

```
# see FAVAR function
```

irf_single *Compute Impulse Response for Every Sample of MCMC*

Description

Compute Impulse Response for Every Sample of MCMC

Usage

```
irf_single(i, varrlt, Lamb, Ynum, type = "orth", impvar = 1, nhor)
```

Arguments

i	the ith sample in MCMC
varrlt	estimation results for VAR equations, and it's got by BayesVAR.
Lamb	a array with 3 dimension. and Lamb[i,,] is factor loading matrix for factor equations.
Ynum	the ncol(Y).
type	'orth' is orthogonal IRF, and 'gen' is generalized IRF.
impvar	a numeric scalar which is position of variables in VAR equation. If it's NULL that is default, its position is the last.
nhor	IRF horizon, default is NULL

Value

IRF matrix, the dimension is ncol(Xmatrix) + ncol(Y)xnhor.

regdata *Sample Data*

Description

A matrix containing a large macro data set regdata.

Usage

```
regdata
```

Format

A matrix regdata with 190 rows and 118 variables,

X X is the first column through the 115th column in regdata, a large macro data set

Y Y is the 116th column through the 118th column in regdata, driving the dynamics of the economy

Source

https://sites.google.com/site/garykoop/home/computer-code-2

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slowcode *Slow-moving or Not*

Description

A logic vector, record the variables that are the 1st column through the 115th column in `regdata` is slow-moving or not.

Usage

```
slowcode
```

Format

An object of class `logical` of length 115.

Source

https://sites.google.com/site/garykoop/home/computer-code-2

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summary.favar *Print Results of FAVAR*

Description

S3 method for class "favar".

Usage

```
## S3 method for class 'favar'
summary(object, xvar = NULL, ...)
```

Arguments

`object`	a "favar" object from function `FAVAR`.
`xvar`	a numeric vector, which variables in `X` was printed. It's a index. If it's `NULL`, estimation results for X = F + Y is not printed.
`...`	additional arguments affecting the summary produced.

Value

No return value, called for side effects

Examples

```
# see FAVAR function
```

`tcode` *Transformation Form for X*

Description

Record the transformation form for the 1st column through the 115th column in `regdata`, and 'level' is Level, 'ln' is logarithm, 'Dln' is first difference of logarithm.

Usage

```
tcode
```

Format

An object of class `character` of length 118.

Source

https://sites.google.com/site/garykoop/home/computer-code-2

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