Package ‘VAR.etp’

July 21, 2025

Type Package

Title VAR Modelling: Estimation, Testing, and Prediction

Version 1.1

Date 2023-08-31

Author Jae. H. Kim

Maintainer Jae H. Kim <jaekim8080@gmail.com>

Description A collection of the functions for estimation, hypothesis testing, prediction for stationary vector autoregressive models.

License GPL-2

NeedsCompilation no

Repository CRAN

Date/Publication 2023-08-31 08:40:02 UTC

Contents

`VAR.etp-package` *VAR Modelling: Estimation, Testing, and Prediction*

Description

Estimation, Hypothesis Testing, Prediction in Stationary Vector Autoregressive Models

Details

Package:	VAR.etp
Type:	Package
Version:	1.1
Date:	2023-08-31
License:	GPL-2

The data set dat.rda is from Lutkepohl's book.

It is German Macrodata in log difference.

Bootstrap bias-correction and prediction intervals are also included.

Estimation and Forecasting based on Predictive Regression is also included.

Author(s)

Jae H. Kim

Maintainer: Jae H. Kim

`dat` *German investment income consumption in log difference*

Description

Lutkepohl's data

Usage

```
data(dat)
```

References

Lutkepohl, H. 2005, New Introduction to Multiple Time Series Analysis, Springer

Examples

```
data(dat)
```

data1 — *stock return data used in Kim (2014)*

Description

stock return data used in Kim (2014)

Usage

```
data(data1)
```

References

Kim, J.H. 2014, Testing for parameter restrictions in a stationary VAR model: a bootstrap alternative. Economic Modelling, 41, 267-273.

Examples

```
data(data1)
```

PR.Fore — *Improved Augmented Regression Method for Predictive Regression*

Description

Function for forecasting based on Imporved ARM

Usage

```
PR.Fore(x, y, M, h = 10)
```

Arguments

`x`	predictor or matrix of predictors in column
`y`	variable to be predicted, usually stock return
`M`	Estimation results of the function PR.IARM
`h`	forecasting period

Details

Function for forecasting based on Imporved ARM

Value

`Fore`	Out-of sample and dynamic forecasts for y and x

Note

Kim J.H., 2014, Predictive Regression: Improved Augmented Regression Method, Journal of Empirical Finance 25, 13-15.

Author(s)

jae H. Kim

References

Kim J.H., 2014, Predictive Regression: Improved Augmented Regression Method, Journal of Empirical Finance 25, 13-15.

Examples

```
data(data1)
# Replicating Table 5 (excess return)
y=data1$ret.nyse.vw*100 -data1$tbill*100
x=cbind(log(data1$dy.nyse), data1$tbill*100); k=ncol(x)
p=4
Rmat1=Rmatrix(p,k,type=1,index=1); Rmat=Rmat1$Rmat; rvec=Rmat1$rvec
M=PR.IARM(x,y,p,Rmat,rvec)
PRF=PR.Fore(x,y,M)
```

PR.IARM — *Improved Augmented Regression Method (IARM) for Predictive Regression*

Description

Function for Improved ARM (IARM) estimation and testing

Usage

```
PR.IARM(x, y, p, Rmat = diag(k * p), rvec = matrix(0, nrow = k * p))
```

Arguments

`x`	predictor or a matrix of predictors in column
`y`	variable to be predicted, usually data1 return
`p`	AR order
`Rmat`	Restriction matrix, refer to function Rmatrix
`rvec`	Restriction matrix, refer to function Rmatrix

Details

Kim J.H., 2014, Predictive Regression: Improved Augmented Regression Method, Journal of Empirical Finance, 26, 13-25.

Value

LS	Ordinary Least Squares Estimators
IARM	IARM Estimators
AR	AR parameter estimators
ARc	Bias-corrected AR parameter estimators
Fstats	Fstats and their p-values
Covbc	Covariance matrix of the IARM estimators (for the predictive coefficients only)

Note

Kim J.H., 2014, Predictive Regression: Improved Augmented Regression Method, Journal of Empirical Finance, 26, 13-25.

Author(s)

Jae H. Kim

References

Kim J.H., 2014, Predictive Regression: Improved Augmented Regression Method, Journal of Empirical Finance, 26, 13-25.

Examples

```
data(data1)
# Replicating Table 5 (excess return) of Kim (2014)
y=data1$ret.nyse.vw*100 -data1$tbill*100
x=cbind(log(data1$dy.nyse), data1$tbill*100);

Rmat1=Rmatrix(p=1,k=2,type=1,index=0); Rmat=Rmat1$Rmat; rvec=Rmat1$rvec
M=PR.IARM(x,y,p=1,Rmat,rvec)
```

PR.order *Improved Augmented Regression Method for Predictive Regression*

Description

Function to select the order p by AIC or BIC

Usage

```
PR.order(x, y, pmax = 10)
```

Arguments

x	predictor or a matrix of predictors in column
y	variable to be predicted, usually stock return
pmax	maximum order for order selection

Details

Kim J.H., 2014, Predictive Regression: Improved Augmented Regression Method, Journal of Empirical Finance 25, 13-15.

Value

p.aic	order chosen by AIC
p.aic	order chosen by BIC

Note

Kim J.H., 2014, Predictive Regression: Improved Augmented Regression Method, Journal of Empirical Finance 25, 13-15.

Author(s)

Jae H. Kim

References

Kim J.H., 2014, Predictive Regression: Improved Augmented Regression Method, Journal of Empirical Finance 25, 13-15.

Examples

```
data(data1)
# Replicating Table 5 (excess return)
y=data1$ret.nyse.vw*100 -data1$tbill*100
x=cbind(log(data1$dy.nyse), data1$tbill*100); k=ncol(x)

p=PR.order(x,y,pmax=10)$p.bic;  # AR(1)
```

Rmatrix *Improved Augmented Regression Method for Predictive Regression*

Description

Function to generate restriction matrices

Usage

```
Rmatrix(p, k, type = 1, index = 0)
```

Arguments

p	AR order
k	number of predictors
type	type = 1: H0: b1=b2=b3=0; type = 2: H0: b1+b2+b3=0
index	index=0 : H0 applies for all parameters; index=k : H0 applies for kth predictor

Details

Function to generate restriction matrices

Value

`Rmat`	this value should be passed to PR.IARM
`rvec`	this value should be passed to PR.IARM

Author(s)

Jae H. Kim

References

Kim J.H., 2014, Predictive Regression: Improved Augmented Regression Method, Journal of Empirical Finance 25, 13-15.

Examples

```
Rmat1=Rmatrix(p=1,k=1,type=2,index=1); Rmat=Rmat1$Rmat; rvec=Rmat1$rvec
```

`VAR.BaBPR` *Bootstrap-after-Bootstrap Prediction Intervals for VAR(p) Model*

Description

Bias-correction given with stationarity Correction

Usage

```
VAR.BaBPR(x, p, h, nboot = 500, nb = 200, type = "const", alpha = 0.95)
```

Arguments

`x`	data matrix in column
`p`	AR order
`h`	forecasting period
`nboot`	number of 2nd-stage bootstrap iterations
`nb`	number of 1st-stage bootstrap iterations
`type`	"const" for the AR model with intercept only, "const+trend" for the AR model with intercept and trend
`alpha`	100(1-alpha) percent prediction intervals

Details

Bias-correction given with stationarity Correction

Value

`Intervals`	Prediction Intervals
`Forecast`	Point Forecasts
`alpha`	Probability Content of Prediction Intervals

Note

Bias-correction given with stationarity Correction

Author(s)

Jae H. Kim

References

Kim, J. H. (2001). Bootstrap-after-bootstrap prediction intervals for autoregressive models, Journal of Business & Economic Statistics, 19, 117-128.

Examples

```
data(dat)
VAR.BaBPR(dat,p=2,h=10,nboot=200,nb=100,type="const",alpha=0.95)
# nboot and nb are set to low numbers for fast execution in the example
# In actual implementation, use higher numbers such as nboot=1000, nb=200
```

`VAR.Boot` *Bootstrapping VAR(p) model: bias-correction based on the bootstrap*

Description

The function returns bias-corrected parmater estimators and Bias estimators based on the bootstrap

Usage

```
VAR.Boot(x, p, nb = 200, type = "const")
```

Arguments

`x`	data matrix in column
`p`	AR order
`nb`	number of bootstrap iterations
`type`	"const" for the AR model with intercept only, "const+trend" for the AR model with intercept and trend

Details

Kilian's (1998) stationarity-correction is used for bias-correction

Value

`coef`	coefficient matrix
`resid`	matrix of residuals
`sigu`	residual covariance matrix
`Bias`	Bootstrap Bias Estimator

Author(s)

Jae H. Kim

References

Kilian, L. (1998). Small sample confidence intervals for impulse response functions, The Review of Economics and Statistics, 80, 218 - 230.

Examples

```
data(dat)
VAR.Boot(dat,p=2,nb=200,type="const")
```

`VAR.BPR` *Bootstrap Prediction Intervals for VAR(p) Model*

Description

No Bias-correction is given

Usage

```
VAR.BPR(x, p, h, nboot = 500, type = "const", alpha = 0.95)
```

Arguments

`x`	data matrix in column
`p`	AR order
`h`	forecasting period
`nboot`	number of bootstrap iterations
`type`	"const" for the AR model with intercept only, "const+trend" for the AR model with intercept and trend
`alpha`	100(1-alpha) percent prediction intervals

Details

Bootstrap Prediction Intervals for VAR(p) Model

Value

`Intervals`	Prediction Intervals
`Forecast`	Point Forecasts
`alpha`	Probability Content of Prediction Intervals

Note

No Bias-correction is given

Author(s)

Jae H. Kim

References

Kim, J. H. (2001). Bootstrap-after-bootstrap prediction intervals for autoregressive models, Journal of Business & Economic Statistics, 19, 117-128.

Examples

```
data(dat)
VAR.BPR(dat,p=2,h=10,nboot=200,type="const",alpha=0.95)
# nboot is set to a low number for fast execution in the example
# In actual implementation, use higher number such as nboot=1000
```

VAR.est — *Estimation of unrestricted VAR(p) model parameters*

Description

This function returns least-squares estimation results for VAR(p) model

Usage

```
VAR.est(x, p, type = "const")
```

Arguments

`x`	data matrix in column
`p`	AR order
`type`	"const" for the AR model with intercept only, "const+trend" for the AR model with intercept and trend

Details

VAR estimation

Value

`coef`	coefficient matrix
`resid`	matrix of residuals
`sigu`	residual covariance matrix
`zzmat`	data moment matrix
`zmat`	data moment matrix
`tratio`	matrix of tratio corresponding to coef matrix

Note

See Chapter 3 of Lutkepohl (2005)

Author(s)

Jae H. Kim

References

Lutkepohl, H. 2005, New Introduction to Multiple Time Series Analysis, Springer

Examples

```
#replicating Section 3.2.3 of of Lutkepohl (2005)
data(dat)
M=VAR.est(dat,p=2,type="const")
print(M$coef)
print(M$tratio)
```

`VAR.FOR` *VAR Forecasting*

Description

Generate point forecasts and prediction intervals

Usage

```
VAR.FOR(x, p, h, type = "const", alpha = 0.95)
```

Arguments

x	data matrix in column
p	VAR order
h	Forecasting Periods
type	"const" for the AR model with intercept only, "const+trend" for the AR model with intercept and trend
alpha	100(1-alpha) percent prediction intervals

Details

Prediction Intervals are based on normal approximation

Value

Intervals	Prediction Intervals, out-of-sample and dynamic
Forecast	Point Forecasts, out-of-sample and dynamic
alpha	Probability Content of Prediction Interva;s

Note

See Chapter 3 of Lutkepohl (2005)

Author(s)

Jae H. Kim

References

Lutkepohl, H. 2005, New Introduction to Multiple Time Series Analysis, Springer

Examples

```
#replicating Section 3.5.3 of Lutkepohl (2005)
data(dat)
VAR.FOR(dat,p=2,h=10,type="const",alpha=0.95)
```

VAR.Fore *VAR Forecasting*

Description

Generate point forecasts using the estimated VAR coefficient matrix

Usage

```
VAR.Fore(x, b, p, h, type = "const")
```

Arguments

`x`	data matrix in column
`b`	matrix of coefficients from VAR.est or VAR.Rest
`p`	VAR order
`h`	Forecasting Periods
`type`	"const" for the AR model with intercept only, "const+trend" for the AR model with intercept and trend

Details

Generate point forecasts using the estimated VAR coefficient matrix

Value

`Fore`	Point Forecasts, out-of-sample and dynamic

Note

See Chapter 3 of Lutkepohl (2005)

Author(s)

Jae H. Kim

References

Lutkepohl, H. 2005, New Introduction to Multiple Time Series Analysis, Springer

Examples

```
#replicating Section 3.5.3 of Lutkepohl (2005)
data(dat)
b=VAR.est(dat,p=2,type="const")$coef
VAR.Fore(dat,b,p=2,h=10,type="const")
```

`VAR.irf` *Orthogonalized impluse response functions from an estimated VAR(p) model*

Description

This function returns Orthogonalized impluse response functions

Usage

```
VAR.irf(b, p, sigu, h=10,graphs=FALSE)
```

Arguments

`b`	VAR coefficient matrix, from VAR.est or similar estimation function
`p`	VAR order
`sigu`	VAR residual covariance matrix, from VAR.est or similar estimation function
`h`	response horizon, the default is set to 10
`graphs`	logical, if TRUE, show the impulse-response functions, the default is FALSE

Details

VAR impulse response functions

Value

`impmat`	matrix that contains orthogonalized impulse-responses

Note

See Lutkepohl (2005) for details

Author(s)

Jae H. Kim

References

Lutkepohl, H. 2005, New Introduction to Multiple Time Series Analysis, Springer

Examples

```
#replicating Table 3.4 and Figure 3.11 Lutkepohl (2005)
data(dat)
M=VAR.est(dat,p=2,type="const")
b=M$coef; sigu=M$sigu
VAR.irf(b,p=2,sigu,graphs=TRUE)
```

`VAR.LR` *The Likelihood Ratio test for parameter restrictions*

Description

Likelihood Ratio test for zero parameter restrictions based on system VAR estimation

Bootstrap option is available: iid bootstrap or wild bootstrap

Bootstrap is conducted under the null hypothesis using estimated GLS estimation: see Kim (2014)

Usage

```
VAR.LR(x, p, restrict0, restrict1, type = "const",bootstrap=0,nb=500)
```

Arguments

`x`	data matrix in column
`p`	VAR order
`restrict0`	Restriction matrix under H0
`restrict1`	Restriction matrix under H1, if "full", the full VAR is estimated under H1
`type`	"const" for the AR model with intercept only, "const+trend" for the AR model with intercept and trend
`bootstrap`	0 for no bootstrap; 1 for iid bootstrap; 2 for wild bootstrap
`nb`	the number of bootstrap iterations

Details

Restriction matrix is of m by 3 matrix where m is the number of restrictions. A typical row of this matrix (k,i,j), which means that (i,j) element of Ak matrix is set to 0. Ak is a VAR coefficient matrix (k = 1,....p).

The bootstrap test is conducted using the GLS estimation under the parameter restrictions implied by the null hypothesis: see Kim (2014) for details.

Kim (2014) found that the bootstrap based on OLS can show inferior small sample properties.

There are two versions of the bootstrap: the first is based on the iid resampling and the second based on wild bootstrapping.

The Wild bootstrap is conducted with Mammen's two-point distribution.

Value

`LRstat`	LR test statistic
`pval`	p-value of the LR test
`Boot.pval`	p-value of the test based on bootstrapping

Note

See Chapter 4 of Lutkepohl (2005)

Author(s)

Jae H. Kim

References

Lutkepohl, H. 2005, New Introduction to Multiple Time Series Analysis, Springer

Kim, J.H. 2014, Testing for parameter restrictions in a stationary VAR model: a bootstrap alternative. Economic Modelling, 41, 267-273.

Examples

```
data(dat)
#replicating Table 4.4 of Lutkepohl (2005)
restrict1="full";
restrict0 = rbind(c(4,1,1), c(4,1,2), c(4,1,3), c(4,2,1),
c(4,2,2),c(4,2,3),c(4,3,1),c(4,3,2),c(4,3,3))
VAR.LR(dat,p=4,restrict0,restrict1,type="const")
```

VAR.Pope *Bias-correction for VAR parameter estimators based on Pope's formula*

Description

The function returns bias-corrected parmater estimators and Bias estimators based on Pope's asymptotic formula

Usage

```
VAR.Pope(x, p, type = "const")
```

Arguments

x	data matrix in column
p	AR order
type	"const" for the AR model with intercept only, "const+trend" for the AR model with intercept and trend

Details

Kilian's (1998) stationarity-correction is used for bias-correction

Value

coef	Bias-corrected coefficient matrix
resid	matrix of residuals
sigu	residual covariance matrix
Bias	Bias Estimate

Author(s)

Jae H. Kim

References

Kim, J. H. 2004, Bias-corrected bootstrap prediction regions for Vector Autoregression, Journal of FOrecasting 23, 141-154.

Kilian, L. (1998). Small sample confidence intervals for impulse response functions, The Review of Economics and Statistics, 80, 218 - 230.

Nicholls DF, Pope AL. 1988, Bias in estimation of multivariate autoregression. Australian Journal of Statistics, 30A, 296-309.

Pope AL. 1990. Biases of estimators in multivariate non-Gaussian autoregression, Journal of Time Series Analysis 11, 249-258.

Examples

```
data(dat)
VAR.Pope(dat,p=2,type="const")
```

`VAR.Rest` *VAR parameter estimation with parameter restrictions*

Description

Estimation of VAR with 0 restrictions on parameters

Usage

```
VAR.Rest(x, p, restrict, type = "const", method = "gls")
```

Arguments

`x`	data matrix in column
`p`	VAR order
`restrict`	Restriction matrix under H0
`type`	"const" for the AR model with intercept only, "const+trend" for the AR model with intercept and trend
`method`	"ols" for OLS estimation, "gls" for EGLS estimation

Details

Restriction matrix is of m by 3 matrix where m is the number of restrictions. A typical row of this matrix (k,i,j), which means that (i,j) element of Ak matrix is set to 0. Ak is a VAR coefficient matrix (k = 1,....p).

Value

coef	coefficient matrix
resid	matrix of residuals
sigu	residual covariance matrix
zmat	data matrix
tstat	matrix of tratio corresponding to coef matrix

Note

See Chapter 5 of Lutkepohl

Author(s)

Jae H. Kim

References

Lutkepohl, H. 2005, New Introduction to Multiple Time Series Analysis, Springer

Examples

```
data(dat)
#replicating Section 5.2.10 of Lutkepohl (2005)
restrict = rbind( c(1,1,2),c(1,1,3),c(1,2,1),c(1,2,2), c(1,3,1),
c(2,1,1), c(2,1,2),c(2,1,3), c(2,2,2), c(2,2,3),c(2,3,1), c(2,3,3),
c(3,1,1), c(3,1,2), c(3,1,3), c(3,2,1), c(3,2,2), c(3,2,3), c(3,3,1),c(3,3,3),
c(4,1,2), c(4,1,3), c(4,2,1), c(4,2,2), c(4,2,3), c(4,3,1),c(4,3,2),c(4,3,3))
M= VAR.Rest(dat,p=4,restrict,type="const",method="gls")
print(M$coef)
print(M$tstat)
```

VAR.select *Order Selection for VAR models*

Description

AIC, HQ, or SC can be used

Usage

```
VAR.select(x, type = "const", ic = "aic", pmax)
```

Arguments

`x`	data matrix in column
`type`	"const" for the AR model with intercept only, "const+trend" for the AR model with intercept and trend
`ic`	choose one of "aic", "sc", "hq"
`pmax`	the maximum VAR order

Details

Order Section Criterion

Value

`IC`	Values of information criterion for VAR models
`p`	AR order selected

Note

See Chapter 4 of Lutkepohl

Author(s)

JAe H. Kim

References

Lutkepohl, H. 2005, New Introduction to Multiple Time Series Analysis, Springer

Examples

```
data(dat)
#replicating Section 4.3.1 of Lutkepohl (2005)
VAR.select(dat,pmax=4,ic="aic")
```

`VAR.Wald` *Wald test for parameter restrictions*

Description

Wald test for zero parameter restrictions based on system VAR estimation

Bootstrap option is available: iid bootstrap or wild bootstrap

Bootstrap is conducted under the null hypothesis using estimated GLS estimation: see Kim (2014)

Usage

```
VAR.Wald(x, p, restrict, type = "const",bootstrap=0,nb=500)
```

Arguments

x	data matrix in column
p	VAR order
restrict	Restriction matrix under H0
type	"const" for the AR model with intercept only, "const+trend" for the AR model with intercept and trend
bootstrap	0 for no bootstrap; 1 for iid bootstrap; 2 for wild bootstrap
nb	the number of bootstrap iterations

Details

Restriction matrix is of m by 3 matrix where m is the number of restrictions. A typical row of this matrix (k,i,j), which means that (i,j) element of Ak matrix is set to 0. Ak is a VAR coefficient matrix (k = 1,....p). Under H1, the model is full VAR.

The bootstrap test is conducted using the GLS estimation under the parameter restrictions implied by the null hypothesis: see Kim (2014) for details.

Kim (2014) found that the bootstrap based on OLS can show inferior small sample properties.

There are two versions of the bootstrap: the first is based on the iid resampling and the second based on wild bootstrapping.

The Wild bootstrap is conducted with Mammen's two-point distribution.

Value

Fstat	Wald test statistic
pval	p-value of the test based on F-distribution
Boot.pval	p-value of the test based on bootstrapping

Note

See Chapter 3 of Lutkepohl

Author(s)

Jae H. Kim

References

Lutkepohl, H. 2005, New Introduction to Multiple Time Series Analysis, Springer.

Kim, J.H. 2014, Testing for parameter restrictions in a stationary VAR model: a bootstrap alternative. Economic Modelling, 41, 267-273.

Examples

```
data(dat)
#replicating Section 3.6.2 of Lutkepohl (2005)
restrict = rbind( c(1,1,2),c(1,1,3), c(2,1,2),c(2,1,3))
VAR.Wald(dat,p=2,restrict,type="const")
```

Index