Package 'VAR.etp'

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Type Package

Title VAR Modelling: Estimation, Testing, and Prediction

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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.

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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
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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")
```

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