Package 'MTS'

February 19, 2015

Type Package

Title All-Purpose Toolkit for Analyzing Multivariate Time Series (MTS) and Estimating Multivariate Volatility Models

Version 0.33

Date 2015-02-11

Author Ruey S. Tsay

Maintainer Ruey S. Tsay <ruey.tsay@chicagobooth.edu>

Description Multivariate Time Series (MTS) is a general package for analyzing multivariate linear time series and estimating multivariate volatility models. It also handles factor models, constrained factor models, asymptotic principal component analysis commonly used in finance and econometrics, and principal volatility component analysis. (a) For the multivariate linear time series analysis, the package performs model specification, estimation, model checking, and prediction for many widely used models, including vector AR models, vector MA models, vector ARMA models, seasonal vector ARMA models, VAR models with exogenous variables, multivariate regression models with time series errors, augmented VAR models, and Error-correction VAR models for co-integrated time series. For model specification, the package performs structural specification to overcome the difficulties of identifiability of VARMA models. The methods used for structural specification include Kronecker indices and Scalar Component Models. (b) For multivariate volatility modeling, the MTS package handles several commonly used models, including multivariate exponentially weighted moving-average volatility, Cholesky decomposition volatility models, dynamic conditional correlation (DCC) models, copula-based volatility models, and low-dimensional BEKK models. The package also considers multiple tests for conditional heteroscedasticity, including rank-based statistics. (c) Finally, the MTS package also performs forecasting using diffusion index, transfer function analysis, Bayesian estimation of VAR models, and multivariate time series analysis with missing values.Users can also use the package to simulate VARMA models, to compute impulse response functions of a fitted VARMA model, and to calculate theoretical cross-covariance matrices of a given VARMA model.

Imports Rcpp, fGarch, mvtnorm

LinkingTo Rcpp

NeedsCompilation yes

Repository CRAN

Date/Publication 2015-02-12 17:29:18

R topics documented:

MTS-package . . . 4
apca . . . 4
archTest . . . 5
BEKK11 . . . 6
Btfm2 . . . 7
BVAR . . . 8
ccm . . . 10
comVol . . . 11
dccFit . . . 12
dccPre . . . 13
diffM . . . 14
Eccm . . . 15
ECMvar . . . 16
ECMvar1 . . . 17
EWMAvol . . . 18
FEVdec . . . 19
GrangerTest . . . 20
hfactor . . . 21
ibmspko . . . 22
Kronfit . . . 23
Kronid . . . 24
Kronspec . . . 25
MarchTest . . . 26
MCHdiag . . . 28
MCholV . . . 29
Mlm . . . 30
mq . . . 30
msqrt . . . 31
mtCopula . . . 32
MTS-internal . . . 33
MTSdiag . . . 33
MTSplot . . . 34
Mtxprod . . . 35
Mtxprod1 . . . 35
PIwgt . . . 36
PSIwgt . . . 37
qgdp . . . 38
refECMvar . . . 38
refECMvar1 . . . 39
refKronfit . . . 40
refREGts . . . 41
refSCMfit . . . 41
refsVARMA . . . 42
refVAR . . . 43
refVARMA . . . 44
refVARX . . . 45

refVMA . . . 46
refVMAe . . . 47
REGts . . . 48
RLS . . . 49
SCCor . . . 50
SCMfit . . . 51
SCMid . . . 52
SCMid2 . . . 53
SCMmod . . . 54
sVARMA . . . 55
sVARMACpp . . . 56
SWfore . . . 58
tenstocks . . . 59
tfm . . . 59
tfm1 . . . 60
tfm2 . . . 61
VAR . . . 63
VARMA . . . 64
VARMAcov . . . 66
VARMACpp . . . 67
VARMAirf . . . 68
VARMApred . . . 69
VARMAsim . . . 70
VARorder . . . 71
VARorderI . . . 72
VARpred . . . 73
VARpsi . . . 74
VARs . . . 75
VARX . . . 76
VARXorder . . . 77
VARXpred . . . 78
Vech . . . 79
VechM . . . 80
VMA . . . 81
VMACpp . . . 82
VMAe . . . 83
VMAorder . . . 85
VMAs . . . 86
Vmiss . . . 87
Vpmiss . . . 88

Index **90**

`MTS-package` *Multivariate Time Series*

Description

Multivariate Time Series (MTS) is a general package for analyzing multivariate linear time series and estimating multivariate volatility models. It also handles factor models, constrained factor models, asymptotic principal component analysis commonly used in finance and econometrics, and principal volatility component analysis. (a) For the multivariate linear time series analysis, the package performs model specification, estimation, model checking, and prediction for many widely used models, including vector AR models, vector MA models, vector ARMA models, seasonal vector ARMA models, VAR models with exogenous variables, multivariate regression models with time series errors, augmented VAR models, and Error-correction VAR models for co-integrated time series. For model specification, the package performs structural specification to overcome the difficulties of identifiability of VARMA models. The methods used for steuctural specificatin include Kronecker indices and Scalar Component Models. (b) For multivariate volatility modeling, the MTS package handles several commonly used models, including multivariate exponentially weighted moving-average volatility, Cholesky decomposition volatility models, dynamic conditional correlation (DCC) models, copula-based volatility models, and low-dimensional BEKK models. The package also considers multiple tests for conditional heteroscedasticity, including rank-based statistics. (c) Finally, the MTS package also performs forecasting using diffusion index, transfer function analysis, Bayesian estimation of VAR models, and multivariate time series analysis with missing values.Users can also use the package to simulate VARMA models, to compute impulse response functions of a fitted VARMA model, and to calculate theoretical cross-covarinace matrices of a given VARMA model.

Details

Package:	MTS
Type:	Package
Version:	0.33
Date:	2015-02-8
License:	Artistic License 2.0

Author(s)

Ruey S. Tsay Maintainer: Ruey S. Tsay <ruey.tsay@chicagobooth.edu>

`apca` *Asymptotic Principal Component Analysis*

Description

Perform asymptotic PCA for a data set. Typically for cases in which the number of variables is greater than the number of data points.

Usage

```
apca(da, m)
```

Arguments

`da`	A T-by-k data set matrix, where T is the sample size and k is the dimension
`m`	The number of common factors

Details

Perform the PCA analysis of interchanging the roles of variables and observations.

Value

`sdev`	Square root of the eigenvalues
`factors`	The common factors
`loadings`	The loading matrix

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 6). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

Examples

```
rtn=matrix(rnorm(1200),12,100)
sp100=apca(rtn,3)
```

`archTest` *ARCH test for univariate time series*

Description

Perform tests to check the conditional heteroscedasticity in a time series. The Ljung-Box statistics of squared series and a rank-based Ljung-Box test are used.

Usage

```
archTest(rt, lag = 10)
```

Arguments

`rt`	A scalar time series. If rt is a matrix, only the first column is used.
`lag`	The number of lags of ACF used in the Ljung-Box statistics. The default is 10.

Details

The Ljung-Box statistics based on the squared series are computed first. The rank series of the squared time series is than used to test the conditional heteroscedasticity.

Value

The Q-statistic and its p-value. Also, the rank-based Q statistic and its p-value.

Author(s)

Ruey Tsay

See Also

MarchTest

Examples

```
rt=rnorm(200)
archTest(rt)
```

BEKK11 — *BEKK Model*

Description

Estimation of a BEKK(1,1) Model for a k-dimensional time series. Only k = 2 or 3 is available

Usage

```
BEKK11(rt, include.mean = T, cond.dist = "normal")
```

Arguments

`rt`	A T-by-k data matrix of k-dimensional asset returns
`include.mean`	A logical switch to include a constant vector in the mean equation. Default is with a constant vector.
`cond.dist`	Conditional innovation distribution. Only Gaussian inoovations are used in the current version.

Value

estimates	Parameter estimates
HessianMtx	Hessian matirx of the estimates
Sigma.t	The multivariate volatilities, each row contains k-by-k elements of the volatility matrix Sigma(t)

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 7)

Examples

```
#data("mts-examples",package="MTS")
#da=ibmspko
#rtn=log(da[,2:3]+1)
#m1=BEKK11(rtn)
```

Btfm2 *Back-Test of a Transfer Function Model with Two Input Variables*

Description

Perform back-test of transfer function model with 2 input variable. For a specified tfm2 model and a given forecast origin, the command iterated between estimation and 1-step ahead prediction starting at the forecast origin until the (T-1)th observation, where T is the sample size.

Usage

```
Btfm2(y,x,x2=NULL,wt=NULL,ct=NULL,orderN=c(1,0,0),orderS=c(0,0,0),sea=12,
order1=c(0,1,0),order2=c(0,-1,0),orig=(length(y)-1))
```

Arguments

y	Data vector of dependent variable
x	Data vector of the first input (or independent) variable
x2	Data vector of the second input variable if any
ct	Data vector of a given deterministic variable such as time trend, if any
wt	Data vector of co-integrated series between input and output variables if any
orderN	Order (p,d,q) of the regular ARMA part of the disturbance component
orderS	Order (P,D,Q) of the seasonal ARMA part of the disturbance component
sea	Seasonalityt, default is 12 for monthly data

`order1` Order (r,s,b) of the transfer function model of the first input variable, where r and s are the degrees of denominator and numerator polynomials and b is the delay

`order2` Order (r2,s2,b2) of the transfer function model of the second input variable, where 2r and s2 are the degrees of denominator and numerator polynomials and b2 is the delay

`orig` Forecast origin with default being T-1, where T is the sample size

Details

Perform out-of-sample 1-step ahead prediction to evaluate a fitted tfm2 model

Value

`ferror` 1-step ahead forecast errors, starting at the given forecast origin

`mse` out-of-sample mean squared forecast errors

`rmse` root mean squared forecast errors

`mae` out-of-sample mean absolute forecast errors

`nobf` The number of 1-step ahead forecast errors computed

`rAR` Regulard AR coefficients

Author(s)

Ruey S. Tsay

References

Box, G. E. P., Jenkins, G. M., and Reinsel, G. C. (1994). Time Series Analysis: Forecasting and Control, 3rd edition, Prentice Hall, Englewood Cliffs, NJ.

See Also

tfm2

`BVAR` *Bayesian Vector Autoregression*

Description

Estimate a VAR(p) model using Bayesian approach, including the use of Minnesota prior

Usage

```
BVAR(z,p=1,C,V0,n0=5,Phi0=NULL,include.mean=T)
```

Arguments

`z`	A matrix of vector time series, each column represents a series.
`p`	The AR order. Default is p=1.
`C`	The precision matrix of the coefficient matrix. With constant, the dimension of C is (kp+1)-by-(kp+1). The covariance marix of the prior for the parameter vec(Beta) is Kronecker(Sigma_a,C-inverse).
`V0`	A k-by-k covariance matrix to be used as prior for the Sigma_a matrix
`n0`	The degrees of freedom used for prior of the Sigma_a matrix, the covariance matrix of the innovations. Default is n0=5.
`Phi0`	The prior mean for the parameters. Default is set to NULL, implying that the prior means are zero.
`include.mean`	A logical switch controls the constant term in the VAR model. Default is to include the constant term.

Details

for a given prior, the program provide the posterior estimates of a VAR(p) model.

Value

`est`	Posterior means of the parameters
`Sigma`	Residual covariance matrix

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 2).

Examples

```
data("mts-examples",package="MTS")
z=log(qgdp[,3:5])
zt=diffM(z)*100
C=0.1*diag(rep(1,7))
V0=diag(rep(1,3))
BVAR(zt,p=2,C,V0)
```

ccm *Cross-Correlation Matrices*

Description

Computes sample cross-correlation matrices of a multivariate time series, including simplified ccm matrix and p-value plot of Ljung-Box statistics.

Usage

```
ccm(x, lags = 12, level = FALSE, output = T)
```

Arguments

`x`	A matrix of vector time series, each column represents a series.
`lags`	The number of lags of CCM to be computed. Default is 12.
`level`	A logical switch. When level=T, numerical values of CCM is printed. Default is no printing of CCM.
`output`	A logical switch. If ouput=F, no output is given. Default is with output.

Details

The p-value of Ljung-Box statistics does not include any adjustment in degrees of freedom.

Value

`ccm`	Sample cross-correlation matrices
`pvalue`	p-values for each lag of CCM being a zero matrix

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 1). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

Examples

```
xt=matrix(rnorm(1500),500,3)
ccm(xt)
ccm(xt,lag=20)
```

comVol *Common Volatility*

Description

Compute the principal volatility components based on the residuals of a VAR(p) model.

Usage

```
comVol(rtn, m = 10, p = 1, stand = FALSE)
```

Arguments

`rtn`	A T-by-k data matrix of k-dimensional asset returns
`m`	The number of lags used to compute generalized cross-Kurtosis matrix
`p`	VAR order for the mean equation
`stand`	A logical switch to standardize the returns

Details

Perform a VAR(p) fit, if any. Then, use the residual series to perform principal volatility component analysis. The ARCH test statistics are also computed for the sample principal components

Value

`residuals`	The residuals of a VAR(p) fit
`values`	Eigenvalues of the pricipal volatility component analysis
`vectors`	Eigenvectors of the principal volatility component analysis
`M`	The transformation matrix

Author(s)

Ruey S. Tsay and Y.B. Hu

References

Tsay (2014, Chapter 7)

Examples

```
data("mts-examples",package="MTS")
zt=diffM(log(qgdp[,3:5]))
m1=comVol(zt,p=2)
names(m1)
```

dccFit *Dynamic Cross-Correlation Model Fitting*

Description

Fits a DCC model using either multivariate Gaussian or multivariate Student-t innovations. Two types of DCC models are available. The first type is proposed by Engle and the other is by Tse and Tsui. Both models appear in the Journal of Business and Economic Statistics, 2002.

Usage

```
dccFit(rt, type = "TseTsui", theta = c(0.9, 0.02),
    ub = c(0.92, 0.079999), lb = c(0.4, 1e-04),
    cond.dist = "std", df = 7, m = 0)
```

Arguments

`rt`	The T-by-k data matrix of k-dimensional standardized asset returns. Typically, they are the standardized residuals of the command dccPre.
`type`	A logical switch to specify the type of DCC model. Type="TseTsui" for Tse and Tsui's DCC model. Type = "Engle" for Engle's DCC model. Default is Tse-Tsui model.
`theta`	The initial parameter values for theta1 and theta2
`ub`	Upper bound of parameters
`lb`	Lower bound of parameters
`cond.dist`	Conditional innovation distribution with std for multivariate Student-t innovations.
`df`	degrees of freedom of the multivariate Student-t innovations.
`m`	For Tse and Tsui method only, m denotes the number of returns used in local correlation matrix estimation

Value

`estimates`	Parameter estimates
`Hessian`	Hessian marix of the estimates
`rho.t`	Time-varying correlation matrices. Each row contains elements of a cross-correlation matrix.

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 7). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

dccPre

`dccPre` *Preliminary Fitting of DCC Models*

Description

This program fits marginal GARCH models to each component of a vector return series and returns the standardized return series for further analysis. The garchFit command of fGarch package is used.

Usage

```
dccPre(rtn, include.mean = T, p = 0, cond.dist = "norm")
```

Arguments

`rtn`	A T-by-k data matrix of k-dimensinal asset returns
`include.mean`	A logical switch to include a mean vector. Deafult is to include the mean.
`p`	VAR order for the mean equation
`cond.dist`	The conditional distribution of the innovations. Default is Gaussian.

Details

The program uses fGarch package to estimate univariate GARCH model for each residual series after a VAR(p) fitting, if any.

Value

`marVol`	A matrix of the volatility series for each return series
`sresi`	Standardized residual series
`est`	Parameter estimates for each marginal volatility model
`se.est`	Standard errors for parameter estimates of marginal volatility models

Note

fGarch package is used

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 7). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

dccFit

`diffM` *Difference of multivariate time series*

Description

Performs the difference operation of a vector time series

Usage

```
diffM(zt, d = 1)
```

Arguments

`zt`	A vector time series (T by k, with sample size T and dimension k)
`d`	Order of differencing. Deafult is d=1.

Details

When d = 1, the command is equivalent to apply(zt,2,diff)

Value

The differenced time series

Author(s)

Ruey S Tsay

Examples

```
data("mts-examples",package="MTS")
zt=log(qgdp[,3:5])
xt=diffM(zt)
```

Eccm *Extended Cross-Correlation Matrices*

Description

Compute the extended cross-correlation matrices and the associated two-way table of p-values of multivariate Ljung-Box statistics of a vector time series.

Usage

```
Eccm(zt, maxp = 5, maxq = 6, include.mean = FALSE, rev = TRUE)
```

Arguments

`zt`	Data matrix (T-by-k) of a vector time series, where T is the sample size and k is the dimension.
`maxp`	Maximum AR order entertained. Default is 5.
`maxq`	Maximum MA order entertained. Default is 6.
`include.mean`	A logical switch controling the mean vector in estimation. Default assumes zero mean.
`rev`	A logical switch to control the cross-correlation matrices used to compute the multivariate Ljung-Box statistics. Traditional way is to compute test statistics from lag-1 to lag-m. If rev = TRUE, then the test statistics are compute from lag-(m-1) to lag-m, from lag-(m-2) to lag-m, etc.

Value

`pEccm`	A two-way table of the p-values of extended cross-correlation matrices
`vEccm`	The sample extended cross-correlation matrices
`ARcoef`	AR coefficient marices of iterated VAR fitting

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 3). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

Examples

```
zt=matrix(rnorm(900),300,3)
m1=Eccm(zt)
```

ECMvar *Error-Correction VAR Models*

Description

Performs estimation of an Error-Correction VAR(p) model using the Quasi Maximum Likelihood Method.

Usage

```
ECMvar(x, p, ibeta, include.const = FALSE, fixed = NULL,
                 alpha = NULL, se.alpha = NULL, se.beta = NULL, phip =
                 NULL, se.phip = NULL)
```

Arguments

`x`	A T-by-k data matrix of a k-dimensional co-integrated VAR process
`p`	VAR order
`ibeta`	Initial estimate of the co-integrating matrix. The number of columns of ibeta is the number of co-integrating series
`include.const`	A logical switch to include a constant term in the model. The default is no constant
`fixed`	A logical matrix to set zero parameter constraints.
`alpha`	Initial estimate of alpha, if any
`se.alpha`	Initial estimate of the standard error of alpha, if any
`se.beta`	Initial estimate of the standard error of beta, if any
`phip`	Initial estimate of the VAR coefficients, if any
`se.phip`	Initial estimate of the stanard error of the VAR coefficients, if any

Value

`data`	The vector time series
`ncoint`	The number of co-integrating series
`arorder`	VAR order
`include.const`	Logical switch to include constant
`alpha,se.alpha`	Estimates and their standard errors of the alpha matrix
`beta,se.beta`	Estimates and their standard errors of the beta matrix
`aic,bic`	Information criteria of the fitted model
`residuals`	The residual series
`Sigma`	Residual covariance matrix
`Phip,se.Phip`	Estimates and their standard errors of VAR coefficients

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 5)

See Also

ECMvar1

Examples

```
phi=matrix(c(0.5,-0.25,-1.0,0.5),2,2); theta=matrix(c(0.2,-0.1,-0.4,0.2),2,2)
Sig=diag(2)
mm=VARMAsim(300,arlags=c(1),malags=c(1),phi=phi,theta=theta,sigma=Sig)
zt=mm$series[,c(2,1)]
beta=matrix(c(1,0.5),2,1)
m1=ECMvar(zt,3,ibeta=beta)
names(m1)
```

ECMvar1 *Error-Correction VAR Model 1*

Description

Perform least-squares estimation of an ECM VAR(p) model with known co-integrating processes

Usage

```
ECMvar1(x, p, wt, include.const = FALSE, fixed = NULL, output = TRUE)
```

Arguments

x	A T-by-k data matrix of a k-dimensional co-integrated VAR process
p	VAR order
wt	A T-by-m data matrix of m-dimensional co-integrated process
include.const	A logical switch to include a constant term. Default is no constant.
fixed	A logical matrix to set zero parameter constraints
output	A logical switch to control output

Value

data	The vector time series
wt	The co-integrated series
arorder	VAR order
include.const	Logical switch to include constant
coef	Parameter estimates
aic,bic	Information criteria of the fitted model
residuals	The residual series
Sigma	Residual covariance matrix

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 5). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

ECMvar

Examples

```
phi=matrix(c(0.5,-0.25,-1.0,0.5),2,2); theta=matrix(c(0.2,-0.1,-0.4,0.2),2,2)
Sig=diag(2)
mm=VARMAsim(300,arlags=c(1),malags=c(1),phi=phi,theta=theta,sigma=Sig)
zt=mm$series
wt=0.5*zt[,1]+zt[,2]
m1=ECMvar1(zt,3,wt)
names(m1)
```

EWMAvol *Exponentially Weighted Moving-Average Volatility*

Description

Use exponentially weighted moving-average method to compute the volatility matrix

Usage

```
EWMAvol(rtn, lambda = 0.96)
```

Arguments

`rtn` A T-by-k data matrix of k-dimensional asset returns, assuming the mean is zero

`lambda` Smoothing parameter. The deafult is 0.96. If lambda is negative, then the multivariate Gaussian likelihood is used to estimate the smoothing parameter.

Value

`Sigma.t` The volatility matrix with each row representing a volatility matrix

`return` The data

`lambda` The smoothing parameeter lambda used

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 7). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

Examples

```
data("mts-examples",package="MTS")
rtn=log(ibmspko[,2:4]+1)
m1=EWMAvol(rtn)
```

`FEVdec` *Forecast Error Variance Decomposition*

Description

Computes the forecast error variance decomposition of a VARMA model

Usage

```
FEVdec(Phi, Theta, Sig, lag = 4)
```

Arguments

`Phi` VAR coefficient matrices in the form Phi=[Phi1, Phi2, ..., Phip], a k-by-kp matrix.

`Theta` VMA coefficient matrices in form form Theta=[Theta1, Theta2, ..., Thetaq], a k-by-kq matrix.

`Sig` The residual covariance matrix Sigma, a k-by-k positive definite matrix.

`lag` The number of lags of forecast errors variance to be computed. Default is 4.

Details

Use the psi-weight matrices to compute the forecast error covariance and use Cholesky decomposition to perform the decomposition

Value

`irf`	Impulse response matrices
`orthirf`	Orthogonal impulse response matrices
`Omega`	Forecast error variance matrices
`OmegaR`	Forecast error variance decomposition

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 3)

Examples

```
p1=matrix(c(0.2,-0.6,0.3,1.1),2,2)
theta1=matrix(c(-0.5,0,0,-0.6),2,2)
Sig=matrix(c(3,1,1,1),2,2)
m1=FEVdec(p1,theta1,Sig)
names(m1)
```

`GrangerTest` *Granger Causality Test*

Description

Performs Granger causality test using a vector autoregressive model

Usage

```
GrangerTest(X,p=1,include.mean=T,locInput=c(1))
```

Arguments

`X`	a T-by-p data matrix with T denoting sample size and p the number of variables
`p`	vector AR order.
`include.mean`	Indicator for including a constant in the model. Default is TRUE.
`locInput`	Locators for the input variables in the data matrix. Deafult is the first column being the input variable. Multiple inputs are allowed.

Details

Perform VAR(p) and constrained VAR(p) estimations to test the Granger causality. It uses likelihood ratio and asymptotic chi-square.

Value

`data`	Original data matrix
`cnst`	logical variable to include a constant in the model
`order`	order of VAR model used
`coef`	Coefficient estimates
`constraints`	Implied constraints of Granger causality
`aic, bic, hq`	values of information criteria
`residuals`	residual vector
`secoef`	standard errors of coefficient estimates
`Sigma`	Residual covariance matrix
`Phi`	Matrix of VAR coefficients
`Ph0`	constant vector
`omega`	Estimates of constrained coefficients
`covomega`	covariance matrix of constrained parameters
`locInput`	Locator vector for input variables

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 2)

`hfactor` *Constrained Factor Model*

Description

Performs factor model analysis with a given constrained matrix

Usage

```
hfactor(X, H, r)
```

Arguments

X	A T-by-k data matrix of an observed k-dimensional time series
H	The constrained matrix with each column representing a constraint
r	The number of common factor

Value

Results of the traditional PCA and constrained factor models are given

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 6). Tsai and Tsay (2010, JASA)

Examples

```
data("mts-examples",package="MTS")
rtn=log(tenstocks[,2:11]+1) # compute log returns
h1=c(1,1,1,1,rep(0,6)) # specify the constraints
h2=c(0,0,0,0,1,1,1,0,0,0)
h3=c(rep(0,7),1,1,1)
H=cbind(h1,h2,h3)
m1=hfactor(rtn,H,3)
```

---

ibmspko *Monthly simple returns of the stocks of International Business Machines (IBM) and Coca Cola (KO) and the S&P Composite index (SP)*

Description

Monthly simple returns of the stocks of International Business Machines (IBM) and Coca Cola (KO) and the S&P Composite index (SP). The sample period is from January 1961 to December 2011. The original data were from the Center for Research in Security Prices (CRSP) of the University of Chicago. The files has four columns. They are dates, IBM, SP, and KO.

Usage

```
ibmspko
```

Format

A 2-d list containing 612x4 observations. The files has four columns. They are dates, IBM, SP, and KO.

Source

World Almanac and Book of Facts, 1975, page 406.

Kronfit *Fitting a VARMA Model via Kronecker Index*

Description

Perform estimation of a VARMA model specified by the Kronecker indices

Usage

```
Kronfit(da, kidx, include.mean = T, fixed = NULL, Kpar=NULL,
  seKpar=NULL, prelim = F, details = F, thres = 1)
```

Arguments

`da`	Data matrix (T-by-k) of a k-dimensional time series
`kidx`	The vector consisting of Kronecker indices
`include.mean`	A logical switch for including the mean vector in estimation. Default is to include the mean vector.
`fixed`	A logical matrix used to set zero parameter constraints. This is used mainly in the command refKronfit.
`Kpar`	Parameter vectors for use in model simplification
`seKpar`	Standard errors of the parameter estimates for use in model simplification
`prelim`	A lofical switch for a preliminary estimation.
`details`	A logical switch to control output.
`thres`	A threshold for t-ratios in setting parameter to zero. Default is 1.

Value

`data`	The observed time series data
`Kindex`	Kronecker indicies
`ARid`	Specification of AR parameters: 0 denotes fixing to zero, 1 denotes fixing to 1, and 2 denoting estimation
`MAid`	Specification of MA parameters
`cnst`	A logical variable: include.mean
`coef`	Parameter estimates
`se.coef`	Standard errors of the estimates
`residuals`	Residual series
`Sigma`	Residual covariance matrix
`aic,bic`	Information criteria of the fitted model
`Ph0`	Constant vector
`Phi`	AR coefficient matrices
`Theta`	MA coefficient matrices

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 4). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

refKronfit, Kronspec

Kronid *Kronecker Index Identification*

Description

Find the Kronecker indices of a k-dimensional time series

Usage

```
Kronid(x, plag = 5, crit = 0.05)
```

Arguments

`x`	Data matrix (T-by-k) of a k-dimensional time series
`plag`	The number of lags used to represent the past vector. Default is 5.
`crit`	Type-I error used in testing for zero canonical correlations. Deafult is 0.05.

Value

`index`	Kronecker indices
`tests`	Chi-square test statistics

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 4). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

Examples

```
phi=matrix(c(0.2,-0.6,.3,1.1),2,2); sigma=diag(2); theta=-0.5*sigma
m1=VARMAsim(300,arlags=c(1),malags=c(1),phi=phi,theta=theta,sigma=sigma)
zt=m1$series
Kronid(zt)
```

Kronspec *Kronecler Index Specification*

Description

For a given set of Kronecker indices, the program specifies a VARMA model. It gives details of parameter specification.

Usage

```
Kronspec(kdx, output = TRUE)
```

Arguments

`kdx`	A vector of Kronecker indices
`output`	A logical switch to control output. Deafult is with output.

Value

`PhiID`	Specification of the AR matrix polynomial. 0 denotes zero parameter, 1 denotes fixing parameter to 1, and 2 denotes the parameter requires estimation
`ThetaID`	Specification of the MA matrix polynomial

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 4)

Examples

```
kdx=c(2,1,1)
m1=Kronspec(kdx)
names(m1)
```

MarchTest *Multivariate ARCH test*

Description

Perform tests to check the conditional heteroscedasticity in a vector time series

Usage

```
MarchTest(zt, lag = 10)
```

Arguments

zt	a nT-by-k data matrix of a k-dimensional financial time series, each column contains a series.
lag	The number of lags of cross-correlation matrices used in the tests

Details

Several tests are used. First, the vector series zt is transformed into rt = [t(zt) perform the test. The second test is based on the ranks of the transformed rt series. The third test is the multivariate Ljung-Box statistics for the squared vector series zt^2. The fourth test is the multivariate Ljung-Box statistics applied to the 5-percent trimmed series of the transformed series rt.

Value

Various test statistics and their p-values

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 7). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

Examples

```
zt=matrix(rnorm(600),200,3)
MarchTest(zt)
function (zt, lag = 10)
{
    if (!is.matrix(zt))
        zt = as.matrix(zt)
    nT = dim(zt)[1]
    k = dim(zt)[2]
    C0 = cov(zt)
    zt1 = scale(zt, center = TRUE, scale = FALSE)
```

```
C0iv = solve(C0)
wk = zt1 %*% C0iv
wk = wk * zt1
rt2 = apply(wk, 1, sum) - k
m1 = acf(rt2, lag.max = lag, plot = F)
acf = m1$acf[2:(lag + 1)]
c1 = c(1:lag)
deno = rep(nT, lag) - c1
Q = sum(acf^2/deno) * nT * (nT + 2)
pv1 = 1 - pchisq(Q, lag)
cat("Q(m) of squared series(LM test): ", "\n")
cat("Test statistic: ", Q, " p-value: ", pv1, "\n")
rk = rank(rt2)
m2 = acf(rk, lag.max = lag, plot = F)
acf = m2$acf[2:(lag + 1)]
mu = -(rep(nT, lag) - c(1:lag))/(nT * (nT - 1))
v1 = rep(5 * nT^4, lag) - (5 * c(1:lag) + 9) * nT^3 + 9 *
    (c(1:lag) - 2) * nT^2 + 2 * c(1:lag) * (5 * c(1:lag) +
    8) * nT + 16 * c(1:lag)^2
v1 = v1/(5 * (nT - 1)^2 * nT^2 * (nT + 1))
QR = sum((acf - mu)^2/v1)
pv2 = 1 - pchisq(QR, lag)
cat("Rank-based Test: ", "\n")
cat("Test statistic: ", QR, " p-value: ", pv2, "\n")
cat("Q_k(m) of squared series: ", "\n")
x = zt^2
g0 = var(x)
ginv = solve(g0)
qm = 0
df = 0
for (i in 1:lag) {
    x1 = x[(i + 1):nT, ]
    x2 = x[1:(nT - i), ]
    g = cov(x1, x2)
    g = g * (nT - i - 1)/(nT - 1)
    h = t(g) %*% ginv %*% g %*% ginv
    qm = qm + nT * nT * sum(diag(h))/(nT - i)
    df = df + k * k
}
pv3 = 1 - pchisq(qm, df)
cat("Test statistic: ", qm, " p-value: ", pv3, "\n")
cut1 = quantile(rt2, 0.95)
idx = c(1:nT)[rt2 <= cut1]
x = zt[idx, ]^2
eT = length(idx)
g0 = var(x)
ginv = solve(g0)
qm = 0
df = 0
for (i in 1:lag) {
    x1 = x[(i + 1):eT, ]
    x2 = x[1:(eT - i), ]
    g = cov(x1, x2)
```

```
        g = g * (eT - i - 1)/(eT - 1)
        h = t(g) %*% ginv %*% g %*% ginv
        qm = qm + eT * eT * sum(diag(h))/(eT - i)
        df = df + k * k
    }
    pv4 = 1 - pchisq(qm, df)
    cat("Robust Test(5%) : ", qm, " p-value: ", pv4, "\n")
}
```

MCHdiag *Multivariate Conditional Heteroscadastic Model Cheking*

Description

Apply four portmanteau test statistics to check the validity of a fitted multivariate volatility model

Usage

```
MCHdiag(at, Sigma.t, m = 10)
```

Arguments

`at`	A T-by-k matrix of residuals for a k-dimensional asset return series
`Sigma.t`	The fitted volatility matrices. The dimension is T-by-k^2 matrix
`m`	The number of lags used in the tests. Default is 10.

Details

The four test statistics are given in Tsay (2014, Chapter 7)

Value

Four test statistics and their p-values

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 7). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

MCholV *Multivariate Cholesky Volatility Model*

Description

Use Cholesky decomposition to obtain multivariate volatility models

Usage

```
MCholV(rtn, size = 36, lambda = 0.96, p = 0)
```

Arguments

`rtn`	A T-by-k data matrix of a k-dimensional asset return series.
`size`	The initial sample size used to start recursive least squares estimation
`lambda`	The exponential smoothing parameter. Default is 0.96.
`p`	VAR order for the mean equation. Default is 0.

Details

Use recursive least squares to perform the time-varying Cholesky decomposition. The least squares estimates are then smoothed via the exponentially weighted moving-average method with decaying rate 0.96. University GARCH(1,1) model is used for the innovations of each linear regression.

Value

`betat`	Recursive least squares estimates of the linear transformations in Cholesky decomposition
`bt`	The transformation residual series
`Vol`	The volatility series of individual innovations
`Sigma.t`	Volatility matrices

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 7)

See Also

fGarch

Mlm *Multivariate Linear Model*

Description

Fit a multivariate multiple linear regression model via the least squares method

Usage

```
Mlm(y, z, constant=TRUE, output=TRUE)
```

Arguments

`y`	data matrix of dependent variable. Each column contains one variable.
`z`	data matrix of the explanatory variables. Each column contains one variable.
`constant`	A logical switch for including the constant term
`output`	A logical switch to print the output

Value

`beta`	coefficient matrix
`se.beta`	standard errors of the coefficient matrix
`residuals`	The residual series
`sigma`	Residual covariance matrix

Author(s)

Ruey S. Tsay

mq *Multivariate Ljung-Box Q Statistics*

Description

Computes the multivariate Ljung-Box statistics for cross-correlation matrices

Usage

```
mq(x, lag = 24, adj = 0)
```

Arguments

`x`	The data matrix of a vector time series or residual series of a fitted multivariate model.
`lag`	The number of cross-correlation matrices used. Default is 24.
`adj`	Adjustment for the degrees of freedom for the Ljung-Box statistics. This is used for residual series. Default is zero.

Details

Computes the multivariate Ljung-Box statistics and their p-values. For model checking, the subcommand adj can be used to adjust the degrees of freedom of the Chi-square statistics.

Value

The multivariate Q-statistics and their p-values. Also, it provides a plot of the p-values.

Author(s)

Ruey S. Tsay

References

Tsay (2014). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

Examples

```
x=matrix(rnorm(1500),500,3)
mq(x)
```

`msqrt` *Square Root Matrix*

Description

Compute the symmetric square root of a positive definite matrix

Usage

```
msqrt(M)
```

Arguments

`M`	A positive definite matrix

Details

Use spectral decomposition to compute the square root of a positive definite matrix

Value

mtxsqrt	The square root matrix
invsqrt	The inverse of the square root matrix

Note

This command is used in some of the MTS functions.

Author(s)

Ruey S. Tsay

Examples

```
m=matrix(c(1,0.2,0.2,1),2,2)
m1=msqrt(m)
names(m1)
```

---

mtCopula *Mulivariate t-Copula Volatility Model*

Description

Fits a t-copula to a k-dimensional standardized return series. The correlation matrices are parameterized by angles and the angles evolve over time via a DCC-type equation.

Usage

```
mtCopula(rt, g1, g2, grp = NULL, th0 = NULL, m = 0, include.th0 = TRUE)
```

Arguments

rt	A T-by-k data matrix of k standardized time series (after univariate volatility modeling)
g1	lamda1 parameter, nononegative and less than 1
g2	lambda2 parameter, nonnegative and satisfying lambda1+lambda2 < 1.
grp	a vector to indicate the number of assets divided into groups. Default means each individual asset forms a group.
th0	initial estimate of theta0
m	number of lags used to estimate the local theta-angles
include.th0	A logical switch to include theta0 in estimation. Default is to inlcude.

Value

`estimates`	Parameter estimates
`Hessian`	Hessian matrix
`rho.t`	Cross-correlation matrices
`theta.t`	Time-varying angel mtrices

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 7). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

`MTS-internal` *MTS Internal Functions*

Description

MTS Internal Functions

Details

These are not to be called by the user.

`MTSdiag` *Multivariate Time Series Diagnostic Checking*

Description

Performs model checking for a fitted multivariate time series model, including residual cross-correlation matrices, multivariate Ljung-Box tests for residuals, and residual plots

Usage

```
MTSdiag(model, gof = 24, adj = 0, level = F)
```

Arguments

`model`	A fitted multivariate time series model
`gof`	The number of lags of residual cross-correlation matrices used in the tests
`adj`	The adjustment for degrees of freedom of Ljung-Box statistics. Typically, the number of fitted coefficients of the model. Default is zero.
`level`	Logical switch for printing residual cross-correlation matrices

Value

Various test statistics, their p-values, and residual plots.

Author(s)

Ruey S Tsay

Examples

```
phi=matrix(c(0.2,-0.6,0.3,1.1),2,2); sigma=diag(2)
m1=VARMAsim(200,arlags=c(1),phi=phi,sigma=sigma)
zt=m1$series
m2=VAR(zt,1,include.mean=FALSE)
MTSdiag(m2)
```

`MTSplot` *Multivariate Time Series Plot*

Description

Provides time plots of a vector time series

Usage

```
MTSplot(data, caltime = NULL)
```

Arguments

`data`	data matrix of a vector time series
`caltime`	Calendar time. Default is NULL, that is, using time index

Details

Provides time plots of a vector time series. The output frame depends on the dimension of the time series

Value

Time plots of vector time series

Author(s)

Ruey S. Tsay

Examples

```
xt=matrix(rnorm(1500),500,3)
MTSplot(xt)
```

Mtxprod *Polynomial Matrix Product*

Description

Compute the product of two polynomial matrices

Usage

```
Mtxprod(Mtx, sMtx, p, P)
```

Arguments

Mtx	The coefficient matrix of a regular polynomial matrix
sMtx	The coefficient matrix of a seasonal polynomial matrix
p	Degree of the regular polynomial matrix
P	Degree of the seasonal polynomial matrix

Value

Coefficient matrix of the product. The product is in the form reg-AR * sAR, etc.

Author(s)

Ruey S. Tsay

Mtxprod1 *Alternative Ploynomial Matrix Product*

Description

Compute the product of two polynomial matrices

Usage

```
Mtxprod1(Mtx, sMtx, p, P)
```

Arguments

Mtx	The coefficient matrix of a regular polynomial matrix
sMtx	The coefficient matrix of a seasonal polynomial matrix
p	Degree of the regular polynomial matrix. p is less than P.
P	Degree of the seasonal polynomial matrix

Details

This polynomial product is used in seasonal VARMA modeling to check the multiplicative nature between the regular and seasonal polynomial matrices

Value

Coefficient matrix of the product. The product matrix is in the form sAR * reg-AR, etc.

Author(s)

Ruey S. Tsay

`PIwgt` *Pi Weight Matrices*

Description

Compute the Pi-weight matrices of a VARMA model

Usage

```
PIwgt(Phi = NULL, Theta = NULL, lag = 12, plot = TRUE)
```

Arguments

`Phi`	A k-by-kp matrix of VAR coefficients in the form [Phi1, Phi2, Phi3, ..., Phip]
`Theta`	A k-by-kq matrix of VMA coefficients in the form [Theta1, Theta2, ..., Thetaq]
`lag`	The number of Pi-weight matrices to be computed.
`plot`	A logical switch to plot the Pi-weight matrices

Details

The Pi-weight matrices for a VARMA model is Pi(B) = inverse(Theta(B)) times Phi(B).

Value

`pi.weight`	The matrix of Pi-weight coefficient

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapters 2 and 3). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

PSIwgt

Examples

```
Phi1=matrix(0,2,2); Phi2=matrix(c(0.2,-0.6,0.3,1.1),2,2)
Theta1=diag(c(-0.5,-0.4))
Phi=cbind(Phi1,Phi2)
m1=PIwgt(Phi=Phi,Theta=Theta1)
names(m1)
```

PSIwgt *Psi Wights Matrices*

Description

Computes the psi-weight matrices of a VARMA model

Usage

```
PSIwgt(Phi = NULL, Theta = NULL, lag = 12, plot = TRUE, output = FALSE)
```

Arguments

Phi	A k-by-kp matrix of VAR coefficient matrix. Phi=[Phi1, Phi1, ..., Phip]
Theta	A k-by-kq matrix of VMA coefficient matrix. Theta=[Theta1, Theta2, ..., Thetaq]
lag	The number of psi-weight matrices to be computed. Deafult is 12.
plot	A lofical switch to control plotting of the psi-weights.
output	A logical switch to control the output.

Value

psi.weight	Psi-weight matrices
irf	Impulse response cofficient matrices

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 3). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

Examples

```
phi=matrix(c(0.2,-0.6,0.3,1.1),2,2)
theta=matrix(c(-0.5,0.2,0.0,-0.6),2,2)
m1=PSIwgt(Phi=phi,Theta=theta)
```

`qgdp` *Quarterly real gross domestic products of United Kingdom, Canada, and the United States*

Description

Quarterly real gross domestic products of United Kingdom, Canada, and the United States from the first quarter of 1980 to the second quarter of 2011. The UK and CA data were originally from OECD and the US data from the Federal Reserve Bank of St Louis.

Usage

```
qgdp
```

Format

A 2-d list containing 126x5 observations. The data set consists of 5 columns, namey year, month, UK, CA, and US.

Source

The data were downloaded from the FRED of the Federal Reserve Bank of St Louis. The UK data were in millions of chained 2006 Pounds, the CA data were in millions of chained 2002 Canadian dolloars, and the US data were in millions of chained 2005 dollars.

`refECMvar` *Refining Error-Correction Model for VAR series*

Description

Refining an estimated ECM VAR model by setting insignificant estimates to zero

Usage

```
refECMvar(m1, thres = 1)
```

Arguments

`m1`	An object of the ECMvar command or the refECMvar command
`thres`	Threshold for individual t-ratio. The default is 1.

Details

Set simultaneously all estimates with t-ratio less than the threshold to zero (in modulus).

Value

Constrained estimation results of a ECM VAR model

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 5). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

`refECMvar1` *Refining ECM for a VAR process*

Description

Performs constrained least squares estimation of a ECM VAR model with known co-integrated processes

Usage

```
refECMvar1(m1, thres = 1)
```

Arguments

`m1`	An object of the ECMvar1 command or the refECMvar1 command
`thres`	Threshold for individual t-ratio. Default is 1.

Details

Setting all estimates with t-ration less than the threshold, in absoluate value, to zero simultaneously.

Value

Constrained estimation results of an ECM VAR model

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 5). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

ECMvar1, refECMvar

`refKronfit` *Refining VARMA Estimation via Kronecker Index Approach*

Description

This program performs model simplification of a fitted VARMA model via the Kronecker index approach

Usage

```
refKronfit(model, thres = 1)
```

Arguments

`model`	The name of a model from the command Kronfit or refKronfit
`thres`	A threshold for t-ratio of individual parameter estimate. The deafult is 1.

Details

For a given threshold, the program sets a parameter to zero if its t-ratio (in modulus) is less than the threshold.

Value

Same as those of the command Kronfit.

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 4). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

Kronfit

`refREGts` *Refining a Regression Model with Time Series Errors*

Description

Refines a fitted REGts by setting simultaneously parameters with t-ratios less than the threshold (in modulus) to zero

Usage

```
refREGts(m1, thres = 1)
```

Arguments

`m1`	An output object from the REGts command or refREGts command
`thres`	Threshold value for individual t-ratio. Default is 1.

Value

The same as those of the command REGts.

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 6). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

refVAR, refVARMA

`refSCMfit` *Refining Estimation of VARMA Model via SCM Approch*

Description

Refine estimation of a VARMA model specified via the SCM approach by removing insignificant parameters

Usage

```
refSCMfit(model, thres = 1)
```

Arguments

`model`	Name of the model from the SCMfit command or the refSCMfit command
`thres`	Threshold for the t-ratio of individual coefficient. Default is 1.

Value

The same as those of the command SCMfit.

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 4)

See Also

SCMfit

`refsVARMA` *Refining a Seasonal VARMA Model*

Description

Refines a fitted seasonal VARMA model by setting insignificant estimates to zero

Usage

```
refsVARMA(model, thres = 0.8)
```

Arguments

`model`	An output object of the sVARMA command or the refsVARMA command
`thres`	Threshold for individual t-ratio. Default is 0.8.

Details

The command removes simultaneously all parameters with t-ratio less than the threshold in modulus.

Value

The same as those of the command sVARMA

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 6)

See Also

sVARMA

---

refVAR *Refining a VAR Model*

Description

Refine a fitted VAR model by removing simultaneously insignificant parameters

Usage

```
refVAR(model, fixed = NULL, thres = 1)
```

Arguments

`model`	An output object of the command VAR or the refVAR command
`fixed`	A logical matrix for VAR polynomial structure
`thres`	Threshold used to set parameter to zero. Default is 1.

Details

Refine a VAR fitting by setting all estimates with t-ratio less than the threshold (in modulus) to zero.

Value

The same as those of the command VAR

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 2)

See Also

VAR

Examples

```
data("mts-examples",package="MTS")
gdp=log(qgdp[,3:5])
zt=diffM(gdp)
m1=VAR(zt,3)
m2=refVAR(m1,thres=1.0)
names(m2)
```

`refVARMA` *Refining VARMA Estimation*

Description

Refines a fitted VARMA model by setting insignificant estimates to zero

Usage

```
refVARMA(model, thres = 1.5)
```

Arguments

`model`	An output object from the command VARMA or the command refVARMA
`thres`	A threshold value for individual t-ratio of the estimates.

Details

The program simultaneously sets estimates with t-ratios less than the threshold (in modulus) to zero.

Value

The same as those of the command VARMA.

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 3). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

VARMA

`refVARX` *Refining a VARX Model*

Description

Refine a fitted VARX model by setting insignificant parameters to zero

Usage

```
refVARX(m1, thres = 1)
```

Arguments

`m1`	An output object of the VARX commond or the refVARX command
`thres`	A threshold for the individual t-ratio. Default is 1.

Details

The program sets simultaneously all estimates with t-ratio less than threshold (in modulus) to zero and re-estimate the VARX model.

Value

The same as those of the command VARX.

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 6). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

VARX

`refVMA` *Refining VMA Models*

Description

Refines a fitted VMA model by setting insignificant parameters to zero

Usage

```
refVMA(model, thres = 1)
```

Arguments

`model`	An output object from the command VMA or the refVMA command
`thres`	A threshold for individual t-ratio of parameter estimate. Default is 1.

Details

The program simultaneously sets all estimates with t-ratios less than the threshold (in modulus) to zero.

Value

The same as those of the command VMA.

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 3). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

VMA

refVMAe *Refining VMA Estimation via the Exact Likelihood Method*

Description

Refines a fitted VMA model via the VMAe command by setting insignificant parameters to zero

Usage

```
refVMAe(model, thres = 1)
```

Arguments

`model`	An output object of the command VMAe or the command refVMAe itself
`thres`	A threshold for individual t-ratio of parameter estimates. Deafult is 1.

Details

The program sets simultaneously all estimates with t-ratios less than the threshold (in modulus) to zero.

Value

The same as those of the command VMAe.

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 3). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

VMAe, refVMA

REGts *Regression Model with Time Series Errors*

Description

Perform the maximum likelihood estimation of a multivariate linear regression model with time-series errors

Usage

```
REGts(zt, p, xt, include.mean = T, fixed = NULL, par = NULL, se.par = NULL, details = F)
```

Arguments

zt	A T-by-k data matrix of a k-dimensional time series
p	The VAR order
xt	A T-by-v data matrix of independent variables, where v denotes the number of independent variables (excluding constant 1).
include.mean	A logical switch to include the constant term. Default is to include the constant term.
fixed	A logical matrix used to set parameters to zero
par	Initial parameter estimates of the beta coefficients, if any.
se.par	Standard errors of the parameters in par, if any.
details	A logical switch to control the output

Details

Perform the maximum likelihood estimation of a multivariate linear regression model with time series errors. Use multivariate linear regression to obtain initial estimates of regression coefficients if not provided

Value

data	The observed k-dimensional time series
xt	The data matrix of independent variables
aror	VAR order
include.mean	Logical switch for the constant vector
Phi	The VAR coefficients
se.Phi	The standard errors of Phi coefficients
beta	The regression coefficients
se.beta	The standard errors of beta
residuals	The residual series
Sigma	Residual covariance matrix
coef	Parameter estimates, to be used in model simplification.
se.coef	Standard errors of parameter estimates

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 6). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken NJ.

`RLS` *Recursive Least Squares*

Description

Compute recursive least squares estimation

Usage

```
RLS(y, x, ist = 30, xpxi = NULL, xpy0 = NULL)
```

Arguments

`y`	data of dependent variable
`x`	data matrix of regressors
`ist`	initial number of data points used to start the estimation
`xpxi`	Inverse of the X'X matrix
`xpy0`	Initial value of X'y.

Value

`beta`	Time-varying regression coefficient estimates
`resi`	The residual series of recursive least squares estimation

Note

This function is used internally, but can also be used as a command.

Author(s)

Ruey S. Tsay

SCCor *Sample Constrained Correlations*

Description

Compute the sample constrained correlation matrices

Usage

```
SCCor(rt,end,span,grp)
```

Arguments

rt	A T-by-k data matrix of a k-dimensional time series
end	The time index of the last data point to be used in computing the sample correlations.
span	The size of the data span used to compute the correlations.
grp	A vector of group sizes. The time series in the same group are pooled to compute the correlation matrix.

Value

unconCor	Un-constrained sample correlation matrix
conCor	Constrained sample correlation matrix

Note

This is an internal function, not intended to be a general command

Author(s)

Ruey S. Tsay

Examples

```
rt=matrix(rnorm(1000),200,5)
grp=c(3,2)
m1=SCCor(rt,200,200,grp)
m1$unconCor
m1$conCor
```

SCMfit	*Scalar Component Model Fitting*

Description

Perform estimation of a VARMA model specified via the SCM approach

Usage

```
SCMfit(da, scms, Tdx, include.mean = T, fixed = NULL,
    prelim = F, details = F, thres = 1, ref = 0,
    SCMpar=NULL, seSCMpar=NULL)
```

Arguments

da	The T-by-k data matrix of a k-dimensional time series
scms	A k-by-2 matrix of the orders of SCMs
Tdx	A k-dimensional vector for locating "1" of each row in the transformation matrix.
include.mean	A logical switch to include the mean vector. Default is to include mean vector.
fixed	A logical matrix to set parameters to zero
prelim	A logical switch for preliminary estimation. Default is false.
details	A logical switch to control details of output
thres	Threshold for individual t-ratio when setting parameters to zero. Default is 1.
ref	A switch to use SCMmod in model specification.
SCMpar	Parameter estimates of the SCM model, to be used in model refinement
seSCMpar	Standard errors of the parameter estimates in SCMpar

Details

Perform conditional maximum likelihood estimation of a VARMA model specified by the scalar component model approach, including the transformation matrix.

Value

data	Observed time series
SCMs	The specified SCMs
Tdx	Indicator vector for the transformation matrix. The length of Tdx is k.
locTmtx	Specification of estimable parameters of the transformation matrix
locAR	Locators for the estimable parameters of the VAR coefficients
locMA	Locators for the estimable parameters of the VMA coefficients
cnst	A logical switch to include the constant vector in the model

`coef`	The parameter estimates
`secoef`	Standard errors of the parameter estimates
`residuals`	Residual series
`Sigma`	Residual covariance matrix
`aic,bic`	Information criteria of the fitted model
`Ph0`	Estimates of the constant vector, if any
`Phi`	Estimates of the VAR coefficients
`Theta`	Estimates of the VMA coefficients

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 4). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

`SCMid` *Scalar Component Identification*

Description

Find the overall order of a VARMA process via the scalar component model approach

Usage

```
SCMid(zt, maxp = 5, maxq = 5, h = 0, crit = 0.05, output = FALSE)
```

Arguments

`zt`	The T-by-k data matrix of a k-dimensional time series
`maxp`	Maximum AR order entertained. Default is 5.
`maxq`	Maximum MA order entertained. Default is 5.
`h`	The additional past lags used in canonical correlation analysis. Default is 0.
`crit`	Type-I error of the chi-square tests used.
`output`	A logical switch to control the output.

Value

`Nmtx`	The table of the numbers of zero canonical correlations
`DDmtx`	The diagonal difference table of the number of zero canonical correlations

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 4). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

Examples

```
phi=matrix(c(0.2,-0.6,0.3,1.1),2,2); sigma=diag(2)
m1=VARMAsim(300,arlags=c(1),phi=phi,sigma=sigma)
zt=m1$series
m2=SCMid(zt)
```

`SCMid2` *Scalar Component Model Specification II*

Description

Provides detailed analysis of scalar component models for a specified VARMA model. The overall model is specified by SCMid.

Usage

```
SCMid2(zt, maxp = 2, maxq = 2, h = 0, crit = 0.05, sseq = NULL)
```

Arguments

`zt`	The T-by-k data matrix of a k-dimensional time series
`maxp`	Maximum AR order specified. Default is 2.
`maxq`	Maximum MA order specified. Default is 2.
`h`	The additional past lags used in canonical correlation analysis. Default is zero.
`crit`	Type-I error used in testing. Default is 0.05.
`sseq`	The search sequence for SCM components. Default sequence starts with AR order.

Value

`Tmatrix`	The transformation matrix T
`SCMorder`	The orders of SCM components

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 4). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

SCMid

Examples

```
phi=matrix(c(0.2,-0.6,0.3,1.1),2,2); sigma=diag(2)
m1=VARMAsim(300,arlags=c(1),phi=phi,sigma=sigma)
zt=m1$series
m2=SCMid2(zt)
names(m2)
```

SCMmod *Scalar Component Model specification*

Description

For a given set of SCMs and locator of transformation matrix, the program specifies a VARMA model via SCM approach for estimation

Usage

```
SCMmod(order, Ivor, output)
```

Arguments

`order`	A k-by-2 matrix of the orders of SCM
`Ivor`	A k-dimensioal vector indicating the location of "1" for each component in the transformation matrix.
`output`	A logical switch to control output.

Details

The command specified estimable parameters for a VARMA model via the SCM components. In the output, "2" denotes estimation, "1" denotes fixing the value to 1, and "0" means fixing the parameter to zero.

Value

`Tmtx`	Specification of the transformation matrix T
`ARpar`	Specification of the VAR parameters
`MApar`	Specification of the VMA parameters

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 4). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

Examples

```
ord=matrix(c(0,1,1,0,0,1),3,2)
Ivor=c(3,1,2)
m1=SCMmod(ord,Ivor,TRUE)
```

`sVARMA` *Seasonal VARMA Model Estimation*

Description

Performs conditional maximum likelihood estimation of a seasonal VARMA model

Usage

```
sVARMA(da, order, sorder, s, include.mean = T, fixed = NULL, details = F, switch = F)
```

Arguments

`da`	A T-by-k data matrix of a k-dimensional seasonal time series
`order`	Regular order (p,d,q) of the model
`sorder`	Seasonal order (P,D,Q) of the model
`s`	Seasonality. s=4 for quarterly data and s=12 for monthly series
`include.mean`	A logical switch to include the mean vector. Deafult is to include the mean
`fixed`	A logical matrix to set zero parameter constraints
`details`	A logical switch for output
`switch`	A logical switch to exchange the ordering of the regular and seasonal VMA factors. Default is theta(B)*Theta(B).

Details

Estimation of a sesonal VARMA model

Value

data	The data matrix of the observed k-dimensional time series
order	The reqular order (p,d,q)
sorder	The seasonal order (P,D,Q)
period	Seasonality
cnst	A logical switch for the constant term
ceof	Parameter estimates for use in model simplification
secoef	Standard errors of the parameter estimates
residuals	Residual series
Sigma	Residual covariance matrix
aic,bic	Information criteria of the fitted model
regPhi	Regular AR coefficients, if any
seaPhi	Seasonal AR coefficients
regTheta	Regular MA coefficients
seaTheta	Seasonal MA coefficients
Ph0	The constant vector, if any
switch	The logical switch to change the ordering of matrix product

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 6). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

---

sVARMACpp *Seasonal VARMA Model Estimation (Cpp)*

Description

Performs conditional maximum likelihood estimation of a seasonal VARMA model. This is the same function as sVARMA, with the likelihood function implemented in C++ for efficiency.

Usage

```
sVARMACpp(da, order, sorder, s, include.mean = T, fixed = NULL, details = F, switch = F)
```

Arguments

`da`	A T-by-k data matrix of a k-dimensional seasonal time series
`order`	Regular order (p,d,q) of the model
`sorder`	Seasonal order (P,D,Q) of the model
`s`	Seasonality. s=4 for quarterly data and s=12 for monthly series
`include.mean`	A logical switch to include the mean vector. Deafult is to include the mean
`fixed`	A logical matrix to set zero parameter constraints
`details`	A logical switch for output
`switch`	A logical switch to exchange the ordering of the regular and seasonal VMA factors. Default is theta(B)*Theta(B).

Details

Estimation of a sesonal VARMA model

Value

`data`	The data matrix of the observed k-dimensional time series
`order`	The reqular order (p,d,q)
`sorder`	The seasonal order (P,D,Q)
`period`	Seasonality
`cnst`	A logical switch for the constant term
`ceof`	Parameter estimates for use in model simplification
`secoef`	Standard errors of the parameter estimates
`residuals`	Residual series
`Sigma`	Residual covariance matrix
`aic,bic`	Information criteria of the fitted model
`regPhi`	Regular AR coefficients, if any
`seaPhi`	Seasonal AR coefficients
`regTheta`	Regular MA coefficients
`seaTheta`	Seasonal MA coefficients
`Ph0`	The constant vector, if any
`switch`	The logical switch to change the ordering of matrix product

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 6). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

sVARMA

SWfore *Stock-Watson Diffusion Index Forecasts*

Description

Uses the diffusion index approach of Stock and Watson to compute out-of-sample forecasts

Usage

```
SWfore(y, x, orig, m)
```

Arguments

`y`	The scalar variable of interest
`x`	The data matrix (T-by-k) of the observed explanatory variables
`orig`	Forecast origin
`m`	The number of diffusion index used

Details

Performs PCA on X at the forecast origin. Then, fit a linear regression model to obtain the coefficients of prediction equation. Use the prediction equation to produce forecasts and compute forecast errors, if any. No recursive estimation is used.

Value

`coef`	Regression coefficients of the prediction equation
`yhat`	Predictions at the forecast origin
`MSE`	Mean squared errors, if available
`loadings`	Loading matrix
`DFindex`	Diffusion indices

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 6). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

tenstocks — *Monthly simple returns of ten U.S. stocks*

Description

Monthly simple returns of ten U.S. stocks. The sample period is from January 2001 to December 2011. Tick symbols of the ten stocks are used as column names for the returns.

Usage

```
tenstocks
```

Format

A 2-d list containing 132x11 observations.

Source

The original data were from Center for Research in Security Prices (CRSP) of the University of Chicago. The first column denotes the dates.

tfm — *Transfer Function Model*

Description

Estimates a transform function model. This program does not allow rational transfer function model. It is a special case of tfm1 and tfm2.

Usage

```
tfm(y, x, b = 0, s = 1, p = 0, q = 0)
```

Arguments

y	Data vector of dependent (output) variable
x	Data vector of independent variable
b	deadtime or delay
s	The order of the transfer function polynomial
p	AR order of the disturbance
q	MA order of the disturbance

Details

The model entertained is y_t = c_0+ v(B)x_t + n_t. v(B) = 1- v1*B - ... - vs*B^s, and n_t is an ARMA(p,q) process.

Value

`coef`	Coefficient estimates of the transfer function
`se.coef`	Standard errors of the transfer function coefficients
`coef.arma`	Coefficient estimates of ARMA models
`se.arma`	Standard errors of ARMA coefficients
`nt`	The disturbance series
`residuals`	The residual series

Author(s)

Ruey S. Tsay

References

Box, G. E. P., Jenkins, G. M., and Reinsel, G. C. (1994). Time Series Analysis: Forecasting and Control, 3rd edition, Prentice Hall, Englewood Cliffs, NJ.

`tfm1` *Transfer Function Model with One Input*

Description

Estimation of a general transfer function model. The model can only handle one input and one output.

Usage

```
tfm1(y, x, orderN, orderX)
```

Arguments

`y`	Data vector of dependent variable
`x`	Data vector of input (or independent) variable
`orderN`	Order (p,d,q) of the disturbance component
`orderX`	Order (r,s,b) of the transfer function model, where r and s are the degrees of denominator and numerator polynomials and b is the delay

Details

Perform estimation of a general transfer function model

Value

estimate	Coefficient estimates
sigma2	Residual variance sigma-square
residuals	Residual series
varcoef	Variance of the estimates
Nt	The disturbance series

Author(s)

Ruey S. Tsay

References

Box, G. E. P., Jenkins, G. M., and Reinsel, G. C. (1994). Time Series Analysis: Forecasting and Control, 3rd edition, Prentice Hall, Englewood Cliffs, NJ.

See Also

tfm

Examples

```
##da=read.table("gasfur.txt")
##y=da[,2]; x=da[,1]
##m1=tfm1(y,x,orderX=c(1,2,3),orderN=c(2,0,0))
```

---

tfm2 *Transfer Function Model with Two Input Variables*

Description

Estimation of a general transfer function model with two input variables. The model can handle one output and up-to 2 input variables. The time series noise can assume multiplicative seasonal ARMA models.

Usage

```
tfm2(y,x,x2=NULL,ct=NULL,wt=NULL,orderN=c(1,0,0),orderS=c(0,0,0),
sea=12,order1=c(0,1,0),order2=c(0,-1,0))
```

Arguments

y	Data vector of dependent variable
x	Data vector of the first input (or independent) variable
x2	Data vector of the second input variable if any
ct	Data vector of a given deterministic variable such as time trend, if any
wt	Data vector of co-integrated series between input and output variables if any
orderN	Order (p,d,q) of the regular ARMA part of the disturbance component
orderS	Order (P,D,Q) of the seasonal ARMA part of the disturbance component
sea	Seasonalityt, default is 12 for monthly data
order1	Order (r,s,b) of the transfer function model of the first input variable, where r and s are the degrees of denominator and numerator polynomials and b is the delay
order2	Order (r2,s2,b2) of the transfer function model of the second input variable, where 2r and s2 are the degrees of denominator and numerator polynomials and b2 is the delay

Details

Perform estimation of a general transfer function model with two input variables

Value

estimate	Coefficient estimates
sigma2	Residual variance sigma-square
residuals	Residual series
varcoef	Variance of the estimates
Nt	The disturbance series
rAR	Regulard AR coefficients
rMA	Regular MA coefficients
sAR	Seasonal AR coefficients
sMA	Seasonal MA coefficients
omega	Numerator coefficients of the first transfer function
delta	Denominator coefficiens of the first transfer function
omega2	Numerator coefficients of the 2nd transfer fucntion
delta2	Denominator coefficients of the 2nd transfer function

Author(s)

Ruey S. Tsay

References

Box, G. E. P., Jenkins, G. M., and Reinsel, G. C. (1994). Time Series Analysis: Forecasting and Control, 3rd edition, Prentice Hall, Englewood Cliffs, NJ.

See Also

tfm, tfm1

VAR — *Vector Autoregressive Model*

Description

Perform least squares estimation of a VAR model

Usage

```
VAR(x, p = 1, output = T, include.mean = T, fixed = NULL)
```

Arguments

`x`	A T-by-k matrix of k-dimensional time series
`p`	Order of VAR model. Default is 1.
`output`	A logical switch to control output. Default is with output.
`include.mean`	A logical switch. It is true if mean vector is estimated.
`fixed`	A logical matrix used in constrained estimation. It is used mainly in model simplifcation, e.g., removing insignificant estimates.

Details

To remove insignificant estimates, one specifies a threshold for individual t-ratio. The fixed matrix is then defined automatically to identify those parameters for removal.

Value

`data`	Observed data
`cnst`	A logical switch to include the mean constant vector
`order`	VAR order
`coef`	Coefficient matrix
`aic,bic,hq`	Information criteria of the fitted model
`residuals`	Residuals
`secoef`	Standard errors of the coefficients to be used in model refinement
`Sigma`	Residual covariance matrix
`Phi`	AR coefficient polynomial
`Ph0`	The constant vector

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 3). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

refVAR command

Examples

```
data("mts-examples",package="MTS")
gdp=log(qgdp[,3:5])
zt=diffM(gdp)
m1=VAR(zt,p=2)
```

VARMA *Vector Autoregressive Moving-Average Models*

Description

Performs conditional maximum likelihood estimation of a VARMA model. Multivariate Gaussian likelihood function is used.

Usage

```
VARMA(da, p = 0, q = 0, include.mean = T,
    fixed = NULL, beta=NULL, sebeta=NULL,
    prelim = F, details = F, thres = 2)
```

Arguments

`da`	Data matrix (T-by-k) of a k-dimensional time series with sample size T.
`p`	AR order
`q`	MA order
`include.mean`	A logical switch to control estimation of the mean vector. Dafault is to include the mean in estimation.
`fixed`	A logical matrix to control zero coefficients in estimation. It is mainly used by the command refVARMA.
`beta`	Parameter estimates to be used in model simplification, if needed
`sebeta`	Standard errors of parameter estimates for use in model simplification
`prelim`	A logical switch to control preliminary estimation. Deafult is none.
`details`	A logical switch to control the amount of output.
`thres`	A threshold used to set zero parameter constraints based on individual t-ratio. Default is 2.

Details

The fixed command is used for model refinement

Value

data	Observed data matrix
ARorder	VAR order
MAorder	VMA order
cnst	A logical switch to include the mean vector
coef	Parameter estimates
secoef	Standard errors of the estimates
residuals	Residual matrix
Sigma	Residual covariance matrix
aic,bic	Information criteria of the fitted model
Phi	VAR coefficients
Theta	VMA coefficients
Ph0	The constant vector

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 3). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

refVARMA

Examples

```
phi=matrix(c(0.2,-0.6,0.3,1.1),2,2); theta=matrix(c(-0.5,0,0,-0.5),2,2)
sigma=diag(2)
m1=VARMAsim(300,arlags=c(1),malags=c(1),phi=phi,theta=theta,sigma=sigma)
zt=m1$series
m2=VARMA(zt,p=1,q=1,include.mean=FALSE)
```

`VARMAcov` *Autocovariance Matrices of a VARMA Model*

Description

Uses psi-weights to compute the autocovariance matrices of a VARMA model

Usage

```
VARMAcov(Phi = NULL, Theta = NULL, Sigma = NULL, lag = 12, trun = 120)
```

Arguments

`Phi`	A k-by-kp matrix consisting of VAR coefficient matrices, Phi = [Phi1, Phi2, ..., Phip].
`Theta`	A k-by-kq matrix consisting of VMA coefficient magrices, Theta = [Theta1, Theta2, ..., Thetaq]
`Sigma`	Covariance matrix of the innovations (k-by-k).
`lag`	Number of cross-covariance matrices to be computed. Default is 12.
`trun`	The lags of pis-weights used in calculation. Default is 120.

Details

Use psi-weight matrices to compute approximate autocovariance matrices of a VARMA model.

Value

`autocov`	Autocovariance matrices
`ccm`	Auto correlation matrices

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 3). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

Examples

```
Phi=matrix(c(0.2,-0.6,0.3,1.1),2,2)
Sig=matrix(c(4,1,1,1),2,2)
VARMAcov(Phi=Phi,Sigma=Sig)
```

VARMACpp *Vector Autoregressive Moving-Average Models (Cpp)*

Description

Performs conditional maximum likelihood estimation of a VARMA model. Multivariate Gaussian likelihood function is used. This is the same function as VARMA, with the likelihood function implemented in C++ for efficiency.

Usage

```
VARMACpp(da, p = 0, q = 0, include.mean = T,
    fixed = NULL, beta=NULL, sebeta=NULL,
    prelim = F, details = F, thres = 2)
```

Arguments

da	Data matrix (T-by-k) of a k-dimensional time series with sample size T.
p	AR order
q	MA order
include.mean	A logical switch to control estimation of the mean vector. Dafault is to include the mean in estimation.
fixed	A logical matrix to control zero coefficients in estimation. It is mainly used by the command refVARMA.
beta	Parameter estimates to be used in model simplification, if needed
sebeta	Standard errors of parameter estimates for use in model simplification
prelim	A logical switch to control preliminary estimation. Deafult is none.
details	A logical switch to control the amount of output.
thres	A threshold used to set zero parameter constraints based on individual t-ratio. Default is 2.

Details

The fixed command is used for model refinement

Value

data	Observed data matrix
ARorder	VAR order
MAorder	VMA order
cnst	A logical switch to include the mean vector
coef	Parameter estimates
secoef	Standard errors of the estimates

residuals	Residual matrix
Sigma	Residual covariance matrix
aic,bic	Information criteria of the fitted model
Phi	VAR coefficients
Theta	VMA coefficients
Ph0	The constant vector

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 3). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

VARMA

Examples

```
phi=matrix(c(0.2,-0.6,0.3,1.1),2,2); theta=matrix(c(-0.5,0,0,-0.5),2,2)
sigma=diag(2)
m1=VARMAsim(300,arlags=c(1),malags=c(1),phi=phi,theta=theta,sigma=sigma)
zt=m1$series
m2=VARMA(zt,p=1,q=1,include.mean=FALSE)
```

VARMAirf *Impulse Response Functions of a VARMA Model*

Description

Compute and plot the impulse response function of a given VARMA model

Usage

```
VARMAirf(Phi = NULL, Theta = NULL, Sigma = NULL, lag = 12, orth = TRUE)
```

Arguments

Phi	A k-by-kp matrix of VAR coefficients in the form Phi=[Phi1, Phi2, ..., Phip].
Theta	A k-by-kq matrix of VMA coefficients in the form Theta=[Theta1, Theta2, ..., Thetaq]
Sigma	Covariance matrix (k-by-k) of the innovations.
lag	Number of lags of impulse response functions to be computed
orth	A logical switch to use orthogonal innovations. Deafult is to perform orthogonalization of the innovations.

Value

`psi`	The Psi-weight matrices
`irf`	Impulse response functions

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 3). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

VARMApsi command

Examples

```
p1=matrix(c(0.2,-0.6,0.3,1.1),2,2)
th1=matrix(c(-0.5,0.2,0.0,-0.6),2,2)
Sig=matrix(c(4,1,1,1),2,2)
m1=VARMAirf(Phi=p1,Theta=th1,Sigma=Sig)
```

`VARMApred` *VARMA Prediction*

Description

Compute forecasts and their associate forecast error covariances of a VARMA model

Usage

```
VARMApred(model, h = 1, orig = 0)
```

Arguments

`model`	A fitted VARMA model
`h`	Number of steps of frecasts, i.e., forecast horizon.
`orig`	Forecast origin. Default is the end of the sample.

Value

`pred`	Predictions
`se.err`	Standard errors of forecasts
`orig`	Forecast origin

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 3). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

VARMAsim *Generating a VARMA Process*

Description

Performs simulation of a given VARMA model

Usage

```
VARMAsim(nobs, arlags = NULL, malags = NULL,
  cnst = NULL, phi = NULL, theta = NULL,
  skip = 200, sigma)
```

Arguments

`nobs`	Sample size
`arlags`	The exact lags of the VAR matrix polynomial.
`malags`	The exact lags of the VMA matrix polynomial.
`cnst`	Constant vector, Phi0
`phi`	Matrix of VAR coefficient matrices in the order of the given arlags.
`theta`	Matrix of VMA coefficient matrices in the order of the given malags.
`skip`	The number of initial data to be omitted. Deafult is 200.
`sigma`	Covariance matrix (k-by-k, positive definite) of the innovations

Details

Use multivariate Gaussian distribution to generate random shocks. Then, generate a given VARMA model. The first skip data points were discarded.

Value

`series`	Generated series
`noises`	The noise series

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 3). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

Examples

```
p1=matrix(c(0.2,-0.6,0.3,1,1),2,2)
sig=matrix(c(4,0.8,0.8,1),2,2)
th1=matrix(c(-0.5,0,0,-0.6),2,2)
m1=VARMAsim(300,arlags=c(1),malags=c(1),phi=p1,theta=th1,sigma=sig)
zt=m1$series
```

`VARorder` *VAR Order Specification*

Description

Computes information criteria and the sequential Chi-square statistics for a vector autoregressive process

Usage

```
VARorder(x, maxp = 13, output = T)
```

Arguments

`x`	Data matrix of dimension T-by-k with T being the sample size and k the number of time series
`maxp`	The maximum VAR order entertained. Default is 13.
`output`	A logical switch to control the output. Default is to provide output

Details

For a given maxp, the command computes Akaike, Bayesin and Hannan-Quinn informtation criteria for various VAR models using the data from t=maxp+1 to T. It also computes the Tiao-Box sequential Chi-square statistics and their p-values.

Value

`aic`	Akaike information criterion
`bic`	Bayesian information criterion
`hq`	Hannan and Quinn information criterion
`aicor, bicor, hqor`	Orders slected by various criteria
`Mstat`	Chi-square test statistics
`Mpv`	p-values of the Mstat

Author(s)

Ruey S. Tsay

References

Tsay (2014). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

VARorderI

Examples

```
data("mts-examples",package="MTS")
zt=diffM(log(qgdp[,3:5]))
VARorder(zt,maxp=8)
```

VARorderI *VAR order specification I*

Description

This program is similar to VARorder, but it uses observations from t=p+1 to T to compute the information criteria for a given VAR(p) model.

Usage

```
VARorderI(x, maxp = 13, output = T)
```

Arguments

x	A T-by-k data matrix of vector time series
maxp	The maximum VAR order entertained
output	A logical switch to control output

Details

For a given VAR(p) model, the program uses observations from t=p+1 to T to compute the information criteria. Therefore, different numbers of data points are used to estimate different VAR models.

Value

`aic`	Akaike information criterion
`aicor`	Order selected by AIC
`bic`	Bayesian information criterion
`bicor`	Order selected by BIC
`hq`	Hannan and Quinn information criterion
`hqor`	Order selected by hq
`Mstat`	Step-wise Chi-square statistics
`Mpv`	p-values of the M-statistics

Author(s)

Ruey S Tsay

References

Tsay (2014)

See Also

VARorder

`VARpred` *VAR Prediction*

Description

Computes the forecasts of a VAR model, the associated standard errors of forecasts and the mean squared errors of forecasts

Usage

```
VARpred(model, h = 1, orig = 0, Out.level = F)
```

Arguments

`model`	An output object of a VAR or refVAR command
`h`	Forecast horizon, a positive integer
`orig`	Forecast origin. Default is zero meaning the forecast origin is the last data point
`Out.level`	A logical switch to control output

Details

Computes point forecasts and the associated variances of forecast errors

Value

`pred`	Point predictions
`se.err`	Standard errors of the predictions
`mse`	Mean-square errors of the predictions

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 2). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

Examples

```
data("mts-examples",package="MTS")
gdp=log(qgdp[,3:5])
zt=diffM(gdp)
m1=VAR(zt,p=2)
VARpred(m1,4)
```

`VARpsi` *VAR Psi-weights*

Description

Computes the psi-weight matrices of a VAR model

Usage

```
VARpsi(Phi, lag = 5)
```

Arguments

`Phi`	A k-by-kp matrix of VAR coefficients in the form Phi=[Phi1, Phi2, ..., Phip]
`lag`	Number of psi-weight lags

Value

Psi-weights of a VAR model

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 2). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

Examples

```
p1=matrix(c(0.2,-0.6,0.3,1.1),2,2)
m1=VARpsi(p1,4)
names(m1)
```

`VARs` *VAR Model with Selected Lags*

Description

This is a modified version of VAR command by allowing the users to specify which AR lags to be included in the model.

Usage

```
VARs(x, lags, include.mean = T, output = T, fixed = NULL)
```

Arguments

`x`	A T-by-k data matrix of k-dimensional time series with T observations
`lags`	A vector of non-zero AR lags. For instance, lags=c(1,3) denotes a VAR(3) model with Phi2 = 0.
`include.mean`	A logical switch to include the mean vector
`output`	A logical switch to control output
`fixed`	A logical matrix to fix parameters to zero.

Details

Performs VAR estimation by allowing certain lag coefficient matrices being zero.

Value

`data`	Observed time series data
`lags`	The selected VAR lags
`order`	The VAR order
`cnst`	A logical switch to include the mean vector
`coef`	Parameter estimates
`aic,bic`	Information criteria of the fitted model
`residuals`	Residual series

secoef	Standard errors of the estimates
Sigma	Residual covariance matrix
Phi	VAR coefficient matrix
Ph0	A constant vector

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 2). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

VAR command

Examples

```
data("mts-examples",package="MTS")
zt=log(qgdp[,3:5])
m1=VARs(zt,lags=c(1,2,4))
```

VARX *VAR Model with Exogenous Variables*

Description

Estimation of a VARX model

Usage

```
VARX(zt, p, xt = NULL, m = 0, include.mean = T, fixed = NULL, output = T)
```

Arguments

zt	A T-by-k data matrix of a k-dimensional time series
p	The VAR order
xt	A T-by-kx data matrix of kx exogenous variables
m	The number of lags of exogenous variables
include.mean	A logical switch to include the constant vector. Default is to include the constant.
fixed	A logical matrix for setting parameters to zero.
output	A logical switch to control output

Details

Performs least squares estimation of a VARX(p,s) model

Value

`data`	The observed time series
`xt`	The data matrix of explanatory variables
`aror`	VAR order
`m`	The number of lags of explanatory variables used
`Ph0`	The constant vector
`Phi`	VAR coefficient matrix
`beta`	The regression coefficient matrix
`residuals`	Residual series
`coef`	The parameter estimates to be used in model simplification
`se.coef`	Standard errors of the parameter estimates
`include.mean`	A logical switch to include the mean vector

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 6). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

`VARXorder` *VARX Order Specification*

Description

Specifies the orders of a VARX model, including AR order and the number of lags of exogenous variables

Usage

```
VARXorder(x, exog, maxp = 13, maxm = 3, output = T)
```

Arguments

`x`	A T-by-k data matrix of a k-dimensional time series
`exog`	A T-by-v data matrix of exogenous variables
`maxp`	The maximum VAR order entertained
`maxm`	The maximum lags of exogenous variables entertained
`output`	A logical switch to control output

Details

Computes the information criteria of a VARX process

Value

aic	Akaike information criterion
aicor	Order selected by AIC
bic	Bayesian information ctierion
bicor	Order selected by BIC
hq	Hannan and Quinn information criterion
hqor	Order selected by hq

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 6). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

VARXpred *VARX Model Prediction*

Description

Computes point forecasts of a VARX model. The values of exogenous variables must be given.

Usage

```
VARXpred(m1, newxt = NULL, hstep = 1, orig = 0)
```

Arguments

m1	An output object of VARX or refVARX command
newxt	The data matrix of exogenous variables needed in forecasts.
hstep	Forecast horizon
orig	Forecast origin. Default is 0, meaning the last data point.

Details

Uses the provided exogenous variables and the model to compute forecasts

Value

Point forecasts and their standard errors

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 6). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

Vech — *Half-Stacking Vector of a Symmetrix Matrix*

Description

Obtain the half-stacking vector of a symmetric matrix

Usage

```
Vech(mtx)
```

Arguments

mtx	A symmetric matrix

Details

Stacking a matrix into a vector using data on and below the diagonal.

Value

a vector consisting of stacked elements of a symmetric matrix

Author(s)

Ruey S. Tsay

Examples

```
m1=matrix(c(1:9),3,3)
m2=(m1+t(m1))/2
v1=Vech(m2)
```

`VechM` *Matrix constructed from output of the Vech Command. In other words, restore the original symmetric matrix from its half-stacking vector.*

Description

Restores the symmetric matrix from the Vech command

Usage

```
VechM(vec)
```

Arguments

`vec`	A vector representing the half-stacking of a symmetric matrix

Details

This command re-construct a symmetric matrix from output of the Vech command

Value

A symmetric matrix

Author(s)

Ruey S. Tsay

References

Tsay (2014, Appendix A)

See Also

Vech

Examples

```
v1=c(2,1,3)
m1=VechM(v1)
m1
```

VMA *Vector Moving Averge Model*

Description

Performs VMA estimation using the conditional multivariate Gaussian likelihood function

Usage

```
VMA(da, q = 1, include.mean = T, fixed = NULL,
    beta=NULL, sebeta=NULL, prelim = F,
    details = F, thres = 2)
```

Arguments

`da`	Data matrix of a k-dimensional VMA process with each column containing one time series
`q`	The order of VMA model
`include.mean`	A logical switch to include the mean vector. The default is to include the mean vector in estimation.
`fixed`	A logical matrix used to fix parameter to zero
`beta`	Parameter estimates for use in model simplification
`sebeta`	Standard errors of parameter estimates for use in model simplification
`prelim`	A logical switch to select parameters to be included in estimation
`details`	A logical switch to control the amount of output
`thres`	Threshold for t-ratio used to fix parameeter to zero. Deault is 2.

Value

`data`	The data of the observed time series
`MAorder`	The VMA order
`cnst`	A logical switch to include the mean vector
`coef`	Parameter estimates
`secoef`	Standard errors of the parameter estimates
`residuals`	Residual series
`Sigma`	Residual covariance matrix
`Theta`	The VAR coefficient matrix
`mu`	The constant vector
`aic,bic`	The information criteria of the fitted model

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 3).

Examples

```
theta=matrix(c(0.5,0.4,0,0.6),2,2); sigma=diag(2)
m1=VARMAsim(200,malags=c(1),theta=theta,sigma=sigma)
zt=m1$series
m2=VMA(zt,q=1,include.mean=FALSE)
```

VMACpp *Vector Moving Averge Model (Cpp)*

Description

Performs VMA estimation using the conditional multivariate Gaussian likelihood function. This is the same function as VMA, with the likelihood function implemented in C++ for efficiency.

Usage

```
VMACpp(da, q = 1, include.mean = T, fixed = NULL,
    beta=NULL, sebeta=NULL, prelim = F,
    details = F, thres = 2)
```

Arguments

`da`	Data matrix of a k-dimensional VMA process with each column containing one time series
`q`	The order of VMA model
`include.mean`	A logical switch to include the mean vector. The default is to include the mean vector in estimation.
`fixed`	A logical matrix used to fix parameter to zero
`beta`	Parameter estimates for use in model simplification
`sebeta`	Standard errors of parameter estimates for use in model simplification
`prelim`	A logical switch to select parameters to be included in estimation
`details`	A logical switch to control the amount of output
`thres`	Threshold for t-ratio used to fix parameeter to zero. Deault is 2.

Value

data	The data of the observed time series
MAorder	The VMA order
cnst	A logical switch to include the mean vector
coef	Parameter estimates
secoef	Standard errors of the parameter estimates
residuals	Residual series
Sigma	Residual covariance matrix
Theta	The VAR coefficient matrix
mu	The constant vector
aic,bic	The information criteria of the fitted model

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 3).

See Also

VMA

Examples

```
theta=matrix(c(0.5,0.4,0,0.6),2,2); sigma=diag(2)
m1=VARMAsim(200,malags=c(1),theta=theta,sigma=sigma)
zt=m1$series
m2=VMACpp(zt,q=1,include.mean=FALSE)
```

VMAe *VMA Estimation with Exact likelihood*

Description

Estimation of a VMA(q) model using the exact likelihood method. Multivariate Gaussian likelihood function is used.

Usage

```
VMAe(da, q = 1, include.mean = T, coef0 = NULL,
    secoef0 = NULL, fixed = NULL, prelim = F,
    details = F, thres = 2)
```

Arguments

`da`	Data matrix (T-by-k) for a k-dimensional VMA process
`q`	The order of a VMA model
`include.mean`	A logicak switch to include the mean vector in estimation. Default is to include the mean vector.
`coef0`	Initial estimates of the coefficients used mainly in model refinement
`secoef0`	Standard errors of the initial estimates
`fixed`	A logical matrix to put zero parameter constraints
`prelim`	A logical switch for preliminary estimation
`details`	A logical switch to control output in estimation
`thres`	The threshold value for zero parameter constraints

Value

`data`	The observed time series
`MAorder`	The VMA order
`cnst`	A logical switch to inlcude the mean vector
`coef`	Parameter estimayes
`secoef`	Standard errors of parameter estimates
`residuals`	Residual series
`Sigma`	Residual covariance matrix
`Theta`	VMA coefficient matrix
`mu`	The mean vector
`aic,bic`	The information criteria of the fitted model

Author(s)

Ruey S. Tsay

References

Tsay (2014). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

VMA

`VMAorder` *VMA Order Specification*

Description

Performs multivariate Ljung-Box tests to specify the order of a VMA process

Usage

```
VMAorder(x, lag = 20)
```

Arguments

`x`	Data matrix of the observed k-dimensional time series. Each column represents a time series.
`lag`	The maximum VMA order entertained. Default is 20.

Details

For a given lag, the command computes the Ljung-Box statistic for testing rho_j = ... = rho_lag = 0, where j = 1, 2, ..., lag. For a VMA(q) process, the Ljung-Box statistics should be significant for the first q lags, and insignificant thereafter.

Value

The Q-statistics and p-value plot

Author(s)

Ruey S. Tsay

References

Tsay (2014). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

Examples

```
zt=matrix(rnorm(600),200,3)
VMAorder(zt)
```

`VMAs` *VMA Model with Selected Lags*

Description

Performs the conditional maximum likelihood estimation of a VMA model with selected lags in the model

Usage

```
VMAs(da, malags, include.mean = T, fixed = NULL, prelim = F, details = F, thres = 2)
```

Arguments

`da`	A T-by-k matrix of a k-dimensional time series with T observations
`malags`	A vector consisting of non-zero MA lags
`include.mean`	A logical switch to include the mean vector
`fixed`	A logical matrix to fix coefficients to zero
`prelim`	A logical switch concerning initial estimation
`details`	A logical switch to control output level
`thres`	A threshold value for setting coefficient estimates to zero

Details

A modified version of VMA model by allowing the user to select non-zero MA lags

Value

`data`	The observed time series
`MAlags`	The VMA lags
`cnst`	A logical switch to include the mean vector
`coef`	The parameter estimates
`secoef`	The standard errors of the estimates
`residuals`	Residual series
`aic,bic`	The information criteria of the fitted model
`Sigma`	Residual covariance matrix
`Theta`	The VMA matrix polynomial
`mu`	The mean vector
`MAorder`	The VMA order

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 3). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

VMA

`Vmiss` *VARMA Model with Missing Value*

Description

Assuming that the model is known, this program estimates the value of a missing data point. The whole data point is missing.

Usage

```
Vmiss(zt, piwgt, sigma, tmiss, cnst = NULL, output = T)
```

Arguments

`zt`	A T-by-k data matrix of a k-dimensional time series
`piwgt`	The pi-weights of a VARMA model defined as piwgt=[pi0, pi1, pi2, ...]
`sigma`	Positive definite covariance matrix of the innovations
`tmiss`	Time index of the missing data point
`cnst`	Constant term of the model
`output`	A logical switch to control output

Details

Use the least squares method to estimate a missing data point. The missing is random.

Value

Estimates of the missing values

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 6). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

Vpmiss

Examples

```
data("mts-examples",package="MTS")
gdp=log(qgdp[,3:5])
m1=VAR(gdp,3)
piwgt=m1$Phi; Sig=m1$Sigma; cnst=m1$Ph0
m2=Vmiss(gdp,piwgt,Sig,50,cnst)
```

Vpmiss *Partial Missing Value of a VARMA Series*

Description

Assuming that the data is only partially missing, this program estimates those missing values. The model is assumed to be known.

Usage

```
Vpmiss(zt, piwgt, sigma, tmiss, mdx, cnst = NULL, output = T)
```

Arguments

zt	A T-by-k data matrix of a k-dimensional time series
piwgt	pi-weights of the model in the form piwgt[pi0, pi1, pi2, ...]
sigma	Residual covariance matrix
tmiss	Time index of the partilly missing data point
mdx	A k-dimensional indicator with "0" denoting missing component and ""1" denoting observed value.
cnst	Constant term of the model
output	values of the partially missing data

Value

Estimates of the missing values

Author(s)

Ruey S. Tsay

References

Tsay (2014, Chapter 6). Multivariate Time Series Analysis with R and Financial Applications. John Wiley. Hoboken, NJ.

See Also

Vmiss

Examples

```
#data("mts-examples",package="MTS")
#gdp=log(qgdp[,3:5])
#m1=VAR(gdp,1)
#piwgt=m1$Phi; cnst=m1$Ph0; Sig=m1$Sigma
#mdx=c(0,1,1)
#m2=Vpmiss(gdp,piwgt,Sig,50,mdx,cnst)
```

Index

∗Topic **datasets**
ibmspko, 22
qgdp, 38
tenstocks, 59

apca, 4
archTest, 5

BEKK11, 6
Btfm2, 7
BVAR, 8

ccm, 10
comVol, 11

dccFit, 12
dccPre, 13
diffM, 14

Eccm, 15
ECMvar, 16
ECMvar1, 17
EWMAvol, 18

FEVdec, 19

GrangerTest, 20

hfactor, 21

ibmspko, 22

Kronfit, 23
Kronid, 24
Kronspec, 25

Lminv *(MTS-internal)*, 33

MarchTest, 26
MCHdiag, 28
MCholV, 29
mFilter *(MTS-internal)*, 33
Mlm, 30
mq, 30
msqrt, 31
mtCopula, 32
MTS *(MTS-package)*, 4
MTS-internal, 33
MTS-package, 4
MTSdiag, 33
MTSplot, 34
Mtxprod, 35
Mtxprod1, 35

PIwgt, 36
PSIwgt, 37

qgdp, 38

refECMvar, 38
refECMvar1, 39
refKronfit, 40
refREGts, 41
refSCMfit, 41
refsVARMA, 42
refVAR, 43
refVARMA, 44
refVARs *(MTS-internal)*, 33
refVARX, 45
refVMA, 46
refVMAe, 47
refVMAs *(MTS-internal)*, 33
REGts, 48
revmq *(MTS-internal)*, 33
RLS, 49

SCCor, 50
SCMfit, 51
SCMid, 52
SCMid2, 53
SCMmod, 54
sVARMA, 55

sVARMACpp, 56
SWfore, 58

tenstocks, 59
tfm, 59
tfm1, 60
tfm2, 61

VAR, 63
VARchi *(*MTS-internal*)*, 33
VARecm *(*MTS-internal*)*, 33
VARfore *(*MTS-internal*)*, 33
VARirf *(*MTS-internal*)*, 33
VARMA, 64
VARMAcov, 66
VARMACpp, 67
VARMAirf, 68
VARMApred, 69
VARMAsim, 70
VARorder, 71
VARorderI, 72
VARpred, 73
VARpsi, 74
VARs, 75
VARX, 76
VARXorder, 77
VARXpred, 78
Vech, 79
VechM, 80
VMA, 81
VMACpp, 82
VMAe, 83
VMAorder, 85
VMApred *(*MTS-internal*)*, 33
VMAs, 86
Vmiss, 87
Vpmiss, 88