

# Package ‘sym.arma’

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**Title** Autoregressive and Moving Average Symmetric Models

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**Description** Functions for fitting the Autoregressive and Moving Average Symmetric Model for univariate time series introduced by Maior and Cysneiros (2018), <[doi:10.1007/s00362-016-0753-z](https://doi.org/10.1007/s00362-016-0753-z)>. Fitting method: conditional maximum likelihood estimation. For details see: Wei (2006), Time Series Analysis: Univariate and Multivariate Methods, Section 7.2.

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sym.arma-package

*Autoregressive and Moving Average Symmetric Models*

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## Description

This package provides a set of functions to fitting of autoregressive and moving average symmetric models.

## Details

Package: sym.arma

Type: Package

Version: 1.0

Date: 2018-09-23

License: GPL-2

## Author(s)

Vinicius Quintas Souto Maior and Francisco Jose A. Cysneiros

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## References

Maior, V. Q. S. and Cysneiros, F. J. A. (2018). SYMARMA: a new dynamic model for temporal data on conditional symmetric distribution. *Statistical Paper*, **59**, 75-97. doi: [10.1007/s00362-016-0753-z](https://doi.org/10.1007/s00362-016-0753-z).

Wei, W. W. S. (2006). *Time Series Analysis: Univariate and Multivariate Methods*, 2nd edition. Pearson Addison Wesley. Section 7.2.1.

Efron, B. and Tibshirani, R. (1993). *An Introduction to the Bootstrap*. Chapman and Hall, New York, London.

Thode, Henry C. (2002). *Testing for normality*, New York: Marcel Dekker.

Cook, R.D. (1986). Assessment of local influence (with discussion). *Journal of the Royal Statistical Society*, **B 48**, 133-169.

## Examples

```
library(sym.arma)
data(assets)
fit <- elliptical.ts(assets$msf[2122:2240], order=c(1,0,0), trace=TRUE)
qqplot(fit, envelope=FALSE)
```

---

assets	<i>Returns of the daily closing prices of assets, Standard and Poors 500 Index and T-bill rates</i>
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**Description**

Returns for all the trading days from November 1, 1993 to April 3, 2003.

**Usage**

```
data("assets")
```

**Format**

A data frame with 2363 observations on the following 8 variables.

tbill a vector of returns of the T-bill rates for the trading days.

msf a vector of returns of the daily closing prices of Microsoft Corporation.

sp500 a vector of returns of the Standard and Poors 500 index for the trading days.

ge a vector of returns of the daily closing prices of General Electric Company.

ford a vector of returns of the daily closing prices of Ford Industries Inc.

day day of trading.

month month of trading.

year year of trading.

**References**

Ruppert, D (2004) *Statistics and Finance*. Springer, New York.

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

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clr.test	<i>Conditional Likelihood Ratio Test</i>
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**Description**

Likelihood ratio test for objects of class SYMARMA.

**Usage**

```
clr.test(model1, model2)
```

**Arguments**

model1, model2 two models of class SYMARMA having the same set of records and the same type ("family").

## Details

Likelihood ratio test checks the difference between  $-2 \cdot \log \text{Likelihood}$  of the two models against the change in degrees of freedom using a chi-squared test. The records used in the dataset for both models MUST be the same.

## Author(s)

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## Examples

```
serie <- symarma.sim(model=list(ar=c(0.2,0.5)),n=70,family="Normal",
  varphi=1)
model0 <- elliptical.ts(serie,order=c(2,0,0))
model1 <- elliptical.ts(serie,order=c(1,0,0))
clr.test(model0,model1)
```

---

elliptical.ts

*Autoregressive and Moving Average Symmetric Models*

---

## Description

Fit an SYMARMA model to a univariate time series. Fitting method: conditional maximum likelihood estimation.

## Usage

```
elliptical.ts(Y, family="Normal", order=c(0,0,0), xreg=NULL,
  include.mean=TRUE, epsilon=0.0001, maxit=100, trace="TRUE",
  index1=NULL, index2=NULL, fixed=NULL)
```

## Arguments

Y	a univariate time series.
family	a description of the conditional distribution of each $Y[t]$ , given the set of past information. Symmetric distributions available for adjustment: Normal ( <i>Normal</i> ), Student- $t$ ( <i>Student</i> ), Generalized Student- $t$ ( <i>Gstudent</i> ), Exponential Power ( <i>ExpPower</i> ) (by Box & Tiao, 1973, ch 3), Logistic I ( <i>LogisticI</i> ), Logistic II ( <i>LogisticII</i> ), Generalized Logistic ( <i>Glogistic</i> ), Cauchy ( <i>Cauchy</i> ) and Contaminated Normal ( <i>Cnormal</i> ). The default is to normal distribution.
order	a specification of the SYMARMA model: the three integer components (p, d, q) are the AR order, the degree of differencing, and the MA order.
xreg	optionally, a vector or matrix of external regressors, which must have the same number of rows as $Y$ .

include.mean	should the SYMARMA model include a mean/intercept term? The default is TRUE.
epsilon	positive convergence tolerance $e$ ; the iterations converge when $ fit - fit\_old /fit < e$ . Default is $e=1e-04$ .
maxit	integer giving the maximal number of iterations. Default is 100 iterations.
trace	a logical indicating if output should be produced.
index1	The parameter to Student- $t$ and Exponential Power distributions or the first argument to Generalized Student- $t$ , Generalized Logistic and Contaminated Normal distributions.
index2	The second argument to Generalized Student- $t$ , Generalized Logistic ( $index2 = index2(index1)$ ) and Contaminated Normal distributions.
fixed	a optional numeric vector of the same length as the total number of parameters. If supplied, only NA entries in fixed will be varied.

### Details

Different definitions of autoregressive and moving average models have different signs for the AR and/or MA coefficients. The dynamic component in SYMARMA model used here has

$$Y[t] = X[t]Beta + phi[1](Y[t - 1] - X[t - 1]Beta) + \dots + phi[np](Y[t - np] - X[t - np]Beta) + theta[1]erro[t - 1] + \dots + theta[nq]erro[t - nq] + erro[t].$$

The estimation of the parameters that index the SYMARMA model is obtained by maximum conditional likelihood method on the first  $m$  observations, where  $m = \max(np, nq)$ .

The variance matrix of the estimates is found from the Hessian of the log-likelihood, and so may only be a rough guide.

### Value

A list of class "Symarma" with components:

coefficients	a vector of estimated AR, MA and regression coefficients.
dispersion	the estimated dispersion parameter.
resid.raw	the ordinary residuals.
resid.stand	the standardized residuals.
fitted.values	the fitted mean values.
loglik	the maximized log-likelihood.
aic	the AIC value corresponding to the log-likelihood.
bic	the BIC value corresponding to the log-likelihood.
rmse	the Root Mean Squared Error value corresponding to the adjusted model.
iter	the number of iterations used in the fitting.
n	the number of observations in the series.
sd.coef	a vector of estimated standard deviation of the coefficients.
sd.disp	estimated standard deviation of the dispersion parameter.
family	the family object used.
X	if requested, the vector or matrix of external regressors.

**Author(s)**

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**References**

Maior, V. Q. S. and Cysneiros, F. J. A. (2018). SYMARMA: a new dynamic model for temporal data on conditional symmetric distribution. *Statistical Paper*, **59**, 75-97. doi: [10.1007/s00362-016-0753-z](https://doi.org/10.1007/s00362-016-0753-z).

Wei, W. W. S. (2006). *Time Series Analysis: Univariate and Multivariate Methods*, 2nd edition. Pearson Addison Wesley. Section 7.2.1.

Box, M. J. and Tiao, G. C. (1973). *Bayesian inference in statistical analysis*. London: Addison-Wesley.

**Examples**

```
data(assets)
attach(assets)

# Return in the prices on Microsoft and SP500 index

N = length(msf)
.sp500 = ((sp500[2:N]-sp500[1:(N-1)])/sp500[1:(N-1)])*100
.msfc = ((msf[2:N]-msf[1:(N-1)])/msf[1:(N-1)])*100

# The T-bill rates were divided by 253 to convert to a daily rate

.tbill = tbill/253

# Excess return in the prices on Microsoft and SP500 index

Y = .msfc - .tbill[1:(N-1)]
X = .sp500 - .tbill[1:(N-1)]

# Period from April 4, 2002 to October 4, 2002

serie = Y[2122:2240]
aux = cbind(X[2122:2240])

# Returns best ARIMA model according to either AIC value.
# auto.arima(Y,xreg=aux,seasonal=FALSE,ic=c("aic"))

# Fit SYMARMA models

fit.1 = elliptical.ts(serie,order=c(0,0,1),xreg=aux,include.mean=FALSE,
  family="Normal")
fit.2 = elliptical.ts(serie,order=c(0,0,1),xreg=aux,include.mean=FALSE,
  family="Student", index1=4)
fit.3 = elliptical.ts(serie,order=c(3,0,1),xreg=aux,family="ExpPower",
  index1=0, fixed=c(0,0,NA,NA,NA,NA))
```

**Description**

This function discusses local influence analysis in SYMARMA models with Student- $t$  and Gaussian distributions through Billor and Loyne's slope, Cook's curvature and Lesaffre and Verbeke's curvature using the methodology of benchmarks proposed by Zhang and King. Although this function is concerned primarily with local influence, some discussion of assessing global influence is presented.

**Usage**

```
influence(model, diag="slope", scheme="additive", iter=2000,
  alpha=0.95, theta=0.05, plot="TRUE")
```

**Arguments**

model	a result of a call to <a href="#">elliptical.ts</a> .
diag	a description of the diagnostic method: "slope" for Billor and Loyne's, "cook" for Cook's and "lv" for Lesaffre and Verbeke's. The default is to <i>slope</i> .
scheme	a description of the perturbation scheme: "additive" for data additive perturbation and "dispersion" for dispersion parameter perturbation. The default is to <i>additive</i> .
iter	integer giving the number of iterations for construction of benchmarks. Default is 2,000 iterations.
alpha	percentile for benchmarks in assessing global influence ( <i>BS_0</i> and <i>BC_0</i> ) and first assessing local influence ( <i>BS_1</i> and <i>BC_1</i> ), e.g., 0.95.
theta	percentile for benchmarks in assessing global influence second assessing local influence ( <i>BS_2</i> and <i>BC_2</i> ), e.g., 0.05.
plot	a logical indicating if plot should be produced.

**Value**

Indiv1	individual benchmark type I.
Indiv2	individual benchmark type II.
VectorInd	slope or curvature vector.

**Author(s)**

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## References

- Cook, R.D. (1986). Assessment of local influence (with discussion). *Journal of the Royal Statistical Society*, **B 48**, 133-169.
- Billor, N. and Loynes, R.M. (1993). Local influence: A new approach. *Communications in Statistics Theory and Methods*, **22**, 1595-1611. doi: [10.1080/03610929308831105](https://doi.org/10.1080/03610929308831105).
- Lesaffre, F. and Verbeke, G. (1998). Local influence in linear mixed models. *Biometrics*, **38**, 963-974. doi: [10.2307/3109764](https://doi.org/10.2307/3109764).
- Zhang, X. and King, M.L. (2005). Influence diagnostics in generalized autoregressive conditional heteroscedasticity processes. *J. Business Econ. Statist.*, **23**, 118-129. doi: [10.1198/073500104000000217](https://doi.org/10.1198/073500104000000217).

## Examples

```

data(assets)
attach(assets)

# Return in the prices on Microsoft and SP500 index

N = length(msf)
.sp500 = ((sp500[2:N]-sp500[1:(N-1)])/sp500[1:(N-1)])*100
.msfc = ((msf[2:N]-msf[1:(N-1)])/msf[1:(N-1)])*100

# The T-bill rates were divided by 253 to convert to a daily rate

.tbill = tbill/253

# Excess return in the d prices on Microsoft and SP500 index

Y = .msfc - .tbill[1:(N-1)]
X = .sp500 - .tbill[1:(N-1)]

# Period from April 4, 2002 to October 4, 2002

serie = Y[2122:2240]
aux = cbind(X[2122:2240])

# Fit SYMARMA models

fit.1 = elliptical.ts(serie,order=c(0,0,1),xreg=aux,include.mean=FALSE,
  family="Normal")
fit.2 = elliptical.ts(serie,order=c(0,0,1),xreg=aux,include.mean=FALSE,
  family="Student", index1=4)

# Assessment of local influence

influence(fit.1,diag="slope",scheme="additive",iter=20,plot="FALSE")
influence(fit.2,diag="lv",scheme="additive",iter=20,plot="FALSE")

```



---

predict                      *Forecasts from a fitted SYMARMA model*

---

### Description

See *Maior and Cysneiros (2018)* for details on this function.

### Usage

```
predict(model, h, xreg = NULL)
```

### Arguments

model	a result of a call to <a href="#">elliptical.ts</a> .
h	number of periods for forecasting. If xreg is used, h is ignored and the number of forecast periods is set to the number of rows of xreg.
xreg	future values of an regression variables.

### Value

pred	predicted values.
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### Author(s)

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### References

Brockwell, P. J. and Davis, R. A. (1991). *Time Series and Forecasting Methods*. Second edition. Springer, New York. Section 11.4.

Brockwell, P. J. and Davis, R. A. (1996). *Introduction to Time Series and Forecasting*. Springer, New York. Sections 5.1 and 7.6.

Maior, V. Q. S. and Cysneiros, F. J. A. (2018). SYMARMA: a new dynamic model for temporal data on conditional symmetric distribution. *Statistical Paper*, **59**, 75-97. doi: [10.1007/s00362-016-0753-z](https://doi.org/10.1007/s00362-016-0753-z).

### Examples

```
data(assets)
attach(assets)

# Return in the prices on Microsoft and SP500 index

N = length(msf)
.sp500 = ((sp500[2:N]-sp500[1:(N-1)])/sp500[1:(N-1)])*100
.msfc = ((msf[2:N]-msf[1:(N-1)])/msf[1:(N-1)])*100
```

```
# The T-bill rates were divided by 253 to convert to a daily rate
.tbill = tbill/253

# Excess return in the d prices on Microsoft and SP500 index

Y = .msf - .tbill[1:(N-1)]
X = .sp500 - .tbill[1:(N-1)]

# Period from April 4, 2002 to October 4, 2002

serie = Y[2122:2240]
aux = cbind(X[2122:2240])

# Fit SYMARMA models

fit.1 = elliptical.ts(serie,order=c(0,0,1),include.mean=FALSE,
  family="Normal")

# Forecasts

predict(fit.1, h=10)
```

---

qqplot

*Quantile-Quantile Plots*

---

### Description

This function produces Q-Q plot with envelopes for a time series following conditional symmetric distribution.

### Usage

```
qqplot(model, envelope = 0.95 , B = 400)
```

### Arguments

model	a result of a call to <a href="#">elliptical.ts</a> .
envelope	confidence level for point-wise confidence envelope, or FALSE for no envelope.
B	integer; number of bootstrap replications for confidence envelope. Default is 400 iterations.

### Author(s)

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## References

- Cleveland, W.S. (1994). *The Elements of Graphing Data*, Hobart Press.
- Thode, Henry C. (2002). *Testing for normality*, New York: Marcel Dekker.

## Examples

```

data(assets)
attach(assets)

# Return in the prices on Microsoft and SP500 index

N = length(msf)
.sp500 = ((sp500[2:N]-sp500[1:(N-1)])/sp500[1:(N-1)])*100
.msfc = ((msf[2:N]-msf[1:(N-1)])/msf[1:(N-1)])*100

# The T-bill rates were divided by 253 to convert to a daily rate

.tbill = tbill/253

# Excess return in the d prices on Microsoft and SP500 index

Y = .msfc - .tbill[1:(N-1)]
X = .sp500 - .tbill[1:(N-1)]

# Period from April 4, 2002 to October 4, 2002

serie = Y[2122:2240]
aux = cbind(X[2122:2240])

# Fit SYMARMA models

fit.1 = elliptical.ts(serie,order=c(0,0,1),xreg=aux,include.mean=FALSE,
  family="Normal")
fit.2 = elliptical.ts(serie,order=c(0,0,1),xreg=aux,include.mean=FALSE,
  family="Student",index1=4)

# Q-Q Plots

qqplot(fit.1, B = 50)
qqplot(fit.2, envelope = FALSE)

```

---

symarma.sim

*Simulate from an SYMARMA model*

---

## Description

Simulate from an SYMARMA model.

**Usage**

```
symarma.sim(model, n, family="Normal", index1, index2, varphi=1)
```

**Arguments**

model	a list with component ar and/or ma giving the AR and MA coefficients respectively. Optionally a component order can be used. An empty list gives an SYMARMA(0,0) model, that is white noise.
n	length of output series, before un-differencing. A strictly positive integer.
family	a description of the conditional distribution of each $Y[t]$ , given the set of past information.
index1, index2	the arguments of the symmetric distributions indexed by parameters.
varphi	the dispersion parameter of the innovations generated. Default is varphi=1.

**Details**

See [elliptical.ts](#) for the precise definition of an SYMARMA model.

The SYMARMA model is checked for stationarity.

SYMARMA models are specified via the *order* component of *model*, in the same way as for [elliptical.ts](#). Other aspects of the *order* component are ignored, but inconsistent specifications of the MA and AR orders are detected. The un-differencing assumes previous values of zero, and to remind the user of this, those values are returned.

**Value**

A time-series object of class "ts".

**See Also**

[elliptical.ts](#) and [arma.sim](#)

**Examples**

```
serie0 <- symarma.sim(model=list(ar=c(0.3,0.2),ma=c(0.34)),n=70,
  varphi=1)
serie1 <- symarma.sim(model=list(ar=c(0,0,0.65)),n=70,family="Student",
  index1 = 4,varphi=1)
```

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