Package 'GARCH.X'

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Title Estimation and Exogenous Covariate Selection for GARCH-X Models

Version 1.0

Description Estimates the parameters of a GARCH-
X model with exogenous covariates, performs hypothesis tests for the parameters returning the p-
values, and uses False Discovery Rate p-value corrections to select the exogenous variables.

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Imports GA, GenSA, pso, stats

NeedsCompilation no

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Contents

AIC   *AIC for GARCHX model*

Description

Calculates the Akaike Information Criterion for GARCHX model

Usage

```
AIC(model)
```

Arguments

model   GARCHX object

Value

AIC of GARCHX model

Examples

```
set.seed(123)
pi <- c(1, 0, 0, 4)
n <- 2000
d <- length(pi)
valinit <- 100
n2 <- n + d + 1
omega <- 0.1
alpha <- 0.2
beta <- 0.3
delta <- 2
e<-rnorm(n2+valinit)
Y<-e
for (t in 2:n2)
 Y[t]<- 0.2*Y[t-1]+e[t]
x<-exp(Y)
X <- matrix(0, nrow = (n+valinit), ncol = length(pi))
for(j in 1:d)
 X[, j] <- x[(d+2-j):(n+d+1-j+valinit)]
data <- GARCH.X::simulate(n, omega, alpha, beta, delta, X, pi, valinit = valinit)
model <- GARCHX_select(eps = data$eps, X = data$X)
AIC_value <- AIC(model)
```

BIC	*BIC for GARCHX model*

Description

Calculates the Bayesian Information Criterion of the GARCHX model

Usage

```
BIC(model)
```

Arguments

model   GARCHX object

Value

BIC of GARCHX model

Examples

```
set.seed(123)
pi <- c(1, 0, 0, 4)
n <- 2000
d <- length(pi)
valinit <- 100
n2 <- n + d + 1
omega <- 0.1
alpha <- 0.2
beta <- 0.3
delta <- 2
e<-rnorm(n2+valinit)
Y<-e
for (t in 2:n2)
 Y[t]<- 0.2*Y[t-1]+e[t]
x<-exp(Y)
X <- matrix(0, nrow = (n+valinit), ncol = length(pi))
for(j in 1:d)
 X[, j] <- x[(d+2-j):(n+d+1-j+valinit)]
data <- GARCH.X::simulate(n, omega, alpha, beta, delta, X, pi, valinit = valinit)
model <- GARCHX_select(eps = data$eps, X = data$X)
BIC_value <- BIC(model)
```

GARCHX   *Fitting GARCHX model for variable selection*

Description

Fits a GARCHX model with given data and estimates the coefficients for omega, alpha, beta, and pi

Usage

```
GARCHX(
  eps,
  X,
  order = c(1, 1),
  delta = 2,
  optim.method = "NR"
)
```

Arguments

eps	Time series
X	Matrix with exogenous covariates where the number of rows is equal to the length of eps
order	Order of the GARCH model. Value of p cannot be 0
delta	Value of the power of the main time series to allow for Power GARCHX, default is 2 for GARCHX
optim.method	Optimization method for maximizing quasi-likelihood function. Options: "NR", "L-BFGS-B", "GA", "PS", "SA". Default value is "NR"

Details

Uses the GARCHX model

$$\mathcal{E}_t = \sigma_t w_t$$

$$\sigma_t^2 = \omega_0 + \sum_{i=1}^{p} \alpha_i \mathcal{E}_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 + \pi^T \mathbf{x}_{t-1}$$

To estimate the coefficients for

$$\omega, \alpha, \beta, \pi$$

. No variable selection is done in this function.

Value

An object of class GARCHX

GARCHX_select   *Variable selection for exogenous covariates in GARCHX models*

Description

Performs variable selection on the exogenous covariates through testing each covariate in X and correcting the p-values for multiple testing.

Usage

```
GARCHX_select(
  eps,
  X,
  order = c(1, 1),
  delta = 2,
  alpha.level = 0.05,
  adjust.method = "fdr",
  optim.method = "NR"
)
```

Arguments

eps	Time series data
X	Matrix with exogenous covariates where the number of rows is equal to the length of eps
order	Order of the GARCH model. Value of p cannot be 0.
delta	Value of the power of the main time series to allow for Power GARCHX, default is 2 for GARCHX
alpha.level	Alpha level for p-value cut-off in variable selection
adjust.method	Multiple testing p-value adjustment, see p.adjust. Possible values are "holm", "hochberg", "hommel", "bonferonni", "BH", "BY", "fdr", "none"
optim.method	Optimization method for maximizing quasi-likelihood function. Options: "NR", "L-BFGS-B", "GA", "PS", "SA". Default value is "NR"

Details

Using the GARCHX model

$$\mathcal{E}_t = \sigma_t w_t$$

$$\sigma_t^2 = \omega_0 + \sum_{i=1}^{p} \alpha_i \mathcal{E}_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 + \pi^T \mathbf{x}_{t-1}$$

performs variable selection by testing

$$H_0 : \pi_j = 0, \forall j$$

and compares the p-values to the adjusted alpha level according to adjust.method. If alpha.level = 1, then no variable selection is performed and the function only estimates the parameters

Value

An object of class GARCHX

References

Francq, C. and Thieu, L.Q.(2018). *QML Inference for Volatility Models with Covariates.* Econometric Theory, Cambridge University Press

Examples

```
set.seed(123)
pi <- c(1, 0, 0, 4)
n <- 2000
d <- length(pi)
valinit <- 100
n2 <- n + d + 1
omega <- 0.1
alpha <- 0.2
beta <- 0.3
delta <- 2
e<-rnorm(n2+valinit)
Y<-e
for (t in 2:n2)
 Y[t]<- 0.2*Y[t-1]+e[t]
x<-exp(Y)
X <- matrix(0, nrow = (n+valinit), ncol = length(pi))
for(j in 1:d)
 X[, j] <- x[(d+2-j):(n+d+1-j+valinit)]
data <- GARCH.X::simulate(n, omega, alpha, beta, delta, X, pi, valinit = valinit)
model <- GARCHX_select(eps = data$eps, X = data$X)
```

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predict	*Predict GARCHX future time series values*

Description

Predicts values for GARCHX model

Usage

```
predict(model, X, n_pred)
```

Arguments

model	GARCHX object
X	Exogenous covariates for predictions
n_pred	Number of predictions into the future

Value

Vector of predicted time series data

References

Francq, C. and Thieu, L.Q.(2018). *QML Inference for Volatility Models with Covariates*. Econometric Theory, Cambridge University Press

Examples

```
set.seed(123)
pi <- c(1, 0, 0, 4)
n <- 2000
d <- length(pi)
valinit <- 100
n2 <- n + d + 1
omega <- 0.1
alpha <- 0.2
beta <- 0.3
delta <- 2
e<-rnorm(n2+valinit)
Y<-e
for (t in 2:n2)
 Y[t]<- 0.2*Y[t-1]+e[t]
x<-exp(Y)
X <- matrix(0, nrow = (n+valinit), ncol = length(pi))
for(j in 1:d)
 X[, j] <- x[(d+2-j):(n+d+1-j+valinit)]
data <- GARCH.X::simulate(n, omega, alpha, beta, delta, X, pi, valinit = valinit)
model <- GARCHX_select(eps = data$eps, X = data$X)
n_pred = 10
test.X <- data$X[(n-n_pred+1):n, ]
predictions <- predict(model = model, X = test.X, n_pred = n_pred)
```

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simulate	*Simulate GARCHX model*

Description

Simulates Time series data from GARCH model with exogenous covariates

Usage

```
simulate(n, omega, alpha, beta, delta = 2, X, pi, shock.distr = "Normal", valinit = 200)
```

Arguments

n	Desired length of simulated time series data
omega	Coefficient value for omega, required to be

$$\omega_0 > 0$$

alpha	ARCH Coefficient value, required to be

$$\alpha_0 \geq 0$$

beta	GARCH Coefficient value, required to be

$$\beta_0 \geq 0$$

delta	Value of the power of the time series to allow for Power GARCHX, default is 2 for GARCHX
X	Matrix with exogenous covariates where the number of rows is equal to the length of n + valinit
pi	Vector containing coefficients for exogenous covariates.
shock.distr	Distribution of the shock eta_t that multiply w_t in the GARCH-X model eps_ = w_t*eta_t.
valinit	Initialization value, default value is 200

Value

A named list containing vector of Time Series data and X covariates used

Examples

```
n <- 200
d <- 4
valinit <- 100
n2 <- n + d + 1
omega <- 0.05
alpha <- 0.05
beta <- 0.05
delta <- 2
pi <- rep(0.05, d)
e<-rnorm(n2+valinit)
Y<-e
for (t in 2:n2)
 Y[t]<- 0.2*Y[t-1]+e[t]
x<-exp(Y)
X <- matrix(0, nrow = (n+valinit), ncol = length(pi))
for(j in 1:d)
 X[, j] <- x[(d+2-j):(n+d+1-j+valinit)]
data <- simulate(n, omega, alpha, beta, delta, X, pi, valinit = valinit)
```

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