

# Package ‘quantilogram’

March 5, 2022

**Title** Cross-Quantilogram

**Version** 2.2.1

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**Description** Estimation and inference methods for the cross-quantilogram. The cross-quantilogram is a measure of nonlinear dependence between two variables, based on either unconditional or conditional quantile functions. The cross-quantilogram can be considered as an extension of the correlogram, which is a correlation function over multiple lag periods and mainly focuses on linear dependency. One can use the cross-quantilogram to detect the presence of directional predictability from one time series to another. This package provides a statistical inference method based on the stationary bootstrap. See Linton and Whang (2007) <[doi:10.1016/j.jeconom.2007.01.004](https://doi.org/10.1016/j.jeconom.2007.01.004)> for univariate time series analysis and Han, Linton, Oka and Whang (2016) <[doi:10.1016/j.jeconom.2016.03.001](https://doi.org/10.1016/j.jeconom.2016.03.001)> for multivariate time series analysis.

**License** GPL (>= 3)

**Encoding** UTF-8

**RoxygenNote** 7.1.2

**Imports** np, quantreg, SparseM, stats

**Depends** R (>= 2.10)

**LazyData** true

**NeedsCompilation** no

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**Repository** CRAN

**Date/Publication** 2022-03-05 15:20:02 UTC

**R topics documented:**

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corr.lag	<i>Correlation Function</i>
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**Description**

The correlation statistics for a given lag order

**Usage**

```
corr.lag(math, k)
```

**Arguments**

math	The matrix with the column size of 2
k	The lag order (integer)

**Details**

The function obtains the simple correlation statistics. The values in the first column of input matrix is interacted with the k-lagged values in the second column.

**Value**

Correlation

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

---

`corr.lag.partial`      *Partial Cross-correlation function*

---

**Description**

A function used to obtain partial cross-correlation function for a give lag order

**Usage**

`corr.lag.partial(matH, k)`

**Arguments**

<code>matH</code>	A matrix with multiple columns (more than 3 columns)
<code>k</code>	The lag order (integer)

**Details**

This function obtains the partial corss-correlation and the simple correlation. To obtain the partial cross-correlation, this function uses the first column of the input matrix and k-lagged values of the rest of the matrix.

**Value**

Partial corss-correlation at k lags and the correlation statistics at k lags.

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

---

`crossq`*Cross-Quantilogram*

---

**Description**

Returns the cross-quantilogram

**Usage**

```
crossq(DATA, vecA, k)
```

**Arguments**

DATA	An input matrix
vecA	A pair of two probability values at which sample quantiles are estimated
k	A lag order (integer)

**Details**

This function obtains the cross-quantilogram at the k lag order.

**Value**

Cross-Quantilogram

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

**References**

Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.

**Examples**

```
## data source
data("sys.risk")

## data: 2 variables
D = sys.risk[,c("Market", "JPM")]

# probability levels for the 2 variables
vecA = c(0.1, 0.5)

## cross-quantilogram with the lag of 5
crossq.max(D, vecA, 5)
```

---

`crossq.max`*Cross-Quantilogram up to a Given Lag Order*

---

**Description**

The cross-quantilograms from 1 to a given lag order.

**Usage**

```
crossq.max(DATA, vecA, Kmax)
```

**Arguments**

DATA	An input matrix
vecA	A pair of two probability values at which sample quantiles are estimated
Kmax	The maximum lag order (integer)

**Details**

This function calculates the partial cross-quantilograms up to the lag order users specify.

**Value**

A vector of cross-quantilogram

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

**References**

Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.

**Examples**

```
## data source
data("sys.risk")

## data: 2 variables
D = sys.risk[,c("Market", "JPM")]

# probability levels for the 2 variables
vecA = c(0.1, 0.5)

## cross-quantilogram with lags between 1 and 5
crossq.max(D, vecA, 5)
```

---

crossq.max.partial      *Partial Corss-Quantilogram upto a given lag order*

---

**Description**

The partial cross-quantilograms from 1 to a given lag order.

**Usage**

```
crossq.max.partial(DATA, vecA, Kmax)
```

**Arguments**

DATA	An input matrix
vecA	A vector of probability values at which sample quantiles are estimated
Kmax	The maximum lag order (integer)

**Details**

This function calculates the partial cross-quantilograms up to the lag order users specify.

**Value**

A vector of cross-quantilogram and a vector of partial cross-quantilograms

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

**References**

Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.

**Examples**

```
## data source
data("sys.risk")

## data with 3 variables
D = sys.risk[,c("Market", "JPM", "VIX")]

## probability levels for the 3 variables
vecA = c(0.1, 0.1, 0.1)

## partial cross-quantilogram with lags from 1 to 5
crossq.max.partial(D, vecA, 5)
```

---

crossq.partial      *Paritial Cross-Quantilogram*

---

### Description

Returns the partial cross-quantilogram

### Usage

```
crossq.partial(DATA, vecA, k)
```

### Arguments

DATA	A matrix
vecA	A vector of probability values at which sample quantiles are estimated
k	The lag order

### Details

This function obtains the partial cross-quantilogram and the cross-quantilogram. To obtain the partial cross-correlation given an input matrix, this function interacts the values of the first column and the k-lagged values of the rest of the matrix.

### Value

The partial cross-quantilogram and the cross-quantilogram

### Author(s)

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

### References

Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.

### Examples

```
## data source
data("sys.risk")

## data with 3 variables
D = sys.risk[,c("Market", "JPM", "VIX")]

## probability levels for the 3 variables
vecA = c(0.1, 0.1, 0.1)
```

```
## partial cross-quantilogram with the lag of 5  
crossq.max.partial(D, vecA, 5)
```

---

crossq.partial.sb      *Stationary Bootstrap for the Partial Cross-Quantilogram*

---

### Description

Returns critical values for the partial cross-quantilogram, based on the stationary bootstrap.

### Usage

```
crossq.partial.sb(DATA, vecA, k, gamma, Bsize, sigLev)
```

### Arguments

DATA	The original data matrix
vecA	A pair of two probability values at which sample quantiles are estimated
k	A lag order
gamma	A parameter for the stationary bootstrap
Bsize	The number of repetition of bootstrap
sigLev	The statistical significance level

### Details

This function generates critical values for for the partial cross-quantilogram, using the stationary bootstrap in Politis and Romano (1994).

### Value

The bootstrap critical values

### Author(s)

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

### References

Politis, Dimitris N., and Joseph P. Romano. "The stationary bootstrap." *Journal of the American Statistical Association* 89.428 (1994): 1303-1313.



---

crossq.partial.sb.opt *Stationary Bootstrap for the Partial Cross-Quantilogram dwith the choice of the stationary-bootstrap parameter*

---

### Description

Returns critical values for the partial cross-quantilogram, based on the stationary bootstrap with the choice of the stationary-bootstrap parameter.

### Usage

```
crossq.partial.sb.opt(DATA, vecA, k, Bsize, sigLev)
```

### Arguments

DATA	The original data matrix
vecA	A pair of two probability values at which sample quantiles are estimated
k	A lag order
Bsize	The number of repetition of bootstrap
sigLev	The statistical significance level

### Details

This function generates critical values for for the partial cross-quantilogram, using the stationary bootstrap in Politis and Romano (1994).

### Value

The bootstrap critical values

### Author(s)

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

### References

- Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.
- Patton, A., Politis, D. N., and White, H. (2009). Correction to "Automatic block-length selection for the dependent bootstrap" by D. Politis and H. White. *Econometric Reviews*, 28(4), 372-375.
- Politis, D. N., and White, H. (2004). "Automatic block-length selection for the dependent bootstrap." *Econometric Reviews*, 23(1), 53-70.
- Politis, Dimitris N., and Joseph P. Romano. (1994). "The stationary bootstrap." *Journal of the American Statistical Association* 89.428: 1303-1313.

---

`crossq.sb`*Stationary Bootstrap for the Cross-Quantilogram*

---

**Description**

Returns critical values for the cross-quantilogram, based on the stationary bootstrap.

**Usage**

```
crossq.sb(DATA, vecA, k, gamma, Bsize, sigLev)
```

**Arguments**

DATA	The original data matrix
vecA	A pair of two probability values at which sample quantiles are estimated
k	A lag order
gamma	A parameter for the stationary bootstrap
Bsize	The number of repetition of bootstrap
sigLev	The statistical significance level

**Details**

This function generates critical values for for the cross-quantilogram, using the stationary bootstrap in Politis and Romano (1994).

**Value**

The bootstrap critical values

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

**References**

Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.

Politis, Dimitris N., and Joseph P. Romano. "The stationary bootstrap." *Journal of the American Statistical Association* 89.428 (1994): 1303-1313.

**Examples**

```

data("sys.risk") ## data source
D = sys.risk[,c("Market", "JPM")] ## data: 2 variables

# probability levels for the 2 variables
vecA = c(0.1, 0.5)

## setup for stationary bootstrap
gamma = 1/10 ## bootstrap parameter depending on data
Bsize = 5    ## small size, 5, for test
sigLev = 0.05 ## significance level

## cross-quantilogram with the lag of 5
crossq.sb(D, vecA, 5, gamma, Bsize, sigLev)

```

---

crossq.sb.opt	<i>Stationary Bootstrap for the Cross-Quantilogram with the choice of the stationary-bootstrap parameter</i>
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---

**Description**

Returns critical values for the cross-quantilogram, based on the stationary bootstrap with the choice of the stationary-bootstrap parameter.

**Usage**

```
crossq.sb.opt(DATA, vecA, k, Bsize, sigLev)
```

**Arguments**

DATA	The original data matrix
vecA	A pair of two probability values at which sample quantiles are estimated
k	A lag order
Bsize	The number of repetition of bootstrap
sigLev	The statistical significance level

**Details**

This function generates critical values for for the cross-quantilogram, using the stationary bootstrap in Politis and Romano (1994). To choose parameter for the stationoary bootstrap, this function first obtains the optimal value for each time serie using the result provided by Politis and White (2004) and Patton, Politis and White (2004) (The R-package, "np", written by Hayfield and Racine is used). Next, the average of the obtained values is used as the parameter value.

**Value**

The bootstrap critical values

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

**References**

Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.

Patton, A., Politis, D. N., and White, H. (2009). Correction to "Automatic block-length selection for the dependent bootstrap" by D. Politis and H. White. *Econometric Reviews*, 28(4), 372-375.

Politis, D. N., and White, H. (2004). "Automatic block-length selection for the dependent bootstrap." *Econometric Reviews*, 23(1), 53-70.

Politis, Dimitris N., and Joseph P. Romano. (1994). "The stationary bootstrap." *Journal of the American Statistical Association* 89.428: 1303-1313.

**Examples**

```
## data source
data("sys.risk")

## data: 2 variables
D = sys.risk[,c("Market", "JPM")]

# probability levels for the 2 variables
vecA = c(0.1, 0.5)

## setup for stationary bootstrap
Bsize = 5    ## small size 5 for test
sigLev = 0.05 ## significance level

## cross-quantilogram with the lag of 5
crossq.sb.opt(D, vecA, 5, Bsize, sigLev)
```

---

crossqreg

*Cross-Quantilogram*

---

**Description**

Returns the cross-quantilogram

**Usage**

```
crossqreg(DATA1, DATA2, vecA, k)
```

**Arguments**

DATA1	An input matrix (T x p1)
DATA2	An input matrix (T x p2)
vecA	A pair of two probability values at which sample quantiles are estimated
k	A lag order (integer)

**Details**

This function obtains the cross-quantilogram at the k lag order.

**Value**

Cross-Quantilogram

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

**References**

Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.

Koenker, R., and Bassett Jr, G. (1978). "Regression quantiles." *Econometrica*, 46(1), 33-50.

**Examples**

```
## data source
data(sys.risk)

## sample size
T = nrow(sys.risk)

## matrix for quantile regressions
## - 1st column: dependent variables
## - the rest: regressors or predictors
D1 = cbind(sys.risk[2:T,"Market"], sys.risk[1:(T-1),"Market"])
D2 = cbind(sys.risk[2:T,"JPM"], sys.risk[1:(T-1),"JPM"])

## probability levels
vecA = c(0.1, 0.2)

## cross-quantilogram with the lag of 5, after quantile regression
crossqreg(D1, D2, vecA, 5)
```

---

`crossqreg.max`*Corss-Quantilogram up to a Given Lag Order*

---

**Description**

The cross-quantilograms from 0 to a given lag order.

**Usage**

```
crossqreg.max(DATA1, DATA2, vecA, Kmax)
```

**Arguments**

DATA1	An input matrix (T x p1)
DATA2	An input matrix (T x p2)
vecA	A pair of two probability values at which sample quantiles are estimated
Kmax	The maximum lag order (integer)

**Details**

This function calculates the partial cross-quantilograms up to the lag order users specify.

**Value**

A vector of cross-quantilogram

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

**References**

Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.

---

crossqreg.max.partial *Partial Corss-Quantilogram upto a given lag order*

---

**Description**

The partial cross-quantilograms from 1 to a given lag order.

**Usage**

```
crossqreg.max.partial(DATA1, DATA2, vecA, Kmax)
```

**Arguments**

DATA1	An input matrix (T x p1)
DATA2	An input matrix (T x p2)
vecA	A vector of probability values at which sample quantiles are estimated
Kmax	The maximum lag order (integer)

**Details**

This function calculates the partial cross-quantilograms up to the lag order users specify.

**Value**

A vector of cross-quantilogram and a vector of partial cross-quantilograms

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

**References**

Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.

---

crossqreg.partial      *Paritial Cross-Quantilogram*

---

**Description**

Returns the partial cross-quantilogram

**Usage**

```
crossqreg.partial(DATA1, DATA2, vecA, k)
```

**Arguments**

DATA1	An input matrix (T x p1)
DATA2	An input matrix (T x p2)
vecA	A vector of probability values at which sample quantiles are estiamted
k	The lag order

**Details**

This function obtains the partial corss-quantilogram and the cross-quantilogram. To obtain the partial cross-correlation given an input matrix, this function interacts the values of the first column and the k-lagged values of the rest of the matrix.

**Value**

The partial corss-quantilogram and the cross-quantilogram

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

**References**

Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.



---

`crossqreg.sb`*Stationary Bootstrap for the Cross-Quantilogram*

---

**Description**

Returns critical values for the cross-quantilogram, based on the stationary bootstrap.

**Usage**

```
crossqreg.sb(DATA1, DATA2, vecA, k, gamma, Bsize, sigLev)
```

**Arguments**

DATA1	The original data matrix (T x p1)
DATA2	The original data matrix (T x p2)
vecA	A pair of two probability values at which sample quantiles are estimated
k	A lag order
gamma	A parameter for the stationary bootstrap
Bsize	The number of repetition of bootstrap
sigLev	The statistical significance level

**Details**

This function generates critical values for for the cross-quantilogram, using the stationary bootstrap in Politis and Romano (1994).

**Value**

The bootstrap critical values

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

**References**

Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.

Politis, Dimitris N., and Joseph P. Romano. "The stationary bootstrap." *Journal of the American Statistical Association* 89.428 (1994): 1303-1313.

**Examples**

```

data(sys.risk)

## sample size
T = nrow(sys.risk)

## matrix for quantile regressions
## - 1st column: dependent variables
## - the rest: regressors or predictors
D1 = cbind(sys.risk[2:T,"Market"], sys.risk[1:(T-1),"Market"])
D2 = cbind(sys.risk[2:T,"JPM"], sys.risk[1:(T-1),"JPM"])

## probability levels
vecA = c(0.1, 0.2)

## setup for stationary bootstrap
gamma = 1/10 ## bootstrap parameter depending on data
Bsize = 5 ## small size 10 for test
sigLev = 0.05 ## significance level

## cross-quantilogram with the lag of 5, after quantile regression
crossqreg.sb(D1, D2, vecA, 5, gamma, Bsize, sigLev)

```

q.hit

*Quantile Hit***Description**

Returns the matrix of quantil-hits

**Usage**

```
q.hit(DATA, vecA)
```

**Arguments**

DATA	A matrix that has time-series observations in its columns
vecA	A vector of probability values at which sample quantiles are estimated

**Details**

This function generates the quantile hits given a vector of probability values. The quantile hits are obtained for each column of an input matrix.

**Value**

A matrix of quantile-hits

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

---

qreg.hit

*Quantile Hit*

---

**Description**

Returns the matrix of quantil-hits

**Usage**

```
qreg.hit(DATA1, DATA2, vecA)
```

**Arguments**

DATA1	An input matrix ( $T \times p1+1$ ) with the first column of the dependent variable and the the rest of columns with regressors
DATA2	An input matrix ( $T \times p2+1$ ) with the first column of the dependent variable and the the rest of columns with regressors
vecA	A vector of probabily values at which sample quantiles are estimated

**Details**

This function generates the quantile hits based on quantile regression, given a vector of probability values. The quantile regressions are esimated for each matrix of data and a pair of quantile hits are produced.

**Value**

A matrix of quantile-hits

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

**References**

Koenker, R., and Bassett Jr, G. (1978). "Regression quantiles." *Econometrica*, 46(1), 33-50.

Qstat

*Q-statistics*

---

**Description**

Te Box-Pierce and Ljung-Box type Q-statistics

**Usage**

```
Qstat(vecTest, Tsize)
```

**Arguments**

vecTest	A vector of test statistics ordered with respect the number of lags
Tsize	A original sample size

**Details**

This function returns Box-Pierce and Ljung-Box type Q-statistics

**Value**

the Box-Pierce and Ljung-Box statistics

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

**References**

Box, G. EP, and D. A. Pierce. (1970). "Distribution of residual autocorrelations in autoregressive-integrated moving average time series models." *Journal of the American Statistical Association* 65.332, pp.1509-1526.

Ljung, G. M., and G. EP Box. (1978). "On a measure of lack of fit in time series models." *Biometrika* 65.2, pp.297-303.

---

`Qstat.reg.sb`*Stationary Bootstrap for Q statistics*

---

**Description**

Stationary Bootstrap procedure to generate critical values for both Box-Pierce and Ljung-Box type Q-statistics

**Usage**

```
Qstat.reg.sb(DATA1, DATA2, vecA, Psize, gamma, Bsize, sigLev)
```

**Arguments**

DATA1	The original data set (1)
DATA2	The original data set (2)
vecA	A pair of two probability values at which sample quantiles are estimated
Psize	The maximum number of lags
gamma	A parameter for the stationary bootstrap
Bsize	The number of repetition of bootstrap
sigLev	The statistical significance level

**Details**

This function returns critical values for for both Box-Pierce and Ljung-Box type Q-statistics through the stationry bootstrap proposed by Politis and Romano (1994).

**Value**

The bootstrap critical values

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

**References**

Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.

Politis, Dimitris N., and Joseph P. Romano. (1994). "The stationary bootstrap." *Journal of the American Statistical Association* 89.428, pp.1303-1313.

**Examples**

```

data(sys.risk)

## sample size
T = nrow(sys.risk)

## matrix for quantile regressions
## - 1st column: dependent variables
## - the rest: regressors or predictors
D1 = cbind(sys.risk[2:T,"Market"], sys.risk[1:(T-1),"Market"])
D2 = cbind(sys.risk[2:T,"JPM"], sys.risk[1:(T-1),"JPM"])

## probability levels
vecA = c(0.1, 0.2)

## setup for stationary bootstrap
gamma = 1/10 ## bootstrap parameter depending on data
Bsize = 5 ## small size, 5, for test
sigLev = 0.05 ## significance level

## Q statistics with lags from 1 to 5, after quantile regression
Qstat.reg.sb(D1, D2, vecA, 5, gamma, Bsize, sigLev)

```

---

Qstat.sb

*Stationary Bootstrap for Q statistics*


---

**Description**

Stationary Bootstrap procedure to generate critical values for both Box-Pierce and Ljung-Box type Q-statistics

**Usage**

```
Qstat.sb(DATA, vecA, Psize, gamma, Bsize, sigLev)
```

**Arguments**

DATA	The original data
vecA	A pair of two probability values at which sample quantiles are estimated
Psize	The maximum number of lags
gamma	A parameter for the stationary bootstrap
Bsize	The number of repetition of bootstrap
sigLev	The statistical significance level

**Details**

This function returns critical values for for both Box-Pierce and Ljung-Box type Q-statistics through the stationary bootstrap proposed by Politis and Romano (1994).

**Value**

The bootstrap critical values

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

**References**

Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.

Politis, Dimitris N., and Joseph P. Romano. (1994). "The stationary bootstrap." *Journal of the American Statistical Association* 89.428, pp.1303-1313.

**Examples**

```
data("sys.risk") ## data source
D = sys.risk[,c("Market", "JPM")] ## data: 2 variables

# probability levels for the 2 variables
vecA = c(0.1, 0.5)

## setup for stationary bootstrap
gamma = 1/10 ## bootstrap parameter depending on data
Bsize = 5    ## small size, 5, for test
sigLev = 0.05 ## significance level

## Q statistics with lags from 1 to 5
Qstat.sb(D, vecA, 5, gamma, Bsize, sigLev)
```

---

Qstat.sb.opt

*Stationary Bootstrap for Q statistics*

---

**Description**

Stationary Bootstrap procedure to generate critical values for both Box-Pierce and Ljung-Box type Q-statistics with the choice of the stationary-bootstrap parameter.

**Usage**

```
Qstat.sb.opt(DATA, vecA, Psize, Bsize, sigLev)
```

**Arguments**

DATA	The original data
vecA	A pair of two probability values at which sample quantiles are estimated
Psize	The maximum number of lags
Bsize	The number of repetition of bootstrap
sigLev	The statistical significance level

**Details**

This function returns critical values for for both Box-Pierce and Ljung-Box type Q-statistics through the stationary bootstrap proposed by Politis and Romano (1994). To choose parameter for the stationary bootstrap, this function first obtains the optimal value for each time series using the result provided by Politis and White (2004) and Patton, Politis and White (2004) (The R-package, "np", written by Hayfield and Racine is used). Next, the average of the obtained values is used as the parameter value.

**Value**

The bootstrap critical values

**Author(s)**

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

**References**

- Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.
- Patton, A., Politis, D. N., and White, H. (2009). Correction to "Automatic block-length selection for the dependent bootstrap" by D. Politis and H. White. *Econometric Reviews*, 28(4), 372-375.
- Politis, D. N., and White, H. (2004). "Automatic block-length selection for the dependent bootstrap." *Econometric Reviews*, 23(1), 53-70.
- Politis, Dimitris N., and Joseph P. Romano. (1994). "The stationary bootstrap." *Journal of the American Statistical Association* 89.428: 1303-1313.

**Examples**

```
data("sys.risk") ## data source
D = sys.risk[,c("Market", "JPM")] ## data: 2 variables

# probability levels for the 2 variables
vecA = c(0.1, 0.5)

## setup for stationary bootstrap
Bsize = 5 ## small size, 5, for test
sigLev = 0.05 ## significance level
```



```
## Q statistics with lags from 1 to5
Qstat.sb.opt(D, vecA, 5, Bsize, sigLev)
```

---

sb.index	<i>Stationary Bootstrap Index</i>
----------	-----------------------------------

---

### Description

A subfunction for the stationanry bootstrap

### Usage

```
sb.index(Nsize, gamma)
```

### Arguments

Nsize	The size of the stationary bootstrap resample
gamma	A parameter for the stationary bootstrap.

### Details

This function resamples blocks of indicies with random block lengths. This code follows the MATLAB file of the Oxford MFE Toolbox written by Kevin Sheppard.

### Value

A vector of indicies for the stationary bootstrap

### Author(s)

Heejoon Han, Oliver Linton, Tatsushi Oka and Yoon-Jae Whang

### References

The Oxford MFE toolbox ([http://www.kevinsheppard.com/wiki/MFE\\_Toolbox](http://www.kevinsheppard.com/wiki/MFE_Toolbox)) by Kevin Sheppard

---

stock

*The Data Set of Monthly Stock Return and Sotck Variance*

---

### Description

The dataset contains monthly excess stock returns and stock varaince, which are included in the data set analyzed in Goyal and Welch (2008). Stock returns are measured by the S&P 500 index and include dividens. A treasury-bill rate is subtracted from stock returns to give excess stock returns The stock variance is a volatility estimate based on daily squared returns and is treated as an estimate of equity risk in the literature. The sample period is from Feburary 1885 to December 2005 with sample size 1,451.

- Date: Year-Month-Day
- Return: excess stock returns
- Variance: stock variance

### Usage

```
data(stock)
```

### Format

A data object with two variables

### References

Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.

Welch, Ivo, and Amit Goyal. "A comprehensive look at the empirical performance of equity premium prediction." *Review of Financial Studies* 21.4 (2008): 1455-1508.

---

sys.risk

*The Data Set for Systemic Risk Analysis*

---

### Description

The data set contains the daily CRSP market value weighted index returns, which are used as the market index returns in Brownless and Engle (2012), and also includes daily stock returns on JP Morgan Chase (JPM), Goldman Sachs (GS) and American International Group (AIG). The sample period is from 2 Jan. 2001 to 30 Dec. 2011 with sample size 2,767.

### Usage

```
data(sys.risk)
```

### **Format**

A data object with five variables

### **Details**

- date: The time index (day)
- Market: The daily CRSP market value weighted index returns
- JPM: stock returns on JP Morgan Chase (JPM)
- GS: stock returns on Goldman Sachs (GS)
- AIG: stock returns on American International Group (AIG)

### **References**

Brownlees, Christian T., and Robert F. Engle. "Volatility, correlation and tails for systemic risk measurement." *Available at SSRN* 1611229 (2012).

Han, H., Linton, O., Oka, T., and Whang, Y. J. (2016). "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series." *Journal of Econometrics*, 193(1), 251-270.

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