# Package 'quantilogram'

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**Title** Quantilogramg

**Version** 0.1

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**Description** This package contains the functions of the cross-quantilograms and related methods. The currenet version is written only for the purpose of the replication of the results reported in Han, Linton, Oka and Whang (2014). The more comprehensive version will be released later.

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**Depends** R (>= 3.0.2), np

**License** GPL (>=2)

**Reference** Han, H., O. Linton, T. Oka and Y-J. Whang (2014) ``The Cross-Quantilogram: Measuring Quantile Dependence and Testing Directional Predictability between Time Series" availabe at SRRN.

## R topics documented:

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`Corr` *Correlation Function*

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## Description

The correlation statistics for a given lag order

## Usage

```
Corr(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.partial *Partial Cross-correlation function*

### Description

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

### Usage

```
Corr.partial(matH, k)
```

### Arguments

| | |
|---|---|
| matH | A matrix with multiple columns |
| k | 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

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

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## 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

## 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

## 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 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

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`CrossQ.partial.SelfN` *Self-Normalized Partial Cross-Quantilogram*

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## Description

Returns the self-normalized version of the partial cross-quantilogram

## Usage

```
CrossQ.partial.SelfN(DATA, vecA, k, scaW)
```

## Arguments

| | |
|---|---|
| `DATA` | An input matrix |
| `vecA` | A pair of two probabilities at which sample quantiles are estimated |
| `k` | A lag order |
| `scaW` | A triming value specifiying the fraction of the sample which corresponds to the minimum subsample size |

## Details

This function obtains the self-normalized version of the partial cross-quantilogram at a given lag order.

## Value

The self-normalized partial cross-quantilogram

## Author(s)

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

`CrossQ.partial.StatBoot` *Stationary Bootstrap for the Partial Cross-Quantilogram*

## Description

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

## Usage

```
CrossQ.partial.StatBoot(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 boostrap 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.StatBoot.OptAve` *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.StatBoot.OptAve(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 boostrap critical values

## Author(s)

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

## References

Patton, A., Politis, D. N., & 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., & 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.SelfN *Self-Normalized Cross-Quantilogram*

### Description

Returns the self-normalized version of the cross-quantilogram

### Usage

```
CrossQ.SelfN(DATA, vecA, k, scaW)
```

### Arguments

| | |
|---|---|
| DATA | An input matrix |
| vecA | A pair of two probabilities at which sample quantiles are estimated |
| k | A lag order |
| scaW | A triming value specifiying the fraction of the sample which corresponds to the minimum subsample size |

### Details

This function obtains the self-normalized version of the cross-quantilogram at a given lag order.

### Value

The self-normalized cross-quantilogram

### Author(s)

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

## CrossQ.StatBoot *Stationary Bootstrap for the Cross-Quantilogram*

### Description

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

### Usage

```
CrossQ.StatBoot(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 boostrap 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.

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## CrossQ.StatBoot.OptAve

*Stationary Bootstrap for the Cross-Quantilogram with the choice of the stationary-bootstrap parameter*

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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.StatBoot.OptAve(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 statioanry bootstrap, this function first obtaines 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 boostrap critical values

### Author(s)

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

### References

Patton, A., Politis, D. N., & 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., & 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.

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## CV.SelfN.trim.0.00 — *Critical Values for the Self-Normalized Statistics with a trimming value 0.00*

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### Description

The critical values are obtained via simulation. The Brownian bridge are approximated by 5,000 normali distribution and the number of repetition is 500,000 to obtain the critical values.

### Usage

```
data(CV.SelfN.trim.0.00)
```

### Details

- dim: The number of restrictions imposed under the null hypothesis
- sig0.10: The critical value for the 0.10 significance level
- sig0.05: The critical value for the 0.05 significance level
- sig0.025: The critical value for the 0.025 significance level
- sig0.01: The critical value for the 0.01 significance level
- sig0.005: The critical value for the 0.005 significance level

`CV.SelfN.trim.0.01` *Critical Values for the Self-Normalized Statistics with a trimming value 0.01*

## Description

See the explanation in CV.SelfN.trim.0.00

`CV.SelfN.trim.0.03` *Critical Values for the Self-Normalized Statistics with a trimming value 0.03*

## Description

See the explanation in CV.SelfN.trim.0.00

`CV.SelfN.trim.0.05` *Critical Values for the Self-Normalized Statistics with a trimming value 0.05*

## Description

See the explanation in CV.SelfN.trim.0.00

`CV.SelfN.trim.0.10` *Critical Values for the Self-Normalized Statistics with a trimming value 0.10*

## Description

See the explanation in CV.SelfN.trim.0.00

`CV.SelfN.trim.0.15` *Critical Values for the Self-Normalized Statistics with a trimming value 0.15*

## Description

See the explanation in CV.SelfN.trim.0.00

## CV.SelfN.trim.0.20 *Critical Values for the Self-Normalized Statistics with a trimming value 0.20*

### Description

See the explanation in CV.SelfN.trim.0.00

## CV.SelfN.trim.0.30 *Critical Values for the Self-Normalized Statistics with a trimming value 0.30*

### Description

See the explanation in CV.SelfN.trim.0.00

## Qhit *Quantile Hit*

### Description

Returns the matrix of quantil-hits

### Usage

```
Qhit(DATA, vecA)
```

### Arguments

| | |
|---|---|
| DATA | A matrix |
| vecA | A vector of probabilty values at which sample quantiles are estimated |

### Details

This function generates the quantile hits given a vector of probabilty 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

`Qstat` *Q-statistics*

## Description

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

## Value

the Box-Pierece 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.SelfN *Self-normalized Q-statistics*

### Description

The self-normalized version of the Q-statistics

### Usage

```
Qstat.SelfN(DATA, vecA, Kmax, vW)
```

### Arguments

| | |
|---|---|
| DATA | The original data |
| vecA | A pair of two probability values at which sample quantiles are estimated |
| Kmax | The maximum lag order |
| vW | A triming value for the self-normalization |

### Details

This function returns the self-normalized Q-statistics.

### Value

The self-normalized Q-statistics

### Author(s)

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

## Qstat.StatBoot *Stationary Bootstrap for Q statistics*

### Description

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

### Usage

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

### Arguments

| | |
|---|---|
| DATA | The original data |
| vecA | A pair of two probabity 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-Pierece and Ljung-Box type Q-statistics through the statioanry 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

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

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## Qstat.StatBoot.OptAve *Stationary Bootstrap for Q statistics*

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### Description

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

### Usage

```
Qstat.StatBoot.OptAve(DATA, vecA, Psize, Bsize, sigLev)
```

### Arguments

| | |
|---|---|
| DATA | The original data |
| vecA | A pair of two probabity 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-Pierece and Ljung-Box type Q-statistics through the statioanry bootstrap proposed by Politis and Romano (1994). To choose parameter for the statioanry bootstrap, this function first obtaines 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

Patton, A., Politis, D. N., & 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., & 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.

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## StatBoot.index *Stationary Bootstrap Index*

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### Description

A subfunction for the statioanry bootstrap

### Usage

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

### Arguments

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

### 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) by Kevin Sheppard

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

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## 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.

- Return: excess stock returns
- Variance: stock variance

## Usage

```
data(stock)
```

## Format

A data object with two variables

## References

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.

SysRisk *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(SysRisk)
```

## Format

A data object with five variables

## Details

- day: The time index (day)
- Market: The daily CRSP market value weighted incex 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).

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