Package ‘modifiedmk’

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Title Modified Versions of Mann Kendall and Spearman’s Rho Trend Tests

Version 1.5.0

Description Power of non-parametric Mann-Kendall test and Spearman’s Rho test is highly influenced by serially correlated data. To address this issue, trend tests may be applied on the modified versions of the time series data by Block Bootstrapping (BBS), Prewhitening (PW), Trend Free Prewhitening (TFPW), Bias Corrected Prewhitening and Variance Correction Approach by calculating effective sample size.


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**Description**

Significant serial correlation present in time series data can be accounted for using the nonparametric block bootstrap technique, which incorporates the Mann-Kendall trend test (Mann, 1945; Kendall, 1975; Kundzewicz and Robson, 2000). Predetermined block lengths are used in resampling the original time series, thus retaining the memory structure of the data. If the value of the test statistic falls in the tails of the empirical bootstrapped distribution, there is likely a trend in the data. The block bootstrap technique is powerful in the presence of autocorrelation (Khaliq et al. 2009; Önöz and Bayazit, 2012).

**Usage**

```r
bbsmk(x, ci=0.95, nsim=2000, eta=1, bl.len=NULL)
```

**Arguments**

- **x** - Time series data vector
- **ci** - Confidence interval
- **nsim** - Number of bootstrapped simulations
- **eta** - Added to the block length
- **bl.len** - Block length

**Details**

Block lengths are automatically selected using the number of contiguous significant serial correlations, to which the eta (η) term is added. A value of η = 1 is used as the default as per Khaliq et al. (2009). Alternatively, the user may define the block length. 2000 bootstrap replicates are recommended as per Svensson et al. (2005) and Önöz, B. and Bayazit (2012).
Value

- Z-Value - Mann-Kendall Z statistic
- Sen’s slope - Sen’s trend slope
- S - Mann-Kendall S statistic
- Tau - Mann-Kendall’s Tau value
- Kendall’s Tau Empirical Bootstrapped CI - Kendall’s Tau empirical bootstrapped confidence interval
- Z-value Empirical Bootstrapped CI - Z-value empirical bootstrapped confidence interval

References


Examples

```r
x<-c(Nile[1:10])
bbsmk(x)
```

---

**bbssr**

*Nonparametric Block Bootstrapped Spearman’s Rank Correlation Trend Test*
Description

Significant serial correlation present in time series data can be accounted for using the nonparametric block bootstrap technique, which incorporates Spearman's Rank Correlation trend test (Lehmann, 1975; Sneyers, 1990; Kundzewicz and Robson, 2000). Predetermined block lengths are used in resampling the original time series, thus retaining the memory structure of the data. If the value of the test statistic falls in the tails of the empirical bootstrapped distribution, there is likely a trend in the data. The block bootstrap technique is powerful in the presence of autocorrelation (Khaliq et al. 2009; Önöz and Bayazit, 2012).

Usage

bbssr(x, ci=0.95, nsim=2000, eta=1, bl.len=NULL)

Arguments

x - Time series data vector
ci - Confidence interval
nsim - Number of bootstrapped simulations
eta - Added to the block length
bl.len - Block length

Details

Block lengths are the number of contiguous significant serial correlations, to which the ($\eta$) term is added. A value of $\eta = 1$ is used as the default as per Khaliq et al. (2009). Alternatively, the user may define the block length. 2000 bootstrap replicates are recommended as per Svensson et al. (2005) and Önöz, B. and Bayazit (2012).

Value

Spearman's Correlation Coefficient - Spearman’s correlation coefficient value
Test Statistic - Z-transformed value to test significance $\rho(\sqrt{n} - T)$
Test Statistic Empirical Bootstrapped CI - Test statistic empirical bootstrapped confidence interval

References


**Examples**

```r
x<-c(Nile[1:10])
bbssr(x)
```

---

**bcpw**


**Description**

Hamed (2009) proposed a prewhitening technique in which the slope and lag-1 serial correlation coefficient are simultaneously estimated. The lag-1 serial correlation coefficient is then corrected for bias before prewhitening.

**Usage**

```r
bcpw(x)
```

**Arguments**

- `x` - Time series data vector

**Details**

Employs ordinary least squares (OLS) to simultaneously estimate the lag-1 serial correlation coefficient and slope of trend. The lag-1 serial correlation coefficient is then bias corrected.

**Value**

- **Z-Value** - Mann-Kendall Z-statistic after bias corrected prewhitening
- **Prewhitened Sen’s Slope** - Sen’s slope of the prewhitened data
- **Sen’s Slope** - Sen’s slope for the original data series ‘x’
- **P-value** - p-value after prewhitening
S - Mann-Kendall 'S' statistic
Var(s) - Variance of 'S'
Tau - Mann-Kendall’s Tau

References

Examples
x<-c(Nile)
bcpw(x)

---

mkttest  Mann-Kendall Trend Test of Time Series Data Without Modifications

Description
The Mann-Kendall trend test is a nonparametric trend test used to identify monotonic trends present in time series data.

Usage
mkttest(x)

Arguments
x - Time series data vector

Details
The Mann-Kendall trend test is a nonparametric trend test which assumes no distribution of the data. The null hypothesis of the test is that there is no trend in the data and the alternative hypothesis is that the data represents a monotonic trend.
Value

Z - Mann-Kendall Z statistic  
Sen’s slope - Sen’s slope  
S - Mann-Kendall S statistic  
Var(s) - Variance of S  
P-value - Mann-Kendall p-value  
Tau - Mann-Kendall’s Tau

References


Examples

```r
x<-c(Nile)
mkttest(x)
```

```
mmkh
Modified Mann-Kendall Test For Serially Correlated Data Using the Hamed and Rao (1998) Variance Correction Approach
```

Description

Time series data is often influenced by previous observations. When data is not random and influenced by autocorrelation, modified Mann-Kendall tests may be used for trend detection studies. Hamed and Rao (1998) have proposed a variance correction approach to address the issue of serial correlation in trend analysis. Data are initially detrended and the effective sample size is calculated using the ranks of significant serial correlation coefficients which are then used to correct the inflated (or deflated) variance of the test statistic.

Usage

```r
mmkh(x, ci=0.95)
```

Arguments

- **x** - Time series data vector  
- **ci** - Confidence interval
Details

A detrended time series is constructed using Sen’s slope and the lag-1 autocorrelation coefficient of the ranks of the data. The variance correction approach proposed by Hamed and Rao (1998) uses only significant lags of autocorrelation coefficients.

Value

Corrected Zc - Z statistic after variance Correction
new P.value - P-value after variance correction
N/N* - Effective sample size
Original Z - Original Mann-Kendall Z statistic
Old P-value - Original Mann-Kendall p-value
Tau - Mann-Kendall’s Tau
Sen’s Slope - Sen’s slope
old.variance - Old variance before variance Correction
new.variance - Variance after correction

References


Examples

```
x<-c(Nile)
mmkh(x)
```
**Description**

Time series data is often influenced by serial correlation. When data are not random and influenced by autocorrelation, modified Mann-Kendall tests may be used for trend detection. Hamed and Rao (1998) have proposed variance correction approach to address the issue of serial correlation in Trend analysis. Data are initially detrended and the effective sample size is calculated using the ranks of significant serial correlation coefficients which are then used to correct the inflated (or deflated) variance of the test statistic.

**Usage**

```r
mmkh3lag(x, ci=0.95)
```

**Arguments**

- `x` - Time series data vector
- `ci` - Confidence interval

**Details**

A detrended time series is constructed using Sen’s slope and the lag-1 autocorrelation coefficient of the ranks of the data. The variance correction approach proposed by Hamed and Rao (1998) uses only significant lags of autocorrelation coefficients. As suggested by Rao et al. (2003), only the first three autocorrelation coefficients are used in this function.

**Value**

- Corrected Zc - Z statistic after variance correction
- new P.value - P-value after variance correction
- N/N* - Effective sample size
- Original Z - Original Mann-Kendall Z statistic
- Old P-value - Original Mann-Kendall p-value
- Tau - Mann-Kendall’s Tau
- Sen’s Slope - Sen’s slope
- old.variance - Old variance before variance Correction
- new.variance - Variance after correction
References


Examples

```r
x<-c(Nile)
mnh3lag(x)
```

---

**mmky**

*Modified Mann-Kendall Test For Serially Correlated Data Using the Yue and Wang (2004) Variance Correction Approach*

Description

Time series data is often influenced by serial correlation. When data are not random and influenced by autocorrelation, modified Mann-Kendall tests may be used for trend detection. Yue and Wang (2004) have proposed variance correction approach to address the issue of serial correlation in trend analysis. Data are initially detrended and the effective sample size is calculated using significant serial correlation coefficients.

Usage

```r
mmky(x)
```

Arguments

- **x** - Time series data vector

Details

The variance correction approach suggested by Yue and Wang (2004) is implemented in this function. Serial correlation coefficients for all lags are used in calculating the effective sample size.
mmky1lag

**Value**

- Corrected Zc - Z statistic after variance Correction
- new P.value - P-value after variance correction
- N/N* - Effective sample size
- Original Z - Original Mann-Kendall Z statistic
- Old P-value - Original Mann-Kendall p-value
- Tau - Mann-Kendall’s Tau
- Sen’s Slope - Sen’s slope
- old.variance - Old variance before variance Correction
- new.variance - Variance after correction

**References**


**Examples**

```r
x<-c(Nile)
mmky(x)
```

---

**mmky1lag**

*Modified Mann-Kendall Test For Serially Correlated Data Using the Yue and Wang (2004) Variance Correction Approach Using the Lag-1 Correlation Coefficient Only*

**Description**

Time series data is often influenced by serial correlation. When data are not random and influenced by autocorrelation, modified Mann-Kendall tests may be used for trend detection. Yue and Wang (2004) have proposed a variance correction approach to address the issue of serial correlation in trend analysis. Data are initially detrended and the effective sample size is calculated using the lag-1 autocorrelation coefficient.

**Usage**

```r
mmky1lag(x)
```
Arguments

x - Time series data vector

Details

The variance correction approach suggested by Yue and Wang (2004) is implemented in this function. Effective sample size is calculated based on the AR(1) assumption.

Value

Corrected Zc - Z statistic after variance Correction
new P.value - P-value after variance correction
N/N* - Effective sample size
Original Z - Original Mann-Kendall Z statistic
Old P.value - Original Mann-Kendall p-value
Tau - Mann-Kendall’s Tau
Sen’s Slope - Sen’s slope
old.variance - Old variance before variance Correction
new.variance - Variance after correction

References


Examples

x<-c(Nile)
mmky1lag(x)
Bootstrapped Mann-Kendall Trend Test with Optional Bias Corrected Prewhitening

Description

The empirical distribution of the Mann-Kendall test statistic is calculated by bootstrapped resampling. The Hamed (2009) bias correction prewhitening technique can optionally be applied as the default for prewhitening before the bootstrapped Mann-Kendall test is applied (Lacombe et al., 2012).

Usage

```
pbmk(x, nsim=1000, pw="Hamed")
```

Arguments

- `x` - Time series data vector
- `nsim` - Number of bootstrapped simulations
- `pw` - Optional bias corrected prewhitening suggested by Hamed (2009)

Details

Bootstrapped samples are calculated by resampling one value at a time from the time series with replacement. The p-value \( p_s \) of the resampled data is estimated by (Yue and Pilon, 2004):

\[
p_s = m_s / M
\]

The Mann-Kendall test statistics \( S \) is calculated for each resampled dataset. The resultant vector of resampled \( S \) statistics is then sorted in ascending ordering, where \( p_s \) is the rank corresponding the largest bootstrapped value of \( S \) being less than the test statistic value calculated from the actual data. \( M \) is the total number of bootstrapped resamples. The default value of \( M \) is 1000, however, Yue and Pilon (2004) suggest values between 1000 and 2000. If the user does not choose to apply prewhitening, this argument 'pw' can be set to NULL.

Value

- Z Value - Mann-Kendall Z statistic from original data
- Sen’s Slope - Sen’s slope from the original data
- S - Mann-Kendall S statistic
- Kendall’s Tau - Mann-Kendall’s Tau
- BCP Z Value - Bias corrected prewhitened Z value
- BCP Sen’s Slope - Bias corrected prewhitened Sen’s slope
- BCP S - Bias corrected prewhitened S
- BCP Kendall’s Tau - Bias corrected prewhitened Kendall’s Tau
- Bootstrapped P-Value - Mann-Kendall bootstrapped p-value
References


Examples

```r
x <- c(Nile[1:10])
pwmk(x)
```

---

**pwmk**


**Description**

When time series data are not random and influenced by autocorrelation, prewhitening the time series prior to application of trend test is suggested.

**Usage**

```r
pwmk(x)
```

**Arguments**

- `x` - Time series data vector

**Details**

The lag-1 serial correlation coefficient is used for prewhitening.
spear

Value

- Z-Value - Z statistic after prewhitening
- Sen’s Slope - Sen’s slope for prewhitened series
- old. Sen’s Slope - Sen’s slope for original data series (x)
- P-value - P-value after prewhitening
- S - Mann-Kendall S statistic
- Var(s) - Variance of S
- Tau - Mann-Kendall’s Tau

References


Examples

x<-c(Nile)
pwmk(x)

spear

Spearman’s Rank Correlation Test

Description

Spearman’s Rank Correlation test by Lehmann (1975) and Sneyers (1990) is useful in detecting trends.

Usage

spear(x)

Arguments

x - Time series data vector
Details

Spearman’s Rank Correlation test by Lehmann (1975) and Sneyers (1990) is implemented in this function.

Value

Correlation coefficient - Spearman’s Correlation coefficient value
Z-Tranformed Test Statistic value - Z-transform value to test significance $\rho(\sqrt{n-1})$

References


Examples

```r
x <- c(Nile)
spear(x)
```

tfpwmk


Description

When the time series data are not random and influenced by autocorrelation, the trend component is removed from the data and is prewhitened prior to the application of the trend test.

Usage

```
tfpwmk(x)
```

Arguments

- `x` - Time series data vector

Details

The linear trend component is removed from the original data and then prewhitened using the lag-1 serial correlation coefficient. The prewhitening data are then tested with Mann-Kendall trend test.
Value

Z-Value - Z statistic after trend-free prewhitening (TFPW)
Sen’s Slope - Sen’s slope for TFPW series
Old Sen’s Slope - Sen’s slope for original data series (x)
P-value - P-value after trend-free prewhitening
S - Mann-Kendall S statistic
Var(s) - Variance of S
Tau - Mann-Kendall’s Tau

References


Examples

x<-c(Nile)
tfpwmk(x)
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