Package ‘caustests’

March 12, 2026

Type Package

Title Multiple Granger Causality Tests

Version 1.0.2

Description Comprehensive suite of Granger causality tests including standard Toda-Yamamoto (1995) <doi:10.1016/0304-4076(94)01616-8>, Fourier-based tests with single frequency (Enders and Jones, 2016) <doi:10.1515/snde-2014-0101> and cumulative frequencies (Nazlioglu et al., 2019) <doi:10.1080/1540496X.2018.1434072>, as well as quantile causality tests (Cai et al., 2023) <doi:10.1016/j.frl.2023.104327> and Bootstrap Fourier Granger Causality in Quantiles (Cheng et al., 2021) <doi:10.1007/s12076-020-00263-0>. All tests include bootstrap inference for robust p-values.

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Encoding UTF-8

LazyData true

Depends R (>= 3.5.0)

Imports stats, quantreg

Suggests testthat (>= 3.0.0)

RoxygenNote 7.3.3

URL `https://github.com/muhammedalkhalaf/caustests`

BugReports `https://github.com/muhammedalkhalaf/caustests/issues`

NeedsCompilation no

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Repository CRAN

Date/Publication 2026-03-12 20:10:03 UTC

Contents

`caustests` *Multiple Granger Causality Tests*

Description

Performs various Granger causality tests including Toda-Yamamoto, Fourier-based tests (single and cumulative frequency), and quantile causality tests with bootstrap inference.

Usage

```
caustests(
  data,
  test,
  pmax = 8,
  ic = 1,
  nboot = 1000,
  kmax = 3,
  dmax = NULL,
  quantiles = seq(0.1, 0.9, 0.1),
  verbose = TRUE
)
```

Arguments

`data` A data frame or matrix with time series variables (columns).

`test` Integer 1-7 specifying the test type:

- 1: Toda-Yamamoto (1995)
- 2: Single Fourier Granger (Enders & Jones, 2016)
- 3: Single Fourier Toda-Yamamoto (Nazlioglu et al., 2016)
- 4: Cumulative Fourier Granger (Enders & Jones, 2019)
- 5: Cumulative Fourier Toda-Yamamoto (Nazlioglu et al., 2019)
- 6: Quantile Toda-Yamamoto (Cai et al., 2023)
- 7: Bootstrap Fourier Granger Causality in Quantiles (Cheng et al., 2021)

`pmax` Maximum lag order for model selection (default: 8).

`ic` Information criterion: 1 for AIC, 2 for SBC/BIC (default: 1).

`nboot` Number of bootstrap replications (default: 1000).

`kmax` Maximum Fourier frequency (default: 3, used for tests 2-5, 7).

`dmax`	Extra lags for Toda-Yamamoto augmentation. If NULL, automatically set to 0 for tests 2, 4 (differences) and 1 for tests 1, 3, 5, 6, 7 (levels).
`quantiles`	Numeric vector of quantiles for tests 6-7 (default: seq(0.1, 0.9, 0.1)).
`verbose`	Logical; print progress messages (default: TRUE).

Details

The package implements seven Granger causality tests:

Test 1: Toda-Yamamoto (1995) Standard Granger causality in levels using VAR with extra lags equal to the maximum integration order (dmax). This approach is robust to unknown integration and cointegration properties.

Tests 2-3: Single Fourier Frequency Incorporate a single Fourier frequency to capture smooth structural breaks. Test 2 uses first differences, Test 3 uses levels (Toda-Yamamoto style).

Tests 4-5: Cumulative Fourier Frequency Use cumulative Fourier frequencies (1 to k) for more flexible break patterns. Test 4 uses first differences, Test 5 uses levels.

Test 6: Quantile Toda-Yamamoto Extends Toda-Yamamoto to quantile regression, allowing causality analysis across different quantiles of the conditional distribution.

Test 7: Bootstrap Fourier Granger Causality in Quantiles (BFGC-Q) Combines Fourier flexibility with quantile regression for robust inference under structural breaks and across quantiles.

Value

An object of class `"caustests"` containing:

`results`	Data frame with test results for each direction
`test`	Test number used
`test_name`	Name of the test
`pmax`	Maximum lag considered
`ic`	Information criterion used
`nboot`	Number of bootstrap replications
`kmax`	Maximum Fourier frequency
`dmax`	Augmentation lags
`quantiles`	Quantiles used (for tests 6-7)
`quantile_results`	Detailed quantile results (for tests 6-7)

References

Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Econometrics*, 66(1-2), 225-250. doi:10.1016/03044076(94)016168

Enders, W., & Jones, P. (2016). Grain prices, oil prices, and multiple smooth breaks in a VAR. *Studies in Nonlinear Dynamics & Econometrics*, 20(4), 399-419. doi:10.1515/snde20140101

Nazlioglu, S., Gormus, N. A., & Soytas, U. (2016). Oil prices and real estate investment trusts (REITs): Gradual-shift causality and volatility transmission analysis. *Energy Economics*, 60, 168-175. doi:10.1016/j.eneco.2016.09.009

Nazlioglu, S., Soytas, U., & Gormus, N. A. (2019). Oil prices and monetary policy in emerging markets: Structural shifts in causal linkages. *Emerging Markets Finance and Trade*, 55(1), 105-117. doi:10.1080/1540496X.2018.1434072

Cai, Y., Chang, T., Xiang, Y., & Chang, H. L. (2023). Testing Granger causality in quantiles between the stock and the foreign exchange markets of Japan. *Finance Research Letters*, 58, 104327. doi:10.1016/j.frl.2023.104327

Cheng, S. C., Hsueh, H. P., Ranjbar, O., Wang, M. C., & Chang, T. (2021). Bootstrap Fourier Granger causality test in quantiles and the asymmetric causal relationship between CO2 emissions and economic growth. *Letters in Spatial and Resource Sciences*, 14, 31-49. doi:10.1007/s12076-020002630

Examples

```
# Load example data
data(caustests_data)


# Test 1: Toda-Yamamoto test
result1 <- caustests(caustests_data, test = 1, nboot = 199)
print(result1)
summary(result1)

# Test 3: Single Fourier Toda-Yamamoto
result3 <- caustests(caustests_data, test = 3, kmax = 2, nboot = 199)
print(result3)

# Test 6: Quantile causality (fewer quantiles for speed)
result6 <- caustests(caustests_data, test = 6,
                     quantiles = c(0.25, 0.50, 0.75), nboot = 199)
print(result6)
```

`caustests_data` *Example Time Series Dataset for Causality Tests*

Description

A simulated dataset containing three time series variables for demonstrating Granger causality tests. The data includes one dependent variable (Y) and two potential causal variables (X1, X2) with known causal relationships.

Usage

```
caustests_data
```

Format

A data frame with 200 observations and 3 variables:

Y Dependent variable, generated as AR(2) plus causal effects from X1

X1 First explanatory variable, AR(1) process

X2 Second explanatory variable, independent AR(1) process

Details

The data generating process is:

- X1 and X2 are independent AR(1) processes
- Y depends on its own lags plus lagged values of X1 (but not X2)
- This creates a true causal relationship from X1 to Y
- There is no true causality from X2 to Y or from Y to X1/X2

This allows users to verify that the causality tests correctly identify the causal direction X1 => Y while finding no significant causality in other directions (with appropriate sample sizes and test settings).

Source

Simulated data for package demonstration

Examples

```
data(caustests_data)
head(caustests_data)
summary(caustests_data)

# Check correlations
cor(caustests_data)
```

`plot.caustests` *Plot Quantile Causality Results*

Description

Creates diagnostic plots for quantile causality tests (tests 6-7).

Usage

```
## S3 method for class 'caustests'
plot(x, which = 1, type = "both", ...)
```

Arguments

`x`	An object of class `"caustests"` from test 6 or 7.
`which`	Which direction to plot (default: 1, first direction).
`type`	Plot type: "wald" for Wald statistics, "pval" for p-values, or "both" (default).
`...`	Additional arguments passed to `plot`.

Value

Invisibly returns the plotted data.

Examples

```
data(caustests_data)
result <- caustests(caustests_data, test = 6,
                    quantiles = c(0.25, 0.50, 0.75), nboot = 199)
plot(result)
```

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