Package 'KRONX'

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Type Package

Title Clock of Regimes for Regime-Switching Fragility Analysis

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Description Implements the Clock of Regimes (KRONX) framework for regime-switching fragility analysis of financial time series. The package fits Gaussian and Student-t Hidden Markov Models (HMMs) to return data, constructs a hazard-adjusted transition operator Q, derives the associated generator K = Q - I, and computes the fundamental matrix N = -K inverse to characterize expected residence times under structural fragility.

License GPL (>= 3)

Encoding UTF-8

Depends R (>= 4.0.0)

Imports stats, utils

Suggests testthat (>= 3.0.0), knitr, rmarkdown

VignetteBuilder utils

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Contents

`compute_log_returns` *Compute log returns from a close-price vector.*

Description

Compute log returns from a close-price vector.

Usage

```
compute_log_returns(close)
```

Arguments

`close`	Numeric vector of close prices.

Value

Numeric vector of log returns (length = `length(close) - 1`).

`fit_hmm_em` *Fit a Gaussian or Student-t HMM via EM with multiple random restarts.*

Description

Fit a Gaussian or Student-t HMM via EM with multiple random restarts.

Usage

```
fit_hmm_em(
  x,
  K = 3L,
  model = c("gaussian", "student"),
  n_starts = 5L,
  max_iter = 200L,
  tol = 1e-06,
  nu_grid = c(3:30, 40, 60, 100),
  verbose = TRUE
)
```

Arguments

x	Numeric vector of observations (log returns).
K	Integer number of hidden states.
model	"gaussian" or "student".
n_starts	Number of random restarts.
max_iter	Maximum EM iterations per restart.
tol	Log-likelihood convergence tolerance.
nu_grid	Candidate degrees-of-freedom for Student-t grid search.
verbose	Logical; if TRUE print iteration progress.

Value

A list with components:

model Model type string.

A K x K transition matrix.

delta Length-K initial state probability vector.

params List with mu, sigma, and (Student-t) nu.

gamma T x K posterior state probabilities.

xi (T-1) x K x K posterior joint transition probabilities.

logLik Scalar log-likelihood at convergence.

n Number of observations.

K Number of states.

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read_close_series *Read a close-price series from a CSV file.*

Description

The function is case-insensitive: it accepts close, Close, CLOSE, or any capitalisation. The first matching column is used.

Usage

```
read_close_series(file, close_col = "close")
```

Arguments

file	Path to the CSV file.
close_col	Name of the close-price column (default "close").

Value

A numeric vector of finite close prices (length >= 10).

run_kronx *Run the full Clock of Regimes (KRONX) analysis.*

Description

Runs the KRONX pipeline on either a CSV file of prices or a numeric vector of returns supplied directly. When `file` is used, the function reads the CSV file, extracts the close-price column (case-insensitive match on `"close"` or `"Close"`), and computes log returns. When `x` is supplied, it is treated as a numeric return series and the file-ingestion step is skipped.

Usage

```
run_kronx(
  file = NULL,
  x = NULL,
  close_col = "close",
  K = 3L,
  n_starts = 5L,
  max_iter = 200L,
  tol = 1e-06,
  seed = 123L,
  epsilon_min = 0.01,
  c_hazard = 0.05,
  tail_alpha = 0.01,
  ruin_horizon = 250L,
  nu_grid = c(3:30, 40, 60, 100),
  verbose = TRUE,
  output_dir = "kronx_output"
)
```

Arguments

`file`	Path to a CSV file containing a close-price column. Ignored if `x` is supplied. Default: `NULL`.
`x`	Optional numeric vector of returns. If supplied, `file` is ignored and no CSV is read. This is intended in particular for small, self-contained examples and tests. Default: `NULL`.
`close_col`	Name of the close-price column. The function first tries the exact name, then a case-insensitive match, and finally falls back to any column whose name contains `"close"`. Default: `"close"`.
`K`	Number of hidden states. Default: `3L`.
`n_starts`	Number of EM random restarts. Default: `5L`.
`max_iter`	Maximum EM iterations per restart. Default: `200L`.
`tol`	Log-likelihood convergence tolerance. Default: `1e-6`.
`seed`	Random seed for reproducibility. Default: `123L`.

epsilon_min	Minimum baseline Talebian hazard. Default: 0.01.
c_hazard	Hazard sensitivity to tail thickness. Default: 0.05.
tail_alpha	Left-tail probability used for the empirical loss threshold. Default: 0.01.
ruin_horizon	Horizon, in observations, used in the risk bound. Default: 250L.
nu_grid	Candidate degrees-of-freedom values for Student-t fitting. Default: c(3:30, 40, 60, 100).
verbose	Logical; if TRUE, print progress and a summary. Default: TRUE.
output_dir	Directory for output files. Created if it does not exist. Pass NULL to suppress file output. Default: "kronx_output".

Details

The function then fits Gaussian and Student-t Hidden Markov Models (HMMs), builds the KRONX operator chain $Q \to K \to N$, and computes a residence-weighted upper bound on extreme downside risk. Results are returned as a named list and, optionally, written to output_dir.

Value

A named list containing:

close_px Numeric vector of raw close prices, or NULL when x is supplied directly.

ret Numeric vector of log returns or supplied returns.

K Number of hidden states.

gauss_fit Fitted Gaussian HMM object.

t_fit Fitted Student-t HMM object.

A_gauss Gaussian transition matrix.

A_t Student-t transition matrix.

epsilon Per-state Talebian hazard vector.

Q Hazard-adjusted operator.

K_mat KRONX generator matrix.

N_mat Fundamental matrix.

pi_qs Quasi-stationary distribution.

pi_res Residence-weight vector.

loss_threshold Empirical left-tail return threshold.

q_state Per-state tail probability.

bar_q Residence-weighted tail probability.

bar_lambda Residence-weighted hazard.

ruin_bound Upper bound over ruin_horizon.

tail_alpha The tail_alpha value used.

ruin_horizon The ruin_horizon value used.

state_summary A data.frame summarising per-state quantities.

vpath_t Integer vector of Viterbi-decoded Student-t state labels.

output_files Character vector of paths to written output files, or NULL if output_dir is NULL.

input_source A short label describing the data source used.

Examples

```
# Small self-contained example suitable for automatic checking
set.seed(123)
x <- rnorm(120, mean = 0, sd = 0.01)
res <- run_kronx(
  x = x,
  K = 2L,
  n_starts = 1L,
  max_iter = 10L,
  tol = 1e-4,
  tail_alpha = 0.05,
  ruin_horizon = 25L,
  verbose = FALSE,
  output_dir = NULL
)
res$ruin_bound
dim(res$A_t)
# Self-contained file-based example
tmp <- tempfile(fileext = ".csv")
dat <- data.frame(
  date = sprintf("2026-01-%02d", 1:20),
  close = c(
    100.0, 100.2, 100.1, 100.5, 100.4,
    100.8, 101.0, 100.9, 101.3, 101.1,
    101.6, 101.5, 101.9, 102.0, 101.8,
    102.2, 102.4, 102.3, 102.7, 102.9
  )
)
utils::write.csv(dat, tmp, row.names = FALSE)
res_file <- run_kronx(
  file = tmp,
  close_col = "close",
  K = 2L,
  n_starts = 1L,
  max_iter = 8L,
  tol = 1e-4,
  tail_alpha = 0.10,
  ruin_horizon = 10L,
  verbose = FALSE,
  output_dir = NULL
)
res_file$ruin_bound
```

`viterbi_decode` *Decode the most likely hidden-state path via the Viterbi algorithm.*

Description

Decode the most likely hidden-state path via the Viterbi algorithm.

Usage

```
viterbi_decode(x, fit)
```

Arguments

`x`	Numeric vector of observations (log returns).
`fit`	A fitted HMM object returned by `fit_hmm_em`.

Value

An integer vector of length `length(x)` with state labels (1-indexed).

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