

Package: fjohansen (via r-universe)

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Type Package

Title Johansen Cointegration Test with Fourier-Type Smooth Nonlinear Trends

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Description Implements the Johansen cointegration test with Fourier-type smooth nonlinear deterministic trends restricted to cointegrating relations, as developed by Kurita and Shintani (2025) <doi:10.1080/07474938.2025.2530640>. Six model variants are supported: CNR (constant plus nonlinear, restricted in the cointegrating space), LNR (linear plus nonlinear, restricted), CNU (constant restricted, nonlinear unrestricted), LNU (linear restricted, nonlinear unrestricted), plus the standard constant- and linear-trend restricted Johansen models. The package also bundles the feasible generalised least squares (FGLS) Wald test of Perron, Shintani and Yabu (2017) <doi:10.1111/obes.12169> used as a frequency-selection pre-step, together with bundled critical-value tables, a vectorised simulator for the limiting distribution, publication-quality table exports (LaTeX and HTML) and 'ggplot2' figures matching those of the paper.

URL <https://github.com/merwanroudane/fjohansen>

BugReports <https://github.com/merwanroudane/fjohansen/issues>

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Encoding UTF-8

Depends R (>= 4.0.0)

Imports stats, utils, grDevices, graphics, ggplot2 (>= 3.4.0), scales

Suggests testthat (>= 3.0.0), kableExtra, knitr, rmarkdown, patchwork

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NeedsCompilation no

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| | |
|-------------------|---|
| fjohansen-package | <i>fjohansen: Johansen Cointegration Test with Fourier-Type Smooth Nonlinear Trends</i> |
|-------------------|---|

Description

Implements the Johansen cointegration test with Fourier-type smooth nonlinear deterministic trends restricted to cointegrating relations, as developed by Kurita and Shintani (2025, *Econometric Reviews*). Also bundles the FGLS Wald test of Perron, Shintani and Yabu (2017) as a frequency-selection pre-step.

Main entry points

- [johansen_fourier](#) – the trace test.
- [select_frequencies](#) – pick the number of Fourier frequencies via PSY 2021.
- [psy_wald_test](#) – the univariate Wald test.
- [simulate_limit_distribution](#) – limit distribution of Proposition 3.1 of the paper.

Author / repository

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References

- Kurita, T. and Shintani, M. (2025). Johansen test with Fourier-type smooth nonlinear trends in cointegrating relations. *Econometric Reviews*, 44(10), 1589-1616. doi:[10.1080/07474938.2025.2530640](https://doi.org/10.1080/07474938.2025.2530640)
- Perron, P., Shintani, M. and Yabu, T. (2017). Testing for flexible nonlinear trends with an integrated or stationary noise component. *Oxford Bulletin of Economics and Statistics*, 79, 822-850. doi:[10.1111/obes.12169](https://doi.org/10.1111/obes.12169)

See Also

Useful links:

- <https://github.com/merwanroudane/fjohansen>
- Report bugs at <https://github.com/merwanroudane/fjohansen/issues>

build_design_matrices *Build Z0, Z1, Z2 design matrices for the reduced-rank regression*

Description

Build Z0, Z1, Z2 design matrices for the reduced-rank regression

Usage

```
build_design_matrices(X, k, n, model = "CNR")
```

Arguments

| | |
|-------|--|
| X | T x p numeric matrix (levels). |
| k | VAR order in levels (≥ 1). |
| n | Number of Fourier frequencies (0 disables them). |
| model | One of "CNR", "LNR", "CNU", "LNU", "constant", "linear". |

Value

A list with elements Z0, Z1, Z2, info.

| | |
|----------------|--|
| clear_jf_cache | <i>Clear the in-memory simulation cache.</i> |
|----------------|--|

Description

Clear the in-memory simulation cache.

Usage

```
clear_jf_cache()
```

Value

Invisible integer = number of cached entries cleared.

| | |
|--------------|--|
| CNR_TABLE_B1 | <i>Approximate limit quantiles for the CNR model (Table B1 of Kurita & Shintani 2025).</i> |
|--------------|--|

Description

Named-list keyed by string "p_minus_r,n". Values are numeric vectors with names q90, q95, q975, q99, mean, var.

Usage

```
CNR_TABLE_B1
```

Format

An object of class list of length 35.

| | |
|---------------|--|
| fourier_basis | <i>Build the Fourier deterministic basis</i> |
|---------------|--|

Description

Constructs the matrix

$$F_{t,T} = [\sin(2\pi t/T), \cos(2\pi t/T), \dots, \sin(2\pi nt/T), \cos(2\pi nt/T)]$$

for $t = t_start, \dots, t_start + T - 1$.

Usage

```
fourier_basis(T_len, n, t_start = 1)
```

Arguments

| | |
|---------|--|
| T_len | Sample size used in the denominator (typically the full sample T). |
| n | Number of frequencies (≥ 0). 0 returns a matrix with 0 columns. |
| t_start | First time index (default 1). |

Value

A numeric matrix of shape $T_len \times (2n)$.

| | |
|---------|---|
| jf_dgps | <i>Data-generating processes from Section 5 of Kurita & Shintani (2025)</i> |
|---------|---|

Description

Data-generating processes from Section 5 of Kurita & Shintani (2025)

Usage

```
generate_nf_dgp1(T = 400L, seed = 0L, ...)
```

```
generate_nf_dgp2(T = 400L, seed = 0L, ...)
```

```
generate_nf_dgp3(T = 400L, seed = 0L, ...)
```

```
generate_nf_dgp4(T = 400L, seed = 0L, ...)
```

```
generate_f_dgp1(T = 400L, seed = 0L)
```

```
generate_f_dgp2(T = 400L, seed = 0L)
```

Arguments

| | |
|------|--|
| T | Sample length. |
| seed | RNG seed (integer). |
| ... | Additional arguments forwarded to the internal skeleton (e.g. s, start, no_cointegration). |

Value

A data.frame with two or four numeric columns.

| | |
|------------|--|
| jf_moments | <i>Mean and variance of the limit distribution</i> |
|------------|--|

Description

Mean and variance of the limit distribution

Usage

```

jf_moments(
  p_minus_r,
  n,
  model = "CNR",
  n_sims = 4000,
  grid_size = 250,
  seed = 12345
)

```

Arguments

| | |
|-----------|--|
| p_minus_r | Common stochastic trends $p - r$ (≥ 1). |
| n | Number of Fourier frequencies (≥ 0). |
| model | One of "CNR", "LNR", "CNU", "LNU", "CONSTANT", "LINEAR". |
| n_sims | Replications used if the cell is not tabulated. |
| grid_size | Discretisation of the unit interval (only used in simulation). |
| seed | RNG seed (only used in simulation). |

Value

Numeric vector of length 2: c(mean, var).

| | |
|-------------------------|---|
| j _f _p_value | <i>Gamma-approximation p-value of an observed trace statistic</i> |
|-------------------------|---|

Description

Gamma-approximation p-value of an observed trace statistic

Usage

```
jf_p_value(stat, p_minus_r, n, model = "CNR", ...)
```

Arguments

| | |
|-----------|---|
| stat | Observed value of $-2 \log LR$. |
| p_minus_r | Common stochastic trends $p - r$ (≥ 1). |
| n | Number of Fourier frequencies (≥ 0). |
| model | One of "CNR", "LNR", "CNU", "LNU", "CONSTANT", "LINEAR". |
| ... | Additional arguments forwarded to j_f_moments() when the requested cell is not tabulated. |

Value

Numeric scalar in $[0, 1]$.

| | |
|--------------------------|---|
| j _f _quantile | <i>Quantile of the limit distribution</i> |
|--------------------------|---|

Description

For tabulated CNR cells and the 90/95/97.5/99 percentiles the paper's hard-coded values are returned. Otherwise the Gamma approximation (Doornik 1998) is used.

Usage

```
jf_quantile(level, p_minus_r, n, model = "CNR", ...)
```

Arguments

| | |
|-----------|---|
| level | Probability ($0 < \text{level} < 1$) or one of "90%", "95%", "97.5%", "99%". |
| p_minus_r | Common stochastic trends $p - r$ (≥ 1). |
| n | Number of Fourier frequencies (≥ 0). |
| model | One of "CNR", "LNR", "CNU", "LNU", "CONSTANT", "LINEAR". |
| ... | Additional arguments forwarded to j_f_moments() when the requested cell is not tabulated. |

Value

Numeric scalar.

jf_tables

Publication-quality table formatters for the trace test

Description

Helpers that turn a fitted johansen_fourier result into a printable table in three different formats.

Usage

```
format_trace_table(x)
```

```
format_trace_latex(x, caption = NULL, label = NULL)
```

```
format_trace_html(x, caption = NULL)
```

Arguments

x A johansen_fourier object.

caption Optional caption.

label Optional label.

Value

Each function returns a single character scalar containing the formatted table:

- `format_trace_table()` – plain-text (ASCII) table suitable for `cat()` or `message()`.
- `format_trace_latex()` – a LaTeX tabular environment (booktabs style) wrapped in a table float.
- `format_trace_html()` – a self-contained HTML fragment with inline CSS, suitable for use in R Markdown / Quarto.

johansen_fourier *Johansen-Fourier cointegration test*

Description

Performs the reduced-rank regression of Kurita & Shintani (2025) for a cointegrated VAR(k) with restricted Fourier-type smooth nonlinear trends in the cointegrating space.

Usage

```
johansen_fourier(
  data,
  k,
  n = 1L,
  model = "CNR",
  sig_level = 0.05,
  select_rank = TRUE,
  n_sims = 5000L
)
```

Arguments

| | |
|-------------|---|
| data | T x p numeric matrix or data.frame of levels. |
| k | VAR order in levels (≥ 1). Uses $k - 1$ lagged differences as unrestricted regressors. |
| n | Number of Fourier frequencies (0 = standard Johansen). |
| model | One of "CNR", "LNR", "CNU", "LNU", "constant", "linear". |
| sig_level | Significance level for the sequential rank rule. |
| select_rank | Logical; sequentially pick the cointegrating rank. |
| n_sims | Replications used to simulate cells not in the bundled tables. |

Value

An S3 object of class johansen_fourier with fields:

- spec – model spec
- eigenvalues – generalised eigenvalues, descending
- trace_stats – data.frame, one row per H_0
- selected_rank – chosen r
- alpha, beta, delta, gamma_const, gamma_trend, Gamma
- Sigma, residuals, fitted_long_run
- series_names, t_index

References

Kurita, T., Shintani, M. (2025). *Econometric Reviews*, 44(10), 1589-1616.

Examples

```
## Small fast example (tabulated critical-value cell, no simulation):
set.seed(1)
data <- sample_jgb_data(T = 60)
res <- johansen_fourier(data, k = 2, n = 1, model = "CNR",
                        n_sims = 200, select_rank = FALSE)
print(res)

## Full paper-style call (slower because of the limit-distribution
## simulation when the requested cell is not in the bundled tables):
data <- sample_jgb_data(T = 108)
res <- johansen_fourier(data, k = 3, n = 3, model = "CNR")
summary(res)
plot(res)
```

model_specs

Model specifications used by johansen_fourier

Description

A list of S3-tagged model specs with the following fields:

- code : canonical name
- label : human-readable description
- z1_constant : restricted constant in cointegrating space
- z1_trend : restricted linear trend in cointegrating space
- z1_fourier : restricted Fourier in cointegrating space
- z2_constant : unrestricted constant
- z2_fourier : unrestricted Fourier

Usage

```
model_specs
```

Format

An object of class `list` of length 6.

Details

Use one of "CNR", "LNR", "CNU", "LNU", "constant", "linear".

| | |
|------------------|---|
| plot_eigenvalues | <i>Bar plot of the Johansen eigenvalues</i> |
|------------------|---|

Description

Bar plot of the Johansen eigenvalues

Usage

```
plot_eigenvalues(x)
```

Arguments

x A johansen_fourier object.

Value

A ggplot bar-chart object.

| | |
|--------------------|--|
| plot_limit_density | <i>Plot the limit-distribution density (paper's Figs. 1-2)</i> |
|--------------------|--|

Description

Plot the limit-distribution density (paper's Figs. 1-2)

Usage

```
plot_limit_density(  
  p_minus_r,  
  n_values = 0:4,  
  model = "CNR",  
  n_sims = 4000L,  
  grid_size = 300L,  
  title = NULL  
)
```

Arguments

p_minus_r Number of common stochastic trends (≥ 1).

n_values Integer vector of n values to compare.

model One of "CNR", "LNR", "CNU", "LNU", "CONSTANT", "LINEAR".

n_sims Number of Monte-Carlo replications.

grid_size Grid size of $[0, 1]$.

title Optional plot title.

Value

A ggplot object showing one kernel-density curve per value of n.

Examples

```
## Fast preview with reduced Monte-Carlo size:
plot_limit_density(p_minus_r = 2, n_values = 0:2,
                  n_sims = 400, grid_size = 80)
```

| | |
|---------------|---|
| plot_long_run | <i>Plot estimated cointegrating relations</i> |
|---------------|---|

Description

Plot estimated cointegrating relations

Usage

```
plot_long_run(x)
```

Arguments

x A johansen_fourier object.

Value

A ggplot object showing one panel per cointegrating relation (the fitted beta' X_t series).

| | |
|---------------------------|---|
| plot_residual_diagnostics | <i>Residual diagnostics (paper's Fig. 12)</i> |
|---------------------------|---|

Description

Returns a ggplot showing standardised residuals only (a single panel per equation). Use directly with `patchwork::wrap_plots` to combine with other diagnostic graphics.

Usage

```
plot_residual_diagnostics(x, max_lag = 14L)
```

Arguments

x A johansen_fourier object.
max_lag Number of ACF lags to show.

Value

A ggplot object with one panel of standardised residuals per equation and +/- 2 reference bands.

| | |
|-------------------|---|
| plot_risk_premium | <i>Implied risk-premium decomposition (paper's Fig. 13)</i> |
|-------------------|---|

Description

Implied risk-premium decomposition (paper's Fig. 13)

Usage

```
plot_risk_premium(x, index = NULL)
```

Arguments

| | |
|-------|--|
| x | A johansen_fourier object. |
| index | Optional x-axis vector (length T_eff). |

Value

A ggplot object decomposing each cointegrating relation into its estimated risk-premium (rho_t) and the Fourier nonlinear component.

| | |
|-------------|--|
| plot_series | <i>Plot a (T x p) data set as multi-panel time series (Fig. 11 of the paper)</i> |
|-------------|--|

Description

Plot a (T x p) data set as multi-panel time series (Fig. 11 of the paper)

Usage

```
plot_series(data, title = NULL, index = NULL)
```

Arguments

| | |
|-------|-----------------------------------|
| data | data.frame or matrix. |
| title | Optional title. |
| index | Optional vector of x-axis values. |

Value

A ggplot object (one facet per series). Can be further modified with + like any other ggplot.

Examples

```
df <- sample_jgb_data(T = 36)
p <- plot_series(df, title = "JGB yields")
```

psy_wald_test

Perron-Shintani-Yabu (2021) FGLS Wald test

Description

Tests for the presence of Fourier-type nonlinear components in a univariate series. Robust to both $I(0)$ and $I(1)$ noise via Prais-Winsten transformation with a super-efficient + Roy-Fuller bias-corrected AR(1) estimator.

Usage

```
psy_wald_test(
  y,
  k_freqs,
  p_d = 1,
  subset_freq = NULL,
  version = "upper-biased",
  p_T_max = NULL
)
```

Arguments

| | |
|-------------|---|
| y | Numeric vector (length T). |
| k_freqs | Integer vector of frequencies. |
| p_d | Polynomial trend order (0 or 1). |
| subset_freq | If supplied, test only that one frequency's two coefficients. |
| version | "upper-biased" or "median-unbiased". |
| p_T_max | Upper bound for the augmentation lag. |

Value

An object of class psy_wald.

| | |
|-----------------|---|
| sample_jgb_data | <i>Synthetic JGB-yield surrogate (Section 6 illustration)</i> |
|-----------------|---|

Description

Synthetic JGB-yield surrogate (Section 6 illustration)

Usage

```
sample_jgb_data(T = 108L, seed = 7L)
```

Arguments

| | |
|------|---|
| T | Sample length (default 108, matching the paper's monthly sample). |
| seed | RNG seed. |

Value

A data.frame with six columns (i_20yr, i_10yr, i_5yr, i_3yr, i_1yr, i_call) and a Date attribute starting 1986-12.

| | |
|--------------------|---|
| select_frequencies | <i>Frequency selection for a multivariate panel</i> |
|--------------------|---|

Description

Each column is tested independently and the final n is the maximum across columns – the same recipe as in Kurita & Shintani (2025).

Usage

```
select_frequencies(  
  data,  
  n_max = 5L,  
  p_d = 1L,  
  sig_level = 0.1,  
  version = "upper-biased"  
)
```

Arguments

| | |
|-----------|---|
| data | Numeric matrix or data.frame. |
| n_max | Upper bound on the number of frequencies. |
| p_d | Polynomial trend order. |
| sig_level | Significance level for stopping the loop. |
| version | "upper-biased" or "median-unbiased". |

Value

A freq_selection object.

| | |
|-------------------------------|--|
| select_frequencies_univariate | <i>General-to-specific frequency selection for a univariate series</i> |
|-------------------------------|--|

Description

General-to-specific frequency selection for a univariate series

Usage

```
select_frequencies_univariate(
  y,
  n_max = 5L,
  p_d = 1L,
  sig_level = 0.1,
  version = "upper-biased"
)
```

Arguments

| | |
|-----------|---|
| y | Numeric vector. |
| n_max | Upper bound on the number of frequencies. |
| p_d | Polynomial trend order. |
| sig_level | Significance level for stopping the loop. |
| version | "upper-biased" or "median-unbiased". |

Value

A freq_selection object.

| | |
|-----------------|--|
| set_paper_theme | <i>Apply the paper-style ggplot2 theme (sunny palette)</i> |
|-----------------|--|

Description

Apply the paper-style ggplot2 theme (sunny palette)

Usage

```
set_paper_theme()
```

Value

Invisibly returns the ggplot2 theme object that has been installed as the global default via `ggplot2::theme_set()`. Called primarily for its side effect.

`simulate_limit_distribution`

Simulate the limiting Johansen-Fourier trace distribution

Description

Vectorised across replications. Results are kept in a per-session in-memory cache; clear it with `clear_jf_cache()`.

Usage

```
simulate_limit_distribution(  
  p_minus_r,  
  n,  
  model = "CNR",  
  n_sims = 5000,  
  grid_size = 300,  
  seed = 12345  
)
```

Arguments

| | |
|------------------------|--|
| <code>p_minus_r</code> | Number of common stochastic trends (≥ 1). |
| <code>n</code> | Number of Fourier frequencies (≥ 0). |
| <code>model</code> | One of "CNR", "LNR", "CNU", "LNU", "CONSTANT", "LINEAR". |
| <code>n_sims</code> | Number of Monte-Carlo replications. |
| <code>grid_size</code> | Grid size of $[0, 1]$. |
| <code>seed</code> | RNG seed. |

Value

Numeric vector of length `n_sims`.

`simulate_limit_moments`*Simulate moments of the limiting distribution*

Description

Simulate moments of the limiting distribution

Usage

```
simulate_limit_moments(  
  p_minus_r,  
  n,  
  model = "CNR",  
  n_sims = 5000,  
  grid_size = 300,  
  seed = 12345  
)
```

Arguments

| | |
|------------------------|--|
| <code>p_minus_r</code> | Number of common stochastic trends (≥ 1). |
| <code>n</code> | Number of Fourier frequencies (≥ 0). |
| <code>model</code> | One of "CNR", "LNR", "CNU", "LNU", "CONSTANT", "LINEAR". |
| <code>n_sims</code> | Number of Monte-Carlo replications. |
| <code>grid_size</code> | Grid size of $[0, 1]$. |
| <code>seed</code> | RNG seed. |

Value

List with elements mean, var, draws.

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