# Package: cointests (via r-universe)

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**Type** Package

**Title** Comprehensive Cointegration Tests with Fourier and Panel Methods

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**Description** A unified toolkit for cointegration testing including Fourier-based cointegration tests (FADL, FEG, FEG2, Tsong) that accommodate smooth structural breaks via flexible Fourier terms, and panel CADF cointegration tests with structural breaks using the Common Correlated Effects (CCE) estimator following Banerjee, Arcabic and Lee (2017) <doi:10.1016/j.econmod.2016.11.004>, Tsong, Lee, Tsai and Hu (2016) <doi:10.1007/s00181-015-1028-6>, and Banerjee and Carrion-i-Silvestre (2025) <doi:10.1080/07350015.2024.2327844>.

**License** GPL-3

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`fcoint` *Fourier Cointegration Tests for Time Series*

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## Description

Residual-based and ADL-based cointegration tests in which smooth structural change in the deterministic component is approximated by a single-frequency Fourier function: the Fourier ADL test (FADL), the Fourier Engle-Granger test (FEG), a covariate-augmented variant (FEG2), and the Fourier test for the null of cointegration of Tsong et al. (2016).

## Usage

```
fcoint(
  y,
  x,
  test = c("fadl", "feg", "feg2", "tsong", "all"),
  model = c("constant", "trend"),
  max_freq = 5L,
  max_lag = 0L,
  criterion = c("aic", "bic"),
  adf_lags = c("tsig", "aic", "bic"),
  dols_lags = 0L,
  lrv = c("iid", "bartlett"),
  bandwidth = NULL
)
```

## Arguments

| | |
|---|---|
| `y` | Numeric vector. Dependent variable. |
| `x` | Numeric vector or matrix. Regressors (one column per variable). |
| `test` | Character. `"fadl"`, `"feg"`, `"feg2"`, `"tsong"` or `"all"`. Default `"fadl"`. |
| `model` | Character. `"constant"` (default) or `"trend"`. |
| `max_freq` | Integer. Largest Fourier frequency searched (1 to 5; at most 3 is used for the Tsong test). Default 5. |
| `max_lag` | Integer. Largest lag order. `0` (default) selects a default: 6 for FADL and `floor(12 * (T/100)^0.25)` for FEG and FEG2. |
| `criterion` | Character. Information criterion used by FADL to choose the lag orders: `"aic"` (default) or `"bic"`. |
| `adf_lags` | Character. Lag selection in the ADF regressions of FEG and FEG2: `"tsig"` (default; general-to-specific, dropping the last lag while its absolute t-ratio is below 1.645), `"aic"` or `"bic"`. |

| | |
|---|---|
| `dols_lags` | Integer. Leads and lags of the differenced regressors in the DOLS regression of the Tsong test. `0` (default) uses `floor(4 * (T/100)^(2/9))`. |
| `lrv` | Character. Long-run variance estimator in the Tsong test: `"iid"` (default) or `"bartlett"`. |
| `bandwidth` | Integer. Bartlett bandwidth for `lrv = "bartlett"`. `NULL` (default) uses `round(4 * (T/100)^(2/9))`. |

## Details

The Fourier terms are $\sin(2\pi kt/T)$ and $\cos(2\pi kt/T)$, $t = 1, \ldots, T$. In every test the frequency is the one that minimises the sum of squared residuals.

**FADL** (Banerjee, Arcabic and Lee, 2017). The ADL regression

$$\Delta y_t = d(t) + \delta y_{t-1} + \gamma' x_{t-1} + \sum_{j=0}^{q} \phi_j' \Delta x_{t-j} + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + e_t$$

is estimated on a common sample. For each frequency the lag orders $p, q \in \{1, \ldots,$`max_lag`$\}$ minimise the chosen information criterion (one $q$ per regressor when there are at most two regressors, a common $q$ otherwise); the statistic is the t-ratio of $\delta$. Critical values are those of the Stata module `fcoint`, which attributes them to Tables 1a and 1b of the paper ($T$ = 100, 500, 2500; interpolated linearly in $T$ between 100 and 500).

**FEG** (Yilanci, 2019). The regression of $y_t$ on a constant (and a trend), the Fourier terms and $x_t$ gives residuals $\hat{u}_t$; the statistic is the t-ratio of $\rho$ in $\Delta\hat{u}_t = \rho\hat{u}_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta\hat{u}_{t-i} + \varepsilon_t$ (no deterministic terms). Critical values are Table 1 of Yilanci (2019) for one to three regressors and frequencies 1 to 5 ($T$ = 100, 500, 1000; linear interpolation in $T$). Two entries of that table carry evident typesetting errors and are corrected here: the 5% value for two regressors, $k = 3$, trend model, $T = 500$ is printed as 4.620 (sign lost), and the 5% and 10% values for three regressors, $k = 4$, constant model, $T = 1000$ are printed in reverse order.

**FEG2**. As FEG, but the ADF regression includes a constant and $\Delta x_t$, and the long-run squared correlation $\rho^2$ between the FEG and FEG2 errors is reported. The Stata module attributes this test and its critical values to an unpublished working paper by Banerjee and Lee, whose tables could not be verified (the Stata table also fills several cells by copying other cells). No critical values are therefore reported for FEG2.

**Tsong et al. (2016)**. Following the TSPDLIB implementation of Nazlioglu, the regression of $y_t$ on a constant (and a trend), $x_t$ and the Fourier terms is estimated by OLS and by DOLS, and $CI_f = T^{-2} \sum_t S_t^2 / \hat{\omega}^2$ with $S_t$ the partial sums of the residuals. Large values reject the null of cointegration. Critical values (DOLS statistic) are the TSPDLIB table for up to four regressors and $k \leq 3$; the entry for four regressors, $k = 3$, constant model repeats the $k = 2$ row in TSPDLIB and differs from the Stata module, so it is reported as `NA`. The F statistics for the Fourier terms are reported without critical values.

## Value

An object of class `"fcoint"`: a list with `test`, `results` (one list per test), `model`, `criterion` and `nobs`.

## References

Banerjee, P., Arcabic, V. and Lee, H. (2017). Fourier ADL cointegration test to approximate smooth breaks with new evidence from crude oil market. *Economic Modelling*, 67, 114-124. doi:10.1016/j.econmod.2016.11.004

Tsong, C.-C., Lee, C.-F., Tsai, L.-J. and Hu, T.-C. (2016). The Fourier approximation and testing for the null of cointegration. *Empirical Economics*, 51(3), 1085-1113. doi:10.1007/s0018101510286

Yilanci, V. (2019). A residual-based cointegration test with a Fourier approximation. MPRA Paper No. 95395, University Library of Munich.

## Examples

```
set.seed(42)
n <- 100
x <- cumsum(rnorm(n))
y <- 1 + 0.5 * x + sin(2 * pi * (1:n) / n) + rnorm(n, sd = 0.3)
fcoint(y, x, test = "feg", max_freq = 3)
```

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`print.fcoint` *Print Method for fcoint Objects*

---

## Description

Print Method for fcoint Objects

## Usage

```
## S3 method for class 'fcoint'
print(x, ...)
```

## Arguments

| | |
|---|---|
| `x` | An object of class `"fcoint"`. |
| `...` | Further arguments passed to or from other methods (unused). |

## Value

Invisibly returns `x`.

## print.xtcadfcoint *Print method for xtcadfcoint objects*

### Description

Print method for xtcadfcoint objects

### Usage

```
## S3 method for class 'xtcadfcoint'
print(x, ...)
```

### Arguments

| | |
|---|---|
| x | An object of class "xtcadfcoint". |
| ... | Additional arguments (ignored). |

### Value

Invisibly returns x.

## summary.xtcadfcoint *Summary method for xtcadfcoint objects*

### Description

Summary method for xtcadfcoint objects

### Usage

```
## S3 method for class 'xtcadfcoint'
summary(object, ...)
```

### Arguments

| | |
|---|---|
| object | An object of class "xtcadfcoint". |
| ... | Additional arguments (ignored). |

### Value

Invisibly returns object.

`xtcadfcoint` *Panel CADF Cointegration Test with Structural Breaks*

## Description

Tests the null hypothesis of no cointegration in panel data using the cross-sectionally augmented Dickey-Fuller (CADF) approach of Banerjee and Carrion-i-Silvestre (2025). Accounts for cross-sectional dependence via the Common Correlated Effects (CCE) estimator and allows for structural breaks.

## Usage

```
xtcadfcoint(
  formula,
  data,
  index,
  model = 1L,
  breaks = 0L,
  trimming = 0.15,
  maxlags = 4L,
  lagselect = "bic",
  nfactors = 1L,
  brk_slope = FALSE,
  brk_loadings = FALSE,
  cce = TRUE,
  simulate = 0L,
  level = 95L
)
```

## Arguments

| | |
|---|---|
| `formula` | A formula of the form `y ~ x1 + x2 + ...` specifying the cointegrating relationship to test. |
| `data` | A data frame containing the panel data in long format. |
| `index` | A character vector of length 2: `c("id_var", "time_var")`. |
| `model` | Integer (0–5) specifying the deterministic component:<br>• 0: No deterministic component<br>• 1: Constant (default)<br>• 2: Linear trend<br>• 3: Constant with level shifts (requires `breaks >= 1`)<br>• 4: Linear trend with level shifts (requires `breaks >= 1`)<br>• 5: Linear trend with level and slope shifts (requires `breaks >= 1`) |
| `breaks` | Integer (0, 1, or 2). Number of structural breaks. Default is 0. |
| `trimming` | Numeric trimming fraction for break date search. Default 0.15. |

| | |
|---|---|
| maxlags | Maximum lag order for ADF augmentation. Default 4. |
| lagselect | Lag selection method: "bic" (default), "aic", "maic", "mbic", or "fixed". |
| nfactors | Integer. Number of common factors for CCE. Default 1. |
| brk_slope | Logical. If TRUE, allows breaks in the cointegrating vector slopes. Default FALSE. |
| brk_loadings | Logical. If TRUE, allows breaks in factor loadings. Default FALSE. |
| cce | Logical. If TRUE (default), applies CCE cross-sectional augmentation to account for common factors. |
| simulate | Integer. Number of Monte Carlo replications used to simulate critical values from independent Gaussian random walks at the estimated break dates (see Details); this is not a bootstrap of the data. Use 0 (default) to skip simulation. |
| level | Confidence level (in percent) for hypothesis test decisions. Default 95. |

## Details

The pooled CCE estimator (equation 13 of the paper) is computed with the projection on the deterministic terms and the cross-section averages of $y$ and $x$ (interacted with the break dummies when brk_loadings = TRUE). With breaks, the break dates are chosen by a grid search: Tb_hat minimises the sum of squared defactored residuals (equation 14) and Tb_tilde the sum of squared residuals after removing only the deterministic terms (equations 15 and 16). Each unit's statistic is the t-ratio of the lagged residual in the cross-section augmented ADF regression (equation 17), with impulse dummies at $T_b + 1$; nfactors sets how many cross-section averages enter. For model 5 the statistic is also computed on data trimmed by three observations on each side of the break (Kim and Perron, 2009), with maxlags fixed lags.

The computations reproduce the Stata module xtcadfcoint, which states that it translates the authors' GAUSS code; results were checked against it. The information criteria and the residual variance use the full $T$ as in that code, and the MAIC and MBIC penalties follow Ng and Perron (2001).

Critical values depend on $N$, $T$, $k$, the model and the break fractions (Tables B.1 to B.24 of the supplementary material of the paper cover one break). simulate draws them from independent random walks at the estimated break dates Tb_hat, without lag augmentation. The Stata module instead fixes the break fractions at 0.5 (one break) or 0.3 and 0.7 (two breaks).

## Value

An object of class "xtcadfcoint" with components:

**panel_cips** Panel CIPS statistic; with breaks, computed at the break dates Tb_hat.

**panel_cips_alt** Panel statistic at the alternative break dates Tb_tilde (NULL without breaks).

**panel_cips_trim** Panel statistic on the Kim and Perron (2009) trimmed data (model 5 only).

**t_individual, t_trim** Individual CADF (or ADF) t-statistics.

**p_selected** Selected lag orders per unit.

**beta_ccep, beta_ccep_alt** Pooled CCE estimates of the cointegrating vector (regime-specific when brk_slope = TRUE).

**SSR** Sums of squared residuals: levels and first differences of the defactored and of the detrended residuals.

**Tb_hat, Tb_tilde, Tb_trim** Estimated break dates (positions in the sample; a break at $T_b$ shifts the level from $T_b + 1$).

**cv** Simulated critical values (if `simulate > 0`): rows `panel` and `individual`, columns 1%, 2.5%, 5%, 10%.

**N, TT, k, model, breaks, ...** Settings of the call.

## References

Banerjee, A. and Carrion-i-Silvestre, J.L. (2025). Panel Data Cointegration Testing with Structural Instabilities. *Journal of Business & Economic Statistics*, 43(1), 122–133. doi:10.1080/07350015.2024.2327844

Kim, D. and Perron, P. (2009). Unit root tests allowing for a break in the trend function at an unknown time under both the null and alternative hypotheses. *Journal of Econometrics*, 148(1), 1–13. doi:10.1016/j.jeconom.2008.08.019

Ng, S. and Perron, P. (2001). Lag length selection and the construction of unit root tests with good size and power. *Econometrica*, 69(6), 1519–1554. doi:10.1111/14680262.00256

Pesaran, M.H. (2006). Estimation and Inference in Large Heterogeneous Panels with a Multifactor Error Structure. *Econometrica*, 74(4), 967–1012. doi:10.1111/j.14680262.2006.00692.x

## Examples

```
set.seed(42)
n <- 8; tt <- 30
dat <- data.frame(
  id   = rep(1:n, each = tt),
  time = rep(1:tt, times = n),
  y    = cumsum(rnorm(n * tt)),
  x1   = cumsum(rnorm(n * tt))
)
res <- xtcadfcoint(y ~ x1, data = dat, index = c("id", "time"),
                   model = 1, breaks = 0)
print(res)
summary(res)
```

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