Package: rbfmvar (via r-universe)

May 28, 2026

Type Package

Title Residual-Based Fully Modified Vector Autoregression

Version 2.0.2

Description Implements the Residual-Based Fully Modified Vector Autoregression (RBFM-VAR) estimator of Chang (2000) <doi:10.1017/S0266466600166071>. The RBFM-VAR procedure extends Phillips (1995) FM-VAR to handle any unknown mixture of I(0), I(1), and I(2) components without prior knowledge of the number or location of unit roots. Provides automatic lag selection via information criteria (AIC, BIC, HQ), long-run variance estimation using Bartlett, Parzen, or Quadratic Spectral kernels with Andrews (1991) <doi:10.2307/2938229> automatic bandwidth selection, Granger non-causality testing with asymptotically chi-squared Wald statistics, impulse response functions (IRF) with bootstrap confidence intervals, forecast error variance decomposition (FEVD), and out-of-sample forecasting.

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URL https://github.com/muhammedalkhalaf/rbfmvar

BugReports https://github.com/muhammedalkhalaf/rbfmvar/issues

Encoding UTF-8

Depends R (>= 3.5.0)

Imports stats, MASS

Suggests testthat (>= 3.0.0), knitr, rmarkdown

RoxygenNote 7.3.3

Config/testthat/edition 3

Repository https://muhammedalkhalaf.r-universe.dev

Date/Publication 2026-04-27 20:56:49 UTC

RemoteUrl https://github.com/muhammedalkhalaf/rbfmvar

RemoteRef HEAD

RemoteSha cbd3b6fed4a3eb59758392649fceec15ab97144b

Contents

`rbfmvar-package` *rbfmvar: Residual-Based Fully Modified Vector Autoregression*

Description

Implements the Residual-Based Fully Modified Vector Autoregression (RBFM-VAR) estimator following Chang (2000). The RBFM-VAR procedure extends Phillips (1995) FM-VAR to handle any unknown mixture of I(0), I(1), and I(2) components without prior knowledge of the number or location of unit roots.

Main Functions

`rbfmvar` Estimate an RBFM-VAR model.

`granger_test` Test for Granger non-causality.

`irf` Compute impulse response functions.

`fevd` Compute forecast error variance decomposition.

`forecast.rbfmvar` Generate out-of-sample forecasts.

Key Features

- Handles unknown mixtures of I(0), I(1), and I(2) variables
- Automatic lag selection via AIC, BIC, or HQ
- Multiple kernels for LRV estimation (Bartlett, Parzen, QS)
- Andrews (1991) automatic bandwidth selection
- Granger non-causality testing with asymptotic chi-squared inference
- Impulse response functions with bootstrap confidence intervals
- Forecast error variance decomposition
- Out-of-sample forecasting

Methodology

The RBFM-VAR model is based on Chang (2000), which develops a fully modified VAR estimation procedure that is robust to unknown integration orders. The key innovation is using second differences to eliminate I(2) trends while applying FM corrections to handle endogeneity from I(1) regressors.

The estimator achieves:

- Zero mean mixed normal limiting distribution
- Chi-square Wald statistics for hypothesis testing
- Consistent estimation regardless of integration orders

Author(s)

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Other contributors:

- Yoosoon Chang (Original RBFM-VAR methodology) [contributor]

References

Chang, Y. (2000). Vector Autoregressions with Unknown Mixtures of I(0), I(1), and I(2) Components. *Econometric Theory*, 16(6), 905-926. doi:10.1017/S0266466600166071

Phillips, P. C. B. (1995). Fully Modified Least Squares and Vector Autoregression. *Econometrica*, 63(5), 1023-1078. doi:10.2307/2171721

Andrews, D. W. K. (1991). Heteroskedasticity and Autocorrelation Consistent Covariance Matrix Estimation. *Econometrica*, 59(3), 817-858. doi:10.2307/2938229

See Also

Useful links:

- `https://github.com/muhammedalkhalaf/rbfmvar`
- Report bugs at `https://github.com/muhammedalkhalaf/rbfmvar/issues`

`coef.rbfmvar` *Extract Coefficients from rbfmvar Object*

Description

Extract Coefficients from rbfmvar Object

Usage

```
## S3 method for class 'rbfmvar'
coef(object, type = "plus", ...)
```

Arguments

`object`	An `rbfmvar` object.
`type`	Character. Type of coefficients to extract: `"plus"` (FM+ corrected, default) or `"ols"`.
`...`	Additional arguments (currently ignored).

Value

Coefficient matrix.

`fevd` *Forecast Error Variance Decomposition*

Description

Computes the forecast error variance decomposition (FEVD) from an RBFM-VAR model.

Usage

```
fevd(object, horizon = 20)
```

Arguments

`object`	An `rbfmvar` object from `rbfmvar`.
`horizon`	Integer. Number of periods for the FEVD. Default is 20.

Details

The FEVD shows the proportion of the forecast error variance of each variable that is attributable to shocks in each of the structural innovations. The decomposition is based on the Cholesky identification scheme, so the ordering of variables matters.

At each horizon h, the FEVD sums to 1 (100

Value

An object of class "rbfmvar_fevd" containing:

fevd Array of FEVD values (horizon x n x n). Element [h, i, j] is the proportion of variable i's forecast error variance at horizon h explained by shocks in variable j.

horizon FEVD horizon.

varnames Variable names.

References

Lutkepohl, H. (2005). *New Introduction to Multiple Time Series Analysis*. Springer-Verlag. doi:10.1007/9783540277521

Examples

```
# Simulate VAR data
set.seed(123)
n <- 200
e <- matrix(rnorm(n * 3), n, 3)
y <- matrix(0, n, 3)
colnames(y) <- c("y1", "y2", "y3")
for (t in 3:n) {
  y[t, ] <- 0.3 * y[t-1, ] + 0.2 * y[t-2, ] + e[t, ]
}

fit <- rbfmvar(y, lags = 2)
fv <- fevd(fit, horizon = 20)
plot(fv)
```

---

fitted.rbfmvar *Extract Fitted Values from rbfmvar Object*

Description

Extract Fitted Values from rbfmvar Object

Usage

```
## S3 method for class 'rbfmvar'
fitted(object, ...)
```

Arguments

`object`	An `rbfmvar` object.
`...`	Additional arguments (currently ignored).

Value

Matrix of fitted values.

`forecast` *Out-of-Sample Forecasting*

Description

The generic function `forecast` computes forecasts from time series models.

Usage

```
forecast(object, ...)
```

Arguments

`object`	A model object.
`...`	Additional arguments passed to methods.

Value

Depends on the method dispatched. See `forecast.rbfmvar` for the RBFM-VAR method, which returns an object of class `"rbfmvar_forecast"`.

`forecast.rbfmvar` *Out-of-Sample Forecasting for RBFM-VAR*

Description

Generates out-of-sample forecasts from an RBFM-VAR model.

Usage

```
## S3 method for class 'rbfmvar'
forecast(object, h = 10, level = 95, ...)
```

Arguments

`object`	An `rbfmvar` object from `rbfmvar`.
`h`	Integer. Forecast horizon (number of periods ahead). Default is 10.
`level`	Numeric. Confidence level for prediction intervals (0-100). Default is 95.
`...`	Additional arguments (currently ignored).

Details

Forecasts are generated iteratively using the estimated VAR coefficients. Standard errors are computed assuming normally distributed innovations.

Note that since the RBFM-VAR is estimated on second differences, forecasts are for $\Delta^2 y_{t+h}$, which need to be accumulated to obtain level forecasts.

Value

An object of class "rbfmvar_forecast" containing:

mean Matrix of point forecasts (n x h).

se Matrix of forecast standard errors (n x h).

lower Matrix of lower prediction bounds (n x h).

upper Matrix of upper prediction bounds (n x h).

horizon Forecast horizon.

level Confidence level.

varnames Variable names.

Examples

```
# Simulate VAR data
set.seed(123)
n <- 200
e <- matrix(rnorm(n * 3), n, 3)
y <- matrix(0, n, 3)
colnames(y) <- c("y1", "y2", "y3")
for (t in 3:n) {
  y[t, ] <- 0.3 * y[t-1, ] + 0.2 * y[t-2, ] + e[t, ]
}

fit <- rbfmvar(y, lags = 2)
fc <- forecast(fit, h = 10)
print(fc)
plot(fc)
```

---

granger_matrix *Granger Causality Matrix*

Description

Computes pairwise Granger causality tests for all variable pairs.

Usage

```
granger_matrix(object)
```

Arguments

object	An rbfmvar object.

Value

A matrix of p-values for all pairwise Granger causality tests. Row i, column j contains the p-value for "variable j causes variable i".

Examples

```
# Generate example data
set.seed(123)
n <- 100
mydata <- data.frame(x = cumsum(rnorm(n)), y = cumsum(rnorm(n)))
fit <- rbfmvar(mydata, lags = 2)
granger_matrix(fit)
```

`granger_test` *Granger Non-Causality Test*

Description

Tests for Granger non-causality in the RBFM-VAR framework using a modified Wald statistic. The test is asymptotically chi-squared under the null hypothesis, regardless of the integration order of the variables.

Usage

```
granger_test(object, cause, effect)
```

Arguments

`object`	An `rbfmvar` object from `rbfmvar`.
`cause`	Character string. Name of the causing variable.
`effect`	Character string. Name of the affected variable.

Details

The Granger non-causality hypothesis is:

$$H_0 : x \text{ does not Granger-cause } y$$

This is tested by examining whether the coefficients on lagged values of `cause` in the equation for `effect` are jointly zero.

Under the FM+ framework of Chang (2000), the Wald statistic has an asymptotic chi-squared distribution that provides a conservative (valid) p-value even when variables have unknown integration orders.

Value

A list of class "rbfmvar_granger" containing:

cause Name of the causing variable.

effect Name of the affected variable.

statistic Modified Wald statistic.

df Degrees of freedom.

p.value P-value (conservative).

coefficients Restricted coefficients being tested.

References

Chang, Y. (2000). Vector Autoregressions with Unknown Mixtures of I(0), I(1), and I(2) Components. *Econometric Theory*, 16(6), 905-926. doi:10.1017/S0266466600166071

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)01616-8

Examples

```
# Simulate VAR data
set.seed(42)
n <- 200
e <- matrix(rnorm(n * 3), n, 3)
y <- matrix(0, n, 3)
colnames(y) <- c("x", "y", "z")
for (t in 3:n) {
  y[t, "x"] <- 0.5 * y[t-1, "x"] + e[t, 1]
  y[t, "y"] <- 0.3 * y[t-1, "y"] + 0.4 * y[t-1, "x"] + e[t, 2]
  y[t, "z"] <- 0.2 * y[t-1, "z"] + e[t, 3]
}

fit <- rbfmvar(y, lags = 2)

# Test if x Granger-causes y (should be significant)
test1 <- granger_test(fit, cause = "x", effect = "y")
print(test1)

# Test if z Granger-causes y (should not be significant)
test2 <- granger_test(fit, cause = "z", effect = "y")
print(test2)
```

ic_table *Get Information Criteria Table*

Description

Returns a table of information criteria values for different lag orders.

Usage

```
ic_table(object, max_lags = 8)
```

Arguments

object	An rbfmvar object.
max_lags	Maximum lag order to evaluate.

Value

A data frame with AIC, BIC, and HQ values.

Examples

```
# Generate example data
set.seed(123)
n <- 100
mydata <- data.frame(x = cumsum(rnorm(n)), y = cumsum(rnorm(n)))
fit <- rbfmvar(mydata, lags = 2)
ic_table(fit, max_lags = 6)
```

irf *Impulse Response Functions*

Description

Computes orthogonalized impulse response functions (IRF) from an RBFM-VAR model with optional bootstrap confidence intervals.

Usage

```
irf(object, horizon = 20, ortho = TRUE, boot = 0, ci = 90, seed = NULL)
```

Arguments

`object`	An `rbfmvar` object from `rbfmvar`.
`horizon`	Integer. Number of periods for the IRF. Default is 20.
`ortho`	Logical. If `TRUE` (default), compute orthogonalized IRFs using Cholesky decomposition of the error covariance matrix.
`boot`	Integer. Number of bootstrap replications for confidence intervals. If 0 (default), no bootstrap is performed.
`ci`	Numeric. Confidence level for bootstrap intervals (0-100). Default is 90.
`seed`	Integer. Random seed for reproducibility. Default is `NULL`.

Details

The IRF measures the response of each variable to a one-standard-deviation shock in each of the structural innovations. When `ortho = TRUE`, the structural shocks are identified using the Cholesky decomposition of the residual covariance matrix (recursive identification).

Bootstrap confidence intervals are computed using the recursive-design bootstrap following Kilian (1998).

Value

An object of class `"rbfmvar_irf"` containing:

irf Array of IRF values (horizon x n x n). Element [h, i, j] is the response of variable i to a shock in variable j at horizon h.

irf_lower Lower confidence bounds (if bootstrap was performed).

irf_upper Upper confidence bounds (if bootstrap was performed).

horizon IRF horizon.

varnames Variable names.

ortho Whether orthogonalized IRFs were computed.

boot Number of bootstrap replications.

ci Confidence level.

References

Kilian, L. (1998). Small-Sample Confidence Intervals for Impulse Response Functions. *Review of Economics and Statistics*, 80(2), 218-230. doi:10.1162/003465398557465

Lutkepohl, H. (2005). *New Introduction to Multiple Time Series Analysis*. Springer-Verlag. doi:10.1007/9783540277521

Examples

```
# Simulate VAR data
set.seed(123)
n <- 200
e <- matrix(rnorm(n * 3), n, 3)
y <- matrix(0, n, 3)
colnames(y) <- c("y1", "y2", "y3")
for (t in 3:n) {
  y[t, ] <- 0.3 * y[t-1, ] + 0.2 * y[t-2, ] + e[t, ]
}

fit <- rbfmvar(y, lags = 2)
ir <- irf(fit, horizon = 20)
plot(ir)

# With bootstrap confidence intervals
ir_boot <- irf(fit, horizon = 20, boot = 500, ci = 95)
plot(ir_boot)
```

`plot.rbfmvar_forecast` *Plot Method for rbfmvar_forecast Objects*

Description

Plots forecasts from an RBFM-VAR model.

Usage

```
## S3 method for class 'rbfmvar_forecast'
plot(x, ...)
```

Arguments

`x`	An `rbfmvar_forecast` object.
`...`	Additional arguments passed to `plot`.

Value

No return value, called for side effects (produces a plot).

print.rbfmvar — *Print Method for rbfmvar Objects*

Description

Prints a summary of an RBFM-VAR estimation.

Usage

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

Arguments

x	An `rbfmvar` object.
...	Additional arguments (currently ignored).

Value

Invisibly returns the input object.

print.rbfmvar_forecast — *Print Method for rbfmvar_forecast Objects*

Description

Prints a summary of an RBFM-VAR forecast.

Usage

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

Arguments

x	An `rbfmvar_forecast` object.
...	Additional arguments (currently ignored).

Value

Invisibly returns `x`.

print.summary.rbfmvar — *Print Method for summary.rbfmvar Objects*

Description

Prints detailed coefficient tables and diagnostics for an RBFM-VAR model summary.

Usage

```
## S3 method for class 'summary.rbfmvar'
print(x, digits = 4, ...)
```

Arguments

`x`	A `summary.rbfmvar` object.
`digits`	Integer. Number of digits to print. Default is 4.
`...`	Additional arguments (currently ignored).

Value

Invisibly returns `x`.

rbfmvar — *Residual-Based Fully Modified VAR Estimation*

Description

Estimates a Residual-Based Fully Modified Vector Autoregression (RBFM-VAR) model following Chang (2000). The RBFM-VAR procedure extends Phillips (1995) FM-VAR to handle any unknown mixture of I(0), I(1), and I(2) components without prior knowledge of the number or location of unit roots.

Usage

```
rbfmvar(
  data,
  lags = 2,
  max_lags = 8,
  ic = "none",
  kernel = "bartlett",
  bandwidth = -1,
  level = 95
)
```

Arguments

`data`	A numeric matrix or data frame containing the time series variables. Must have at least 2 columns.
`lags`	Integer. The VAR lag order p. Must be at least 1. Default is 2.
`max_lags`	Integer. Maximum number of lags to consider for information criterion selection. Default is 8.
`ic`	Character string specifying the information criterion for lag selection: `"aic"`, `"bic"`, `"hq"`, or `"none"` (use `lags` directly). Default is `"none"`.
`kernel`	Character string specifying the kernel for long-run variance estimation: `"bartlett"`, `"parzen"`, or `"qs"` (Quadratic Spectral). Default is `"bartlett"`.
`bandwidth`	Numeric. Bandwidth for kernel estimation. If `-1` (default), automatic bandwidth selection via Andrews (1991) is used.
`level`	Numeric. Confidence level for coefficient intervals (0-100). Default is 95.

Details

The RBFM-VAR model is specified as:

$$\Delta^2 y_t = \sum_{j=1}^{p-2} \Gamma_j \Delta^2 y_{t-j} + \Pi_1 \Delta y_{t-1} + \Pi_2 y_{t-1} + e_t$$

where Δ is the difference operator and $\Delta^2 = \Delta \circ \Delta$.

The FM+ correction eliminates the second-order asymptotic bias that arises from the correlation between the regression errors and the innovations in integrated regressors. The estimator achieves:

- Zero mean mixed normal limiting distribution
- Chi-square Wald statistics for hypothesis testing
- Robustness to unknown integration orders

Value

An object of class `"rbfmvar"` containing:

F_ols OLS coefficient matrix.

F_plus FM+ corrected coefficient matrix.

SE_mat Standard errors for FM+ coefficients.

Pi1_ols, Pi1_plus Coefficient matrices for Δy_{t-1}.

Pi2_ols, Pi2_plus Coefficient matrices for y_{t-1}.

Gamma_ols, Gamma_plus Coefficient matrices for $\Delta^2 y_{t-j}$ (if p >= 3).

Sigma_e Residual covariance matrix.

Omega_ev, Omega_vv Long-run variance components.

Delta_vdw One-sided long-run covariance for FM correction.

residuals Matrix of residuals from FM+ estimation.

fitted Matrix of fitted values.

nobs Number of observations in original data.

T_eff Effective sample size after differencing.

n_vars Number of variables.

p_lags VAR lag order used.

bandwidth Bandwidth used for LRV estimation.

kernel Kernel used for LRV estimation.

ic Information criterion used (if any).

varnames Variable names.

call The matched call.

References

Chang, Y. (2000). Vector Autoregressions with Unknown Mixtures of I(0), I(1), and I(2) Components. *Econometric Theory*, 16(6), 905-926. doi:10.1017/S0266466600166071

Phillips, P. C. B. (1995). Fully Modified Least Squares and Vector Autoregression. *Econometrica*, 63(5), 1023-1078. doi:10.2307/2171721

Andrews, D. W. K. (1991). Heteroskedasticity and Autocorrelation Consistent Covariance Matrix Estimation. *Econometrica*, 59(3), 817-858. doi:10.2307/2938229

Examples

```
# Simulate a simple VAR(2) process
set.seed(123)
n <- 200
e <- matrix(rnorm(n * 3), n, 3)
y <- matrix(0, n, 3)
for (t in 3:n) {
  y[t, ] <- 0.3 * y[t-1, ] + 0.2 * y[t-2, ] + e[t, ]
}
colnames(y) <- c("y1", "y2", "y3")

# Estimate RBFM-VAR
fit <- rbfmvar(y, lags = 2)
summary(fit)

# With automatic lag selection
fit_aic <- rbfmvar(y, max_lags = 6, ic = "aic")
summary(fit_aic)
```

`residuals.rbfmvar` *Extract Residuals from rbfmvar Object*

Description

Extract Residuals from rbfmvar Object

Usage

```
## S3 method for class 'rbfmvar'
residuals(object, ...)
```

Arguments

`object`	An `rbfmvar` object.
`...`	Additional arguments (currently ignored).

Value

Matrix of residuals.

`summary.rbfmvar` *Summary Method for rbfmvar Objects*

Description

Provides detailed summary of RBFM-VAR estimation results.

Usage

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

Arguments

`object`	An `rbfmvar` object.
`...`	Additional arguments (currently ignored).

Value

A list of class `"summary.rbfmvar"` containing summary information.

`vcov.rbfmvar` *Extract Variance-Covariance Matrix from rbfmvar Object*

Description

Extract Variance-Covariance Matrix from rbfmvar Object

Usage

```
## S3 method for class 'rbfmvar'
vcov(object, ...)
```

Arguments

`object`	An `rbfmvar` object.
`...`	Additional arguments (currently ignored).

Value

Error covariance matrix.

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