

Package ‘pvarife’

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Type Package

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Title Panel VAR Models with Interactive Fixed Effects

Description Implements the estimator of Tugan (2021) <[doi:10.1093/ectj/utaa021](https://doi.org/10.1093/ectj/utaa021)> for panel vector autoregression (VAR) models with interactive fixed effects. Provides joint estimation of VAR coefficients, latent common factors, and factor loadings via an iterative algorithm that alternates between principal component estimation of the factors and least squares estimation of the VAR coefficients, following the approach of Bai (2009). Supports impulse response functions under recursive (Cholesky) identification, parametric confidence bands from the joint asymptotic distribution of the estimator (Theorem 2.3), and a classical residual bootstrap for robustness checks.

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asymptotic_var	<i>Asymptotic variance and bias of the pvarife estimator</i>
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Description

Computes the asymptotic bias and variance-covariance matrix of $\hat{\beta}$ under Theorem 2.3 of Tugan (2021). These quantities are used by [irf_bands](#) to construct parametric confidence bands.

Usage

```
asymptotic_var(fit)
```

Arguments

`fit` An object of class "pvarife_result" returned by [pvarife](#).

Details

The function computes three components:

D The Hessian $D_{F,\Lambda}$ (Eq. A.4), which accounts for factor estimation uncertainty via a two-term formula.

Omega The sandwich variance Ω , accumulated unit by unit.

Bias Two bias terms: B_Ψ (from factor loading estimation) and B_γ (HAC serial correction with bandwidth $\bar{G} = \lfloor T^{1/3} \rfloor$).

Note on MATLAB replication: The original `Asymptotic_Distribution_of_beta.m` contains a bug at line 189 where the B_γ accumulation uses only the final value of the loop variable g rather than summing over $g = 1, \dots, \bar{G}$. This function implements the *corrected* version.

Value

A list with:

bias Bias vector for $\hat{\beta}$, of the same length as `fit$beta`.

variance Asymptotic variance-covariance matrix of $\hat{\beta}$.

References

Tugan, M. (2021). Panel VAR models with interactive fixed effects. *Econometrics Journal*, 24, 225–246. doi:10.1093/ectj/utaa021

Examples

```
sim <- sim_pvarife(n_units = 30, n_time = 20, n_vars = 2,
                 n_lags = 1, n_factors = 1, seed = 1)
fit <- pvarife(sim$y, n_lags = 1, n_factors = 1, n_out = 5, n_in = 3)
avar <- asymptotic_var(fit)
cat("Bias:", avar$bias, "\n")
```

bootstrap_irf_bands *Classical residual bootstrap confidence bands for IRFs*

Description

Constructs confidence bands for structural impulse responses via a classical residual bootstrap. For each bootstrap replicate, residuals are resampled (by time index, preserving cross-sectional dependence), a new panel is constructed, the full pvarife model is re-estimated, and IRFs are computed. This is computationally expensive but does not rely on asymptotic approximations.

Usage

```
bootstrap_irf_bands(
  fit,
  n_periods,
  shock = 1L,
  diff_vars = integer(0),
  identification = c("short_run", "long_run"),
  n_boot = 200L,
  level = 0.95,
  seed = NULL
)
```

Arguments

fit	An object of class "pvarife_result".
n_periods	Positive integer. Number of IRF horizons.
shock	Positive integer. Index of the structural shock (default 1).
diff_vars	Integer vector. Variables to cumulate (default none).
identification	Character. "short_run" (default) or "long_run". Passed to <code>compute_irf</code> for each bootstrap replicate.
n_boot	Positive integer. Number of bootstrap replicates (default 200).
level	Numeric in (0, 1). Confidence level (default 0.95).
seed	Optional integer seed for reproducibility.

Value

An object of class "pvarife_bands" with components `irf`, `lower`, `upper`, `level`, and method = "bootstrap".

See Also

[irf_bands](#), [compute_irf](#)

Examples

```
sim <- sim_pvarife(n_units = 20, n_time = 15, n_vars = 2,
                 n_lags = 1, n_factors = 1, seed = 1)
fit <- pvarife(sim$y, n_lags = 1, n_factors = 1, n_out = 5, n_in = 3)
bands <- bootstrap_irf_bands(fit, n_periods = 6, n_boot = 20, seed = 42)
plot(bands)
```

coef.pvarife_result *Extract coefficients from a pvarife_result*

Description

Extract coefficients from a pvarife_result

Usage

```
## S3 method for class 'pvarife_result'
coef(object, ...)
```

Arguments

object	An object of class "pvarife_result".
...	Ignored.

Value

Named numeric vector of coefficients.

compute_irf	<i>Compute impulse response functions under recursive (Cholesky) identification</i>
-------------	---

Description

Computes structural impulse responses from an estimated `pvarife_result` using a recursive (lower-triangular Cholesky) identification scheme. The identification follows the short-run restriction approach of Tugan (2021).

Usage

```
compute_irf(
  fit,
  n_periods,
  shock = 1L,
  diff_vars = integer(0),
  identification = c("short_run", "long_run"),
  bias_correct = FALSE
)
```

Arguments

<code>fit</code>	An object of class "pvarife_result".
<code>n_periods</code>	Positive integer. Number of IRF horizons to compute.
<code>shock</code>	Positive integer. Index of the structural shock (1 = first variable in the ordering). Default is 1.
<code>diff_vars</code>	Integer vector. Indices of variables for which cumulative IRFs are reported (e.g., for variables entered in first differences). Default is <code>integer(0)</code> (no cumulation). For long-run identification <code>diff_vars = 1L</code> is common when variable 1 is treated as I(1).
<code>identification</code>	Character. Either "short_run" (default, Cholesky of $\hat{\Sigma}$) or "long_run" (Blanchard-Quah: long-run multiplier lower-triangular). See Details.
<code>bias_correct</code>	Logical. If TRUE, the IRF is evaluated at the bias-corrected coefficient vector $\hat{\beta} - \hat{b}$ from <code>asymptotic_var</code> . Default FALSE (faster; use <code>irf_bands</code> for full bias-corrected inference).

Details

The MA representation is computed recursively:

$$B_0 = I_K, \quad B_h = \sum_{l=1}^h \Theta_l B_{h-l},$$

with the convention $B_j = 0$ for $j < 0$.

Short-run identification (default): The impact matrix is the lower-triangular Cholesky factor of $\hat{\Sigma}$: $A_0 = \text{chol}(\hat{\Sigma})^\top$.

Long-run identification (Blanchard-Quah type): The long-run multiplier $C(1) = (I - \sum_{\ell} \Theta_{\ell})^{-1} A_0$ is constrained to be lower-triangular. The impact matrix is

$$A_0 = (I - \Theta) \text{chol}(D)^\top,$$

where $\Theta = \sum_{\ell=1}^L \Theta_{\ell}$ and $D = (I - \Theta)^{-1} \hat{\Sigma} (I - \Theta)^{-\top}$. This identification restricts shock 1 to have no long-run effect on variable 2 (in a 2-variable system). Faithful to `IRs_to_Shocks_LR_Identification.m` in the Monte Carlo replication code.

Bias correction: When `bias_correct = TRUE`, the impact matrix is evaluated at the bias-corrected coefficient vector $\hat{\beta} - \hat{b}$ from `asymptotic_var`. The uncorrected estimator is used by default (`bias_correct = FALSE`) for speed; users who need confidence bands can rely on `irf_bands`, whose median is already implicitly bias-corrected.

The impulse response to shock s at horizon h is $B_h A_0 e_s$ where e_s is the s -th standard basis vector.

Value

A matrix of dimension $K \times n_periods$. Row k gives the response of variable k to the structural shock at horizons $1, \dots, n_periods$. The object has class `c("pvarife_irf", "matrix")`.

References

Tugan, M. (2021). Panel VAR models with interactive fixed effects. *Econometrics Journal*, 24, 225–246. doi:10.1093/ectj/utaa021

See Also

`irf_bands`, `bootstrap_irf_bands`

Examples

```
sim <- sim_pvarife(n_units = 30, n_time = 20, n_vars = 2,
                 n_lags = 1, n_factors = 1, seed = 1)
fit <- pvarife(sim$y, n_lags = 1, n_factors = 1, n_out = 5, n_in = 3)
ir <- compute_irf(fit, n_periods = 8)
dim(ir) # 2 x 8

# Long-run identification
ir_lr <- compute_irf(fit, n_periods = 8, identification = "long_run",
                   diff_vars = 1L)
```

extract_factors	<i>Extract factors and loadings at an arbitrary coefficient vector</i>
-----------------	--

Description

Given an estimated `pvarife_result` and an arbitrary coefficient vector `beta`, runs the inner EM loop to extract common factors and factor loadings. Useful for advanced users (e.g., bootstrap procedures that need factor estimates at a perturbed `beta`).

Usage

```
extract_factors(beta, fit, n_in = 10L)
```

Arguments

<code>beta</code>	Numeric vector of VAR coefficients (same length as <code>fit\$beta</code>).
<code>fit</code>	An object of class "pvarife_result".
<code>n_in</code>	Number of inner iterations (default 10).

Details

Faithful translation of `Inner_Iteration.m` from Tugan (2021).

Value

A list with `ff` ($T \times r$ factor matrix) and `loadings` ($Kr \times I$ loading matrix).

Examples

```
sim <- sim_pvarife(n_units = 20, n_time = 15, n_vars = 2,
                 n_lags = 1, n_factors = 1, seed = 2)
fit <- pvarife(sim$y, n_lags = 1, n_factors = 1, n_out = 5, n_in = 3)
ef <- extract_factors(fit$beta * 0.9, fit)
dim(ef$ff)      # T x r
```

irf_bands	<i>Parametric confidence bands for impulse response functions</i>
-----------	---

Description

Constructs confidence bands for structural impulse responses by drawing from the joint asymptotic distribution of the estimator and the common component (Theorem 2.3 of Tugan 2021). This is a parametric simulation, not a residual bootstrap.

Usage

```

irf_bands(
  fit,
  n_periods,
  shock = 1L,
  diff_vars = integer(0),
  identification = c("short_run", "long_run"),
  n_draw = 500L,
  level = 0.95,
  seed = NULL
)

```

Arguments

<code>fit</code>	An object of class "pvarife_result".
<code>n_periods</code>	Positive integer. Number of IRF horizons.
<code>shock</code>	Positive integer. Index of the structural shock (default 1).
<code>diff_vars</code>	Integer vector. Variables to cumulate (default none).
<code>identification</code>	Character. "short_run" (default) or "long_run". Passed to <code>compute_irf</code> for each draw. The median IRF returned is implicitly bias-corrected regardless of this choice (draws are centred on $\hat{\beta} - \hat{b}$).
<code>n_draw</code>	Positive integer. Number of simulation draws (default 500).
<code>level</code>	Numeric in (0, 1). Confidence level (default 0.95).
<code>seed</code>	Optional integer seed for reproducibility.

Details

For each of the `n_draw` repetitions, the function:

1. Draws $\beta^{(b)} \sim N(\hat{\beta} - \hat{b}, \hat{V})$ where \hat{b} and \hat{V} are the estimated bias and variance from `asymptotic_var`.
2. Draws the common component $\tilde{C}_{i,t,k}$ from a normal with mean $\hat{F}_t \hat{\lambda}_k$ and standard deviation

$$\sqrt{\hat{\Xi}_{i,t,k}^*/I + \hat{\Xi}_{i,t,k}^{**}/T},$$

capturing cross-sectional and time-series uncertainty in factor estimation.

3. Computes the IRF at $(\beta^{(b)}, \tilde{C}^{(b)})$.

The median and the $(1 - \text{level})/2$ and $(1 + \text{level})/2$ quantiles across draws give the point estimate and confidence bands.

Value

An object of class "pvarife_bands" with components:

irf Point estimate (median across draws, bias-corrected), $K \times n_periods$.
lower Lower confidence bound, $K \times n_periods$.
upper Upper confidence bound, $K \times n_periods$.
level The confidence level used.
method "asymptotic".

References

Tugan, M. (2021). Panel VAR models with interactive fixed effects. *Econometrics Journal*, 24, 225–246. doi:10.1093/ectj/utaa021

See Also

[bootstrap_irf_bands](#), [compute_irf](#)

Examples

```
sim <- sim_pvarife(n_units = 20, n_time = 15, n_vars = 2,
                 n_lags = 1, n_factors = 1, seed = 1)
fit <- pvarife(sim$y, n_lags = 1, n_factors = 1, n_out = 5, n_in = 3)
bands <- irf_bands(fit, n_periods = 6, n_draw = 100, seed = 42)
plot(bands)
```

lag_lead_matrix	<i>Build a matrix of lags and/or leads</i>
-----------------	--

Description

Creates a matrix whose columns are lagged or lead copies of the columns of x , for integer offsets from_lag through to_lag. A positive offset k produces a lag (rows $k + 1$ to T of the output receive rows 1 to $T - k$ of x); a negative offset k produces a lead. Unfilled positions are set to NA.

Usage

```
lag_lead_matrix(x, from_lag, to_lag)
```

Arguments

<code>x</code>	A numeric matrix with T rows and K columns.
<code>from_lag</code>	Integer. The smallest offset to include (may be negative for leads).
<code>to_lag</code>	Integer. The largest offset to include (must be \geq from_lag).

Details

Faithful translation of `lagleadmatrix.m` from the replication package of Tugan (2021).

Value

A matrix with T rows and $K \times (to_lag - from_lag + 1)$ columns. Column block j (1-indexed) corresponds to offset $from_lag + j - 1$.

References

Tugan, M. (2021). Panel VAR models with interactive fixed effects. *Econometrics Journal*, 24, 225–246. doi:10.1093/ectj/utaa021

Examples

```
x <- matrix(1:12, nrow = 4)
lag_lead_matrix(x, 1, 2) # two lags
lag_lead_matrix(x, -1, 1) # one lead, contemporaneous, one lag
```

plot.pvarife_bands *Plot impulse response bands*

Description

Plot impulse response bands

Usage

```
## S3 method for class 'pvarife_bands'
plot(x, var_names = NULL, normalise_by_h1 = FALSE, ...)
```

Arguments

x	An object of class "pvarife_bands".
var_names	Character vector of variable names (optional).
normalise_by_h1	Logical. If TRUE, divide all responses by the first-horizon response of the shock variable (replicates Figure 1 of Tugan 2021). Default FALSE.
...	Ignored.

Value

A ggplot2 plot object.

plot.pvarife_irf *Plot impulse response functions*

Description

Plot impulse response functions

Usage

```
## S3 method for class 'pvarife_irf'  
plot(x, var_names = NULL, ...)
```

Arguments

x	An object of class "pvarife_irf".
var_names	Character vector of variable names (optional).
...	Ignored.

Value

A ggplot2 plot object.

print.pvarife_result *Print method for pvarife_result*

Description

Print method for pvarife_result

Usage

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

Arguments

x	An object of class "pvarife_result".
...	Ignored.

Value

Invisibly returns x.

pvarife

*Estimate a Panel VAR with Interactive Fixed Effects***Description**

Jointly estimates VAR coefficients β , latent common factors F , and factor loadings Λ for a panel vector autoregression with interactive fixed effects, following the iterative algorithm of Tugan (2021) based on Bai (2009).

Usage

```
pvarife(y, n_lags, n_factors, n_out = 50L, n_in = 10L, balanced_init = TRUE)
```

Arguments

y	A numeric array of dimension $I \times T \times K$ (units \times time \times variables). NA values are allowed for unbalanced panels.
n_lags	Positive integer. Lag order ℓ .
n_factors	Positive integer. Number of interactive fixed effects r .
n_out	Positive integer. Number of outer iterations (default 50). Corresponds to out_number in the MATLAB replication code.
n_in	Positive integer. Number of inner PCA/EM iterations per outer step (default 10). Corresponds to in_number in the MATLAB code.
balanced_init	Logical. If TRUE (default), the initial beta estimate is obtained from units that have at least 10 fully observed periods in the last window of the sample — matching the approach of the MATLAB Initial_Step_in_Iteration.m for unbalanced real data. Set to FALSE for balanced panels (e.g., Monte Carlo simulations) to skip this selection step and use all units directly.

Details

The model is

$$y_{i,t} = \sum_{l=1}^{\ell} \Theta_l y_{i,t-l} + F_t \lambda_i + e_{i,t},$$

where $y_{i,t}$ is a $K \times 1$ vector of endogenous variables for unit i at time t , F_t is an $r \times 1$ vector of unobservable common factors, λ_i is a unit-specific loading vector, and $e_{i,t}$ is an idiosyncratic error.

The algorithm alternates between:

1. An **inner loop** that extracts factors and loadings via PCA (principal components on the residual cross-product matrix) and imputes missing observations (EM step of Bai 2009).
2. An **outer loop** that updates β via least squares after projecting out the estimated factors (using $M_F = I - F(F'F)^{-1}F'$).

Value

An object of class "pvarife_result", which is a list with:

beta Coefficient vector of length $K + K^2\ell$. The first K elements are equation-specific intercepts; the remaining $K^2\ell$ elements are VAR lag coefficients stacked as $[\Theta_1, \Theta_2, \dots, \Theta_\ell]'$ (column-major).

ff Factor matrix of dimension $T \times r$ (one row per time period; analogous to MATLAB `f`).

factors_mat Block-diagonal factor matrix of dimension $TK \times Kr$, built as $I_K \otimes f_t'$.

loadings Matrix of dimension $Kr \times I$ (factor loadings per unit, stacked by variable).

sigma Reduced-form error covariance matrix ($K \times K$).

u_c Array of residuals $TK \times 1 \times I$ (NA at unobserved positions).

y_c, z_c Stacked outcome/regressor arrays ($TK \times 1 \times I$ and $TK \times (K + K^2\ell) \times I$).

y_stack, z_stack Pooled outcome/regressor matrices (complete-case rows only).

i_obs Integer matrix $TK \times I$: 1 = observed, 0 = missing.

n_time_i Integer vector of length I : number of observed time periods per unit (analogous to MATLAB `TC`).

tnc_i Integer vector of length I : $n_time_i \times K$ (analogous to MATLAB `TNC`).

n_lags, n_factors, n_vars, n_units, n_time Dimensions.

References

Tugan, M. (2021). Panel VAR models with interactive fixed effects. *Econometrics Journal*, 24, 225–246. doi:10.1093/ectj/utaa021

Bai, J. (2009). Panel data models with interactive fixed effects. *Econometrica*, 77(4), 1229–1279.

Examples

```
sim <- sim_pvarife(n_units = 30, n_time = 20, n_vars = 2,
                 n_lags = 1, n_factors = 1, seed = 1)
fit <- pvarife(sim$y, n_lags = 1, n_factors = 1, n_out = 5, n_in = 3)
print(fit)
```

pvarife_sim

Simulated panel VAR dataset with interactive fixed effects

Description

A synthetic panel dataset generated from the DGP of Tugan (2021), Section S10, via `sim_pvarife`. Provided as a compact example dataset for vignettes and function examples.

Usage

pvarife_sim

Format

A list with the following components:

y Numeric array of dimension $50 \times 30 \times 2$ (50 units, 30 time periods, 2 variables).

beta_true True coefficient vector of length 6 (2 intercepts + 4 VAR lag coefficients).

theta_true True VAR coefficient array of dimension $2 \times 2 \times 1$.

sigma_true True reduced-form covariance matrix 2×2 .

factors_true True factor matrix of dimension 30×1 .

loadings_true True factor loadings matrix of dimension 2×50 .

Details

Generated with `sim_pvarife(n_units = 50, n_time = 30, n_vars = 2, n_lags = 1, n_factors = 1, seed = 42)`.

Source

Simulated; see [sim_pvarife](#).

References

Tugan, M. (2021). Panel VAR models with interactive fixed effects. *Econometrics Journal*, 24, 225–246. doi:10.1093/ectj/utaa021

sim_pvarife

Simulate panel VAR data with interactive fixed effects

Description

Generates synthetic panel data from the DGP of Tugan (2021), Section S10, with a single common factor following an AR(1) process and factor loadings drawn from $N(1, 1)$.

Usage

```
sim_pvarife(
  n_units = 50L,
  n_time = 30L,
  n_vars = 2L,
  n_lags = 1L,
  n_factors = 1L,
  identification = c("short_run", "long_run"),
  seed = 42L
)
```

Arguments

<code>n_units</code>	Positive integer. Number of cross-sectional units I (default 50).
<code>n_time</code>	Positive integer. Number of time periods T after burn-in (default 30).
<code>n_vars</code>	Positive integer. Number of VAR variables K (default 2).
<code>n_lags</code>	Positive integer. VAR lag order (default 1; higher lags use zero coefficient matrices).
<code>n_factors</code>	Positive integer. Number of common factors (default 1; each factor has its own AR(1) process and independent loadings).
<code>identification</code>	Character. "short_run" (default) uses $A_0 = \text{chol}(\Sigma_e)^\top$; "long_run" uses the Blanchard-Quah impact matrix $A_0 = (I - \Theta_1) \text{chol}(D)^\top$ where $D = (I - \Theta_1)^{-1} \Sigma_e (I - \Theta_1)^{-\top}$. The long-run multiplier $C(1) = (I - \Theta_1)^{-1} A_0 = \text{chol}(D)^\top$ is lower-triangular. Matches the MATLAB <code>GeneratingSynteticDataSets.m</code> with <code>Identification='WithLongRunRestrictions'</code> .
<code>seed</code>	Optional integer seed for reproducibility (default 42).

Details

The data generating process is:

$$y_{i,t} = c + \Theta_1 y_{i,t-1} + f_t \lambda_i + A_0 \varepsilon_{i,t},$$

where

$$\Theta_1 = \begin{pmatrix} 0.65 & 0.30 \\ 0.20 & 0.60 \end{pmatrix}, \quad \Sigma_e = \begin{pmatrix} 1 & 0.5 \\ 0.5 & 1 \end{pmatrix},$$

$$f_t = 0.5 f_{t-1} + \eta_t, \quad \eta_t \sim N(0, 0.5),$$

$$\lambda_{k,i} \sim N(1, 1) \text{ (independently),}$$

and $A_0 = \text{chol}(\Sigma_e)^\top$ (Cholesky identification). A burn-in of 1000 periods is discarded.

For `n_vars = 2` and `n_lags = 1`, the parameters match the MATLAB `GeneratingSynteticDataSets.m` (Short-Run identification variant).

Value

A list with:

y Array of dimension $I \times T \times K$ (unit \times time \times variable). No missing values.

beta_true True coefficient vector, same format as `fit$beta`.

theta_true True VAR coefficient array $K \times K \times n_lags$.

sigma_true True reduced-form covariance matrix $K \times K$.

a0_true True structural impact matrix $K \times K$.

factors_true $T \times n_factors$ matrix of true factors.

loadings_true $K \times n_units$ matrix of true loadings.

identification The identification scheme used ("short_run" or "long_run").

diff_vars_suggested Integer vector: variables that should be cumulated in `compute_irf()`. `integer(0)` for short-run; `1L` for long-run (to display cumulative responses, matching the MATLAB MC code's `DifferencedVariables = [1]`).

Examples

```
sim <- sim_pvarife(n_units = 30, n_time = 20, n_vars = 2,  
                 n_lags = 1, n_factors = 1, seed = 1)  
dim(sim$y)      # 30 x 20 x 2  
sim$beta_true
```

summary.pvarife_result

Summary method for pvarife_result

Description

Summary method for pvarife_result

Usage

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

Arguments

object	An object of class "pvarife_result".
...	Ignored.

Value

Invisibly returns a list with fit, avar.

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