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Description Implements Transmission Channel Analysis (TCA) for structural vector autoregressive (SVAR) models following the methodology of Wegner, Lieb, Smeekes and Wilms (2025) <doi:10.48550/arXiv.2405.18987>. TCA decomposes impulse response functions (IRFs) into contributions from distinct transmission channels using a systems form representation and directed acyclic graph (DAG) path analysis. Supports overlapping channels, exhaustive 3-way and 4-way decompositions via inclusion-exclusion principle. This is a parallel R implementation of the 'tca-matlab-toolbox' (<https://github.com/enweg/tca-matlab-toolbox>).

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`SVARtca-package` *Transmission Channel Analysis in Structural VAR Models*

Description

The SVARtca package implements Transmission Channel Analysis (TCA) for decomposing impulse response functions in structural vector autoregressive (SVAR) models. The package follows the methodology presented in Wegner, Lieb, Smeekes and Wilms (2025).

TCA enables researchers to decompose the total impulse response to a shock into contributions from different transmission channels. Supported channels include effects passing through specific intermediate variables, allowing analysts to distinguish direct effects from indirect effects that operate through identified transmission mechanisms.

Key features:

- Multiple decomposition modes: overlapping, exhaustive 3-way, and exhaustive 4-way.
- Support for VAR and SVAR models via integration with the **vars** package.
- Visualization of channel contributions using **ggplot2**.
- Diagnostic tools for validating decomposition accuracy.

Main Functions

`tca_systems_form` Build the systems form representation (B and Omega matrices) from VAR coefficients and structural impact matrix.

`tca_analyze` Run the main TCA analysis with specified decomposition mode.

`tca_decompose_binary` Decompose IRF into "through" and "not_through" components for a single variable.

`tca_validate_additivity` Validate that the binary decomposition satisfies exact additivity.

`tca_from_var` Convenience wrapper to run TCA directly from a fitted VAR model object.

`plot_tca` Create publication-quality visualizations of channel contributions.

Identification

The package supports two identification schemes:

- **Cholesky**: Lower-triangular Cholesky decomposition of the residual covariance matrix. Set `Phi0 = t(chol(Sigma))`.
- **Manual**: User-supplied structural impact matrix for alternative identifications (e.g., sign restrictions, zero restrictions).

Citation

If you use the SVARtca package in your research, please cite the original methodology paper:

Wegner, E., Lieb, L., Smeekes, S. and Wilms, I. (2025). *Transmission Channel Analysis in Dynamic Models.* arXiv:2405.18987, doi:10.48550/arXiv.2405.18987. https://github.com/enweg/tca-matlab-toolbox

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References

Wegner, E., Lieb, L., Smeekes, S. and Wilms, I. (2025). Transmission Channel Analysis in Dynamic Models. arXiv:2405.18987, doi:10.48550/arXiv.2405.18987.

`plot_tca` *Plot TCA Channel Decomposition*

Description

Creates a stacked bar chart (for exhaustive modes) or a line chart (for overlapping mode) showing channel contributions over horizons.

Usage

```
plot_tca(x, target = NULL, type = NULL, title = NULL,
  colors = NULL)
```

Arguments

`x`	A `tca_result` object from `tca_analyze`.
`target`	Integer index of the response variable to plot (default: first variable after shock).
`type`	Plot type: `"bar"` for stacked bar chart (default for exhaustive modes), `"line"` for overlaid lines (default for overlapping mode). If `NULL`, chosen automatically.
`title`	Custom plot title (optional).
`colors`	Named character vector of colours for channels (optional).

Value

A ggplot object.

Examples

```
K <- 4
A1 <- matrix(c(0.7,-0.1,0.05,-0.05, -0.3,0.6,0.10,-0.10,
               -0.2,0.1,0.70,0.05, -0.1,0.2,0.05,0.65), K, K, byrow=TRUE)
Sigma <- matrix(c(1,0.3,0.2,0.1, 0.3,1.5,0.25,0.15,
                  0.2,0.25,0.8,0.1, 0.1,0.15,0.1,0.6), K, K, byrow=TRUE)
Phi0 <- t(chol(Sigma))
sf <- tca_systems_form(Phi0, list(A1), h = 20)
res <- tca_analyze(from = 1, B = sf$B, Omega = sf$Omega,
                   intermediates = c(2, 4), K = K, h = 20,
                   order = 1:K, mode = "exhaustive_4way",
                   var_names = c("IntRate","GDP","Inflation","Wages"))
plot_tca(res, target = 3)
```

---

print.tca_result *Print TCA Result*

Description

S3 print method for tca_result objects. Displays a formatted table of transmission channel contributions across horizons.

Usage

```
## S3 method for class 'tca_result'
print(x, target = NULL, ...)
```

Arguments

x	A tca_result object.
target	Integer index (original ordering) of the response variable to display. Default NULL, which displays variable 1 (the first variable), not the first intermediate.
...	Additional arguments (ignored).

Value

Invisibly returns x.

`tca_analyze` *Transmission Channel Analysis*

Description

Decomposes impulse response functions into transmission channel contributions using the methodology of Wegner, Lieb, Smeekes and Wilms (2025), doi:10.48550/arXiv.2405.18987.

Three decomposition modes are supported:

`"overlapping"` Each channel is through(j) = total - not_through(j). Channels may overlap, so their sum may differ from the total.

`"exhaustive_3way"` (2 intermediates only) Non-overlapping: (1) through var1 inclusive, (2) through var2 only, (3) direct. Sum equals total.

`"exhaustive_4way"` (2 intermediates only) Full inclusion-exclusion: (1) var1 only, (2) var2 only, (3) both, (4) direct. Sum equals total.

Usage

```
tca_analyze(from, B, Omega, intermediates, K, h, order,
  mode = "overlapping", var_names = NULL)
```

Arguments

`from`	Shock variable number (1-based).
`B`	Systems form B matrix (from `tca_systems_form`).
`Omega`	Systems form Omega matrix.
`intermediates`	Integer vector of intermediate variable numbers (1-based, original ordering).
`K`	Number of variables.
`h`	Maximum horizon.
`order`	Transmission ordering vector.
`mode`	Decomposition mode: `"overlapping"`, `"exhaustive_3way"`, or `"exhaustive_4way"`.
`var_names`	Character vector of variable names (optional).

Value

A list of class `"tca_result"` with components:

irf_total Matrix (h+1) x K of total IRFs.

irf_channels Named list of channel IRF matrices, each (h+1) x K.

channel_names Character vector of channel names.

mode Decomposition mode used.

from Shock variable number.

K Number of variables.

h Maximum horizon.

order Transmission ordering.

var_names Variable names.

References

Wegner, E., Lieb, L., Smeekes, S. and Wilms, I. (2025). *Transmission Channel Analysis in Dynamic Models.* arXiv:2405.18987, doi:10.48550/arXiv.2405.18987.

Examples

```
# Monetary policy model
K <- 4
A1 <- matrix(c(0.7,-0.1,0.05,-0.05, -0.3,0.6,0.10,-0.10,
               -0.2,0.1,0.70,0.05, -0.1,0.2,0.05,0.65), K, K, byrow=TRUE)
Sigma <- matrix(c(1,0.3,0.2,0.1, 0.3,1.5,0.25,0.15,
                  0.2,0.25,0.8,0.1, 0.1,0.15,0.1,0.6), K, K, byrow=TRUE)
Phi0 <- t(chol(Sigma))
sf <- tca_systems_form(Phi0, list(A1), h = 20)
result <- tca_analyze(from = 1, B = sf$B, Omega = sf$Omega,
                      intermediates = c(2, 4), K = K, h = 20,
                      order = 1:K, mode = "exhaustive_4way",
                      var_names = c("IntRate","GDP","Inflation","Wages"))
print(result)
```

`tca_decompose_binary` *Binary Decomposition: Total = Through + Not-Through*

Description

Decomposes the total IRF into the effect passing through a variable and the effect not passing through it. The not-through effect is obtained by blocking every node of the variable (NOT condition) and the through effect is defined as `total - not_through`, so the three matrices satisfy `total = through + not_through` by construction. Use `tca_validate_additivity` to check the decomposition against an independent computation of the through effect.

Usage

```
tca_decompose_binary(from, B, Omega, var_idx, K, h, order)
```

Arguments

`from`	Shock variable (1-based).
`B`	Systems form B matrix.
`Omega`	Systems form Omega matrix.
`var_idx`	Variable to decompose through (1-based).
`K`	Number of variables.
`h`	Maximum horizon.
`order`	Transmission ordering.

Value

A list with matrices `total`, `through`, `not_through` (each (h+1) x K).

`tca_from_var` *Run TCA from a VAR Estimation Object*

Description

Extracts coefficient matrices and residual covariance from a fitted VAR model (from the **vars** package) and runs TCA.

Usage

```
tca_from_var(var_model, from, intermediates, h = 20,
  order = NULL, mode = "overlapping",
  identification = "cholesky", Phi0 = NULL)
```

Arguments

`var_model`	A fitted VAR model object from `VAR`.
`from`	Shock variable (integer or name).
`intermediates`	Integer vector or character vector of intermediate variable names.
`h`	Maximum horizon (default: 20).
`order`	Transmission ordering (default: variable ordering in the VAR).
`mode`	Decomposition mode: `"overlapping"`, `"exhaustive_3way"`, or `"exhaustive_4way"`.
`identification`	Identification scheme: `"cholesky"` (default) or `"manual"`.
`Phi0`	Manual impact matrix. Required if `identification = "manual"`.

Value

A `tca_result` object (see `tca_analyze`).

Examples

```
library(vars)
data(Canada)
var_est <- VAR(Canada, p = 2, type = "const")
result <- tca_from_var(var_est, from = "e",
                       intermediates = c("prod", "rw"),
                       h = 20, mode = "exhaustive_4way")
plot_tca(result, target = "U")
```

`tca_systems_form` *Build Complete Systems Form*

Description

Constructs both B and Omega matrices for the systems form representation x = Bx + Omega*epsilon, following the methodology of Wegner, Lieb, Smeekes and Wilms (2025).

Usage

```
tca_systems_form(Phi0, As, h, order = NULL, Psis = NULL)
```

Arguments

`Phi0`	Structural impact matrix (K x K). For Cholesky identification, use `t(chol(Sigma))`.
`As`	List of VAR coefficient matrices (A_1, A_2, ..., A_p).
`h`	Maximum IRF horizon.
`order`	Transmission ordering vector (default: `1:K`).
`Psis`	Optional list of reduced-form MA coefficient matrices (Psi_1, ..., Psi_q), each K x K, for VARMA or DSGE models. See Details. Default `NULL` (no MA component).

Details

Note on `Psis`. For a pure VAR or SVAR model leave `Psis` at its default (`NULL`, treated as an empty list): the moving-average dynamics are generated by `(I - B)^{-1}`. Only VARMA or DSGE models with a moving-average component pass `Psis`. The matrices in `Psis` must be the *reduced-form* MA coefficient matrices, that is, the coefficients on the lagged reduced-form errors `u_t = Phi0 %*% epsilon_t` in `y_t = A_1 y_{t-1} + ... + u_t + Psi_1 u_{t-1} + ...`. If the model is written with structural MA matrices on the structural shocks, `y_t = ... + Phi0 %*% (epsilon_t + Psi^s_1 epsilon_{t-1} + ...)`, convert them first: `Psi_j = Phi0 %*% Psi^s_j %*% solve(Phi0)`. Passing the structural matrices directly gives wrong impulse responses at horizons 1 and above, because `makeOmega_systems` multiplies each `Psi_j` by `Phi0` on the right, so that `Psi_j %*% Phi0` is the horizon-j structural MA coefficient.

Value

A list with components:

B Systems form B matrix (K*(h+1) x K*(h+1)).

Omega Systems form Omega matrix (K*(h+1) x K*(h+1)).

References

Wegner, E., Lieb, L., Smeekes, S. and Wilms, I. (2025). *Transmission Channel Analysis in Dynamic Models.* arXiv:2405.18987, doi:10.48550/arXiv.2405.18987. https://github.com/enweg/tca-matlab-toolbox

Examples

```
# 2-variable VAR(1)
Phi0 <- matrix(c(1, 0.3, 0, 0.95), 2, 2)
As <- list(matrix(c(0.5, -0.1, 0.2, 0.4), 2, 2))
sf <- tca_systems_form(Phi0, As, h = 10)
dim(sf$B)  # 22 x 22
```

`tca_validate_additivity` *Validate Binary Additivity*

Description

Checks Theorem 2(ii) of Wegner, Lieb, Smeekes and Wilms (2025): the effects of disjoint transmission channels sum to the total effect. For every variable `j`, the effect of the paths passing through `j` (at any horizon) is computed independently of the identity `through = total - not_through`, by partitioning those paths by the first node of `j` they visit and summing the AND-conditioned effects of the parts (see `tca_analyze` for the AND and NOT conditions). This independent through effect plus the NOT-conditioned not-through effect is then compared with the total effect. The residual is evaluated at all response variables other than `j` itself, because the AND condition sets the effect on the conditioning node to zero while the effect on `j` counts entirely as "through `j`" in the `total - not_through` convention.

If `pair` is given, the inclusion-exclusion identity used by the `"exhaustive_4way"` mode of `tca_analyze`, `through(v1 and v2) = through(v1) + through(v2) - through(v1 or v2)`, is also checked: the left-hand side is computed directly with AND conditions on both variables (a double first-passage sum of `(h+1)^2` linear solves, so keep `h` moderate), the right-hand side from the independent single-variable through effects and `total - not_through(v1, v2)`. The residual is evaluated at all response variables other than `v1` and `v2`.

The function also reports whether `B` is strictly lower triangular (entries on and above the diagonal at most `1e-12` times the largest absolute entry), which the systems form requires for the graph to be acyclic. Before version 1.0.3 the residual was computed as `total - ((total - not_through) + not_through)`, which is zero by construction and could not detect any error.

Usage

```
tca_validate_additivity(from, B, Omega, K, h, order,
  var_names = NULL, verbose = TRUE, pair = NULL, tol = 1e-10)
```

Arguments

`from`	Shock variable (1-based).
`B`	Systems form B matrix.
`Omega`	Systems form Omega matrix.
`K`	Number of variables.
`h`	Maximum horizon.

order	Transmission ordering.
var_names	Character vector of variable names (optional).
verbose	Logical; print results? Default TRUE.
pair	Optional integer vector of two distinct variable numbers (1-based) for which the inclusion-exclusion identity is checked.
tol	Tolerance for the maximum absolute residual. Default 1e-10.

Value

Invisibly returns a logical, TRUE if B is strictly lower triangular and every residual is below tol, with attributes residuals (named numeric vector, the maximum absolute additivity residual for each variable), pair_residual (the maximum absolute inclusion-exclusion residual, or NA if pair is NULL), max_residual (the largest of these) and lower_triangular (logical).

References

Wegner, E., Lieb, L., Smeekes, S. and Wilms, I. (2025). *Transmission Channel Analysis in Dynamic Models.* arXiv:2405.18987, doi:10.48550/arXiv.2405.18987.

Examples

```
Phi0 <- matrix(c(1, 0.3, 0, 0.95), 2, 2)
As <- list(matrix(c(0.5, -0.1, 0.2, 0.4), 2, 2))
sf <- tca_systems_form(Phi0, As, h = 5)
ok <- tca_validate_additivity(1, sf$B, sf$Omega, K = 2, h = 5,
                              order = 1:2, pair = c(1, 2))
attr(ok, "max_residual")
# A backward edge breaks the acyclic structure and is detected
Bc <- sf$B; Bc[1, 4] <- 0.2
tca_validate_additivity(1, Bc, sf$Omega, K = 2, h = 5, order = 1:2)
```

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