

Package ‘citsr’

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Title Controlled Interrupted Time Series Analysis and Visualization

Version 0.1.4

Description Implements controlled interrupted time series (CITS) analysis for evaluating interventions in comparative time-series data.

The package provides tools for preparing panel time-series datasets, fitting models using generalized least squares (GLS) with optional autoregressive–moving-average (ARMA) error structures, and computing fitted values and robust standard errors using cluster-robust variance estimators (CR2).

Visualization functions enable clear presentation of estimated effects and counterfactual trajectories following interventions.

Background on methods for causal inference in interrupted time series can be found in Linden and Adams (2011) <[doi:10.1111/j.1365-2753.2010.01504.x](https://doi.org/10.1111/j.1365-2753.2010.01504.x)> and Lopez Bernal, Cummins, and Gasparrini (2018) <[doi:10.1093/ije/dyy135](https://doi.org/10.1093/ije/dyy135)>.

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Imports dplyr, nlme, clubSandwich, ggplot2, stats, AICcmodavg

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Contents

cits	2
df_cits_example	4
plot_cits_result	4
plot_cits_result_cf	5
Index	7

cits	<i>Controlled Interrupted Time Series (CITS) Estimation</i>
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Description

Fit a generalized least squares (GLS) Controlled Interrupted Time Series (CITS) model with optional autoregressive–moving-average (ARMA) correlation. Robust standard errors (CR2) are computed using the clubSandwich package. Interaction terms are automatically created if not provided.

Usage

```
cits(  
  data,  
  y_col,  
  T_col,  
  I_col,  
  E_col,  
  TI_col = NULL,  
  ET_col = NULL,  
  EI_col = NULL,  
  ETI_col = NULL,  
  p_range = 0:3,  
  q_range = 0:3  
)
```

Arguments

data	A data frame containing the variables for CITS analysis.
y_col	Outcome variable column name (string).
T_col	Time index column name (string).
I_col	Intervention indicator column name (string). Numeric: 1 indicates the intervention is applied at that time, 0 otherwise.
E_col	Group indicator column name (string). Numeric: 1 indicates the treatment/experimental group, 0 indicates the control group.
TI_col	Optional: Column name for the $T \times I$ interaction (default = NULL). Will be computed if NULL.
ET_col	Optional: Column name for the $E \times T$ interaction (default = NULL). Will be computed if NULL.

EI_col	Optional: Column name for the $E \times I$ interaction (default = NULL). Will be computed if NULL.
ETI_col	Optional: Column name for the $E \times T \times I$ interaction (default = NULL). Will be computed if NULL.
p_range	Range of autoregressive (AR) terms to search (default = 0:3).
q_range	Range of moving average (MA) terms to search (default = 0:3).

Details

This function fits a controlled interrupted time series (CITS) model using generalized least squares (GLS). It automatically calculates interaction terms if they are not provided in the input data. If ARMA fitting fails or produces non-stationary estimates, the function falls back to GLS without correlation.

The treatment group ('E_col = 1') is the group that receives the intervention, while 'E_col = 0' denotes the control group. The intervention indicator ('I_col') marks whether the intervention is applied at a given time point.

Value

A list containing:

model The fitted GLS model object.

robust_se CR2 robust covariance matrix from clubSandwich.

data Data frame including fitted values and standard errors.

best_p Selected AR order based on AIC.

best_q Selected MA order based on AIC.

arma_used Logical: TRUE if ARMA correlation selected, else FALSE.

Examples

```
df <- data.frame(
  T = 1:100,
  E = rep(c(0,1), each = 100),
  I = c(rep(0,50), rep(1,50), rep(0,50), rep(1,50)),
  y = rnorm(200)
)

# Use lightweight ARMA search for examples (CRAN speed requirement)
res <- cits(
  df,
  y_col = "y",
  T_col = "T",
  I_col = "I",
  E_col = "E",
  p_range = 0:1,
  q_range = 0:0
)
```

```
summary(res$model)
```

df_cits_example	<i>Example CITS Dataset</i>
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Description

A simulated example dataset used in the citsr package vignette and examples.

Usage

```
df_cits_example
```

Format

A data frame with 240 rows and 4 variables:

T Time index (1–120 repeated for two groups).

E Group indicator (0 = control, 1 = treatment).

I Intervention indicator (0/1).

y Numeric outcome variable.

Source

Simulated data generated for package examples.

plot_cits_result	<i>CITS Automatic Analysis and Visualization</i>
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Description

Visualizes the results of a controlled interrupted time series (CITS) model fitted using ‘cits()’. The function plots observed data points, fitted values, and 95

Usage

```
plot_cits_result(
  res,
  y_col = "y",
  T_col = "T",
  E_col = "E",
  intervention_time = NULL
)
```

Arguments

<code>res</code>	A list returned by <code>'cits()'</code> , containing model output and fitted values.
<code>y_col</code>	Name of the outcome variable (string). Corresponds to <code>'y'</code> in <code>'cits()'</code> .
<code>T_col</code>	Name of the time index variable (string). Corresponds to <code>'T'</code> in <code>'cits()'</code> .
<code>E_col</code>	Name of the group indicator variable (string). Corresponds to <code>'E'</code> in <code>'cits()'</code> .
<code>intervention_time</code>	Optional numeric. If provided, a vertical dashed line is drawn at this time to mark the intervention point.

Value

A ggplot object showing observed points, fitted lines, confidence ribbons, and (optionally) the intervention line.

Examples

```
# Synthetic example
df <- data.frame(
  T = 1:100,
  E = rep(c(0,1), each = 100),
  I = c(rep(0,50), rep(1,50), rep(0,50), rep(1,50)),
  y = rnorm(200)
)

# Use lightweight ARMA search for examples (CRAN speed requirement)
res <- cits(
  df,
  y_col = "y",
  T_col = "T",
  I_col = "I",
  E_col = "E",
  p_range = 0:1,
  q_range = 0:0
)

plot_cits_result(res)
```

Description

Visualizes the results of a controlled interrupted time series (CITS) model fitted using `'cits()'`, and generates a counterfactual trajectory for the treatment group ($E = 1$) by setting the intervention indicator (`'I'`) to 0 after the intervention time. The function displays observed points, fitted values, 95 with a vertical marker for the intervention.

Usage

```
plot_cits_result_cf(
  res,
  y_col = "y",
  T_col = "T",
  I_col = "I",
  E_col = "E",
  intervention_time
)
```

Arguments

<code>res</code>	A list returned by <code>'cits()'</code> , containing model output and fitted values.
<code>y_col</code>	Name of the outcome variable (string). Corresponds to <code>'y'</code> in <code>'cits()'</code> .
<code>T_col</code>	Name of the time index variable (string). Corresponds to <code>'T'</code> in <code>'cits()'</code> .
<code>I_col</code>	Name of the intervention indicator variable (string). Corresponds to <code>'I'</code> in <code>'cits()'</code> .
<code>E_col</code>	Name of the group indicator variable (string). Corresponds to <code>'E'</code> in <code>'cits()'</code> .
<code>intervention_time</code>	Numeric. Time point at which the intervention occurs.

Value

A ggplot object showing observed points, fitted lines, confidence ribbons, a counterfactual trajectory for the treatment group, and an intervention marker.

Examples

```
df <- data.frame(
  T = 1:100,
  E = rep(c(0,1), each = 100),
  I = c(rep(0,50), rep(1,50), rep(0,50), rep(1,50)),
  y = rnorm(200)
)

# Use lightweight ARMA search for examples (CRAN speed requirement)
res <- cits(
  df,
  y_col = "y",
  T_col = "T",
  I_col = "I",
  E_col = "E",
  p_range = 0:1,
  q_range = 0:0
)

plot_cits_result_cf(res, intervention_time = 10)
```

Index

* **datasets**

df_cits_example, [4](#)

cits, [2](#)

df_cits_example, [4](#)

plot_cits_result, [4](#)

plot_cits_result_cf, [5](#)