

# Package ‘contTimeCausal’

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**Type** Package

**Title** Continuous Time Causal Models

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**Description** Implements the semiparametric efficient estimators of continuous-time causal models for time-varying treatments and confounders in the presence of dependent censoring (including structural failure time model and Cox proportional hazards marginal structural model).  
S. Yang, K. Pieper, and F. Cools (2019) <[doi:10.1111/biom.12845](https://doi.org/10.1111/biom.12845)>.

**License** GPL (>= 2)

**LazyData** TRUE

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**Collate** 'zooStep.R' 'IPCWStep.R' 'VStep.R' 'VStep2.R' 'verifyInputs.R'  
'ctCoxMSM.R' 'ctSFTM.R' 'ctcData.R' 'print.ctc.R'

**NeedsCompilation** no

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## R topics documented:

ctcData	2
ctCoxMSM	2
ctSFTM	4
print	6

ctcData *Toy Dataset For Illustration*

### Description

This data set is provided for the purposes of illustrating the use of the software. It includes a one-dimensional baseline covariate and a one-dimensional time-dependent covariate.

### Usage

```
data(ctcData)
```

### Format

ctcData is a data.frame containing data for 1,000 participants. The data.frame contains 9 columns:

**id** An integer participant identifier.

**start** The left side of the time interval for time-dependent covariate xt.

**stop** The right side of the time interval for time-dependent covariate xt.

**xt** A continuous time-dependent covariate.

**x** A continuous baseline covariate.

**deltaU** A binary indicator of the clinical event. If the clinical event occurred, takes value 1; otherwise 0.

**deltaV** A binary indicator of treatment discontinuation. If treatment discontinuation was optional, takes value 1. If treatment discontinuation was due to the clinical event, censoring, or a treatment-terminating event, takes value 0.

**U** The time to the clinical event or censoring.

**V** The time to optimal treatment discontinuation, the clinical event, censoring, or a treatment-terminating event.

ctCoxMSM *Continuous-time Cox Marginal Structural Model*

### Description

The function estimates the effect of treatment regime (in terms of time to treatment discontinuation) for a survival outcome under a Cox proportional hazards model with time-varying confounding in the presence of dependent censoring. Studying the effect of time to treatment initiation is applicable by redefining "treatment discontinuation" in the current description to "treatment initiation".

### Usage

```
ctCoxMSM(data, base = NULL, td = NULL)
```

## Arguments

<code>data</code>	A data.frame object. A data.frame containing all observed data. At a minimum, this data.frame must contain columns with headers "id", "U", "V", "deltaU", and "deltaV". If time-dependent covariates are included, additional columns include "stop" and "start". See Details for further information
<code>base</code>	A character or integer vector or NULL. The columns of data to be included in the time-independent component of the model. If NULL, time-independent covariates are excluded from the Cox model for treatment discontinuation.
<code>td</code>	A character or integer vector or NULL. The columns of data to be included in the time-dependent component of the model. If NULL, time-dependent covariates are excluded from the Cox model for treatment discontinuation.

## Details

The Cox marginal structural model (MSM) assumes that the potential failure time  $T^{\bar{a}}$  under the treatment  $\bar{a}$  follows a proportional hazards model with  $\psi * a_u$ . We assume that the participant continuously received treatment until time  $V$ . The observed failure time can be censored assuming the censoring time is independent of the failure time given the treatment and covariate history (the so-called ignorable censoring). The function allows for multi-dimensional baseline covariates and/or multi-dimensional time-dependent covariates. Variance estimates can be implemented by delete-one-group jackknifing and recalling ctCoxMSM.

If only time-independent covariates are included, the data.frame must contain the following columns:

**id:** A unique participant identifier.

**U:** The time to the clinical event or censoring.

**deltaU:** The clinical event indicator (1 if U is the event time; 0 otherwise).

**V:** The time to optional treatment discontinuation, a clinical event, censoring, or a treatment-terminating event.

**deltaV:** The indicator of optional treatment discontinuation (1 if treatment discontinuation was optional; 0 if treatment discontinuation was due to a clinical event, censoring or a treatment-terminating event).

If time-dependent covariates are to be included, the data.frame must be a time-dependent dataset as described by package survival. Specifically, the time-dependent data must be specified for an interval (lower,upper] and the data must include the following additional columns:

**start:** The lower boundary of the time interval to which the data pertain.

**stop:** The upper boundary of the time interval to which the data pertain.

## Value

An S3 object of class etc. Object contains element 'psi', the estimate of the Cox MSM parameter(s) and 'coxPH', the Cox regression for V.

## References

Yang, S., A. A. Tsiatis, and M. Blazing (2018). Modeling survival distribution as a function of time to treatment discontinuation: A dynamic treatment regime approach, *Biometrics*, 74, 900–909.

**See Also**[ctSFTM](#)**Examples**

```

data(ctcData)

# sample data to reduce computation time of example
smp <- ctcData$id %in% sample(1:1000, 150, FALSE)
ctcData <- ctcData[smp,]

# analysis with both time-dependent and time-independent components
res <- ctCoxMSM(data = ctcData, base = "x", td = "xt")

# analysis with only the time-independent component
res <- ctCoxMSM(data = ctcData, base = "x")

# analysis with only the time-dependent component
res <- ctCoxMSM(data = ctcData, td = "xt")

```

ctSFTM

*Continuous-time Structural Failure Time Model***Description**

The function estimates the regime (in terms of time to treatment initiation) of treatment effect for a survival outcome under a Structural Failure Time Model (SFTM) with time-varying confounding in the presence of dependent censoring. Studying the effect of time to treatment discontinuation is applicable by redefining "treatment initiation" in the current description to "treatment discontinuation".

**Usage**

```
ctSFTM(data, base = NULL, td = NULL)
```

**Arguments**

data	A data.frame object. A data.frame containing all observed data. At a minimum, this data.frame must contain columns with headers "id", "U", "V", "deltaU", and "deltaV". If time-dependent covariates are included, additional columns include "stop" and "start". See Details for further information
base	A character or integer vector or NULL. The columns of data to be included in the time-independent component of the model. If NULL, time-independent covariates are excluded from the Cox model for treatment discontinuation.
td	A character or integer vector or NULL. The columns of data to be included in the time-dependent component of the model. If NULL, time-dependent covariates are excluded from the Cox model for treatment discontinuation.

## Details

The SFTM assumes that the potential failure time  $U$  had the individual never received treatment and the observed failure time  $T$  follow

$$U \sim \int_0^T e^{\psi A_u} du,$$

where  $\sim$  means "has the same distribution as", and  $A_u$  is the treatment indicator at time  $u$ . We assume that the individual continuously received treatment until time  $V$ . The observed failure time can be censored assuming the censoring time is independent of the failure time given the treatment and covariate history (the so-called ignorable censoring). The current function allows for multi-dimensional baseline covariates and/or multi-dimensional time-dependent covariate. Variance estimates should be implemented by delete-one-group jackknifing and recalling ctSFTM.

If only time-independent covariates are included, the data.frame must contain the following columns:

**id:** A unique participant identifier.

**U:** The time to the clinical event or censoring.

**deltaU:** The clinical event indicator (1 if U is the event time; 0 otherwise).

**V:** The time to optional treatment discontinuation, a clinical event, censoring, or a treatment-terminating event.

**deltaV:** The indicator of optional treatment discontinuation (1 if treatment discontinuation was optional; 0 if treatment discontinuation was due to a clinical event, censoring or a treatment-terminating event).

If time-dependent covariates are to be included, the data.frame must be a time-dependent dataset as described by package survival. Specifically, the time-dependent data must be specified for an interval (lower,upper] and the data must include the following additional columns:

**start:** The lower boundary of the time interval to which the data pertain.

**stop:** The upper boundary of the time interval to which the data pertain.

## Value

An S3 object of class ctc. Object contains element 'psi', the estimate of the SFTM parameter(s) and 'coxPH', the Cox regression for V.

## References

Yang, S., K. Pieper, and F. Cools. (2019) Semiparametric estimation of structural failure time model in continuous-time processes. *Biometrika*, 107(1), 123-136.

## See Also

[ctCoxMSM](#)

**Examples**

```

data(ctcData)

# sample data to reduce computation time of example
smp <- ctcData$id %in% sample(1:1000, 200, FALSE)
ctcData <- ctcData[smp,]

# analysis with both time-dependent and time-independent components
res <- ctSFTM(data = ctcData, base = "x", td = "xt")

# analysis with only the time-independent component
res <- ctSFTM(data = ctcData, base = "x")

# analysis with only the time-dependent component
res <- ctSFTM(data = ctcData, td = "xt")

```

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print

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*Print the Primary Results*


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**Description**

Print the primary results of a ctCoxMSM() or ctSFTM() analysis.

**Usage**

```

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

```

**Arguments**

x	An S3 object of class ctc. The value object returned by a call to ctCoxMSM() or ctSFTM().
...	ignored

**Value**

No return value, called to display key results.

**Examples**

```

data(ctcData)

# sample data to reduce computation time of example
smp <- ctcData$id %in% sample(1:1000, 150, FALSE)
ctcData <- ctcData[smp,]

```

```
# analysis with both time-dependent and time-independent components
res <- ctCoxMSM(data = ctcData, base = "x", td = "xt")

print(x = res)

# analysis with both time-dependent and time-independent components
res <- ctSFTM(data = ctcData, base = "x", td = "xt")

print(x = res)
```

# Index

## \* datasets

ctcData, [2](#)

ctcData, [2](#)

ctCoxMSM, [2](#), [5](#)

ctSFTM, [4](#), [4](#)

print, [6](#)