

# Package ‘dynsurv’

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**Title** Dynamic Models for Survival Data

**Version** 0.3-3.9000

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**Description** Functions to fit time-varying coefficient models for interval censored and right censored survival data. Three major approaches are implemented: 1) Bayesian Cox model with time-independent, time-varying or dynamic coefficients for right censored and interval censored data; 2) Spline based time-varying coefficient Cox model for right censored data; 3) Transformation model with time-varying coefficients for right censored data using estimating equations.

**Depends** R ( $\geq 3.0.2$ ), survival

**Imports** ggplot2, grDevices, grid, nleqslv, plyr, reshape, stats, utils

**LinkingTo** BH ( $\geq 1.54.0-2$ )

**License** GPL ( $\geq 3$ )

**LazyLoad** Yes

**LazyData** Yes

**NeedsCompilation** yes

**URL** <https://github.com/wenjie2wang/dynsurv>

**BugReports** <https://github.com/wenjie2wang/dynsurv/issues>

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## R topics documented:

bayesCox	2
bcos	5
coef.bayesCox	5
coef.splineCox	6
coef.tvTran	7
dynsurv	8

jump . . . . .	8
nu . . . . .	9
plotCoef . . . . .	9
plotJump . . . . .	10
plotNu . . . . .	11
plotSurv . . . . .	12
splineCox . . . . .	13
survCurve . . . . .	14
survDiff . . . . .	15
tooth . . . . .	16
tvTran . . . . .	17
<b>Index</b>	<b>19</b>

bayesCox

*Fit Bayesian Cox Model for Interval Censored Survival Data*

## Description

Fit Bayesian Cox model with time-independent, time-varying or dynamic covariate coefficient. The fit is done within a Gibbs sampling framework. The reversible jump algorithm is employed for the dynamic coefficient model. The baseline hazards are allowed to be either time-varying or dynamic.

## Usage

```
bayesCox(formula, data, grid, out,
          model = c("TimeIndep", "TimeVarying", "Dynamic"),
          base.prior = list(), coef.prior = list(),
          gibbs = list(), control = list())
```

## Arguments

formula	A formula object, with the response on the left of a '~' operator, and the terms on the right. The response must be a survival object as returned by the Surv function.
data	A data.frame in which to interpret the variables named in the formula.
grid	Vector of pre-specified time grid points.
out	Name of Markov chain Monte Carlo (MCMC) samples output file.
model	Model type to fit.
base.prior	List of options for prior of baseline lambda. Use list(type = "Gamma", shape = 0.1, rate = 0.1) for all models; list(type = "Const", value = 1) for Dynamic model when intercept = TRUE.
coef.prior	List of options for prior of coefficient beta. Use list(type = "Normal", mean = 0, sd = 1) for TimeIndep model; list(type = "AR1", sd = 1) for TimeVarying and Dynamic models; list(type = "HAR1", shape = 2, scale = 1) for TimeVarying and Dynamic models.
gibbs	List of options for Gibbs sampler.
control	List of general control options.

## Details

To use default hyper parameters in the specification of either `base.prior` or `coef.prior`, one only has to supply the name of the prior, e.g., `list(type = "Gamma")`, `list(type = "HAR1")`.

The `gibbs` argument is a list of components:

**iter:** number of iterations, default 3000;

**burn:** number of burning, default 500;

**thin:** number of thinning, default 1;

**verbose:** a logical value, default TRUE. If TRUE, print the iteration;

**nReport:** print frequency, default 100.

The `control` argument is a list of components:

**intercept:** a logical value, default FALSE. If TRUE, the model will estimate the intercept, which is the log of baseline hazards. If TRUE, please remember to turn off the direct estimation of baseline hazards, i.e., `base.prior = list(type = "Const")`

**a0:** multiplier for initial variance in time-varying or dynamic models, default 100;

**eps0:** size of auxiliary uniform latent variable in dynamic model, default 1.

## Value

An object of S3 class `bayesCox` representing the fit.

## References

X. Wang, M.-H. Chen, and J. Yan (2011). Bayesian dynamic regression models for interval censored survival data. Under review.

D. Sinha, M.-H. Chen, and S.K. Ghosh (1999). Bayesian analysis and model selection for interval-censored survival data. *Biometrics* 55(2), 585–590.

## See Also

[coef.bayesCox](#), [jump.bayesCox](#), [nu.bayesCox](#), [plotCoef](#), [plotJumpTrace](#), [plotNu](#), [survCurve](#), [survDiff](#), and [plotSurv](#).

## Examples

```
## Not run:
#####
### Attach one of the following two data sets
#####

## breast cancer data
data(bcos) ## attach bcos and bcos.grid
mydata <- bcos
mygrid <- bcos.grid
myformula <- Surv(left, right, type = "interval2") ~ trt

## tooth data
## data(tooth) ## load tooth and tooth.grid
## mydata <- tooth
## mygrid <- tooth.grid
```

```

## myformula <- Surv(left, right, type = "interval2") ~ dmf + sex

#####
### Fit Bayesian Cox models
#####

## Fit time-independent coefficient model
fit0 <- bayesCox(myformula, mydata, mygrid, out = "tiCox.txt",
  model = "TimeIndep",
  base.prior = list(type = "Gamma", shape = 0.1, rate = 0.1),
  coef.prior = list(type = "Normal", mean = 0, sd = 1),
  gibbs = list(iter = 100, burn = 20, thin = 1,
    verbose = TRUE, nReport = 5))
plotCoef(coef(fit0, level = 0.9))

## Fit time-varying coefficient model
fit1 <- bayesCox(myformula, mydata, mygrid, out = "tvCox.txt",
  model = "TimeVarying",
  base.prior = list(type = "Gamma", shape = 0.1, rate = 0.1),
  coef.prior = list(type = "AR1", sd = 1),
  gibbs = list(iter = 100, burn = 20, thin = 1,
    verbose = TRUE, nReport = 5))
plotCoef(coef(fit1))

## Fit dynamic coefficient model with time-varying baseline hazards
fit2 <- bayesCox(myformula, mydata, mygrid, out = "dynCox1.txt",
  model = "Dynamic",
  base.prior = list(type = "Gamma", shape = 0.1, rate = 0.1),
  coef.prior = list(type = "HAR1", shape = 2, scale = 1),
  gibbs = list(iter = 100, burn = 20, thin = 1,
    verbose = TRUE, nReport = 5))
plotCoef(coef(fit2))
plotJumpTrace(jump(fit2))
plotJumpHist(jump(fit2))
plotNu(nu(fit2))

## Plot the coefficient estimates from three models together
plotCoef(rbind(coef(fit0), coef(fit1), coef(fit2)))

## Fit dynamic coefficient model with dynamic hazards (in log scales)
fit3 <- bayesCox(myformula, mydata, mygrid, out = "dynCox2.txt",
  model = "Dynamic",
  base.prior = list(type = "Const"),
  coef.prior = list(type = "HAR1", shape = 2, scale = 1),
  gibbs = list(iter = 100, burn = 20, thin = 1,
    verbose = TRUE, nReport=5),
  control = list(intercept = TRUE))
plotCoef(coef(fit3))
plotJumpTrace(jump(fit3))
plotJumpHist(jump(fit3))
plotNu(nu(fit3))

## Plot the estimated survival function and hazard function
newDat <- bcos[c(1, 47), ]
row.names(newDat) <- c("Rad", "RadChem")
plotSurv(survCurve(fit3, newdata = newDat, type = "survival"),
  legendName = "Treatment", conf.int = TRUE)

```

```
plotSurv(survDiff(fit3, newdata = newDat, type = "cumhaz"),
         legendName = "Treatment", conf.int = TRUE, smooth = TRUE)

## End(Not run)
```

bcos

*Breast Cancer Data*

## Description

The breast cancer data from Finkelstein (1985) has been analyzed extensively for illustrating new methods in modeling interval censored data. The objective of the study was to compare the time to cosmetic deterioration between two groups: 46 patients receiving radiotherapy only and 48 patients receiving radiotherapy plus chemotherapy. Because the detection of deterioration required a clinic visit, the 56 women who experience deterioration were interval censored, and the other 38 women who did not were right censored.

## Format

bcos is a data frame with 94 observations and 3 columns.

**left:** left censoring time;

**right:** right censoring time;

**trt:** treatment (Rad = radiotherapy only, RadChem = radiotherapy plus chemotherapy).

bcos.grid is a numeric vector of grid time points.

## References

D.M. Finkelstein, and R.A. Wolfe (1985). A semiparametric model for regression analysis of interval-censored failure time data. *Biometrics* 41: 731-740.

## Examples

```
data(bcos)
```

coef.bayesCox

*Extract Coefficients from Bayesian Cox Model*

## Description

Extract coefficient values from bayesCox fitting results, and summarize the posterior mean, posterior 2.5% and 97.5% quantiles into a data frame.

## Usage

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

**Arguments**

object	An object returned by function bayesCox.
...	Optional arguments. Currently, the only applicable argument is level for the credible level. The default value is 0.95.

**Value**

A data.frame with 6 columns ("Low", "Mid", "High", "Time", "Cov", "Model"), where "Low" and "High" are the posterior 2.5% and 97.5% quantiles as default; "Mid" is the posterior mean; "Cov" and "Model" contain character values of the covariates and model types.

**See Also**

[bayesCox](#), and [plotCoef](#).

**Examples**

```
## See the examples in bayesCox.
```

---

coef.splineCox	<i>Extract Coefficients from Spline Base Cox Model</i>
----------------	--

---

**Description**

Extract coefficient values from splineCox fitting results, and summarize the point estimate and 95% confidence band into a data frame.

**Usage**

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

**Arguments**

object	An object returned by function splineCox.
...	Optional arguments. Currently, the only applicable argument is level for the credible level. The default value is 0.95.

**Value**

A data.frame with 6 columns ("Low", "Mid", "High", "Time", "Cov", "Model"), where "Mid" is the point estimates; "Low" and "High" are the point estimates plus and minus 1.96 times standard deviations (under default level); "Cov" and "Model" contain character values of the covariates and model type.

**Note**

It essentially expand the break points, and then call function coxph in package survival

**See Also**

[splineCox](#), and [plotCoef](#).

**Examples**

```
## See the examples in splineCox.
```

---

coef.tvTran

---

*Extract Coefficients from Time-varying Transformation Model*


---

**Description**

Extract coefficient values from tvTran fitting results, and summarize the point estimate and 95% credible band into a data frame.

**Usage**

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

**Arguments**

object	An object returned by function tvTran.
...	Optional arguments. Currently, the only applicable argument is level for the credible level. The default value is 0.95.

**Value**

A data.frame with 6 columns ("Low", "Mid", "High", "Time", "Cov", "Model"), where "Mid" is the point estimates; "Low" and "High" are the 2.5% and 97.5% quantiles estimates from resampling method as default; "Cov" and "Model" contain character values of the covariates and model type.

**See Also**

[tvTran](#), and [plotCoef](#).

**Examples**

```
## See the examples in tvTran.
```

---

dysurv

*dysurv: Time-varying coefficient models for interval censored data.*


---

### Description

Functions to fit time-varying coefficient models for interval censored and right censored survival data. Three major approaches are implemented:

1. Bayesian Cox model with time-independent, time-varying or dynamic coefficients for right censored and interval censored data;
2. Spline based time-varying coefficient Cox model for right censored data;
3. Transformation model with time-varying coefficients for right censored data using estimating equations.

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jump

*Generic function for jump information*


---

### Description

Generic function for jump information

### Usage

```
jump(object, ...)

## S3 method for class 'bayesCox'
jump(object, ...)
```

### Arguments

**object**            An object returned by function bayesCox.  
**...**             Other arguments.

### Value

A data.frame with 3 columns ("Count", "Iter", "Cov"), where "Count" is the number of coefficient pieces (jumps) for each iteration; Iter is the iteration number; Cov contains the character values of the covariates.

### Methods (by class)

- bayesCox: Extract Jump Information from Bayesian Dyanmic Model  
 Extract number of coefficient pieces from bayesCox fitting results, and summarize them into a data frame. It is only applicable when model="Dynamic" is specified.

### See Also

[bayesCox](#), [plotJumpTrace](#), and [plotJumpHist](#).

### Examples

```
## See the examples in bayesCox
```



---

nu	<i>Generic function for the latent variance</i>
----	---

---

**Description**

Generic function for the latent variance

**Usage**

```
nu(object, ...)

## S3 method for class 'bayesCox'
nu(object, ...)
```

**Arguments**

object	An object returned by function bayesCox.
...	Other arguments.

**Value**

A data.frame with 4 columns ("Iter", "Model", "Cov", "Value"), where Iter is the iteration number; Model and Cov contain the character values of the model type and covariates.

**Methods (by class)**

- bayesCox: Extract Latent Variance from Bayesian Cox Model  
Extract latent variance from bayesCox fitting results, and summarize them into a data frame. It is applicable when model="TimeVarying" or model="Dynamic", and coef.prior=list(type="HAR1").

**See Also**

[bayesCox](#), and [plotNu](#).

**Examples**

```
## See the examples in bayesCox.
```

---

plotCoef	<i>Plot Coefficient Function</i>
----------	----------------------------------

---

**Description**

Plot coefficient values formatted in a data frame returned by function coef.

**Usage**

```
plotCoef(object, smooth = FALSE, ...)
```

**Arguments**

object	A data.frame returned by function coef.
smooth	A logical value, default FALSE. If TRUE, plot the coefficients as smooth lines; otherwise, plot the coefficients as piece-wise constant step functions.
...	Other arguments.

**Details**

To plot estimated coefficient functions from different models together, one can first combine the data frames returned by coef, and then call plotCoef, for example, plotCoef(rbind(coef(fit1),coef(fit2))).

To specify the time range of the plot, one can either utilize the ggplot functionality, say plotCoef(coef(fit)) + xlim( or manipulate the data frame first before calling plotCoef, e.g., plotCoef(subset(coef(fit), Time > 2 & Time < 10

**Value**

A ggplot object.

**See Also**

[coef.bayesCox](#), [coef.splineCox](#), and [coef.tvTran](#).

**Examples**

```
## See the examples in bayesCox, splineCox, and tvTran.
```

---

plotJump

---

*Plot Jump Information in Bayesian Dynamic Model*


---

**Description**

plotJumpTrace plots the MCMC history of the number of pieces. plotJumpHist plots the histogram of the number of pieces. The input data frame is returned by function jump.

**Usage**

```
plotJumpTrace(object, ...)
```

```
plotJumpHist(object, ...)
```

**Arguments**

object	A data.frame returned by function jump.
...	Other arguments.

**Value**

A ggplot object.

**See Also**

[jump.bayesCox.](#)

**Examples**

```
## See the examples in bayesCox
```

---

plotNu	<i>Plot Latent Variance in Bayesian Cox Model</i>
--------	---

---

**Description**

Plot the latent variance nu when the hierarchical AR(1) process prior is used for the bayesCox model. It is applicable when `model="TimeVarying"` or `model="Dynamic"`, and `coef.prior=list(type="HAR1")`. The input data frame is returned by function nu.

**Usage**

```
plotNu(object, ...)
```

**Arguments**

object	A data.frame returned by the function nu.
...	Other arguments.

**Value**

A ggplot object.

**See Also**

[nu.bayesCox.](#)

**Examples**

```
## See the examples in bayesCox
```

---

plotSurv	<i>Plot Survival Curves (or Cumulative Hazard Function) and their difference</i>
----------	--

---

## Description

Plot the survival curves (or cumulative hazard) and their difference for objects returned by function `survCurve` or `survDiff`. By using `ggplot2` plotting system, the plots generated are able to be further customized properly.

## Usage

```
plotSurv(object, legendName = "", conf.int = FALSE, smooth = FALSE,
         lty, col, ...)
```

## Arguments

<code>object</code>	An object returned by function <code>survCurve</code> or <code>survDiff</code> .
<code>legendName</code>	An optional name for the figure legend.
<code>conf.int</code>	A logical value indicating whether to plot the credible interval(s).
<code>smooth</code>	A logical value, default <code>FALSE</code> . If <code>TRUE</code> , plot the coefficients as smooth lines; otherwise, plot the coefficients as piece-wise constant step functions.
<code>lty</code>	An optional numeric vector indicating line types specified to different groups: 0 = blank, 1 = solid, 2 = dashed, 3 = dotted, 4 = dotdash, 5 = longdash, 6 = twodash.
<code>col</code>	An optional character or numeric vector indicating line colors specified to different groups.
<code>...</code>	Other arguments for future usage.

## Value

A `ggplot` object.

## See Also

[bayesCox](#), [survCurve](#), and [survDiff](#).

## Examples

```
## See the examples in bayesCox.
```

splineCox

*Fit Spline Based Cox Model for Right Censored Survival Data***Description**

Rearrange the right censored survival data in a counting process style. Model the time-varying co-efficient function using B-splines. The fit is done by introducing pseudo time-dependent covariates and then calling function `coxph` in **survival** package.

**Usage**

```
splineCox(formula, data, control = list())
```

**Arguments**

<code>formula</code>	A formula object, with the response on the left of a '~' operator, and the terms on the right. The response must be a survival object as returned by the <code>Surv</code> function.
<code>data</code>	A data.frame in which to interpret the variables named in the formula.
<code>control</code>	List of control options.

**Details**

The control argument is a list of components:

**df:** degree of freedom for the B-splines, default 5;

**knots:** interior knots point, default NULL. If NULL, the knots will be automatically choosen;

**boundary:** lower and upper boundaries for the spline function, default NULL. If NULL, the minimum and maximum finite event time or censoring time will be specified.

**Value**

An object of S3 class `splineCox` representing the fit.

**Note**

This function is essentially a wrapper function of `coxph` for the expanded data set. It does not implements the algorithm discussed in the reference paper. These authors implemented their algorithm into a `tvcox` package, which is more efficient for larger data set, but may not be stable compared to `coxph`.

**References**

A. Perperoglou, S. le Cessie, and H.C. van Houwelingen (2006). A fast routine for fitting Cox models with time varying effects of the covariates. *Computer Methods and Programs in Biomedicine* 81, 154–161.

**See Also**

[coef.splineCox](#), [plotCoef](#).

## Examples

```
## Not run:
## Attach the veteran data from the survival package
mydata <- survival::veteran
mydata$celltype <- relevel(mydata$celltype, ref = "large")
myformula <- Surv(time, status) ~ karno + celltype

## Fit the time-varying transformation model
fit <- splineCox(myformula, mydata, control = list(df = 5))

## Plot the time-varying coefficient function between two time points
plotCoef(subset(coef(fit), Time > 15 & Time < 175), smooth = TRUE)

## End(Not run)
```

---

survCurve

*Estimated Survival Function or Cumulative Hazard Function*


---

## Description

survCurve returns estimated survival function or cumulative function from posterior sample. Note that the function is currently only applicable to the Bayesian dynamic Cox model with dynamic hazard, where the control argument is specified to be `control = list(intercept = TRUE)` in function `bayesCox`.

## Usage

```
survCurve(object, newdata, type = c("survival", "cumhaz"),
          level = 0.95, centered = FALSE, cache = FALSE, ...)
```

## Arguments

object	An object returned by function <code>bayesCox</code> .
newdata	An optional data frame used to generate a design matrix.
type	An optional character value indicating the type of function to compute. The possible values are "survival" and "cumhaz". The former means the estimated survival function; the latter represents the estimated cumulative hazard function for the given newdata.
level	A numerical value between 0 and 1 indicating the level of credible band.
centered	A logical value. If TRUE, the mean function for the given newdata will be computed. The default is FALSE.
cache	A logical value. If TRUE, the cache RData file will be generated in the working directory to improve the performance of function <code>survCurve</code> and <code>survDiff</code> . This option would be quite helpful if the number of MCMC sample is large.
...	Other arguments for further usage.

## Details

The estimated survival curve is a step function representing the posterior mean survival proportion at the given time grid from the posterior sample. The credible interval for the survival curve is constructed based on the quantiles of all the survival curves from posterior sample at given credible level.

## Value

A data frame with column: "Low", "Mid", "High", "Time", "Design", and "type", and attribute, "surv" valued as "survCurve".

## See Also

[bayesCox](#), [survDiff](#), and [plotSurv](#).

## Examples

```
## See the examples in bayesCox.
```

---

survDiff	<i>Estimated Difference Between Survival or Cumulative Hazard Functions</i>
----------	---

---

## Description

survDiff returns estimated survival function or cumulative function from posterior estimates. Note that currently, the function is only applicable to the Bayesian dynamic Cox model with dynamic hazard, where the control argument is specified to be `control = list(intercept = TRUE)` in function `bayesCox`.

## Usage

```
survDiff(object, newdata, type = c("survival", "cumhaz"),
         level = 0.95, cache = FALSE, ...)
```

## Arguments

object	An object returned by function <code>bayesCox</code> .
newdata	An optional data frame used to generate a design matrix. Note that it must lead to a design matrix with two different design.
type	An optional character value indicating the type of function to compute. The possible values are "survival" and "cumhaz". The former means the estimated survival function; the latter represents the estimated cumulative hazard function for the given newdata.
level	A numerical value between 0 and 1 indicating the level of credible band.
cache	A logical value. If TRUE, the cache RData file will be generated in the working directory to improve the performance of function <code>survCurve</code> and <code>survDiff</code> . This option would be quite helpful if the number of MCMC sample is large.
...	Other arguments for further usage.

## Details

The estimated difference between survival curves is a step function representing the difference between the posterior mean survival proportion at the given time grid from the posterior sample. Its credible interval is constructed based on the quantiles of all the pair difference between the survival curves from posterior sample at given credible level.

## Value

A data frame with column: "Low", "Mid", "High", "Time", "Design", and "type", and attribute, "surv" valued as "survDiff".

## See Also

[bayesCox](#), [survCurve](#), and [plotSurv](#).

## Examples

```
## See the examples in bayesCox.
```

---

tooth	<i>Tooth Data</i>
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---

## Description

The tooth data was from a longitudinal prospective dental study performed in Flanders (Belgium) in 1996 – 2001. Every one of 4,386 randomly sampled children in the cohort was examined annually by one of 16 trained dentists, resulting at most 6 dental observations for each child. The outcome of interest was the time to emergence of permanent tooth 24, which was either interval censored (2,775, 63%) or right censored (1,611, 37%).

## Format

tooth is a data frame with 4,386 observations and 7 columns

**id:** children's id;

**left:** left censoring time;

**right:** right censoring time where infinity is coded as 999.

**sex:** gender of children (0 = boy, 1 = girl);

**dmf:** status of the primary predecessor of this tooth (0 = sound, 1 = delayed, missing or filled);

**rightInf:** right censoring time where infinity is coded as Inf;

**rightNA:** right censoring time where infinity is coded as NA.

tooth.grid is a numeric vector of grid time points.

## Source

Adapted from the data set available at <http://grass.upc.edu/en/software/tooth24>.



## References

J. Vanobbergen, L. Martens, D. Declerck, and M. Lesaffre (2000). The signal tandmobi(r) project: a longitudinal intervention oral health promotion study in Flanders (Belgium): baseline and first year results. *European Journal of Paediatric Dentistry* 2, 87.

G. Gomez, M. Calle, R. Oller, and K. Langohr (2009). Tutorial on methods for interval-censored data and their implementation in R. *Statistical Modeling* 9(4), 259.

## Examples

```
data(tooth)
```

---

tvTran	<i>Fit Time-varying Transformation Model for Right Censored Survival Data</i>
--------	---

---

## Description

Unlike the time-varying coefficient Cox model, the transformation model fomulates the temporal covariate effects in terms of survival function, i.e.,

$$S(t|X) = g(\beta_0(t)'X),$$

where  $g(z) = \exp(-\exp(z))$ . It can be viewed as a functional generalized linear model with response  $I(T > t)$ , and other transformation function is possible. The time-varying coefficients are solved a set of estimating equations sequentially.

## Usage

```
tvTran(formula, data, control = list())
```

## Arguments

formula	A formula object, with the response on the left of a '~' operator, and the terms on the right. The response must be a survival object as returned by the Surv function.
data	A data.frame in which to interpret the variables named in the formula.
control	List of control options.

## Details

Note that because the time-varying coefficient function is connected to the survival function, it has a different interpretation of the time-varying coefficient function in Cox model.

The control argument is a list of components:

**resample** A logical value, default TRUE. If TRUE, the model will estimate a 95% confidence band by resampling method.

**R** Number of resamplings, default 30.

## Value

An object of S3 class tvTran representing the fit.

## References

L. Peng, and Y. Huang (2007). Survival analysis with temporal covariate effects. *Biometrika* 94(3), 719–733.

## See Also

[coef.tvTran](#), [plotCoef](#).

## Examples

```
## Not run:
## Attach the veteran data from the survival package
mydata <- survival::veteran
mydata$celltype <- releval(mydata$celltype, ref = "large")
myformula <- Surv(time, status) ~ karno + celltype

## Fit the time-varying transformation model
fit <- tvTran(myformula, mydata, control = list(resample = TRUE, R = 30))

## Plot the time-varying coefficient function between two time points
plotCoef(subset(coef(fit), Time > 15 & Time < 175))

## End(Not run)
```

# Index

- \*Topic **B-spline**
    - splineCox, [13](#)
  - \*Topic **Bayesian**
    - bayesCox, [2](#)
  - \*Topic **Cox**
    - bayesCox, [2](#)
    - splineCox, [13](#)
  - \*Topic **bayesCox**
    - coef.bayesCox, [5](#)
    - jump, [8](#)
    - nu, [9](#)
  - \*Topic **censor**
    - bayesCox, [2](#)
    - splineCox, [13](#)
    - tvTran, [17](#)
  - \*Topic **coefficient**
    - coef.bayesCox, [5](#)
    - coef.splineCox, [6](#)
    - coef.tvTran, [7](#)
    - plotCoef, [9](#)
  - \*Topic **datasets**
    - bcos, [5](#)
    - tooth, [16](#)
  - \*Topic **dynamic**
    - bayesCox, [2](#)
  - \*Topic **extract**
    - coef.bayesCox, [5](#)
    - coef.splineCox, [6](#)
    - coef.tvTran, [7](#)
    - jump, [8](#)
    - nu, [9](#)
  - \*Topic **interval**
    - bayesCox, [2](#)
  - \*Topic **jump**
    - jump, [8](#)
    - plotJump, [10](#)
  - \*Topic **latent**
    - nu, [9](#)
    - plotNu, [11](#)
  - \*Topic **plot**
    - plotCoef, [9](#)
    - plotJump, [10](#)
    - plotNu, [11](#)
  - \*Topic **right**
    - splineCox, [13](#)
    - tvTran, [17](#)
  - \*Topic **splineCox**
    - coef.splineCox, [6](#)
  - \*Topic **transformation**
    - tvTran, [17](#)
  - \*Topic **tvTran**
    - coef.tvTran, [7](#)
  - \*Topic **variance**
    - nu, [9](#)
    - plotNu, [11](#)
- bayesCox, [2](#), [6](#), [8](#), [9](#), [12](#), [15](#), [16](#)  
bcos, [5](#)
- coef.bayesCox, [3](#), [5](#), [10](#)  
coef.splineCox, [6](#), [10](#), [13](#)  
coef.tvTran, [7](#), [10](#), [18](#)
- dynsurv, [8](#)  
dynsurv-package (dynsurv), [8](#)
- jump, [8](#)  
jump.bayesCox, [3](#), [11](#)
- nu, [9](#)  
nu.bayesCox, [3](#), [11](#)
- plotCoef, [3](#), [6](#), [7](#), [9](#), [13](#), [18](#)  
plotJump, [10](#)  
plotJumpHist, [8](#)  
plotJumpHist (plotJump), [10](#)  
plotJumpTrace, [3](#), [8](#)  
plotJumpTrace (plotJump), [10](#)  
plotNu, [3](#), [9](#), [11](#)  
plotSurv, [3](#), [12](#), [15](#), [16](#)
- splineCox, [7](#), [13](#)  
survCurve, [3](#), [12](#), [14](#), [16](#)  
survDiff, [3](#), [12](#), [15](#), [15](#)
- tooth, [16](#)  
tvTran, [7](#), [17](#)