

# Package ‘autostsm’

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**Type** Package

**Title** Automatic Structural Time Series Models

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## Description

Automatic model selection for structural time series decomposition into trend, cycle, and seasonal components, plus optionality for structural interpolation, using the Kalman filter. Koopman, Siem Jan and Marius Ooms (2012) ``Forecasting Economic Time Series Using Unobserved Components Time Series Models" <[doi:10.1093/oxfordhb/9780195398649.013.0006](https://doi.org/10.1093/oxfordhb/9780195398649.013.0006)>. Kim, Chang-Jin and Charles R. Nelson (1999) ``State-Space Models with Regime Switching: Classical and Gibbs-Sampling Approaches with Applications" <<http://econ.korea.ac.kr/~cjkim/doi:10.7551/mitpress/6444.001.0001>><<http://econ.korea.ac.kr/~cjkim/>>.

**License** GPL (>= 2)

**Imports** maxLik (>= 1.5-2), forecast (>= 8.15), lubridate (>= 1.7), ggplot2 (>= 3.3), gridExtra (>= 2.3), strucchange (>= 1.5), foreach (>= 1.5), doSNOW (>= 1.0.19), parallel (>= 4.1.1), lmtest (>= 0.9-38), ggrepel (>= 0.9), progress (>= 1.2), sandwich (>= 3.0), data.table (>= 1.14)

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autostsm	<i>AutoSTSM</i>
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### Description

*autostsm* Automatic model selection for structural time series decomposition into trend, cycle, and seasonal components using the Kalman filter. See the package vignette using `browseVignettes("autostsm")` to view it in your browser.

### Author(s)

Alex Hubbard

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DGS5

*5 Year Treasury Yield*

---

**Description**

5 Year Treasury Yield

**Usage**

data(DGS5)

**Format**

data.table with columns DATE and DGS5, monthly frequency

**Source**

FRED

---

GDP

*US GDP Seasonally Adjusted*

---

**Description**

US GDP Seasonally Adjusted

**Usage**

data(GDP)

**Format**

data.table with columns DATE and GDP, quarterly frequency

**Source**

FRED

---

NA000334Q

*US GDP Not Seasonally Adjusted*

---

**Description**

US GDP Not Seasonally Adjusted

**Usage**

data(NA000334Q)

**Format**

data.table with columns DATE and NA000334Q, quarterly frequency

**Source**

FRED

---

SP500

*S&P 500*

---

**Description**

S&P 500

**Usage**

data(SP500)

**Format**

data.table with columns DATE and SP500, daily frequency

**Source**

FRED

---

stsm_bdiag	<i>Build a block diagonal matrix from two matrices</i>
------------	--------------------------------------------------------

---

**Description**

Build a block diagonal matrix from two matrices

**Usage**

```
stsm_bdiag(A, B)
```

**Arguments**

A	The top left matrix
B	The bottom right matrix

**Value**

A block diagonal matrix

---

stsm_build_dates	<i>Build the date sequence as a Date type</i>
------------------	-----------------------------------------------

---

**Description**

Build the date sequence as a Date type

**Usage**

```
stsm_build_dates(y)
```

**Arguments**

y	a list object created from stsm_detect_frequency
---	--------------------------------------------------

**Value**

a list with the univariate time series and corrected dates

---

stsm_check_exo	<i>Data check for input exo</i>
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---

**Description**

Checks for proper input of the table exo

**Usage**

```
stsm_check_exo(exo, y)
```

**Arguments**

exo	matrix of exogenous data
y	input data y

**Value**

none

---

stsm_check_exo_fc	<i>Data check for input exo.fc</i>
-------------------	------------------------------------

---

**Description**

Checks for proper input of the table exo.fc

**Usage**

```
stsm_check_exo_fc(exo.fc, n.ahead)
```

**Arguments**

exo.fc	exogenous forecast data
n.ahead	forecast periods

**Value**

none

---

stsm_check_y	<i>Data check for input y</i>
--------------	-------------------------------

---

**Description**

Checks for proper input of the table y

**Usage**

```
stsm_check_y(y)
```

**Arguments**

y	input data y
---	--------------

**Value**

none

---

stsm_constraints	<i>Set the inequality constraints for estimation</i>
------------------	------------------------------------------------------

---

**Description**

Inequality constraints: ineqA

**Usage**

```
stsm_constraints(  
  prior,  
  par,  
  freq,  
  unconstrained,  
  det_trend,  
  det_drift,  
  det_cycle,  
  det_seas,  
  det_obs,  
  saturating_growth  
)
```

**Arguments**

prior	A data table created by stsm_prior
par	parameter values for the state space model
freq	Frequency of the data
unconstrained	Whether to remove inequality constraints on the trend during estimation
det_trend	Set the trend error variance to 0 (deterministic trend)
det_drift	Set the drift error variance to 0 (deterministic drift)
det_cycle	Set the cycle error variance to 0 (deterministic cycle)
det_seas	Set the seasonality error variances to 0 (deterministic seasonality)
det_obs	Set the observation equation error variance to 0 (deterministic observation equation)
saturating_growth	Force the growth rate to converge to 0 in the long term

**Value**

list containing the initial values for the Kalman filter

---

stsm_coxstuart	<i>Cox-Stuart Test</i>
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---

**Description**

Taken from the 'tsutils' package. Performs the Cox-Stuart test for trend, deviation, or dispersion

**Usage**

```
stsm_coxstuart(
  y,
  type = c("trend", "deviation", "dispersion"),
  sig_level = 0.01
)
```

**Arguments**

y	input data
type	Type of test: "trend", "deviation", or "dispersion" If type = "trend", test for changes in trend If type = "deviation", test for changes in deviation If type = "dispersion", test for changes in dispersion (range)
sig_level	Significance level to determine statistically significant seasonal frequencies

**Value**

list describing the results



---

stsm\_dates\_to\_interpolate  
*Create dates to interpolate*

---

## Description

Create dates to interpolate

## Usage

```
stsm_dates_to_interpolate(y, dates, exo = NULL, interpolate)
```

## Arguments

y	Univariate time series of data values.
dates	Vector of date values for y
exo	Matrix of exogenous variables. Can be used to specify regression effects or other seasonal effects like holidays, etc.
interpolate	Character string of how to interpolate

## Value

List of the data, dates, and exo

## Examples

```
## Not run:  
#GDP Not seasonally adjusted  
library(autostsm)  
data("NA000334Q", package = "autostsm") #From FRED  
NA000334Q = data.table(NA000334Q, keep.rownames = TRUE)  
colnames(NA000334Q) = c("date", "y")  
NA000334Q[, "date" := as.Date(date)]  
NA000334Q[, "y" := as.numeric(y)]  
NA000334Q = NA000334Q[date >= "1990-01-01", ]  
dates_interp = stsm_dates_to_interpolate(y = NA000334Q$y, dates = NA000334Q$date,  
interpolate = "monthly")  
  
## End(Not run)
```

---

 stsm\_detect\_anomalies *Detect Anomalies*


---

### Description

Detect anomalies using the estimated structural time series model

### Usage

```
stsm_detect_anomalies(
  model,
  y = NULL,
  freq = NULL,
  exo_obs = NULL,
  exo_state = NULL,
  sig_level = 0.01,
  smooth = TRUE,
  plot = FALSE
)
```

### Arguments

model	Structural time series model estimated using stsm_estimate.
y	Univariate time series of data values. May also be a 2 column data frame containing a date column.
freq	Frequency of the data (1 (yearly), 4 (quarterly), 12 (monthly), 365.25/7 (weekly), 365.25 (daily)), default is NULL and will be automatically detected
exo_obs	Matrix of exogenous variables to be used in the observation equation.
exo_state	Matrix of exogenous variables to be used in the state matrix.
sig_level	Significance level to determine statistically significant anomalies
smooth	Whether or not to use the Kalman smoother
plot	Whether to plot everything

### Value

data table (or list of data tables) containing the dates of detected anomalies from the filtered and/or smoothed series

### Examples

```
## Not run:
#GDP Not seasonally adjusted
library(autostsm)
data("NA000334Q", package = "autostsm") #From FRED
NA000334Q = data.table(NA000334Q, keep.rownames = TRUE)
colnames(NA000334Q) = c("date", "y")
```

```

NA000334Q[, "date" := as.Date(date)]
NA000334Q[, "y" := as.numeric(y)]
NA000334Q = NA000334Q[date >= "1990-01-01", ]
stsm = stsm_estimate(NA000334Q)
anomalies = stsm_detect_anomalies(model = stsm, y = NA000334Q, plot = TRUE)

## End(Not run)

```

---

stsm\_detect\_breaks      *Detect Structural Breaks*

---

### Description

Detect structural breaks using the estimated structural time series model

### Usage

```

stsm_detect_breaks(
  model,
  y,
  components = c("trend", "cycle", "seasonal"),
  freq = NULL,
  exo_obs = NULL,
  exo_state = NULL,
  sig_level = 0.01,
  ci = 0.8,
  smooth = TRUE,
  plot = FALSE,
  cores = NULL,
  show_progress = FALSE
)

```

### Arguments

model	Structural time series model estimated using stsm_estimate.
y	Univariate time series of data values. May also be a 2 column data frame containing a date column.
components	Vector of components to test for structural breaks
freq	Frequency of the data (1 (yearly), 4 (quarterly), 12 (monthly), 365.25/7 (weekly), 365.25 (daily)), default is NULL and will be automatically detected
exo_obs	Matrix of exogenous variables to be used in the observation equation.
exo_state	Matrix of exogenous variables to be used in the state matrix.
sig_level	Significance level to determine statistically significant anomalies
ci	Confidence interval, value between 0 and 1 exclusive.
smooth	Whether or not to use the Kalman smoother

plot	Whether to plot everything
cores	Number of cores to use for break detection
show_progress	Whether to show progress bar

**Value**

data table (or list of data tables) containing the dates of detected anomalies from the filtered and/or smoothed series

**Examples**

```
## Not run:
#GDP Not seasonally adjusted
library(autostsm)
data("NA000334Q", package = "autostsm") #From FRED
NA000334Q = data.table(NA000334Q, keep.rownames = TRUE)
colnames(NA000334Q) = c("date", "y")
NA000334Q[, "date" := as.Date(date)]
NA000334Q[, "y" := as.numeric(y)]
NA000334Q = NA000334Q[date >= "1990-01-01", ]
stsm = stsm_estimate(NA000334Q)
breaks = stsm_detect_breaks(model = stsm, y = NA000334Q, plot = TRUE, cores = 2)

## End(Not run)
```

---

stsm_detect_cycle	<i>Detect cycle from the data</i>
-------------------	-----------------------------------

---

**Description**

Detect cycle from the data

**Usage**

```
stsm_detect_cycle(
  y,
  freq,
  sig_level = 0.01,
  prior = NULL,
  interpolate = NA,
  cl = NULL,
  cores = NULL,
  show_progress = FALSE
)
```

**Arguments**

y	Univariate time series of data values.
freq	Frequency of the data (1 (yearly), 4 (quarterly), 12 (monthly), 365.25/7 (weekly), 365.25 (daily))
sig_level	Significance level to determine statistically significant seasonal frequencies
prior	A data table created by stsm_prior
interpolate	Character string giving frequency to interpolate to: i.e. "quarterly", "monthly", "weekly", "daily"
cl	a parallel cluster object
cores	Number of cores to use
show_progress	Whether to show progress bar

**Value**

Numeric value of cycle periodicity

**Examples**

```
## Not run:
#GDP Not seasonally adjusted
library(autostsm)
data("NA000334Q", package = "autostsm") #From FRED
NA000334Q = data.table(NA000334Q, keep.rownames = TRUE)
colnames(NA000334Q) = c("date", "y")
NA000334Q[, "date" := as.Date(date)]
NA000334Q[, "y" := as.numeric(y)]
NA000334Q = NA000334Q[date >= "1990-01-01", ]
cycle = stsm_detect_cycle(y = NA000334Q$y, freq = 4)

## End(Not run)
```

---

stsm\_detect\_frequency *Detect frequency and dates from the data*

---

**Description**

Detect frequency and dates from the data

**Usage**

```
stsm_detect_frequency(y, freq = NULL)
```

**Arguments**

y	Univariate time series of data values. May also be a 2 column data frame containing a date column.
freq	Initial setting for the frequency detection

**Value**

List giving the dates and frequency of the data

**Examples**

```
## Not run:
#GDP Not seasonally adjusted
library(autostsm)
data("NA000334Q", package = "autostsm") #From FRED
NA000334Q = data.table(NA000334Q, keep.rownames = TRUE)
colnames(NA000334Q) = c("date", "y")
NA000334Q[, "date" := as.Date(date)]
NA000334Q[, "y" := as.numeric(y)]
NA000334Q = NA000334Q[date >= "1990-01-01", ]
freq = stsm_detect_frequency(y = NA000334Q)

## End(Not run)
```

---

stsm\_detect\_multiplicative

*Detect if log transformation is best*

---

**Description**

Detect if log transformation is best

**Usage**

```
stsm_detect_multiplicative(y, freq, sig_level = 0.01, prior = NULL)
```

**Arguments**

y	an object created from stsm_detect_frequency
freq	Frequency of the data
sig_level	Significance level to determine statistically significant seasonal frequencies
prior	A data table created by stsm_prior

**Value**

a logical indicating if the model should be multiplicative or not

**Examples**

```
## Not run:
#GDP Not seasonally adjusted
library(autostsm)
data("NA000334Q", package = "autostsm") #From FRED
NA000334Q = data.table(NA000334Q, keep.rownames = TRUE)
colnames(NA000334Q) = c("date", "y")
NA000334Q[, "date" := as.Date(date)]
NA000334Q[, "y" := as.numeric(y)]
NA000334Q = NA000334Q[date >= "1990-01-01", ]
multiplicative = stsm_detect_multiplicative(y = NA000334Q$y, freq = 4)

## End(Not run)
```

---

```
stsm_detect_seasonality
```

*Detect seasonality from the data*

---

**Description**

Detect seasonality from the data

**Usage**

```
stsm_detect_seasonality(
  y,
  freq,
  sig_level = 0.01,
  prior = NULL,
  interpolate = NA,
  cl = NULL,
  cores = NULL,
  show_progress = FALSE
)
```

**Arguments**

y	Univariate time series of data values.
freq	Frequency of the data (1 (yearly), 4 (quarterly), 12 (monthly), 365.25/7 (weekly), 365.25 (daily))
sig_level	Significance level to determine statistically significant seasonal frequencies
prior	A data table created from stsm_prior
interpolate	Character string giving frequency to interpolate to: i.e. "quarterly", "monthly", "weekly", "daily"
cl	a parallel cluster object
cores	Number of cores to use
show_progress	Whether to show progress bar

**Value**

Numeric vector of seasonal periodicities

**Examples**

```
## Not run:
#GDP Not seasonally adjusted
library(autostsm)
data("NA000334Q", package = "autostsm") #From FRED
NA000334Q = data.table(NA000334Q, keep.rownames = TRUE)
colnames(NA000334Q) = c("date", "y")
NA000334Q[, "date" := as.Date(date)]
NA000334Q[, "y" := as.numeric(y)]
NA000334Q = NA000334Q[date >= "1990-01-01", ]
seasonality = stsm_detect_seasonality(y = NA000334Q$y, freq = 4)

## End(Not run)
```

---

stsm_detect_trend	<i>Detect trend type</i>
-------------------	--------------------------

---

**Description**

Detect trend type

**Usage**

```
stsm_detect_trend(
  y,
  freq,
  decomp = "",
  sig_level = 0.01,
  prior = NULL,
  seasons = NULL,
  cycle = NULL,
  cl = NULL,
  cores = NULL,
  verbose = FALSE
)
```

**Arguments**

y	Univariate time series of data values. May also be a 2 column data frame containing a date column.
freq	Frequency of the data (1 (yearly), 4 (quarterly), 12 (monthly), 365.25/7 (weekly), 365.25 (daily))
decomp	Decomposition model ("tend-cycle-seasonal", "trend-seasonal", "trend-cycle", "trend-noise")



sig_level	Significance level to determine statistically significant seasonal frequencies
prior	A data table created by stsm_prior
seasons	The seasonal periods
cycle	The cycle period
cl	a parallel cluster object
cores	Number of cores to use
verbose	Logical whether to print messages or not

### Value

list with trend type and logical flag for deterministic trend if the trend is determined to have 0 differencing

### Examples

```
## Not run:
#GDP Not seasonally adjusted
library(autostsm)
data("NA000334Q", package = "autostsm") #From FRED
NA000334Q = data.table(NA000334Q, keep.rownames = TRUE)
colnames(NA000334Q) = c("date", "y")
NA000334Q[, "date" := as.Date(date)]
NA000334Q[, "y" := as.numeric(y)]
NA000334Q = NA000334Q[date >= "1990-01-01", ]
trend = stsm_detect_trend(y = NA000334Q$y, freq = 4)

## End(Not run)
```

---

stsm\_estimate

*Trend cycle seasonal decomposition using the Kalman filter.*


---

### Description

Estimates a structural time series model using the Kalman filter and maximum likelihood. The seasonal and cycle components are assumed to be of a trigonometric form. The function checks three trend specifications to decompose a univariate time series into trend, cycle, and/or seasonal components plus noise. The function automatically detects the frequency and checks for a seasonal and cycle component if the user does not specify the frequency or decomposition model. This can be turned off by setting freq or specifying decomp. State space model for decomposition follows  $Y_t = T_t + C_t + S_t + B \cdot X_t + e_t$ ,  $e_t \sim N(0, \sigma_e^2)$  Y is the data T is the trend component C is the cycle component S is the seasonal component X is the exogenous data with parameter vector B e is the observation error

**Usage**

```

stsm_estimate(
  y,
  exo_obs = NULL,
  exo_state = NULL,
  state_eqns = NULL,
  freq = NULL,
  decomp = NULL,
  trend = NULL,
  unconstrained = FALSE,
  saturating_growth = FALSE,
  multiplicative = NULL,
  par = NULL,
  seasons = NULL,
  cycle = NULL,
  arma = c(p = NA, q = NA),
  interpolate = NA,
  interpolate_method = NA,
  det_obs = FALSE,
  det_trend = NULL,
  det_seas = FALSE,
  det_drift = FALSE,
  det_cycle = FALSE,
  sig_level = NULL,
  sig_level_seas = NULL,
  sig_level_cycle = NULL,
  sig_level_trend = NULL,
  optim_methods = c("BFGS", "NM", "CG", "SANN"),
  maxit = 10000,
  verbose = FALSE,
  cores = NULL
)

```

**Arguments**

<code>y</code>	Univariate time series of data values. May also be a 2 column data frame containing a date column.
<code>exo_obs</code>	Matrix of exogenous variables to be used in the observation equation.
<code>exo_state</code>	Matrix of exogenous variables to be used in the state matrix.
<code>state_eqns</code>	Character vector of equations to apply <code>exo_state</code> to the unobserved components. If left as the default, then all variables in <code>exo_state</code> will be applied to all the unobserved components. The equations should look like: "trend ~ var - 1", "drift ~ var - 1", "cycle ~ var - 1", "seasonal ~ var - 1". If only some equations are specified, it will be assumed that the exogenous data will be applied to only those specified equations.
<code>freq</code>	Frequency of the data (1 (yearly), 4 (quarterly), 12 (monthly), 365.25/7 (weekly), 365.25 (daily)), default is NULL and will be automatically detected

decomp	Decomposition model ("tend-cycle-seasonal", "trend-seasonal", "trend-cycle", "trend-noise")
trend	Trend specification ("random-walk", "random-walk-drift", "double-random-walk", "random-walk2"). The default is NULL which will choose the best of all specifications based on the maximum likelihood. "random-walk" is the random walk trend. "random-walk-drift" is the random walk with constant drift trend. "double-random-walk" is the random walk with random walk drift trend. "random-walk2" is a 2nd order random walk trend as in the Hodrick-Prescott filter. If trend is "random-walk", the trend model is $T_t = T_{t-1} + e_t$ , $e_t \sim N(0, \text{sig}_t^2)$ If trend is "random-walk-drift", the trend model is $T_t = T_{t-1} + D_{t-1} + e_t$ , $e_t \sim N(0, \text{sig}_t^2)$ with $D_t = d + \text{phi}_d * D_{t-1} + n_t$ , $n_t \sim N(0, \text{sig}_d^2)$ If trend is "double-random-walk", the trend model is $T_t = M_{t-1} + T_{t-1} + e_t$ , $e_t \sim N(0, \text{sig}_t^2)$ with $M_t = M_{t-1} + n_t$ , $n_t \sim N(0, \text{sig}_d^2)$ If trend is "random-walk2", the trend model is $T_t = 2T_{t-1} - T_{t-2} + e_t$ , $e_t \sim N(0, \text{sig}_t^2)$
unconstrained	Logical whether to remove inequality constraints on the trend during estimation
saturating_growth	Force the growth rate to converge to 0 in the long term
multiplicative	If data should be logged to create a multiplicative model. If multiplicative = TRUE, then the data is logged and the original model becomes multiplicative ( $Y_t = T_t * C_t * S_t * BX_t * e_t$ )
par	Initial parameters, default is NULL and will auto-select them
seasons	The seasonal periods: i.e. c(365.25, 7 if yearly and weekly seasonality). Default is NULL and will be estimated via wavelet analysis. Can set to FALSE if want no seasonality
cycle,	The period for the longer-term cycle. Default is NULL and will be estimated via wavelet analysis. Can set to FALSE if want no cycle, "trig" for trigonometric specification only, or "arma" for ARMA(p,q) specification only.
arma	Named vector with values for p and q corresponding to the ARMA(p,q) specification if cycle is set to 'arma'. If NA, then will auto-select the order.
interpolate	Character string giving frequency to interpolate to: i.e. "quarterly", "monthly", "weekly", "daily"
interpolate_method	Character string giving the interpolation method: i.e. "eop" for end of period, "avg" for period average, or "sum" for period sum.
det_obs	Set the observation equation error variance to 0 (deterministic observation equation) If det_obs = TRUE then the error variance of the observation equation (sig_e) is set to 0
det_trend	Set the trend error variance to 0 (deterministic trend) If det_trend = TRUE then the error variance of the trend equation (sig_t) is set to 0 and is referred to as a smooth trend
det_seas	Set the seasonality error variances to 0 (deterministic seasonality) If det_seas = TRUE then the error variance all seasonality frequency j equations (sig_s) are set to 0 and is referred to as deterministic seasonality

det_drift	Set the drift error variance to 0 (deterministic drift) If det_drift = TRUE then the error variance of the drift equation (sig_d) is set to 0 and is referred to as a deterministic drift
det_cycle	Set the cycle error variance to 0 (deterministic cycle) If det_cycle = TRUE then the error variance of the cycle equation (sig_c) is set to 0 and is referred to as a deterministic cycle
sig_level	Significance level to determine statistically significance for all tests. Default is 0.01
sig_level_seas	Significance level to determine statistically significant seasonal frequencies. Default is 0.01
sig_level_cycle	Significance level to determine a statistically significant cycle frequency. Default is 0.01
sig_level_trend	Significance level to determine statistically significant order of integration. Default is 0.01
optim_methods	Vector of 1 to 3 optimization methods in order of preference ("NR", "BFGS", "CG", "BHHH", or "SANN")
maxit	Maximum number of iterations for the optimization
verbose	Logical whether to print messages or not
cores	Number of cores to use for seasonality and cycle detection

## Value

List of estimation values including a data table with coefficients, convergence code, frequency, decomposition, seasonality, cyclicity, and trend specification as well as the a data table with the original data with dates. Any exogenous data given is also returned.

## Examples

```
## Not run:
#GDP Not seasonally adjusted
library(autostsm)
data("NA000334Q", package = "autostsm") #From FRED
NA000334Q = data.table(NA000334Q, keep.rownames = TRUE)
colnames(NA000334Q) = c("date", "y")
NA000334Q[, "date" := as.Date(date)]
NA000334Q[, "y" := as.numeric(y)]
NA000334Q = NA000334Q[date >= "1990-01-01", ]
stsm = stsm_estimate(NA000334Q)

## End(Not run)
```

---

stsm\_filter

*Kalman Filter*


---

### Description

Kalman filter an estimated model from stsm\_estimate output. This is a wrapper to stsm\_forecast with n.ahead = 0.

### Usage

```
stsm_filter(
  model,
  y,
  freq = NULL,
  exo_obs = NULL,
  exo_state = NULL,
  ci = 0.8,
  plot = FALSE,
  plot.decomp = FALSE,
  smooth = TRUE
)
```

### Arguments

model	Structural time series model estimated using stsm_estimate.
y	Univariate time series of data values. May also be a 2 column data frame containing a date column.
freq	Frequency of the data (1 (yearly), 4 (quarterly), 12 (monthly), 365.25/7 (weekly), 365.25 (daily)), default is NULL and will be automatically detected
exo_obs	Matrix of exogenous variables to be used in the observation equation.
exo_state	Matrix of exogenous variables to be used in the state matrix.
ci	Confidence interval, value between 0 and 1 exclusive.
plot	Logical, whether to plot everything
plot.decomp	Logical, whether to plot the filtered historical data
smooth	Whether or not to use the Kalman smoother

### Value

data table (or list of data tables) containing the filtered and/or smoothed series.

**Examples**

```

## Not run:
#GDP Not seasonally adjusted
library(autostsm)
data("NA000334Q", package = "autostsm") #From FRED
NA000334Q = data.table(NA000334Q, keep.rownames = TRUE)
colnames(NA000334Q) = c("date", "y")
NA000334Q[, "date" := as.Date(date)]
NA000334Q[, "y" := as.numeric(y)]
NA000334Q = NA000334Q[date >= "1990-01-01", ]
stsm = stsm_estimate(NA000334Q)
fc = stsm_filter(stsm, y = NA000334Q, plot = TRUE)

## End(Not run)

```

---

stsm_fixed_pars	<i>Fixed parameter setting</i>
-----------------	--------------------------------

---

**Description**

Fixed parameter setting

**Usage**

```

stsm_fixed_pars(
  par,
  y,
  det_obs = FALSE,
  det_trend = FALSE,
  det_drift = FALSE,
  det_cycle = FALSE,
  det_seas = FALSE,
  saturating_growth = FALSE
)

```

**Arguments**

par	Initial parameters
y	Vector of univariate time series
det_obs	Set the observation equation error variance to 0 (deterministic observation equation) If det_obs = TRUE then the error variance of the observation equation (sig_e) is set to 0
det_trend	Set the trend error variance to 0 (deterministic trend) If det_trend = TRUE then the error variance of the trend equation (sig_t) is set to 0 and is referred to as a smooth trend

det_drift	Set the drift error variance to 0 (deterministic drift) If det_drift = TRUE then the error variance of the drift equation (sig_d) is set to 0 and is referred to as a deterministic drift
det_cycle	Set the cycle error variance to 0 (deterministic cycle) If det_cycle = TRUE then the error variance of the cycle equation (sig_c) is set to 0 and is referred to as a deterministic cycle
det_seas	Set the seasonality error variances to 0 (deterministic seasonality) If det_seas = TRUE then the error variance all seasonality frequency j equations (sig_s) are set to 0 and is referred to as deterministic seasonality
saturating_growth	Force the growth rate to converge to 0 in the long term

---

stsm\_forecast                      *Kalman Filter and Forecast*

---

### Description

Kalman filter and forecast an estimated model from stsm\_estimate output

### Usage

```
stsm_forecast(
  model,
  y,
  n.ahead = 0,
  freq = NULL,
  exo_obs = NULL,
  exo_state = NULL,
  exo_obs.fc = NULL,
  exo_state.fc = NULL,
  ci = 0.8,
  plot = FALSE,
  plot.decomp = FALSE,
  plot.fc = FALSE,
  n.hist = NULL,
  smooth = TRUE,
  dampen_cycle = FALSE,
  envelope_ci = FALSE
)
```

### Arguments

model	Structural time series model estimated using stsm_estimate.
y	Univariate time series of data values. May also be a 2 column data frame containing a date column.
n.ahead	Number of periods to forecast

freq	Frequency of the data (1 (yearly), 4 (quarterly), 12 (monthly), 365.25/7 (weekly), 365.25 (daily)), default is NULL and will be automatically detected
exo_obs	Matrix of exogenous variables to be used in the observation equation.
exo_state	Matrix of exogenous variables to be used in the state matrix.
exo_obs.fc	Matrix of exogenous variables in the observation matrix used for the forecast
exo_state.fc	Matrix of exogenous variables in the state matrix used for the forecast
ci	Confidence interval, value between 0 and 1 exclusive.
plot,	Logical, whether to plot everything
plot.decomp	Logical, whether to plot the filtered historical data
plot.fc	Logical, whether to plot the forecast
n.hist	Number of historical periods to include in the forecast plot. If plot = TRUE and n.hist = NULL, defaults to 3 years.
smooth	Whether or not to use the Kalman smoother
dampen_cycle	Whether to remove oscillating cycle dynamics and smooth the cycle forecast into the trend using a sigmoid function that maintains the rate of convergence
envelope_ci	Whether to create a envelope for the confidence interval to smooth out seasonal fluctuations to the longest seasonal period

### Value

data table (or list of data tables) containing the filtered and/or smoothed series.

### Examples

```
## Not run:
#GDP Not seasonally adjusted
library(autostsm)
data("NA000334Q", package = "autostsm") #From FRED
NA000334Q = data.table(NA000334Q, keep.rownames = TRUE)
colnames(NA000334Q) = c("date", "y")
NA000334Q[, "date" := as.Date(date)]
NA000334Q[, "y" := as.numeric(y)]
NA000334Q = NA000334Q[date >= "1990-01-01", ]
stsm = stsm_estimate(NA000334Q)
fc = stsm_forecast(stsm, y = NA000334Q, n.ahead = floor(stsm$freq)*3, plot = TRUE)

## End(Not run)
```



---

stsm_format_exo	<i>Format exo</i>
-----------------	-------------------

---

**Description**

Format the exo table

**Usage**

```
stsm_format_exo(exo_obs, exo_state, dates, range)
```

**Arguments**

exo_obs	exogenous observation data
exo_state	exogenous state data
dates	dates vector
range	range of data to include

**Value**

a data table

---

stsm_init_pars	<i>Get initial parameter estimates for estimation</i>
----------------	-------------------------------------------------------

---

**Description**

Get initial parameter estimates for estimation

**Usage**

```
stsm_init_pars(
  y,
  freq,
  trend,
  cycle,
  decomp = "",
  seasons = NULL,
  prior = NULL,
  sig_level = 0.01,
  arma = c(p = NA, q = NA),
  exo = NULL,
  state_eqns = NULL,
  interpolate = NA,
  interpolate_method = NA
)
```

**Arguments**

y	an object created from stsm_detect_frequency
freq	Frequency of the data
trend	Trend specification ("random-walk", "random-walk-drift", "double-random-walk", "random-walk2").
cycle	The period for the longer-term cycle
decomp	Decomposition model ("tend-cycle-seasonal", "trend-seasonal", "trend-cycle", "trend-noise")
seasons	The seasonal lengths to split the seasonality into
prior	A data table created by stsm_prior
sig_level	Significance level for statistical tests
arma	Named vector with values for p and q corresponding to the ARMA(p,q) specification if
exo	Matrix of exogenous variables. Can be used to specify regression effects or other seasonal effects like holidays, etc.
state_eqns	Character vector of equations to apply exo_state to the unobserved components. If left as the default, then all variables in exo_state will be applied to all the unobserved components. The equations should look like: "trend ~ var - 1", "drift ~ var - 1", "cycle ~ var - 1", "seasonal ~ var - 1". If only some equations are specified, it will be assumed that the exogenous data will be applied to only those specified equations.
interpolate	Character string giving frequency to interpolate to: i.e. "quarterly", "monthly", "weekly", "daily" cycle is set to 'arma'. If NA, then will auto-select the order.
interpolate_method	Character string giving the interpolation method:

**Value**

named vector containing the initial parameter estimates for estimation

---

stsm_na_kalman	<i>Missing Value Imputation by Kalman Smoothing and State Space Models</i>
----------------	----------------------------------------------------------------------------

---

**Description**

Simplified version taken from the 'imputeTS' package. Uses Kalman Smoothing on structural time series models for imputation. It uses "StructTS" to build a "basic structural model" if the frequency of y is greater than 1. Otherwise, it uses a local trend model.

**Usage**

```
stsm_na_kalman(y)
```

**Arguments**

y                      Univariate time series

---

stsm\_prior                      *Return a naive model prior decomposition*

---

**Description**

Return a naive model prior decomposition

**Usage**

```
stsm_prior(y, freq, decomp = "", seasons = NULL, cycle = NULL)
```

**Arguments**

y                      an object created from stsm\_detect\_frequency  
 freq                      Frequency of the data  
 decomp                      decomposition string  
 seasons                      The seasonal periods to split the seasonality into  
 cycle                      The cycle periods

**Value**

data table containing a naive decomposition using STL

**Examples**

```
## Not run:
##GDP Not seasonally adjusted
library(autostsm)
data("NA000334Q", package = "autostsm") #From FRED
NA000334Q = data.table(NA000334Q, keep.rownames = TRUE)
colnames(NA000334Q) = c("date", "y")
NA000334Q[, "date" := as.Date(date)]
NA000334Q[, "y" := as.numeric(y)]
NA000334Q = NA000334Q[date >= "1990-01-01", ]
prior = stsm_prior(y = NA000334Q$y, freq = 4)

## End(Not run)
```

stsm\_ssm

*State space model***Description**

Creates a state space model in list form  $yt = H*B + B^O X^O_t + e_t$   $B = F*B_{t-1} + B^S X^S_t + u_t$

**Usage**

```
stsm_ssm(
  par = NULL,
  yt = NULL,
  decomp = NULL,
  trend = NULL,
  init = NULL,
  model = NULL,
  prior = NULL,
  freq = NULL,
  seasons = NULL,
  cycle = NULL,
  interpolate = NULL,
  interpolate_method = NULL
)
```

**Arguments**

par	Vector of named parameter values, includes the harmonics
yt	Univariate time series of data values
decomp	Decomposition model ("tend-cycle-seasonal", "trend-seasonal", "trend-cycle", "trend-noise")
trend	Trend specification ("random-walk", "random-walk-drift", "double-random-walk", "random-walk2"). The default is NULL which will choose the best of all specifications based on the maximum likelihood. "random-walk" is the random walk trend. "random-walk-drift" is the random walk with constant drift trend. "double-random-walk" is the random walk with random walk drift trend. "random-walk2" is a 2nd order random walk trend as in the Hodrick-Prescott filter.
init	Initial state values for the Kalman filter
model	a stsm_estimate model object
prior	Model prior built from stsm_prior. Only needed if prior needs to be built for initial values
freq	Frequency of the data. Only needed if prior needs to be built for initial values and prior = NULL
seasons	Numeric vector of seasonal frequencies. Only needed if prior needs to be built for initial values and prior = NULL

cycle            Numeric value for the cycle frequency. Only needed if prior needs to be built for initial values and prior = NULL  
 interpolate     Character string of how to interpolate  
 interpolate\_method     Character string for the method of interpolation

**Value**

List of space space matrices

**Examples**

```

## Not run:
#GDP Not seasonally adjusted
library(autostsm)
data("NA000334Q", package = "autostsm") #From FRED
NA000334Q = data.table(NA000334Q, keep.rownames = TRUE)
colnames(NA000334Q) = c("date", "y")
NA000334Q[, "date" := as.Date(date)]
NA000334Q[, "y" := as.numeric(y)]
NA000334Q = NA000334Q[date >= "1990-01-01", ]
stsm = stsm_estimate(NA000334Q)
ssm = stsm_ssm(model = stsm)

## End(Not run)

```

---

UNRATE

*Unemployment Rate Seasonally Adjusted*


---

**Description**

Unemployment Rate Seasonally Adjusted

**Usage**

data(UNRATE)

**Format**

data.table with columns DATE and UNRATE, monthly frequency

**Source**

FRED

---

UNRATENSA

*Unemployment Rate Not Seasonally Adjusted*

---

**Description**

Unemployment Rate Not Seasonally Adjusted

**Usage**

```
data(UNRATENSA)
```

**Format**

data.table with columns DATE and UNRATENSA, monthly frequency

**Source**

FRED

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