# Package 'regts'

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**Type** Package

**Title** Regular Timeseries

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**Description** An extension of the ts class with enhanced possibilities for period selection. regts particularly aims at yearly, quarterly and monthly timeseries. It also supports labels that can be used to describe the timeseries in multivariate timeseries objects. The package includes functions for reading and writing timeseries from Excel and csv files, conversion of timeseries to growth series and the inverse transformation, special aggregation methods for growth series, and several other functions.

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---

`aggregate_gr` *Convert timeseries with absolute or relative changes to a lower frequency*

---

## Description

This function implements temporal aggregation for timeseries with absolute, relative or percentage changes. As shown in vignette *"Temporal Aggregation of (Growth) Timeseries"*, the standard function `aggregate` does not yield correct results for these type of timeseries.

## Usage

```
aggregate_gr(x, method = c("pct", "rel", "difmean", "difsum", "dif1s",
  "dif1"), nfrequency = 1)
```

## Arguments

| | |
|---|---|
| `x` | a `ts` or `regts` object |
| `method` | aggregation methods. See Details. |
| `nfrequency` | the frequency of the result. This should be higher than the frequency of timeseries `x` |

## Details

There are methods for different types of input timeseries. The `"pct"` and `"rel"` methods assume timeseries that contain percentage or relative changes of a timeseries with only positive values. They calculate the exact percentage or relative change for the output timeseries. The `"difmean"` and `"difsum"` methods assume that the input timeseries contain a first difference. The result is a first difference in the output frequency. Method names `"dif1s"` and `"dif1"` are obsolete and have been replaced by `"difmean"` and `"difsum"`, respectively. More details for the various methods are provided in vignette *"Temporal Aggregation of (Growth) Timeseries"*.

As explained before, the `"pct"` and `"rel"` methods assume that `x` is is a percentage or relative change of a series with only positive values. This imposes a restriction on `x`: for the `pct` method, x >= -100%, and for `rel`, x >= -1. Function `aggregate_gr` gives an error if this condition is not satisfied.

## Value

a `regts` with frequency `nfrequency`

## Examples

```
ts_q <- regts(abs(rnorm(10)), start = "2016Q1")
aggregate_gr(ts_q, method = "difmean")

ts_m <- regts(matrix(abs(rnorm(20)), ncol = 2), start = "2017M1", names = c("a", "b"))
aggregate_gr(ts_m, method = "rel", nfrequency = 4)
```

---

`as.data.frame` *Convert a* `regts` *to a* `data.frame`

---

## Description

Convert a `regts` to a `data.frame`

## Usage

```
## S3 method for class 'regts'
as.data.frame(x, ..., rowwise = FALSE, row_names = TRUE,
  period_as_date = FALSE)
```

## Arguments

| | |
|---|---|
| `x` | a `regts` |
| `...` | additional arguments to be passed to methods. |
| `rowwise` | a logical value: should the timeseries be stored rowwise or columnwise in the data frame? Defaults to `FALSE` |
| `row_names` | Whether to create row names. If `FALSE`, then an additional column with name `"period"` or `"name"` is created for columnwise or rowwise timeseries, respectively. |
| `period_as_date` | A logical (default `FALSE`). If `TRUE` the periods are stored as `Date` objects. Depending on arguments `rowwise` and `row_names` the periods may appear in the row or column names of the result data frame. In that case the dates are coerced to character vectors, using the standard date format `"%Y-%m-%d"` (see the documentation of function `strptime` for more information about date formats). |

## Details

If the `regts` has labels and argument `rowwise` is `FALSE`, then the labels are added to columns of the data frame These labels are visible in the data viewer.

## Value

A `data.frame`

## Examples

```
ts <- regts(matrix(1:4, ncol = 2) , start = "2015Q3", names = c("a", "b"),
           labels = c("Timeseries a", "Timeseries b"))
print(as.data.frame(ts))
```

as.list *Convert a* regts *to a list of univariate regts objects*

## Description

This function converts a regts to a list of univariate regts objects.

## Usage

```
## S3 method for class 'regts'
as.list(x, ...)
```

## Arguments

| | |
|---|---|
| x | a regts object |
| ... | arguments passed to methods (not used in the default implementation) |

## Value

a list of univariate regts objects

## See Also

list2env and cbind

## Examples

```
regts1 <- regts(matrix(1:6, ncol = 2), start = "2015Q3", names = c("a", "b"))

# convert regts1 to a list
ts_list1 <- as.list(regts1)

# use the within function to modify timeseries and create new timeseries
ts_list2 <- within (ts_list1, {
   b["2015q2"] <- 2
   c <- a * b
   d <- lag(c)
 })

# use functions do.call and cbind to convert
# the list of timeseries objects to a multivariate regts
regts2 <- do.call(cbind, ts_list2)

# transfer all timeseries in the list to the global environment
list2env(ts_list2, .GlobalEnv)
```

as.regts *Coerce an object to a* regts *timeseries object*

## Description

Coerce an object to a regts timeseries object

## Usage

```
as.regts(x, ...)

## S3 method for class 'ts'
as.regts(x, ...)

## S3 method for class 'data.frame'
as.regts(x, time_column = 0, numeric = TRUE, fun = period, strict = TRUE, ...)

## S3 method for class 'matrix'
as.regts(x, numeric = TRUE, fun = period, strict = TRUE, ...)

## S3 method for class 'list'
as.regts(x, union = TRUE, ...)

## S3 method for class 'numeric'
as.regts(x, fun = period, strict = TRUE, ...)

## Default S3 method:
as.regts(x, ...)
```

## Arguments

| | |
|---|---|
| x | an arbitrary R object. |
| ... | arguments passed to fun. |
| time_column | the column names or numbers of the data frame in which the time (periods) is stored. Specify 0 if the index is in the row names of the data frame. If time_column has length > 1, then argument fun should be a function which converts a data frame to period vector. |
| numeric | logical: should non numeric values be converted to numeric data. By default they are converted to numeric. This can be changed by setting numeric = FALSE. |
| fun | a function for converting values in the row names, time column(s), or names of a numeric vector to period objects. Normally this is a function which converts a vector to a period vector (for example function period). See argument time_column for exceptions. |
| strict | A logical. If TRUE (the default) all periods between the start and the end period must be present. Otherwise the timeseries are filled with NA for the missing periods. |
| union | A logical (default TRUE). Only used in as.regts.list. If the list contains multiple timeseries and union is TRUE, then the period range of the result is the union of the period ranges of the individual timeseries objecct in the list. Otherwise the period range is the intersection of the period ranges of the individual timeseries. |

## Value

a regts object

## Methods (by class)

- ts: Coerce a ts to a regts
- data.frame: Convert a data.frame to a regts. The time should be stored in the row numbers of the matrix
- matrix: Convert a matrix to a regts
- list: Convert a list to a regts. At least one of the elements of the list should contain a timeseries. The result is a multivariate timeseries with the combined timeseries
- numeric: Convert a numeric vector to a regts
- default: Default method to convert an R object to a regts. This method first employs as.ts and then as.regts.ts

## See Also

regts, is.regts, as.data.frame, as.list, start_period, end_period

## Examples

```
# convert a ts to regts
x <- ts(1:3, start = c(2015,3), frequency = 4)
x <- as.regts(x)

# Now three examples for converting a data.frame

# create a data frame with timeseries and with the
# time index in the rownames, and convert to a regts
df <- data.frame(a = 1:3)
rownames(df) <- c("2015Q3", "2015Q4", "2016Q1")
ts <- as.regts(df)

# create a data frame with the time index in the first column and special
# time format "2015 3" instead of "2015Q3", and convert to regts
df <- data.frame(periods = c("2015 3", "2015 4", "2016 1"),  a = 1:3)
ts <- as.regts(df, time_column = 1, frequency = 4)

# create a data frame with non numeric data and convert to regts
# Strings containing non numeric values are converted to NA
# Logical values TRUE/FALSE are converted to 1/0
df <- data.frame(a = c("1", "2", "X"), b
= c(TRUE, FALSE, TRUE), stringsAsFactors = FALSE)
as.regts(df)

# data frame with the years in the first column and quarters in the
# second column
df <- data.frame(years = c(2018, 2018), quarters = c(1, 2), a = 1:2)
fun <- function(x) {period(paste(x[[1]], x[[2]]), frequency = 4)}
as.regts(df, time_column = c("years", "quarters"), fun = fun)
```

as_matrix *Convert a* ts *to a* matrix

## Description

This function converts a ts object to a normal matrix, i.e. a matrix without timeseries class and attributes.The periods are stored in the row or column names of the returned matrix, depending on argument rowwise.

## Usage

```
as_matrix(x, ...)

## S3 method for class 'ts'
as_matrix(x, rowwise = FALSE, ...)
```

## Arguments

| | |
|---|---|
| x | a ts or regts |
| ... | additional arguments to be passed to methods. |
| rowwise | a logical value: should the timeseries be stored rowwise or columnwise in the matrix? Defaults to FALSE |

## Details

The function behaves differently than base method as.matrix. If the input timeseries is a matrix with timeseries attributes, then as.matrix just returns the input value. If the input timeseries is not a matrix (a univariate timeseries with vector data), then as.matrix returns a matrix without row and column names and without timeseries attributes. In contrast, as_matrix always returns a matrix without timeseries attributes.

## Value

A matrix

## Methods (by class)

- ts: Coerce a ts to a matrix without timeseries class and attributes

## Examples

```
ts <- regts(matrix(1:4, ncol = 2) , start = 2015, names = c("a", "b"))
as_matrix(ts, rowwise = TRUE)
```

## cbind *Bind two or more timeseries*

### Description

Bind two or more timeseries objects with a common frequency. By default, the period range of the result is the union of the period ranges of the individual timeseries. The result is padded with NAs if necessary. If argument union is false, then the period range of the result is the intersection of the period ranges.

### Usage

```
## S3 method for class 'regts'
cbind(..., union = TRUE, suffixes)
```

### Arguments

| | |
|---|---|
| ... | two or more univariate or multivariate timeseries, or objects which can be coerced to timeseries |
| union | if TRUE, then the period range of the result is the union of the period ranges of the joined objects (the result is padded with NAs if necessary). If FALSE, then the period range of the result is the intersection of the period ranges of the joined objects. |
| suffixes | Suffixes appended to the column names for all overlapping columns. This argument is obligatory if the timeseries have overlapping column names. Length suffixes must be equal to the number of joined timeseries or objects. |

### See Also

as.list

### Examples

```
a <- regts(1:5, start = "2011Q1")
b <- regts(matrix(11:15, nc = 1), start = "2011Q2")
cbind(a, b)
cbind(a, b, union = FALSE)
x1 <- regts(matrix(1:27, nc = 3), start = "2008Q4", names = c("a", "b", "c"))
x2 <- regts(matrix(1:27, nc = 3), start = "2008Q4", names = c("a", "c", "d"))
cbind(x1, x2, suffixes = c("_1","_2"))
```

## change_colnames *Change the column names of a matrix or data frame by applying a function.*

### Description

Change the column names of a matrix or data frame by applying a function.

## Usage

```
change_colnames(x, fun, ...)
```

## Arguments

| | |
|---|---|
| x | an R object with column names (e.g. a data.frame, matrix, ts or regts) |
| fun | a function |
| ... | arguments passed to fun |

## Value

an R object with modified columm names

## See Also

tag_colnames

## Examples

```
data <- regts(matrix(1:8, ncol = 2), start = "2010Q2", names = c("a", "b"))

# convert to column names tp upper case
change_colnames(data, toupper)
```

---

# change_frequency *Change the frequency of a* period *or* period_range *object.*

---

## Description

A period can be converted to lower frequency. For example, a month "2017M4" can be converted to the quarter "2017Q2". The old frequency should be divisible by the new frequency.

A period_range can be converted to both lower and higher frequency. For example, the range "2017Q3/2018Q1" can be converted to the month range "2017M7/2018M3" or the year range "2017/2018". If the period_range is converted to lower frequency, then the old frequency should be divisible by the new frequency. If the range is converted to higher frequency, then the new frequency should be divisible by the old frequency.

## Usage

```
change_frequency(x, new_frequency, ...)

## S3 method for class 'period'
change_frequency(x, new_frequency, ...)

## S3 method for class 'period_range'
change_frequency(x, new_frequency, ...)
```

### Arguments

| | |
|---|---|
| x | a period or period_range |
| new_frequency | the new_frequency |
| ... | arguments passed to methods (not used in package regts) |

### Value

a period or period_range (depending on the type of argument x) with the new frequency

### Methods (by class)

- period: Change the frequency of a period to lower frequency
- period_range: Change the frequency of a period_range to higher or lower frequency

### Examples

```
p <- period("2017M4")
change_frequency(p, 4)

range <- period_range("2017Q3/2018Q1")
change_frequency(range, 12)
change_frequency(range, 1)
```

---

## cvgdif *Calculate the 'convergence difference'*

---

### Description

cvgdif calculates the difference between two numeric vectors x1 and x2 according to |x1 -x2| / max(|x2|,1). This difference is equivalent to the convergence test employed in the package isismdl.

### Usage

```
cvgdif(x1, x2)
```

### Arguments

| | |
|---|---|
| x1 | first numeric vector |
| x2 | second numeric vector |

### Value

the 'convergence difference' as described above

### See Also

tsdif

## Examples

```
# create two timeseries x1 and x2
x1 <- regts(matrix(data = rep(1:27), nc = 3), start = "2008Q4",
           names = c("a", "b", "c"))
x2 <- x1 + 0.001
colnames(x2) <- c("a", "b", "d")

# calculate the differences
cvgdif(x1, x2)
```

---

`diff_ts` *Lagged differences of a timeseries*

---

## Description

Returns suitably lagged and iterated differences of a timeseries. This function works similarly as `diff`, except that the period range of the result is the same as that of the input timeseries. This behaviour can be changed by specifying argument `keep_range`.

## Usage

```
diff_ts(x, lag = 1, differences = 1, keep_range = TRUE, ...)

## S3 method for class 'ts'
diff_ts(x, lag = 1, differences = 1, keep_range = TRUE, ...)

## Default S3 method:
diff_ts(x, lag = 1, differences = 1, keep_range = TRUE, ...)
```

## Arguments

| | |
|---|---|
| `x` | a univariate or multivariate timeseries. Can also be a vector, matrix or data frame (see details). |
| `lag` | an integer indicating which lag to use |
| `differences` | an integer indicating the order of the difference. |
| `keep_range` | if `TRUE` (the default), then the output timeseries has the same period range as the input timeseries. Then the result timeseries will have `lag + differences -1` `NA` values at the beginning. If `FALSE` then the result timeseries starts `lag + differences -1` periods later than the input timeseries. |
| `...` | further arguments to be passed to or from methods (currently not used in package `regts`) |

## Details

Vector, matrix and data frame arguments are first converted to a `regts` with function `regts`. This conversion results in a timeseries with frequency 1 and starting at year 1.

## See Also

`lag_ts` and `lead_ts`

## Examples

```
x <- regts(1:10, start = "2018q3")
diff_ts(x)
diff_ts(x, lag = 2, keep_range = FALSE)
```

---

`disagg` *Disaggregation of timeseries using cubic spline interpolation.*

---

## Description

This function converts a timeseries to a timeseries with higher frequency, for example a yearly timeseries to a quarterly timeseries. Cubic spline interpolation is used to interpolate between the low frequency observations.

## Usage

```
disagg(x, nfrequency, constraint = c("average", "sum", "first", "last"),
  conds = c("natural", "not-a-knot"))
```

## Arguments

| | |
|---|---|
| `x` | a `regts` or `ts` object |
| `nfrequency` | the frequency of the result. This should be higher than the frequency of timeseries `x`. |
| `constraint` | Constraint on the high frequency result. Possible values are `"average"`, `"sum"`, `"first"` and `"last"`. Either the average, the sum, the first or last value of the resulting high-frequency series should be equal to the corresponding low-frequency value. |
| `conds` | a character specifying the boundary conditions: `"natural"` or `"not-a-knot"`. Default is `"natural"`. See details. |

## Details

Argument `conds` can be used to select the boundary conditions for the cubic spline interpolation. Choose `"natural"` for a natural cubic spline (zero second derivatives at the end points). For `"not-a-knot"` the third derivative is continuous at the second and one but last point.

Leading and trailing `NA` values are removed before the interpolation.

## See Also

Alternative spline methods are available in package `tempdisagg`

## Examples

```
# construct quarterly series
q <- regts(matrix(c(1:3, NA, -3, -5),  ncol = 2),
           period = "2017Q2/2017Q4", names = c("a", "b"))

disagg(q, nfrequency = 12)

disagg(q, constraint = "last", conds = "not-a-knot", nfrequency = 12)
```

## frequency *Return the frequency of a* period *or a* period_range

### Description

This is an extension to S3 generic function frequency. Function now also returns the frequency of a period or a period_range

### Usage

```
## S3 method for class 'period'
frequency(x, ...)

## S3 method for class 'period_range'
frequency(x, ...)
```

### Arguments

| | |
|---|---|
| x | a period or a period_range |
| ... | additional arguments for future methods |

### Value

the frequency of the period or the period_range

### Methods (by class)

- period: frequency of a period object
- period_range: frequency of a period_range object

### Examples

```
p <- period("2016Q1")
freq <- frequency(p)

p <- period_range("2016Q1", "2018Q2")
freq <- frequency(p)#'
```

## get_periods *Return all periods in a* period_range *or timeseries.*

### Description

The periods in a period_range or timeseries are returned as a period vector

### Usage

```
get_periods(x, ...)
```

### Arguments

| | |
|---|---|
| x | a period_range or times series (ts or regts). |
| ... | arguments passed to methods (currently not used). |

### See Also

get_period_range

### Examples

```
# example for period range
range <- period_range("2018m1/2018m3")
get_periods(range)

# example for timeseries
x <- regts(1:3, start = "2010Q4")
get_periods(x)
```

---

## get_period_range *Return the period_range of a timeseries.*

---

### Description

Return the period_range of a timeseries.

### Usage

```
get_period_range(x)
```

### Arguments

| | |
|---|---|
| x | a timeseries (ts or regts) |

### Value

a period_range

### See Also

get_periods

## get_subperiod *Return the subperiod of a period*

### Description

This function returns the subperiod within a year. For example, for period 2011Q3 the function returns 3.

### Usage

```
get_subperiod(x)
```

### Arguments

| | |
|---|---|
| x | a period |

### Value

the subperiod of a period

### See Also

get_year

### Examples

```
get_subperiod(period("2010Q3"))
```

## get_year *This function returns the year of a period*

### Description

This function returns the year of a period

### Usage

```
get_year(x)
```

### Arguments

| | |
|---|---|
| x | a period |

### Value

the year

### See Also

get_subperiod

## Examples

```
get_year(period("2010Q3"))
```

---

growth *Return the relative change of a timeseries*

---

## Description

Function growth computes the relative change of a timeseries. The one period relative change of a timeseries is defined as: growth(x) = (x[t] -x[t-1]) / |x[t-1]|

The n period relative change of a timeseries is defined as: growth(x,n) = (x[t] -x[t-n]) / |x[t-n]|

The formula implies that when the timeseries decreases, the result will be negative regardless of the sign of x. The function also works for multivariate timeseries.

## Usage

```
growth(x, n = 1, keep_range = TRUE)
```

## Arguments

| | |
|---|---|
| x | a ts or regts object |
| n | an integer indicating the period of relative change |
| keep_range | if TRUE (the default), then the output timeseries has the same period range as the input timeseries. Then the result timeseries will have n NA values at the start. If FALSE then the result timeseries is n periods shorter than the input timeseries. |

## Value

a regts object with relative changes

## See Also

rel2index

## Examples

```
x <- regts(rnorm(10), start = "2018Q1")
growth(x, keep_range = FALSE)
growth(x, 4)
```

index_ts *Construct an index timeseries by scaling*

## Description

This function scales a timeseries by dividing all observations by one selected observation or by the mean of a range of observations. The index series `i` is calculated from the input series `x` as

```
i[t] = scale * x[t] / mean(x[base]),
```

where `scale` is usually 100 and `base` the base period, which can be a single `period` or a `period_range` (by default the base period is the first period of `x`). If `mean(x[base])` is negative then a warning is given and the (mean) value of the resulting index series at the base period will be `-scale`.

## Usage

```
index_ts(x, base = NULL, scale = 100)
```

## Arguments

| | |
|---|---|
| `x` | a `ts` of `regts` object |
| `base` | a `period` or a `period_range` specifying the base period, or an object that can be coerced to a `period` or `period_range`. By default the base period is the first period of the input timeseries. |
| `scale` | the (average) value of the index series at the base period (by default 100). This should be a positive number. |

## See Also

`rel2index` and `pct2index`

## Examples

```
ab <- regts(matrix(1:18 + rnorm(18), ncol = 2), start = "2016Q1",
            names = c("a", "b"))

index_ts(ab)

index_ts(ab, base = "2017", scale = 1)
```

## is.period *Test if an object is a* period

### Description

Test if an object is a period

### Usage

```
is.period(x)
```

### Arguments

| | |
|---|---|
| x | any R object |

### Value

TRUE if the object is a period

### Examples

```
p <- period("2016Q1")
is.period(p)
is.period("2016Q1")
```

## is.period_range *Test if an object is a* period_range

### Description

Test if an object is a period_range

### Usage

```
is.period_range(x)
```

### Arguments

| | |
|---|---|
| x | any R object |

### Value

TRUE if the object is a period_range

### Examples

```
range <- period_range("2016Q1/2017Q1")
is.period_range(range)
is.period_range("2016Q1/2017Q1")
```

## is.regts *Test whether an object is a regts timeseries object*

### Description

Test whether an object is a regts timeseries object

### Usage

```
is.regts(x)
```

### Arguments

| | |
|---|---|
| x | any R object. |

### Value

TRUE if x is a regts

### See Also

regts and as.regts

### Examples

```
a <- regts(1:15, start = "2011Q2")
is.regts(a)
```

## join_ts *Join timeseries objects with overlapping period ranges*

### Description

This function joins two timeseries with the same frequency and different but overlapping period ranges. All observations from the old timeseries, the first timeseries, are scaled in such a way that the common observations from the two timeseries have the same value (on average). The new timeseries, the second timeseries, must contain the most recent data.

### Usage

```
join_ts(old, new, method = c("mult", "add"))
```

### Arguments

| | |
|---|---|
| old | the first timeseries (a regts or ts object). |
| new | the second timeseries (a regts or ts object). |
| method | two different ways to join the timeseries: mult and add. By default the timeseries are joined multiplicatively. |

## Details

The period range of the result is the union of the period ranges of the old and new timeseries.

When the overlapping period is determined, the trailing NA values of the old timeseries and the leading NA values of the new timeseries are ignored.

If both the old and new timeseries are multivariate regts objects, only the common columns are joined. For each common timeseries the overlapping period is determined, ignoring the NA values as described above. The remaining columns in the new timeseries are added to the result. Remaining columns in the old timeseries are ignored. The result series and the new series have the same columns, in the same order. The joined timeseries can be found in the common columns.

If both input timeseries are vectors (i.e. there are no column names), the result is also a vector.

## Value

a regts object.

## See Also

regts and update_ts

## Examples

```
x1 <- regts((1:15)/10, start = "2016q1")
x2 <- regts(1:10, start = "2018q4")
join_ts(x1, x2)

data <- (1:10)/10
x_old <- regts(cbind(data, 2 * data), period = "2001/2010",
            names = c("a", "b"))
x_new <- regts(cbind(10 * data, 20 * data), period = "2008/2017",
            names = c("a", "b"))
join_ts(x_old, x_new, method = "add")

# join timeseries with different column names
x_old <- regts(matrix(rep(10:15, 3), nc = 3), period = "2010/2015",
            names = c("a", "c", "d"))
x_new <- regts(matrix(rep(17:20, 3), nc = 3), period = "2014/2017",
            names = c("a", "b", "c"))
join_ts(x_old, x_new)
```

---

# lag_ts *Lag a Timeseries*

---

## Description

Compute the lag of a timeseries, shifting the observations forwards by a given number of periods.

## Usage

```
lag_ts(x, n = 1, keep_range = TRUE, ...)

## S3 method for class 'ts'
lag_ts(x, n = 1, keep_range = TRUE, ...)
```

### Arguments

| | |
|---|---|
| x | a univariate or multivariate timeseries. Can also be a vector, matrix or data frame (see details). |
| n | the number of lags (in units of observations). Must be a positive number. |
| keep_range | if TRUE (the default), then the output timeseries has the same period range as the input timeseries. The result timeseries will have n NA values at the beginning. If FALSE the period range of the result timeseries is shifted by n periods. The result timeseries starts and ends n periods later. |
| ... | further arguments to be passed to or from methods (currently not used in package regts) |

### Details

Vector, matrix and data frame arguments are first converted to a regts with function regts. This conversion results in a timeseries with frequency 1 and starting at year 1.

lag_ts differs from lag in the stats package in that the specified number of lags is positive, and that by default the resulting timeseries has the same period range as the input timeseries. In function lag the time base is always shifted. lag_ts(x,1,keep_range = FALSE) is the same as lag(x,-1)

### See Also

lead_ts, diff_ts and lag

### Examples

```
x <- regts(1:10, start = "2018q3")
lag_ts(x)
lag_ts(x, k = 2, keep_range = FALSE)
```

---

## lead_ts *Lead a Timeseries*

---

### Description

Compute the lead of a timeseries, shifting the observations backwards by a given number of periods.

### Usage

```
lead_ts(x, n = 1, keep_range = TRUE, ...)

## S3 method for class 'ts'
lead_ts(x, n = 1, keep_range = TRUE, ...)

## Default S3 method:
lead_ts(x, n = 1, keep_range = TRUE, ...)
```

### Arguments

| | |
|---|---|
| x | a univariate or multivariate timeseries. Can also be a vector, matrix or data frame (see details). |
| n | the number of leads (in units of observations). Must be a positive number. |
| keep_range | if TRUE (the default), then the output timeseries has the same period range as the input timeseries. The result timeseries will have n NA values at the beginning end. If FALSE the period range of the result timeseries is shifted by n periods. The result timeseries starts and ends n periods earlier. |
| ... | further arguments to be passed to or from methods (currently not used in package regts) |

### Details

Vector, matrix and data frame arguments are first converted to a regts with function regts. This conversion results in a timeseries with frequency 1 and starting at year 1.

Function lead_ts is an alternative for function lag in the stats package which computes both lags and leads. By default in lead_ts the resulting timeseries has the same period range as the input timeseries. In function lag the time base is always shifted. lead_ts(x,1,keep_range = FALSE) is the same as lag(x,1)

### See Also

lag_ts and diff_ts

### Examples

```
x <- regts(1:10, start = "2018q3")
lead_ts(x)
lead_ts(x, k = 2, keep_range = FALSE)
```

---

## movav *Moving average of a timeseries*

---

### Description

Function movavb computes the backward moving average and function movavc the centered moving average.

For example, the backward moving average of order 3 is defined as

A[t] = (x[t -2] + x[t -1] + x[t]) / 3,

while the centered moving average of order 3 is calculated as

A[t] = (x[t -1] + x[t] + x[t + 1]) / 3.

The calculation of the centered moving average for even orders is somewhat more complicated, see Details.

### Usage

```
movavb(x, order, keep_range = TRUE)

movavc(x, order, keep_range = TRUE, method = c("centre", "left", "right"))
```

## Arguments

| | |
|---|---|
| x | a ts or regts object |
| order | the order of the moving average |
| keep_range | If TRUE (the default), then the output timeseries has the same period range as the input timeseries. Then the result timeseries will have order NA values. For movavb these NAs will appear on the left side and for movavc they will be distributed over both sides. If FALSE then the result timeseries is order periods shorter than the input timeseries. |
| method | method used to handle the centered moving average for even orders. Possible values are "centre" (the default), "left" and "right". See Details. This argument is ignored for odd orders. |

## Details

The centered moving average for even orders is usually computed by using one more observation than the order and to use weights 0.5 for the end points. For example, for order 4 we have

A[t] = (0.5 x[t -2] + x[t -1] + x[t] + x[t + 1] + 0.5 x[t + 2]) / 4.

In this way the observations are distributed evenly over the past and future. An alternative approach is to use the same number of observations as the order but use one more observation from the past than from the future, or the other way around. These methods can be used by specifying argument method. Possible methods are

centre Standard method e.g. (0.5 x[t - 2] + x[t - 1] + x[t] + x[t + 1] + 0.5 x[t + 2]) / 4

left Use one more observation from the past, e.g. (x[t - 2] + x[t - 1] + x[t] + x[t + 1]) / 4

right Use one more observation from the future, e.g. (x[t - 1] + x[t] + x[t + 1] + x[t + 2]) / 4

## Value

a regts object with the moving average values

## Functions

- movavb: Backward moving average
- movavc: Centered moving average

## Examples

```
x <- regts(rnorm(10), start = "2018Q1")

movavb(x, order = 3)

movavc(x, order = 3, keep_range = FALSE)
```

na_trim *Function for removing leading and trailing NAs*

## Description

This function removes leading or trailing NAs or both from a (multivariate) regts object. For multivariate regts a row will by default be regarded as NA if all elements in the row are NA. Use argument `is.na = "any"` to change this behaviour. The function returns `NULL` if all values are `NA`.

## Usage

```
na_trim(x, method = c("both", "first", "last"), is_na = c("all", "any"))
```

## Arguments

| | |
|---|---|
| `x` | a `regts` object |
| `method` | character string with values `"both"`, `"first"` or `"last"` to remove NAs at both ends (by default), just at the start or just at the end. |
| `is_na` | character string with values `"all"` or `"any"`. If `"all"` (default) then a row will be regarded as `NA` only if all elements in the row are `NA`. If `"any"` then a row will be regarded as `NA` if it has any `NA`s. For one dimensional regts objects this argument has no effect. |

## Value

A `regts` object in which leading and/or trailing NAs have been removed, or `NULL` if all values are `NA`.

## See Also

`zero_trim`

## Examples

```
# remove only leading NAs
ts1 <- regts(c(NA,1,3,NA,4,8,NA), start = "2000")
na_trim(ts1, method = "first")

# remove trailing NAs
data <- matrix(c(1,3,NA,2,5,NA,3,7,NA), ncol = 3)
rts <- regts(data, start = "2010Q2", names = c("a", "b", "c"))
na_trim(rts, method = "last")

data <- matrix(c(NA,3,NA,NA,5,6,NA,7,NA), ncol = 3)
rts <- regts(data, start = "2010Q1", names = c("a", "b", "c"))
# remove leading NAs if all elements in the row are NA
na_trim(rts, method = "first")
# or remove rows on both sides if any NA occurs in that row
na_trim(rts, is_na = "any")
```

## nperiod *Return the number of periods in a period range*

### Description

Return the number of periods in a period range

### Usage

```
nperiod(x)
```

### Arguments

| | |
|---|---|
| x | a period_range or an object that can be coerced to a period_range |

### Value

The number of periods in the range, or Inf if the range is not bounded

### Examples

```
range <- period_range("2010Q2", "2011Q3")
nperiod(range)  # the result will be 6
```

## period *Create a period object*

### Description

Function period creates a period object based on a character or numeric vector. Possible character string formats are for example "2017Q2", "2017m2", "2017", "2017-2", "aug 2017" or "august-2017". Possible numeric formats are for example 2017 or 2017.25 (the second quarter or the fourth month of 2017). The function also accepts a Date, POSIXct or POSIXlt argument. See Details.

Function as.period coerces an R object to a period object if possible.

### Usage

```
period(x, frequency = NA)

as.period(x, ...)
```

### Arguments

| | |
|---|---|
| x | a character, numeric, Date, POSIXct or POSIXlt vector. |
| frequency | frequency of the period. Argument frequency is mandatory if the frequency cannot be inferred from x (for example "2017-2" could be a quarter, month, etc.) |
| ... | additional arguments to be passed to or from methods (currently not used in package regts) |

## Details

The function period accepts a character or numeric vector as arguments. The specific format is described below.

**string format**

The format for yearly periods is for example "2017" or "2017Y" (the suffix "Y" is optional).

The standard format format for quarterly periods is for example "2017Q3". Alternative formats such as "2017 3Q" and "2017.3Q" are also recognized. The separator between the year and the quarter can be a blank or a dot, as in the previous examples, but also a forward slash ("/") and underscore ("_") are allowed.

The format for monthly periods is similar as that of quarterly periods, except that the "Q" is replaced by "M". Monthly periods may also be specified with a month name (possibly abbreviated) and year (e.g. "aug 2017", "2018-August"). The parser only understands English month names.

Periods with other frequencies than year, quarter and month can be specified as for example "2017-2". Alternative separators (blank, dot, etc.) are possible. In this case argument frequency should be specified.

The string format is case insensitive, and may be prefixed with "Y" or "T". Thus for example "t2017q3" is also an allowed period string.

**numeric format**

An integer number, such as 2017 specifies a year, or the first subperiod in a year if argument frequency has been specified.

If the numeric has a non-zero fractional part, then argument frequency is mandatory, For example, the numeric 2017.25 can specify the second quarter of 2017 or the fourth month of 2017.

Date**,** POSIXct **and** POSIXlt

The function also accepts a Date, POSIXct or POSIXlt argument. By default the function converts this object to a period with frequency month. It is possible to specify another output frequency, provided that this frequency is a divisor of 12.

## Value

a period vector if all periods have the same frequency, otherwise a list of period objects.

## See Also

period_range and seq

## Examples

```
period("2010Q3")
period("2010-2", frequency = 3)
period(2015)
period(2010.25, frequency = 4)

# examples for as.period
as.period("2010q3")
p <- period("2010m11")
as.period(p)

# example with a Date object
d <- Sys.Date()
period(d)
```

```
# create a vector of period objects
period(c("2018q2", "2019q4"))
```

---

period_range *Create a* period_range *object.*

---

## Description

A period_range object represents an interval of periods, for example a period from "2017Q2" to "2019Q3". Function period_range creates a period_range from a single character string (e.g. "2017Q2/2019Q3", see Details) or from two R objects that can be coerced to period objects.

Function as.period_range coerces an R object to a period_range if possible.

## Usage

```
period_range(start = NULL, end = NULL, frequency = NA)

as.period_range(x, frequency = NA, ...)
```

## Arguments

| | |
|---|---|
| start | the first period (a period, an object that can be coerced to a period, or by default NULL). If start is NULL the lower bound of the period range is undetermined. start can also be a character string specifying a period range, for example "2010Q2/2011Q3"). |
| end | the last period (a period, an object that can be coerced to a period, or by default NULL). If end is NULL, the upper bound of the period range is undetermined. |
| frequency | frequency of the period objects. This argument is mandatory if argument start or end is a character with general period format without frequency indicator (e.g. "2011-1") |
| x | an R object |
| ... | additional arguments to be passed to or from methods (currently not used in package regts) |

## Details

It is possible to create a period_range from a single string specifying a period range, for example "2017Q2/2019Q3". For this format, the first and last period are separated by "/". The first and last period are specified according to the same format recognized by function period. The first or last period may be omitted (e.g. "2017Q3/")), in that case the period range has no lower or upper bound. The string format is case insensitive.

## Value

a period_range object

## See Also

period, nperiod, start_period, end_period, seq and get_periods.

## Examples

```
# two methods to create a period_range from 2010Q2 to 2016Q3
period_range("2010Q2", "2016Q3")
period_range("2010Q2/2016Q3")

# create a period_range for the first 5 quarters after 2013Q2
start <- period("2013q3")
period_range(start, start + 5)

# create a period_range up to 2010Q2 with no lower bound
period_range(end = "2010q2")

# create a period_range for a timeseries with frequency 2 (half year)
period_range("2010-2", "2016-2", frequency = 2)

# convert a period object to a period_range with equal start and end period
p <- period("2010Q2")
as.period_range(p, p)

# create a month range starting at the month 1000 days before
# the current day and ending at the current month.
today <- Sys.Date()
period_range(today - 1000, today)
```

---

# printobj *Print the name, class and value of an object*

---

## Description

This function prints the name, class and value of its argument. The value is printed using the standard `print` function. It returns the value of the argument invisibly.

## Usage

```
printobj(x, ...)
```

## Arguments

| | |
|---|---|
| `x` | an R object |
| `...` | further arguments passed to `print` |

## Examples

```
x <- regts(1:5, start = "2017Q2")
printobj(x)
printobj(2 * x)
```

## range_intersect/range_union

*Calculate the intersection or union of two* period_range *objects.*

### Description

These functions calculate the intersection or union of two period_range objects. The start and end periods of the period_range objects may not be NULL.

### Usage

```
range_intersect(range1, range2)

range_union(range1, range2)
```

### Arguments

| | |
|---|---|
| range1 | a period_range object or object that can be coerced to a period_range |
| range2 | another such (period_range) object |

### Value

the intersection or union of range1 and range2. If there are no common periods range_intersection returns NULL

### Examples

```
range1 <- period_range("2016Q1", "2017Q4")
range2 <- period_range("2017Q1", "2018Q2")
range_intersect <- range_intersect(range1, range2)
range_union <- range_union(range1, range2)
```

## read_ts_csv

*Read timeseries from a csv file*

### Description

This function reads timeseries from a csv file, employing function fread of package data.table. The functions searches for period texts and automatically determines how the timeseries are stored (rowwise or columnwise) and which columns contain the numerical values of the timeseries. Period texts should have the format recognized by function period, for example "2010Q2", "2010.2Q", "2010m2", "2011" or "2011-1". Use argument period_fun if the period texts have a different format.

### Usage

```
read_ts_csv(filename, skiprow = 0, skipcol = 0, rowwise, frequency = NA,
  labels = c("after", "before", "no"), sep = "auto", fill = FALSE,
  dec = if (sep != ".") "." else ",", na_string = "", name_fun, period_fun,
  strict = TRUE)
```

## Arguments

| | |
|---|---|
| filename | a string with the filename. |
| skiprow | the number of rows to skip. If 0 (default) and if argument fill is FALSE, then comment rows are automatically skipped. See Details. |
| skipcol | the number of columns to skip. |
| rowwise | a logical value: are the timeseries stored rowwise? If not specified, then read_ts_csv tries to figure out itself if the timeseries are stored rowwise or columnwise. |
| frequency | the frequency of the timeseries. This argument is mandatory if the file contains a period texts without frequency indicator (for example "2011-1"). |
| labels | label option. See Details. |
| sep | the separator between columns. If not specified, then the separator is determined automatically by inspecting the first 30 lines of the csv file (see the details of function fread). |
| fill | logical (default is FALSE). If TRUE then in case the rows have unequal length, blank fields are implicitly filled with NA. |
| dec | the decimal separator as in base::read.csv. If not "." (default) then usually ",". |
| na_string | Character vector of strings to use for missing values. By default, read_ts_csv treats blank cells as missing data. |
| name_fun | function to apply to the names of the timeseries. |
| period_fun | function applied to period texts. This should be a function that converts a character vector to another character vector or a period vector with the same length. Use this argument if the period texts do not have a standard format (see Description). |
| strict | A logical. If TRUE (the default) all periods between the start and the end period must be present. Otherwise the timeseries are filled with NA for the missing periods. |

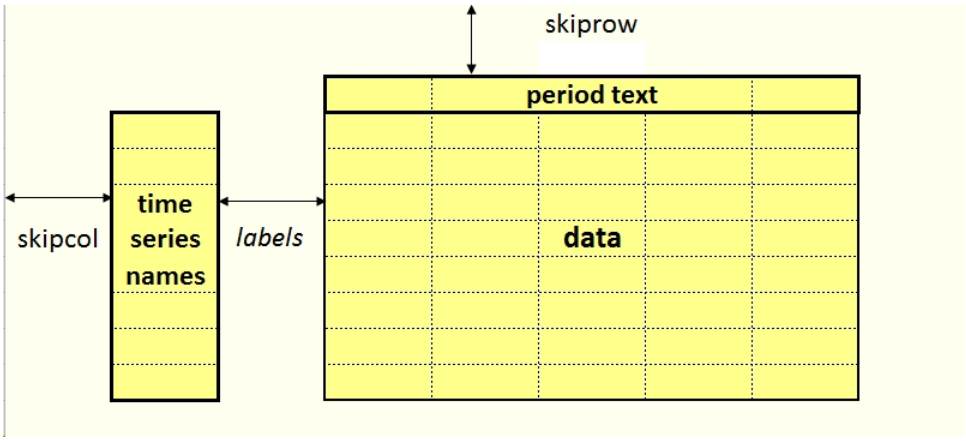
## Details

In many cases, this function will read timeseries correctly. If the function fails or if the result is not what you want, it might help to specify arguments rowwise, frequency, period_fun, skipcol or skiprow. Specify option rowwise if you know that the timeseries are stored rowwise or columnwise. Specify argument frequency if you already know the frequency of the timeseries. Arguments skipcol and skiprow can be used to read only a part of the file. If that does not help, then you can read the data into a data frame (for example by using function read.csv or function fread of package data.table), then convert the data frame to a standard columnwise data frame and finally convert it to a regts by using function as.regts.

If argument rowwise has not been specified, then function read_ts_csv tries to guess if the timeseries are stored rowwise or columnwise based on the positions of the fields with period texts.

### rowwise timeseries

For rowwise timeseries, the function searches for the first row with periods. All rows before the period row are ignored. Columns without a valid period in the period row are also ignored. The first non-empty column should contain the timeseries names (or labels if argument labels = "before", see the discussion below). Otherwise use argument skipcol to specify the number of columns to skip.

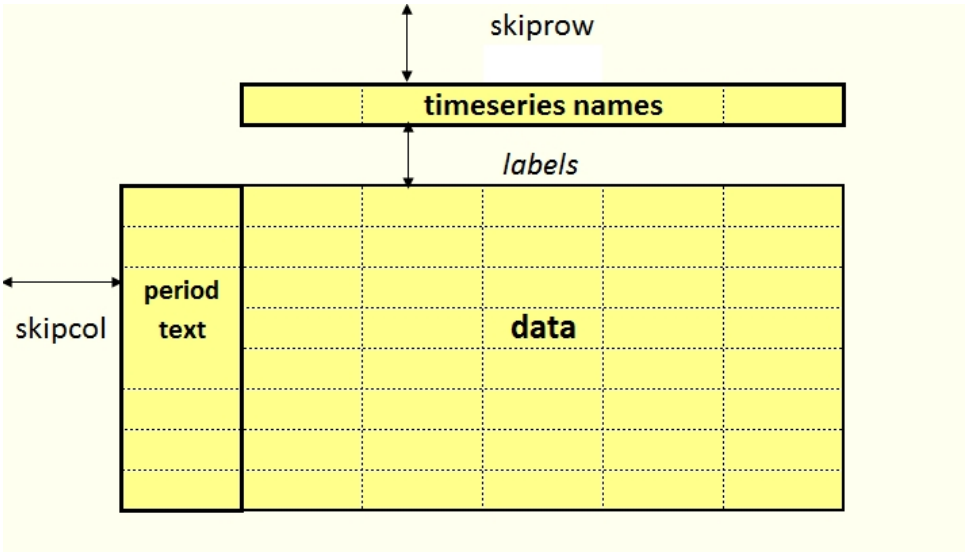



There may be more than one column before the columns with timeseries values (data columns). In that case one column should contain the variable names. The other columns before the first data column are used to create timeseries labels (see `ts_labels`). If argument `labels = "after"` (default), then the first column contains the variable names. If `labels = "no"` the first column also contains variable names but the other columns before the first data column are ignored. If argument `labels = "before"`, then the variable names should be in the last column before the first data column.

With argument `name_fun` a function can be applied to names of the timeseries, e.g. `tolower`.

**columnwise timeseries**

For columnwise timeseries, the first non-empty row that is not skipped (see argument `skiprow`) should contain the variable names (or labels if argument `labels = "before"`, see the discussion below). The periods can be in any column. Rows without a valid period in the period column are ignored. All columns to the left of the period column are also ignored.




There may be more than one row before the rows with timeseries values (data rows). In that case one row should contain the variable names. The other rows before the first data row are used to create timeseries labels (see `ts_labels`). If argument `labels = "after"` (default), then the first row contains the variable names. If `labels = "no"` the first row also contains variable names but the other rows before the first data row are ignored. If argument `labels = "before"`, then the variable names should be in the last row before the first data row.

### automatic row skip

If skiprow = 0, then the first rows with less columns than the rest of the file are automatically skipped. These rows are assumed to be comment rows. This procedure is described in detail in the documentation of function fread of the data.table package. Briefly, fread first determines the number of columns and then searches for the first data row based on this number of columns. All rows before this data row are skipped.

If argument fill is TRUE, then all rows have the same number of columns, and automatic row skipping is therefore disabled.

## Value

a regts object

## See Also

write_ts_csv and read_ts_xlsx

## Examples

```
## Not run:
read_ts_csv("series.csv", sep = ";", dec = ",")
read_ts_csv("data.csv", labels = "after", name_fun = tolower)

## End(Not run)
```

---

# read_ts_xlsx *Read timeseries from a sheet of an xls(x) file*

---

## Description

This function reads timeseries from a sheet of an xls(x) file, employing function read_excel of package readxl. read_ts_xlsx searches for period cells and automatically determines how the timeseries are stored (rowwise or columnwise) and which columns contain the numerical values of the timeseries. Period cells are cells containing

- a text with the format recognized by function period, for example "2010Q2", "2010.2Q", "2010m2", "2011" or "2011-1",
- an integer value (e.g. 2018), which is considered as a year,
- a date, which is assumed to specify a month unless argument frequency has been specified.

Use argument period_fun if the period cells contain a text with a format not recognized by function period.

## Usage

```
read_ts_xlsx(filename, sheet = NULL, range = NULL, skiprow = 0,
  skipcol = 0, rowwise, frequency = NA, labels = c("after", "before",
  "no"), na_string = "", name_fun, period_fun, strict = TRUE,
  warn_num_text = TRUE)
```

## Arguments

| | |
|---|---|
| filename | a string with the filename. |
| sheet | Sheet to read. Either a string (the name of a sheet), or an integer (the position of the sheet). Ignored if the sheet is specified via range. If neither argument specifies the sheet, defaults to the first sheet. |
| range | A cell range to read from, as described in cell-specification. Includes typical Excel ranges like "B3:D87", possibly including the sheet name like "Budget!B2:G14", and more. Takes precedence over skiprow, skipcol and sheet. |
| skiprow | the number of rows to skip, including leading empty rows. Ignored if range is given. By default, all leading empty rows are skipped. |
| skipcol | the number of columns to skip, including empty columns. Ignored if range is given. By default, all leading empty columns are skipped. |
| rowwise | a logical value: are the timeseries stored rowwise? If not specified, then read_ts_xlsx tries to figure out itself if the timeseries are stored rowwise or columnwise. |
| frequency | the frequency of the timeseries. This argument is mandatory if the file contains period texts without frequency indicator (for example "2011-1"). |
| labels | label option. See Details. |
| na_string | Character vector of strings to use for missing values. By default, read_ts_xlsx treats blank cells as missing data. |
| name_fun | function to apply to the names of the timeseries. |
| period_fun | function applied to period texts. This should be a function that converts a character vector to another character vector or a period vector with the same length. Use this argument if the period texts do not have a standard format (see Description). |
| strict | A logical. If TRUE (the default) all periods between the start and the end period must be present. Otherwise the timeseries are filled with NA for the missing periods. |
| warn_num_text | A logical. If TRUE (the default) a warning is issued when a cell contains a number as text (e.g. "2012.2") when a numeric value is expected. The text is always converted to a numeric value assuming the decimal separator ".". |

## Details

read_ts_xlsx reads the timeseries data in two steps. In the first step, the first 25 rows are read to inspect the structure of the data on the sheet: are the timeseries stored rowwise or columnwise, which row or column contains the period cells and which columns contain the numerical data of the timeseries. Using this information, the complete sheet is read and the timeseries are constructed.

In many cases, this function will read timeseries correctly. If the function fails or if the result is not what you want, it might help to specify arguments rowwise, frequency, period_fun, range, skipcol or skiprow. Specify option rowwise if you know that the timeseries are stored rowwise or columnwise. Specify argument frequency if you already know the frequency of the timeseries. Arguments range, skipcol and skiprow can be used to read only a part of the file.

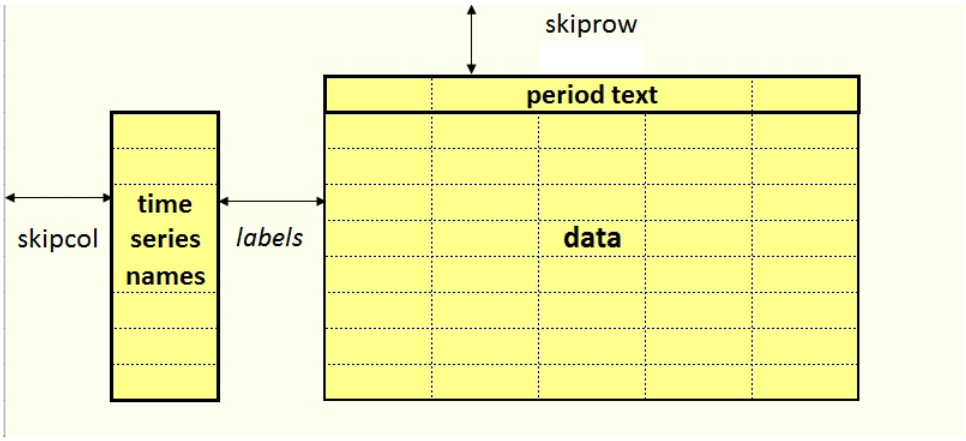
If that does not help, then you can read the data into a data frame (for example by using function read_excel of package readxl), then convert the data frame to a standard columnwise data frame and finally convert it to a regts by using function as.regts.

read_ts_xlsx skips all empty rows and columns. Use arguments skipcol and skiprow to skip additional leading rows and columns. Argument range can be used to read only a part of the sheet.

If argument `rowwise` has not been specified, then function `read_ts_xlsx` tries to guess if the timeseries are stored rowwise or columnwise based on the positions of the period cells.

### rowwise timeseries

For rowwise timeseries, the function searches for the first row with periods. All rows before the period row are ignored. Columns without a valid period in the period row are also ignored. The first non-empty column in the sheet should contain the timeseries names (or labels if argument `labels = "before"`, see the discussion below). Otherwise, use argument `skipcol` to specify the number of columns to skip.

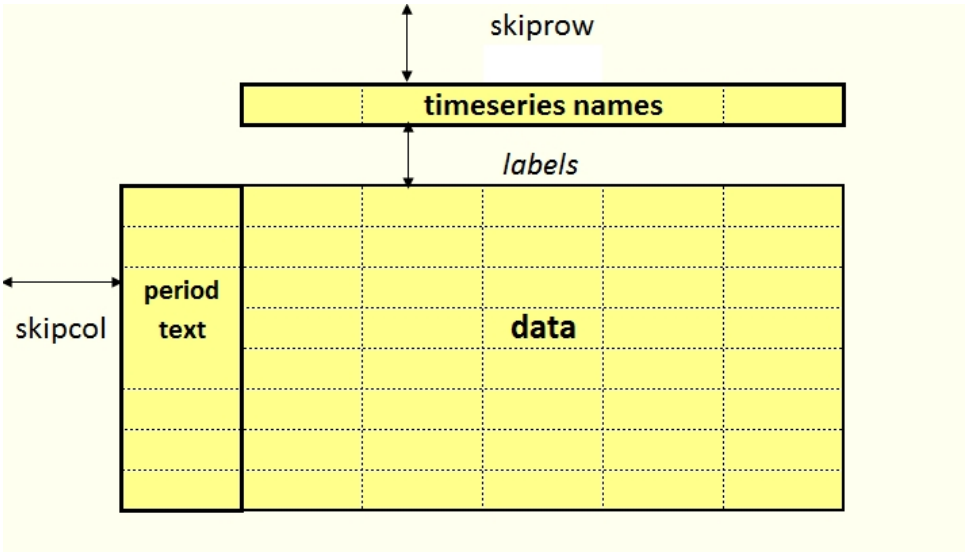



There may be more than one column before the columns with timeseries values (data columns). In that case one column should contain the variable names. The other columns before the first data column are used to create timeseries labels (see `ts_labels`). If argument `labels = "after"` (default), then the first column contains the variable names. If `labels = "no"` the first column also contains variable names but the other columns before the first data column are ignored. If argument `labels = "before"`, then the variable names should be in the last column before the first data column.

With argument `name_fun` a function can be applied to names of the timeseries, e.g. `tolower`.

### columnwise timeseries

For columnwise timeseries, the first non-empty row that has been read (see argument `range` or `skiprow`) should contain the variable names (or labels if argument `labels = "before"`, see the discussion below). The periods can be in any column on the sheet. Rows without a valid period in the period column are ignored. All columns to the left of the period column are also ignored.




There may be more than one row before the rows with timeseries values (data rows). In that case one row should contain the variable names. The other rows before the first data row are used to create timeseries labels (see ts_labels). If argument labels = "after" (default), then the first row contains the variable names. If labels = "no" the first row also contains variable names but the other rows before the first data row are ignored. If argument labels = "before", then the variable names should be in the last row before the first data row.

## Value

a regts object

## See Also

write_ts_xlsx and read_ts_csv

## Examples

```
## Not run:
read_ts_xlsx("series.xlsx", skipcol = 2, na_string = c("", "NA"))
read_ts_xlsx("data.xlsx", sheet = "Budget", labels = "after",
             name_fun = tolower)

## End(Not run)
```

---

regts *Create a* regts *timeseries object*

---

## Description

The regts class is an extension of the ts class of the stats package. Working with regts makes it easier to select periods.

## Usage

```
regts(data, start, end, period, frequency = NA, names = colnames(data),
  labels = NULL)
```

## Arguments

| | |
|---|---|
| data | a vector or matrix of the observed timeseries values. A data.frame will be coerced to a numeric matrix via data.matrix. (See also the description of the function ts of the stats package). |
| start | the starting period as a period object or a character string that can be converted to a period object. If not specified, then the start period is calculated from argument end and the dimension of data. |
| end | the end period as a period object or a character string that can be converted to a period object. If not specified, then the end period is calculated from argument start and the dimension of data. |
| period | the period range as a period_range object or a character string that can be converted to a period_range object. This argument replaces arguments start and end. |
| frequency | the frequency of the timeseries. This argument should only be specified if the start, end or period argument is specified with a general period format without period indicator, e.g. "2011-3". |
| names | a character vector with the column names for the series if data is a matrix or data frame. Defaults to the column names of data. |
| labels | a character vector of labels (descriptions of the timeseries) |

## Value

a regts object

## See Also

The function is.regts can be used to test if an object is a regts.

The S3 generic as.regts can be used to coerce an R object to a regts. There are currently methods for ts and data.frame.

as.data.frame and as.list can be used to convert regts to a data.frame or a list.

Function cbind can be used to bind two or more timeseries objects and create a multivariate regts.

Information about the time period of the timeseries can be obtained with the functions get_period_range, start_period and end_period.

See also the description of the functions for handling labels (ts_labels and update_ts_labels).

## Examples

```
# univariate timeseries
ts1 <- regts(1:10, start = "2010Q4")

# period selection
print(ts1["2011Q2/2011Q3"])

# multivariate timeseries
ts2 <- regts(matrix(1:9, ncol = 3), start = "2010Q4", names = c("a", "b", "c"))
```

```
# two equivalent ways to select a column in a multivariate ts
print(ts2$a)
print(ts2[, "a"])

# period selection in multivariate regts
print(ts2["2011Q2/2011Q3"])

# period and column selection in multivariate regts
print(ts2["2011Q2/2011Q3", "a"])

# two equivalent ways to add a column
ts2$d <- 2
ts2[ , "e"] <- 2

# multivariate timeseries with labels
ts3 <- regts(matrix(1:9, ncol = 3), start = "2010Q4", names = c("a", "b", "c"),
             labels = paste("Timeseries", c("a", "b", "c")))

# multivariate timeseries created with a period_range object
range <- period_range("2016Q1", "2017Q4")
ts4 <- regts(matrix(1:16, ncol = 2), period = range, names = c("a", "b"))

# create a half-yearly timeseries; because argument end is specified the
# length of the timeseries is smaller than the length of data (10).
ts5 <- regts(1:10, start = "2010-1", end = '2011-2', frequency = 2)
```

---

`rel2index/pct2index` *Calculate an index timeseries from a timeseries with relative or percentage changes.*

---

## Description

Function `rel2index` is the inverse of function `growth`. The growth `x[t]` (also called the relative change) of a timeseries `z[t]` is defined as

```
x[t] = (z[t] - z[t - 1]) / |z[t - 1]|.
```

The function constructs an index series for `z[t]` given the values of `x[t]`, assuming that the value of timeseries `z` at the period before the start period of timeseries `x` is positive. See Details.

Function `pct2index` computes the index series from a timeseries of percentage changes, defined as `100 * g[t]`. Thus expression `pct2index(x)` gives the same result as `rel2index(x / 100)`.

## Usage

```
rel2index(x, base = NULL, scale = 100, keep_range = TRUE)

pct2index(x, base = NULL, scale = 100, keep_range = TRUE)
```

## Arguments

| | |
|---|---|
| x | a ts or regts (can also be a multivariate timeseries) with the relative of percentage changes. |
| base | a period or a period_range specifying the base period, or an object that can be coerced to a period or period_range. By default the base period is the period before the first period of the input timeseries x. For example, if x starts at 2018q1, then the default base period is 2017q4. If the base period is a period_range, then the average value of the index series will be equal to scale. |
| scale | the (average) value of the index series at the base period (by default 100) |
| keep_range | if TRUE (the default), then the output timeseries has the same period range as the input timeseries. If FALSE then the result timeseries starts 1 period earlier. |

## Details

If x[t] is given but z[t] is unknown, we can compute z[t] as

```
z[t] = z[t - 1] * (1 + sign(z[t - 1]) x[t]).
```

Given an initial value for z at some period (say z[0]), the equation above can be used repeatedly to calculate the values of z[t] for t > 0. In function rel2index z[0] is not known, but if we assume that it is positive, then this value is not needed if we calculate the index series defined as

```
i[t] =  scale * z[t] / mean(z[base]),
```

where base is the base period. The index series i is independent of the absolute value of z[0], but does depend on the sign of z[0]. If z[0] is actually negative then the results of rel2index and pct2index are not correct.

If mean(x[base]) is negative then a warning is given and the (mean) value of the resulting index series in the base period will be -scale.

## Functions

- rel2index: Calculates an index timeseries from a timeseries with relative changes
- pct2index: Calculates an index timeseries from a timeseries with percentage changes

## See Also

index_ts and growth

## Examples

```
ts1 <- regts(abs(rnorm(10)), start = "2010Q2")
print(rel2index(ts1))
print(rel2index(ts1, base = "2010Q3", scale = 1, keep_range = TRUE))
```

## remove_na_columns *Function for removing columns with NAs in a (multivariate) regts*

### Description

This function removes columns with NA values from a (multivariate) regts. A column will by default be regarded as NA if all elements in the column are NA. Specify argument is.na = "any" to change this behaviour. If all columns are removed the function returns NULL.

### Usage

```
remove_na_columns(x, is_na = c("all", "any"))
```

### Arguments

| | |
|---|---|
| x | a regts object |
| is_na | character with values "all" or "any". If "all" (default) then a column will be regarded as NA only if all elements in the column are NA. If "any" then a column will be regarded as NA if it has any NAs. |

### Value

A regts object in which NA columns have been removed.

### Examples

```
# remove columns with all NAs
data <- matrix(c(1,3, 5, NA, NA, NA,3,7,9), ncol = 3)
rts <- regts(data, start = "2010Q2", names = c("a", "b", "c"))
remove_na_columns(rts)

data <- matrix(c(NA,3,NA,NA,5,6,NA,7,9), ncol = 3)
rts <- regts(data, start = "2010Q1", names = c("a", "b", "c"))
remove_na_columns(rts, is_na = "any")
```

## rename_cols *Rename the columns of a matrix or timeseries.*

### Description

Function rename_cols renames the columns of a matrix using the new_name = old_name syntax. This works similarly as functions rename of the dplyr package, but also works on matrix objects (a matrix or ts) objects.

### Usage

```
rename_cols(.data, ...)
```

### Arguments

| | |
|---|---|
| .data | An R object with column names (a matrix, ts, regts or data.frame) |
| ... | Use new_name = old_name to rename variables. |

### Value

An object with the same type and contents as .data, except that the columns are renamed.

### See Also

tag_colnames and change_colnames

### Examples

```
data <- regts(matrix(1:20, ncol = 4), start = "2010Q2",
              names = c("a1", "a2", "b1", "b1"))
rename_cols(data, x = a1, y = b1)

rename_cols(data, p = 1)
```

---

## select_columns *Select columns using a regular expression*

---

### Description

This function selects columns of an R object with column names (for example a data.frame, matrix, ts or regts). The columns with names matching a given regular expression are selected. This function employs base R function grep

### Usage

```
select_columns(x, regex, drop = TRUE, ...)
```

### Arguments

| | |
|---|---|
| x | an R object with column names (e.g. a data.frame, matrix, ts or regts) |
| regex | a regular expression used to select a column |
| drop | if TRUE, the result is coerced to a vector if possible |
| ... | arguments passed to function grep |

### Value

the column selection of object x

## Examples

```
data <- regts(matrix(1:20, ncol = 4), start = "2010Q2",
              names = c("nlc", "ukc", "nly", "uky"))

# select all columns with names starting with nl
nl_data <- select_columns(data, "^nl")

# select all columns except column "nlc"
no_nlc <- select_columns(data, "^nlc$", invert = TRUE)
```

---

`seq` *Generates a sequence of periods*

---

## Description

Generates a regular sequence of `period` objects.

## Usage

```
## S3 method for class 'period'
seq(from, to, by, length.out, ...)
```

## Arguments

| | |
|---|---|
| `from` | a `period` object specifying the first period of the sequence. |
| `to` | a `period` object (or an object that can be coerced to a `period` object) specifying the last period of the sequence |
| `by` | an integer number, the increment of the sequence (the number of periods between each period in the sequence). |
| `length.out` | the desired length of the sequence. A non-negative number. If both `from` and `to` have been specified, and if `length.out` > 1, then the number of periods between `from` and `to` should be divisible by `length.out` -1. |
| `...` | arguments passed to or from methods (not used) |

## Value

a `period` vector

## See Also

`period`, `period_range` and `get_periods`

## Examples

```
p1 <- period("2018q2")
seq(p1, length.out = 4)
seq(p1, "2019q4")
seq(p1, "2019q4", by = 2)

# use seq in a for loop
ts <- regts(1:10, start = "2018q1")
```

```
seqp <- seq(period("2018q1"), "2020q1", by = 4)

# print first quarters ts
for (prd in as.list(seqp))
  {print(ts[prd])
}

# Note that we do not loop directly over the period vector, but first convert
# the vector to a list. Otherwise the \code{period} class is lost.
```

---

start_period/end_period *Return the start or end period of a timeseries object or a* period_range

---

## Description

This function returns the start or end period of a timeseries object (a regts or ts) or a period_range.

## Usage

```
start_period(x)

end_period(x)

## S3 method for class 'period_range'
start_period(x)

## S3 method for class 'ts'
start_period(x)

## S3 method for class 'period_range'
end_period(x)

## S3 method for class 'ts'
end_period(x)
```

## Arguments

| | |
|---|---|
| x | a regts, ts or period_range object. |

## Value

A period object representing the first or last period of the range. The return value can be NULL if argument x is a period_range with no lower or upper boundary.

## Examples

```
# start and end period of a range
range <- period_range("2010Q4", "2011Q3")
start_period(range)
end_period(range)
```

```
# start and end period of a regts
data <- regts(matrix(1:20, ncol = 2), start = "2010Q2", names = c("nl", "uk"))
start_period(data)
end_period(data)
```

---

`tag_colnames` *Append a tag to the column names of a matrix or data frame*

---

## Description

This function adds a suffix to all column names of an R object.

## Usage

```
tag_colnames(x, tag)
```

## Arguments

| | |
|---|---|
| x | an R object with column names (e.g. a `data.frame`, `matrix`, `ts` or `regts`) |
| tag | a character |

## Value

an R object with modified columm names

## See Also

`change_colnames`

## Examples

```
data <- regts(matrix(1:8, ncol = 2), start = "2010Q2", names = c("a", "b"))

#  append the column names with a tag "_input"
tag_colnames(data, "_input")
```

---

`topleft` *Return the topleft part of a* `regts`.

---

## Description

This function returns the topleft part of a `regts`. By default the first 10 columns for the first 6 periods.

## Usage

```
topleft(x, n = 6L, ncol = 10L)
```

### Arguments

| | |
|---|---|
| x | a multivariate regts or ts |
| n | a single integer. Length period for the resulting object. |
| ncol | a single integer. Number of columns in regts. By default only the first 10 columns are printed. |

### See Also

head, tail

### Examples

```
data <- regts(matrix(rnorm(200), ncol = 20), start = "2010Q2",
              names = paste0("abc", 1:20))
topleft(data)
```

---

## transpose_df *Transpose a* data.frame

---

### Description

The function transposes a data.frame. If the input data frame has column labels (i. e., column vectors with an attribute "label"), then the first column of the returned data frame will contain the labels. With argument label_column you can specify a column that will be used to create column labels for the output data frame. These labels are visible in de data viewer.

### Usage

```
transpose_df(x, colname_column, label_column)
```

### Arguments

| | |
|---|---|
| x | a data frame |
| colname_column | the name or the index of the column that contains the column names of the transposed data frame. By default the row names of the original data frame are used as column names of the new data frame. |
| label_column | a numeric or character vector with the indices or the names of the columns that contains the row labels. If this is a vector of length larger than 1, then the texts in the columns are combined to create single labels for the columns of the transposed data frame. By default labels are ignored. |

### Value

the transposed data frame

## Examples

```
df <- data.frame(variables = c("a", "b"),
                 labels = c("Variabele a", "Variable b"),
                 x = 1:2, y = 10:11)
df_t <- transpose_df(df, colname_column = 1, label_column = 2)
print(df_t)
print(transpose_df(df_t))
```

---

# tsdif *Calculate the differences between two multivariate timeseries objects*

---

## Description

This function can be used to compare two multivariate timeseries objects. The result is a list with a regts component with the computed differences or NULL if there are no differences. The function returns a list with the differences, the names of columns with differences larger than a specified tolerance, and the names of the columns present in one object but missing in the other object. The return value also includes differences in the period ranges.

## Usage

```
tsdif(x1, x2, tol = 0, fun = function(x1, x2) (x1 - x2))
```

## Arguments

| | |
|---|---|
| x1 | the first timeseries (a multivariate regts or ts object). |
| x2 | the second timeseries (a multivariate regts or ts object). |
| tol | difference tolerance (by default zero). Differences with absolute values smaller than or equal to tol are ignored. |
| fun | function to compute differences. This function should accept two arguments (two numbers) for which the difference is computed. By default the normal difference ($x_1 - x_2$) is computed. A useful function for computing differences is cvgdif, which computes relative differences if the absolute value of x2 is larger than 1. |

## Details

This function calculates the difference between common columns of two multivariate timeseries objects x1 and x2. The two timeseries must have the same frequency, but may have a different period range. The difference is computed for the intersection of the two period ranges. Two NA or two NaN values are considered to be equal. A NA value is not equal to a NaN value. The function also returns missing column names in one of the two objects,

## Value

a list with class "tsdif", with the following components

| | |
|---|---|
| equal | TRUE if x1 and x2 have the same column names and period ranges, and if all differences are smaller than or equal to tol |
| difnames | The names of the timeseries with differences larger than tol |

| | |
|---|---|
| dif | A regts with the computed differences, or NULL if there are no differences larger than tol. Only timeseries with differences larger than tol are included. Leading and trailing rows with differences less than tol have also been removed. |
| common_names | the names of the common columns |
| missing_names1 | The names of columns present in x2 but missing in x1 |
| missing_names2 | The names of columns present in x1 but missing in x2 |
| period_range1 | The period ranges of x1 as a period_range object |
| period_range2 | The period ranges of x2 as a period_range object |
| common_range | The intersection of the period ranges |
| ranges_equal | A logical indicating whether the period ranges of x1 and x2 differ |
| ts_names | a character string giving the names of the two input timeseries |
| tol | The tolerance parameter |
| fun | a character string specifying the supplied function fun, or NULL if fun has not been specified |

## See Also

regts

## Examples

```
# create two timeseries x1 and x2
x1 <- regts(matrix(data = rep(1:27), nc = 3), start = "2008Q4",
           names = c("a", "b", "c"))
x2 <- x1 + 0.001
colnames(x2) <- c("a", "b", "d")

# calculate and print the differences
dif1 <- tsdif(x1, x2)
print(dif1)

# use the function cvgdif (convergence difference)
dif2 <- tsdif(x1, x2, fun = cvgdif)

# calculate differences with tol = 1e-4, and print the
# names of the timeseries with differences larger than tol
dif3 <- tsdif(x1, x2, tol = 1e-4, fun = cvgdif)
print(dif3$difnames)
```

---

# ts_labels *Timeseries labels*

---

## Description

Retrieve or set labels for the timeseries. Timeseries labels can be used to give a description of the contents of the timeseries.

### Usage

```
ts_labels(x)

ts_labels(x) <- value
```

### Arguments

| | |
|---|---|
| x | a regts |
| value | a character vector with the labels or NULL. The length should be equal to the number of columns. Specify NULL to remove all labels. |

### Value

The retrieval function ts_labels() returns a named character vector: the names are the timeseries names (the column names) and the values the corresponding labels. The replacement method returns a regts object with labels.

### Functions

- ts_labels: Retrieve timeseries labels
- ts_labels<-: Sets the timeseries labels

### See Also

regts, update_ts_labels

### Examples

```
ts <- regts(matrix(1:6, ncol = 2), start = "2016Q2", names = c("a", "b"))
ts_labels(ts) <- c("Timeseries a", "Timeseries b")
print(ts_labels(ts))

# print the column names and labels as a nice data.frame
print(as.data.frame(ts_labels(ts)))
```

---

## update_ts *Update a timeseries with another timeseries object*

---

### Description

This function can be used to update, replace or extend a (reg)ts object with another (reg)ts object. The result is an updated regts object.

### Usage

```
update_ts(x1, x2, method = c("upd", "updna", "updval", "replace"),
  join_second = TRUE)
```

## Arguments

| | |
|---|---|
| x1 | the first timeseries (a regts or ts object). |
| x2 | the second timeseries (a regts or ts object). |
| method | four different ways to update the timeseries. By default the timeseries are updated. This behaviour can be changed by using one of the other methods. See details. |
| join_second | A logical (default TRUE) indicating whether columns present in the second timeseries but missing in the first timeseries should be added to the result. |

## Details

The two timeseries must have the same frequency, but may have a different period range. The common columns in the timeseries can be updated in four different ways:

upd the first timeseries are updated with the second timeseries for the total period range of the second timeseries. Outside this period the values in the first timeseries do not change.

updna if method updna is selected instead of upd, only NA values in the first timeseries will be updated

updval if method updval is selected instead of upd, the values in the first timeseries are only replaced with valid (i.e. non-NA) values from the second timeseries.

replace like method upd, the values in the first timeseries are replaced by the values in the second timeseries for the total period range of these second timeseries. Outside this period the values in the first timeseries will become NA.

By default, columns only present in one of the two timeseries objects are added to the result. The result columns are the columns of the first series, supplemented with the columns of the second series. If parameter join_second is FALSE then the remaining columns of the second timeseries are *not* added to the result. Thus the result series has the same columns as the first series.

The period range of the result is the union of the period ranges of the first and second timeseries, except for the updval method. For this method the result period range is the union of the period ranges of the first timeseries and the timeseries obtained by applying function na_trim to the second timeseries.

## Value

an updated regts object.

## See Also

regts and join_ts

## Examples

```
x1 <- regts(matrix(data = rep(1:9), nc = 3), period = "2000/2002",
            names = c("a", "b", "c"))
x2 <- regts(matrix(data = rep(10:15), nc = 3), period = "2000/2001",
            names = c("a", "c", "d"))
update_ts(x1, x2, method = "upd")
```

## update_ts_labels *Update one or more timeseries labels in a multivariate regts object*

### Description

Update one or more timeseries labels in a multivariate regts object

### Usage

```
update_ts_labels(x, labels)
```

### Arguments

| | |
|---|---|
| x | a multivariate regts object |
| labels | a named character vector. The names are the names of the timeseries (columns) whose label will be updated. Specify NULL to remove all labels. |

### See Also

ts_labels

### Examples

```
ts <- regts(matrix(1:6, ncol = 2), start = "2016Q2", names = c("a", "b"),
            labels = c("Timeseries a", "???"))
ts <- update_ts_labels(ts, c(b = "Timeseries b"))
print(ts_labels(ts))
```

## write_ts_csv *Write timeseries to a csv file*

### Description

This function writes timeseries to a csv file. The csv file is actually written by function fwrite of package data.table.

### Usage

```
write_ts_csv(x, file, rowwise = TRUE, sep = ",", dec = ".",
  labels = c("after", "before", "no"), period_format = "regts")
```

### Arguments

| | |
|---|---|
| x | a ts or regts object |
| file | a regts object |
| rowwise | a logical value: should the timeseries be written rowwise? |
| sep | The separator between columns. Default is ",". |
| dec | The decimal separator, by default ".". Cannot be the same as sep. |
| labels | should labels we written, and if so before the names or after the names? By default, labels are written after the names if present. |
| period_format | The period format. By default the regts format (e.g. "2010Q2", see period) is used. Alternatively, it is possible to specify a format employed by base R function strptime, e.g. "%Y-%m-%d". |

### See Also

read_ts_csv and write_ts_xlsx

### Examples

```
# create a timeseries object
ts1 <- regts(matrix(rnorm(50), ncol =  2), names = c("a", "b"),
             labels = c("Timeseries a", "Timeseries b"), start = "2017Q2")

# write timeseries to csv
write_ts_csv(ts1, file = "ts1.csv", labels = "after")

# write timeseries columnwise to csv, using a specified period_format
write_ts_csv(ts1, file = "ts1_2.csv", rowwise = FALSE, period_format = "%Y-%m-%d")
```

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## write_ts_xlsx/write_ts_sheet

*Functions for writing timeseries to an xlsx file*

---

### Description

These functions can be used to write timeseries to a sheet of an xlsx file. write_ts_xlsx creates or opens an Excel workbook (depending on argument append) and writes the timeseries to a sheet with a specified name. write_ts_sheet writes timeseries to a sheet of a Workbook object created with function createWorkbook or loadWorkbook of package openxlsx.

### Usage

```
write_ts_xlsx(x, file, sheet_name = "Sheet1", rowwise = TRUE,
  append = FALSE, labels = c("after", "before", "no"), comments,
  number_format, period_as_date = FALSE)

write_ts_sheet(x, wb, sheet_name = "Sheet1", rowwise = TRUE,
  labels = c("after", "before", "no"), comments, number_format,
  period_as_date = FALSE)
```

## Arguments

| | |
|---|---|
| x | a ts or regts object |
| file | the filename of the output file |
| sheet_name | the sheet name |
| rowwise | a logical value: should the timeseries be written rowwise? |
| append | If FALSE (the default), then the original file, if it exists, is replaced with the new file. All original data is lost. If TRUE, then only data on the sheet with the specified sheet name is erased and replaced with new data. If the sheet does not yet exist, then a new sheet is created and appended to the original file. |
| labels | should labels be written, and if so before or after the names? By default, labels are written after the names if present |
| comments | a character vector or data frame. The comments are written to the beginning of the sheet, before the timeseries data is written. |
| number_format | a character value specifying the number format. For example, "#.00" corresponds to two decimal spaces. For details see the description of the function createStyle in the openxlsx package. |
| period_as_date | A logical (default FALSE). If TRUE the periods are written as date values to the Excel file. By default the periods are written as characters using the standard regts format (e.g. "2010Q2", see period). |
| wb | a Workbook object created with function createWorkbook or loadWorkbook of package openxlsx |

## Details

The functions employ package openxlsx package for writing the Excel file.

If you want to write multiple timeseries objects to different sheets, you can use write_ts_xlsx with argument append = TRUE. Alternatively, you can create a Workbook object with function createWorkbook of package openxlsx and then add a sheet with write_ts_sheet. The latter approach is more efficient. When the workbook is written to a file with function saveWorkbook, it is often useful to set the minimum column width option for package openxlsx, as shown in the example below.

## Functions

- write_ts_xlsx: writes timeseries to an Excel workbook
- write_ts_sheet: writes a timeseries to a Workbook object

## See Also

read_ts_xlsx and write_ts_csv

## Examples

```
# create a timeseries object
ts1 <- regts(matrix(rnorm(50), ncol =  2), names = c("a", "b"),
             labels = c("Timeseries a", "Timeseries b"), start = "2017Q2")

# write timeseries ts1 to an Excel file
write_ts_xlsx(ts1, file = "ts1.xlsx", sheet_name = "ts1", labels = "after")

# write two sheets using write_ts_sheet
```

```
library(openxlsx)
wb <- createWorkbook()
write_ts_sheet(ts1, wb, "ts1", labels = "after")
write_ts_sheet(ts1 * 100, wb, "ts1_times_100", labels = "after")

# Set the minimum column width. saveWorkbook will adjust
# the column widths for the sheets written by write_ts_xlsx,
# Setting a minimum column width prevents that some columns are very
# narrow.
options("openxlsx.minWidth" = 8.43)

# save the workbook with openxlsx::saveWorkbook. Because saveWorkbook
# only gives an error when something goes wrong, for example if the file
# is not writable, we use tryCatch to turn a warning to a message.
tryCatch({
 saveWorkbook(wb, "timeseries.xlsx", overwrite = TRUE)
}, warning = function(w) {
 stop(w$message, call. = FALSE)
})


# write a timeseries with comments
comments <- c("Timeseries ts1 is created on the Central Bureau of Policy Analysis",
              "using a random number generator")
write_ts_xlsx(ts1, file = "ts_comments.xlsx", sheet_name = "ts1",
              comments = comments)
```

---

`zero_trim` *Function for removing leading and trailing zeros*

---

## Description

This function removes leading or trailing zeros or both from a (multivariate) regts object. For multivariate regts a row will by default be regarded as 0 if all elements in the row are 0. The function returns `NULL` if all values are zero.

## Usage

```
zero_trim(x, method = c("both", "first", "last"))
```

## Arguments

| | |
|---|---|
| `x` | a regts object |
| `method` | character string with values `"both"`, `"first"` or `"last"` to remove zeros at both ends (by default), just at the start or just at the end. |

## Value

A `regts` object in which leading and/or trailing zeros have been removed, or `NULL` if all values in the timeseries are zero.

## Examples

```
# remove only leading zeros
ts1 <- regts(c(0, 1, 3, 0, 4, 8, 0), start = "2000")
zero_trim(ts1, method = "first")

# remove trailing zeros
data <- matrix(c(1, 3, 0,2, 5, 0, 3, 7, 0), ncol = 3)
rts <- regts(data, start = "2010Q2", names = c("a", "b", "c"))
zero_trim(rts, method = "last")

# removing zeros in a multivariate regts
data <- matrix(c(0, 3, 0, 0, 5, 6, 0, 7, 0), ncol = 3)
rts <- regts(data, start = "2010Q1", names = c("a", "b", "c"))
# remove leading zeros if all elements in the row are zero
zero_trim(rts, method = "first")
```

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