

# Package ‘tsintermittent’

July 18, 2022

**Type** Package

**Title** Intermittent Time Series Forecasting

**Version** 1.10

**Date** 2022-07-15

**Description**

Time series methods for intermittent demand forecasting. Includes Croston's method and its variants (Moving Average, SBA), and the TSB method. Users can obtain optimal parameters on a variety of loss functions, or use fixed ones (Kourentzes (2014) <[doi:10.1016/j.ijpe.2014.06.007](https://doi.org/10.1016/j.ijpe.2014.06.007)>). Intermittent time series classification methods and iMAPA that uses multiple temporal aggregation levels are also provided (Petropoulos & Kourentzes (2015) <[doi:10.1057/jors.2014.62](https://doi.org/10.1057/jors.2014.62)>).

**LazyData** yes

**License** GPL (>= 2)

**Imports** MAPA, parallel

**URL** <https://kourentzes.com/forecasting/2014/06/23/intermittent-demand-forecasting-package-for-r/>

**NeedsCompilation** no

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**Repository** CRAN

**Date/Publication** 2022-07-18 08:10:05 UTC

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crost	<i>Croston's method and variants</i>
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## Description

Croston's method and variants for intermittent demand series with fixed or optimised parameters.

## Usage

```
crost(data,h=10,w=NULL,init=c("mean","naive"),nop=c(2,1),
      type=c("croston","sba","sbj"),cost=c("mar","msr","mae","mse"),
      init.opt=c(TRUE,FALSE),outplot=c(FALSE,TRUE),opt.on=c(FALSE,TRUE),
      na.rm=c(FALSE,TRUE))
```

## Arguments

data	Intermittent demand time series.
h	Forecast horizon.
w	Smoothing parameters. If w == NULL then parameters are optimised. If w is a single parameter then the same is used for smoothing both the demand and the intervals. If two parameters are provided then the second is used to smooth the intervals.
init	Initial values for demand and intervals. This can be: 1. c(z,x) - Vector of two scalars, where first is initial demand and second is initial interval; 2. "naive" - Initial demand is first non-zero demand and initial interval is first interval; 3. "mean" - Same as "naive", but initial interval is the mean of all in sample intervals.
nop	Specifies the number of model parameters. Used only if they are optimised. 1. 1 - Demand and interval parameters are the same; 2. 2 - Different demand and interval parameters.
type	Croston's method variant: 1. "croston" Croston's method; 2. "sba" Syntetos-Boylan approximation; 3. "sbj" Shale-Boylan-Johnston.
cost	Cost function used for optimisation: 1. "mar" - Mean Absolute Rate; 2. "msr" - Mean Squared Rate; 3. "mae" - Mean Absolute Error; 4. "mse" - Mean Squared Error.
init.opt	If init.opt==TRUE then initial values are optimised.
outplot	If TRUE a plot of the forecast is provided.
opt.on	This is meant to use only by the optimisation function. When opt.on is TRUE then no checks on inputs are performed.
na.rm	A logical value indicating whether NA values should be remove using the method.

**Value**

model	Type of model fitted.
frc.in	In-sample demand rate.
frc.out	Out-of-sample demand rate.
weights	Smoothing parameters for demand and interval.
initial	Initialisation values for demand and interval smoothing.
component	List of c.in and c.out containing the non-zero demand and interval vectors for in- and out-of-sample respectively. Third element is the coefficient used to scale demand rate for sba and sbj.

**Author(s)**

Nikolaos Kourentzes

**References**

Optimisation of the methods described in: N. Kourentzes, 2014, On intermittent demand model optimisation and selection, International Journal of Production Economics, 156: 180-190. doi: [10.1016/j.ijpe.2014.06.007](https://doi.org/10.1016/j.ijpe.2014.06.007).

<https://kourentzes.com/forecasting/2014/06/11/on-intermittent-demand-model-optimisation-and-selection>

**See Also**

[tsb](#), [sexsm](#), [crost.ma](#).

**Examples**

```
crost(ts.data1, outplot=TRUE)
```

---

crost.decomp	<i>Croston's decomposition</i>
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---

**Description**

Apply Croston's decomposition on a time series.

**Usage**

```
crost.decomp(data, init=c("naive", "mean"))
```

**Arguments**

data	Intermittent demand time series.
init	Initial values for intervals. This can be: 1. x - Numerical value; 2. "naive" - Initial interval is the first interval from start of time series; 3. "mean" - Initial interval is the mean of all in sample intervals.

**Value**

demand	Non-zero demand vector.
interval	Intervals vector.

**Author(s)**

Nikolaos Kourentzes

**See Also**

[crost](#), [crost.ma](#).

**Examples**

```
crost.decomp(ts.data1)
```

---

crost.ma	<i>Moving average with Croston's method decomposition</i>
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---

**Description**

Moving average with Croston's method decomposition for intermittent demand series with fixed or optimised parameters.

**Usage**

```
crost.ma(data,h=10,w=NULL,nop=c(2,1),type=c("croston","sba","sbj"),
         cost=c("mar","msr","mae","mse"),outplot=c(FALSE,TRUE),
         na.rm=c(FALSE,TRUE))
```

**Arguments**

data	Intermittent demand time series.
h	Forecast horizon.
w	Moving average order. If <code>w == NULL</code> then moving average orders are optimised. If <code>w</code> is a single value then the same order is used for smoothing both the demand and the intervals. If two values are provided then the second is used to smooth the intervals.
nop	Specifies the number of model parameters. Used only if they are optimised. 1. 1 - Demand and interval moving average order are the same; 2. 2 - Different demand and interval orders.
type	Croston's method variant: 1. "croston" Croston's method; 2. "sba" Syntetos-Boylan approximation; 3. "sbj" Shale-Boylan-Johnston.
cost	Cost function used for optimisation: 1. "mar" - Mean Absolute Rate; 2. "msr" - Mean Squared Rate; 3. "mae" - Mean Absolute Error; 4. "mse" - Mean Squared Error.
outplot	If TRUE a plot of the forecast is provided.
na.rm	A logical value indicating whether NA values should be remove using the method.

**Value**

model	Type of model fitted.
frc.in	In-sample demand rate.
frc.out	Out-of-sample demand rate.
order	Moving averages orders for demand and interval.
component	List of c.in and c.out containing the non-zero demand and interval vectors for in- and out-of-sample respectively. Third element is the coefficient used to scale demand rate for sba and sbj.

**Author(s)**

Nikolaos Kourentzes

**References**

Optimisation cost functions described in: N. Kourentzes, 2014, On intermittent demand model optimisation and selection, International Journal of Production Economics, 156: 180-190. doi: [10.1016/j.ijpe.2014.06.007](https://doi.org/10.1016/j.ijpe.2014.06.007).

<https://kourentzes.com/forecasting/2014/06/11/on-intermittent-demand-model-optimisation-and-selection/>

**See Also**

[crost](#), [tsb](#), [sexsm](#).

**Examples**

```
crost.ma(ts.data1, outplot=TRUE)
```

---

data.frc

*Wrapper to forecasts data.frames with a single call*

---

**Description**

Wrapper to forecasts data.frames with a single call.

**Usage**

```
data.frc(data.in, method=c("crost", "crost.ma", "tsb", "sexsm", "imapa", "auto"), ...)
```

**Arguments**

data.in	Data frame with time series. This can also be a matrix or array with each column being a different time series.
method	Which method to use for forecasting: "crost", "crost.ma", "tsb", "sexsm", "imapa", "auto". "auto" uses PKa classification to select automatically between Croston, SBA and SES.
...	Additional inputs to pass to forecasting functions. See individual function documentation for options.

**Value**

`frc.out` Data frame containing forecasts for all time series.

`out` List with detailed output per series. To access individual outputs of the list use: `sapply(out, get, x="element")`, where "element" could be for example "frc.in".

**Author(s)**

Nikolaos Kourentzes

**References**

By default methods are optimised using the cost functions introduced by: N. Kourentzes, 2014, On intermittent demand model optimisation and selection, *International Journal of Production Economics*, 156: 180-190. doi: [10.1016/j.ijpe.2014.06.007](https://doi.org/10.1016/j.ijpe.2014.06.007).

<https://kourentzes.com/forecasting/2014/06/11/on-intermittent-demand-model-optimisation-and-selection/>

The PK approximate classification is described in: F. Petropoulos and N. Kourentzes, 2015, *Journal of Operational Research Society*. <https://link.springer.com/article/10.1057/jors.2014.62>.

<https://kourentzes.com/forecasting/2014/05/13/forecast-combinations-for-intermittent-demand/>

**See Also**

[crost](#), [crost.ma](#), [tsb](#), [sexsm](#), [imapa](#), [idclass](#).

**Examples**

```
data.frc(simID(10,30),method="crost",type="sba",h=5)$frc.out
```

---

idclass

*Time series categorisation for intermittent demand*

---

**Description**

Time series categorisation for intermittent demand data.

**Usage**

```
idclass(data,type=c("PKa","SBC","KHa","KH","PK"),a.in=NULL,
        outplot=c("summary","detail","none"),plot.focus=NULL)
```

**Arguments**

`data` Time series dataset. Each column is a series. Alternatively this can be a single series.

type	Type of categorisation: 1. "SBC" - Syntetos Boylan Croston; 2. "KH" - Kostenko Hyndman (exact*); 3. "KHa" - Kostenko Hyndman (approximate); 4. "PK" - Petropoulos Kourentzes (exact*); 5. "PKa" - Petropoulos Kourentzes (approximate). *These are computationally expensive, as SBA is optimised for each time series.
a.in	Vector of SBA demand interval smoothing parameters. This must be same length as number of series. This is used for categorisations "KH" and "PK". If a.in == NULL then the parameters are calculated internally using MAR as a cost function.
outplot	Plot results of categorisation: 1. "summary" - simplified plot that reports number of series in each class and cut-off points; 2. "detail" - scatterplot between average interdemand interval (p) and squared coefficient of variation of non-zero demand (CV <sup>2</sup> ). Series that are categorised for SBA or SES are plotted in shaded areas; 3. "none" - do not produce plot.
plot.focus	Only relevant to outplot == "detail". Can be used to specify the maximum p and CV <sup>2</sup> to plot, so that the scatterplot can be focused on the separation area between the categories. Use vector of two elements. First one is max p and second one is max CV <sup>2</sup> . Example: plot.focus=c(1.5,1.5). If NULL then maximums are defined from the dataset.

### Value

idx.croston	Index of series that are categorised under Croston.
idx.sba	Index of series that are categorised under SBA.
idx.ses	Index of series that are categorised under SES. Provided only for "PK" and "PKa" types.
cv2	Coefficient of variation squared of non-zero demand.
p	Inter-demand interval.
summary	Summary of number of series under each category.

### Author(s)

Nikolaos Kourentzes

### References

Classification schemes described in: F. Petropoulos and N. Kourentzes, 2015, Journal of Operational Research Society. <https://link.springer.com/article/10.1057/jors.2014.62>. <https://kourentzes.com/forecasting/2014/05/13/forecast-combinations-for-intermittent-demand/>

Optimisation of the methods described in: N. Kourentzes, 2014, On intermittent demand model optimisation and selection, International Journal of Production Economics, 156: 180-190. doi: [10.1016/j.ijpe.2014.06.007](https://doi.org/10.1016/j.ijpe.2014.06.007).

<https://kourentzes.com/forecasting/2014/06/11/on-intermittent-demand-model-optimisation-and-selection/>

### See Also

[crost](#), [tsb](#), [imapa](#).

## Examples

```
# Create/load some data. Each column is a time series
dataset <- simID(100,60,idi=1.15,cv2=0.3)
idclass(dataset)
```

---

imapa

*MAPA for intermittent demand data*


---

## Description

MAPA for intermittent demand data with automatic model selection based on the PK classification.

## Usage

```
imapa(data,h=10,w=NULL,minimumAL=1,maximumAL=NULL,comb=c("mean","median"),
      init.opt=c(TRUE,FALSE),paral=c(0,1,2),outplot=c(0,1,2,3,4),model.fit=NULL,
      na.rm=c(FALSE,TRUE))
```

## Arguments

<code>data</code>	Intermittent demand time series.
<code>h</code>	Forecast horizon.
<code>w</code>	Smoothing parameters. If <code>w == NULL</code> then parameters are optimised. If <code>w</code> is single parameter then the same is used for smoothing both the demand and the intervals. If two parameters are provided then the second is used to smooth the intervals. SES is always optimised.
<code>minimumAL</code>	Lowest aggregation level to use. Default = 1.
<code>maximumAL</code>	Highest aggregation level to use. Default = maximum interval.
<code>comb</code>	Combination operator. One of "mean" or "median". Default is "mean".
<code>init.opt</code>	If <code>init.opt==TRUE</code> then Croston and SBA initial values are optimised.
<code>paral</code>	Use parallel processing. 0 = no; 1 = yes (requires initialised cluster); 2 = yes and initialise cluster. Default is 0.
<code>outplot</code>	Optional plot: 0 = No plot; 1 = Time series and combined forecast; 2 = Time series and all aggregation level forecasts; 3 = Summary model selection plot; 4 = Detailed model selection plot.
<code>model.fit</code>	Optional input with model types and parameters. This is the <code>model.fit</code> output from this function. If used it overrides other model settings.
<code>na.rm</code>	A logical value indicating whether NA values should be remove using the method.



**Value**

<code>frc.in</code>	In-sample demand rate.
<code>frc.out</code>	Out-of-sample demand rate.
<code>summary</code>	An array containing information for each aggregation level: AL - Aggregation level; n - Number of observations of aggregated series; p - Average inter-demand interval; cv2 - Coefficient of variation squared of non-zero demand; model - Selected model, where 1 is Croston, 2 is SBA and 3 is SES; use - If == 0 then this aggregation level is ignored because it contains less than 4 observations.
<code>model.fit</code>	Parameters and initialisation values of fitted model in each aggregation level.

**Note**

Note on optimal model paramaters: This implementation of MAPA for intermittent demand data optimises smoothing parameters for all Croston's method, SBA and SES. Optimisation is based on:

N. Kourentzes, 2014, On intermittent demand model optimisation and selection, International Journal of Production Economics, 156: 180-190. doi: [10.1016/j.ijpe.2014.06.007](https://doi.org/10.1016/j.ijpe.2014.06.007).

<https://kourentzes.com/forecasting/2014/06/11/on-intermittent-demand-model-optimisation-and-selection/>

Note on parallelisation: Option `paral=2` incurs substantial overheads. For a single time series using no parallelisation seems to be as good. If `imapa` is to be applied on multiple series, then initialising the parallel cluster externally and using the option `paral=1` is advised.

**Author(s)**

Nikolaos Kourentzes

**References**

Optimisation of the methods described in: F. Petropoulos and N. Kourentzes, 2015, Forecast Combinations for Intermittent Demand, Journal of Operational Research Society. <https://link.springer.com/article/10.1057/jors.2014.62>.

<https://kourentzes.com/forecasting/2014/05/13/forecast-combinations-for-intermittent-demand/>

**See Also**

[tsb](#), [sexsm](#), [crost](#), [idclass](#).

**Examples**

```
imapa(ts.data1, outplot=1)
```

sexsm

*Simple exponential smoothing***Description**

Simple exponential smoothing with fixed or optimised parameters.

**Usage**

```
sexsm(data,h=10,w=NULL,init=c("mean","naive"),
      cost=c("mar","msr","mae","mse"),init.opt=c(TRUE,FALSE),
      outplot=c(FALSE,TRUE),opt.on=c(FALSE,TRUE),
      na.rm=c(FALSE,TRUE))
```

**Arguments**

data	Intermittent demand time series.
h	Forecast horizon.
w	Smoothing parameter. If w == NULL then parameter is optimised.
init	Initial values for demand and intervals. This can be: 1. x - Numeric value for the initial level; 2. "naive" - Initial value is a naive forecast; 3. "mean" - Initial value is equal to the average of data.
cost	Cost function used for optimisation: 1. "mar" - Mean Absolute Rate; 2. "msr" - Mean Squared Rate; 3. "mae" - Mean Absolute Error; 4. "mse" - Mean Squared Error.
init.opt	If init.opt==TRUE then initial values are optimised.
outplot	If TRUE a plot of the forecast is provided.
opt.on	This is meant to use only by the optimisation function. When opt.on is TRUE then no checks on inputs are performed.
na.rm	A logical value indicating whether NA values should be remove using the method.

**Value**

model	Type of model fitted.
frc.in	In-sample demand.
frc.out	Out-of-sample demand.
alpha	Smoothing parameter.
initial	Initialisation value.

**Author(s)**

Nikolaos Kourentzes

## References

Optimisation of the method described in: N. Kourentzes, 2014, On intermittent demand model optimisation and selection, International Journal of Production Economics, 156: 180-190. doi: [10.1016/j.ijpe.2014.06.007](https://doi.org/10.1016/j.ijpe.2014.06.007).

<https://kourentzes.com/forecasting/2014/06/11/on-intermittent-demand-model-optimisation-and-selection>

## See Also

[crost](#), [tsb](#), [crost.ma](#).

## Examples

```
sexsm(ts.data1, outplot=TRUE)
```

---

simID

*Simulator for Intermittent Demand Series*

---

## Description

Simulator of Intermittent Demand Series.

## Usage

```
simID(n=1, obs=60, idi=2, cv2=0.5, level=NULL)
```

## Arguments

n	Number of time series to be generated.
obs	Number of observation of each series.
idi	Average intermittent demand interval of each series.
cv2	Squared coefficient of variation of the non-zero demands.
level	Mean level of the non-zero demands. If NULL, then a random level in [10,100] is selected.

## Value

series      A data matrix containing all the generated series.

## Author(s)

Fotios Petropoulos

## References

This simulator assumes that non-zero demand arrivals follow a bernoulli distribution and the non-zero demands a negative binomial distribution. Petropoulos F., Makridakis S., Assimakopoulos V. & Nikolopoulos K. (2014) "'Horses for Courses' in demand forecasting", European Journal of Operational Research, Vol. 237, No. 1, pp. 152-163

**See Also**

[crost](#), [tsb](#), [idclass](#).

**Examples**

```
dataset <- t(simID(100,60,idi=1.15,cv2=0.3))
```

---

ts.data1

*Example intermittent demand series - 'ts.data1'*

---

**Description**

Example intermittent demand series - 'ts.data1'.

**Usage**

```
ts.data1
```

**Format**

Time series data

**Examples**

```
plot(ts.data1)
```

---

ts.data2

*Example intermittent demand series - 'ts.data2'*

---

**Description**

Example intermittent demand series - 'ts.data2'.

**Usage**

```
ts.data2
```

**Format**

Time series data

**Examples**

```
plot(ts.data2)
```

---

tsb	<i>TSB (Teunter-Syntetos-Babai) method</i>
-----	--------------------------------------------

---

### Description

TSB intermittent demand method with fixed or optimised parameters.

### Usage

```
tsb(data,h=10,w=NULL,init=c("mean","naive"),
    cost=c("mar","msr","mae","mse"),
    init.opt=c(TRUE,FALSE),outplot=c(FALSE,TRUE),
    opt.on=c(FALSE,TRUE),na.rm=c(FALSE,TRUE))
```

### Arguments

<code>data</code>	Intermittent demand time series.
<code>h</code>	Forecast horizon.
<code>w</code>	Smoothing parameters. If <code>w == NULL</code> then parameters are optimised. Otherwise first parameter is for demand and second for demand probability.
<code>init</code>	Initial values for demand and intervals. This can be: 1. <code>c(z,x)</code> - Vector of two scalars, where first is initial demand and second is initial interval; 2. "naive" - Initial demand is first non-zero demand and initial demand probability is again the first one; 3. "mean" - Same as "naive", but initial demand probability is the mean of all in sample probabilities.
<code>cost</code>	Cost function used for optimisation: 1. "mar" - Mean Absolute Rate; 2. "msr" - Mean Squared Rate; 3. "mae" - Mean Absolute Error; 4. "mse" - Mean Squared Error.
<code>init.opt</code>	If <code>init.opt==TRUE</code> then initial values are optimised.
<code>outplot</code>	If <code>TRUE</code> a plot of the forecast is provided.
<code>opt.on</code>	This is meant to use only by the optimisation function. When <code>opt.on</code> is <code>TRUE</code> then no checks on inputs are performed.
<code>na.rm</code>	A logical value indicating whether NA values should be remove using the method.

### Value

<code>model</code>	Type of model fitted.
<code>frc.in</code>	In-sample demand rate.
<code>frc.out</code>	Out-of-sample demand rate.
<code>weights</code>	Smoothing parameters for demand and demand probability.
<code>initial</code>	Initialisation values for demand and demand probability smoothing.

### Author(s)

Nikolaos Kourentzes

**References**

Optimisation of the method described in: N. Kourentzes, 2014, On intermittent demand model optimisation and selection, International Journal of Production Economics, 156: 180-190. doi: [10.1016/j.ijpe.2014.06.007](https://doi.org/10.1016/j.ijpe.2014.06.007).

<https://kourentzes.com/forecasting/2014/06/11/on-intermittent-demand-model-optimisation-and-selection/>

**See Also**

[crost](#), [sexsm](#), [crost.ma](#).

**Examples**

```
tsb(ts.data1, outplot=TRUE)
```

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