Package 'adoption'

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Title Modelling Adoption Process in Marketing

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LinkingTo RandomFieldsUtils

Depends R (>= 3.0), RandomFieldsUtils (>= 0.5.3)

Imports stats, graphics, methods, grDevices, utils, quadprog, tcltk, tkrplot

Description The classical Bass (1969) <doi:10.1287/mnsc.15.5.215> model and the agent based models, such as that by Goldenberg, Libai and Muller (2010) <doi:10.1016/j.ijresmar.2009.06.006> have been two different approaches to model adoption processes in marketing. These two approaches can be unified by explicitly modelling the utility functions. This package provides a GUI that allows, in a unified way, the modelling of these two processes and other processes.

URL http://ms.math.uni-mannheim.de/de/publications/software/adoption

NeedsCompilation yes

Repository CRAN

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R topics documented:

adoption *Modelling Utility Diffusion (GUI)*

Description

This GUI allows real-time simulations of utility diffusion processes with various paramaters to better understand the dynamics of first trials.

Usage

```
adoption(user = NULL, Tend=25, quantiles = c(0.25, 0.75),
         included.models = c("Bass (1969)",
           "Modified Bass",
     "Goldenberg et al. (2010)",
     "Generalized Goldenberg",
     "Rand & Rust (2011)",
     "Autoregressive (VAR)"),
         dt = NULL, data = NULL, cumdata = NULL, ...)
```

Arguments

`user`	string or list of model specifications. If `model` is a string, the gui expects a name of file that has been created by the button 'pdf & save' in a preceding session. Otherwise `user` can be the return value of a preceding
`Tend`	`Tstart` and `Tend` give start and end point, respectively, of the simulation period. The time step is given in the gui.
`quantiles`	if given, also the quantiles of the (cumulative) number of adopters is shown. Note that `quantiles` leads to a slower performance of the gui.
`included.models`	character vector of standard models that should be included in the gui. Default is all.
`data, dt, cumdata`	A vector of number of trials `data` (or cummulative trials) and its corresponding time lag `dt`.
`...`	additional, secondary options, see RFoptions.

Details

The package allows for parallel computing when the number of repetitions is larger than one. See the example below. HOWEVER THIS FUNCTION MAY NOT BE USED TOGETHER WITH THE R PACKAGE PARALLEL, OR SIMILAR PACKAGES.

Comments on the model definition and the gui are given in file adoption_gui.pdf.

Value

A list of models with the latest parameters chosen.

Author(s)

Martin Schlather, <schlather@math.uni-mannheim.de>, http://ms.math.uni-mannheim.de

References

- N.N., Schlather, M., N.N., (2019) Toward a Generalized Adoption Modeling Framework. Manuscript.
- Schlather, M. (2018) Introduction to the Gui of the R package 'adoption'. Technical Report. Attached with the package.

See Also

See the file adoption_gui.pdf for an introduction.

Examples

```
RFoptions(cores=2)  ## see package RandomFieldsUtils
adoption(gui=interactive())
```

---

distances *Special distances for* adoption

Description

Distance function given here are defined for the sole use within the model definition for adoption. These functions increase the processing speed in adoption.

THESE FUNCTIONS SHOULD NEVER BE USED OUTSIDE THE MODEL DEFINITION FOR adoption. THEY SHOULD BE USED ONLY IN THE SAME WAY AS GIVEN IN THE EXAMPLES OF adoption, WITHOUT ANY MODIFICATIONS!

Usage

```
GoldenbergDistance(param, dist, W, Goldenberg_C)
VarDistance(param, dist, W)
```

Arguments

param	the weight parameter. For the Goldenberg distance it has (at least) two parameters; for the VAR distance it has one parameter.
dist	the matrix for Euclidean distances between the coordinates that are given by the function coord in the model definition.
W	A square matrix of size m, where m is the market size. Because of this argument, (nearly) any arbitrary use of the distance function will crash the whole system! Within adoption the correct size of the matrix will be passed.
Goldenberg_C	Some large constant, e.g. $1e6$

Details

DO NOT USE THESE FUNCTIONS OUTSIDE THE MODEL DEFINITIONS FOR adoption.

Value

NULL

Note

Since these distance function modify the values of the argument W by reference, the use of these distance functions will nearly always lead to a system crash if these functions are used wrongly. However, it is save to use them in the model definition for defining the weight function, e.g.,

```
weight =  function(param, dist, W)
GoldenbergDistance(param, dist, W, Goldenberg_C)
```

which equivalent to (but much faster than)

```
weight = function(param, dist) {
neighbour <- dist <= param[1]
diag(neighbour) <- 0
neighbour / Goldenberg_C
}
```

Note that the weight is, in the first piece of code, defined with an additional argument W more, which refers to a matrix of correct size in adoption.

Author(s)

Martin Schlather, <schlather@math.uni-mannheim.de>, http://ms.math.uni-mannheim.de

References

- N.N., Schlather, M., N.N., (2019) Toward a Generalized Adoption Modeling Framework. Manuscript.
- Schlather, M. (2018) Introduction to the Gui of the R package 'adoption'. Technical Report. Attached with the package.

Examples

```
Goldenberg <- list( ## model by Goldenberg, Libai, Muller (2010)
    m = 1000L,
    repetitions=10L,
    dt = 1,
    relative.instance = 0.2,
    SOCIAL = c(1, 5, 5),
    PRIVATE = c(5, 1, 5),
    Ic.start = function(param, m, rep, ...) {
      m * rnorm(m * rep, param[1], prod(param[1:2]))
    },
    Ic = function(param, Nt, m, start) {
      Inf * (2 * (Nt > start) - 1) ## start has size m * rep, i.e. Nt is
      ##                                    recycled
    },
    Ic.param = c("mean h" = 0.02,
 "sigma" = 0.4),
    Ic.param.min = c(0.005, 0.08),
    Ic.param.max = c(0.1, 1.5),

    coord = function(param, m) {
      if (param[1] == 1) as.matrix(1:m)
      else {
m2 <- ceiling(sqrt(m))
m3 <- ceiling(m / m2)
as.matrix(expand.grid(1:m2, 1:m3))[1:m, ]
      }},
    coord.param = c(dim = 2),
    weight =  function(param, dist, W) {
      GoldenbergDistance(param, dist, W, 1e6)
    },

    weight.param.min = 1.5,
    weight.param.max = 1.5,
    weight.param = c("max distance d"=1.5),

    Utrafo = function(U, threshold, ...) 1e6 * as.double(U>=threshold),

    Uthreshold = 0, ## here: constant for any people; we might
    Uthreshold.min = 0,
    Uthreshold.max = 0,
    Up.start = function(param, m, rep) rep(-1, m * rep),
    Up = function(param, m, nT, rep, ...) {
      pmax(-1e6 + 1,
   -log(runif(nT * rep * m)/(1-param[1])) / log(1-param[2]))
      },
    Up.param = c(prob_a=0.1, prob_b=0.1),
    Up.param.min = c(0.005, 0.05),
    Up.param.max = c(0.99, 0.99),
```

```
    "MAX/PLUS OPERATORS" = rep(5, 3),
    alpha = c("alpha_1"=0, "alpha_2"=1),
    alpha.min = c(0, 1),
    alpha.max = c(0, 1),
    beta = c("beta_1"=1, "beta_2"=1),
    beta.min = c(1, 1),
    beta.max = c(1, 1),
    gamma = c("gamma_1"=0.5, "gamma_2"=0.5),
    gamma.min = c(0.5, 0.5),
    gamma.max = c(0.5, 0.5)
 )

RFoptions(cores=2)  ## see package RandomFieldsUtils
print(adoption(Goldenberg, join_models=FALSE, buttons2right=TRUE,
               gui=interactive()))
```

`Output of adoption` `print` *and* `str` *for the output of the function* `adoption`

Description

`"adoption"` is an S3 class which indicates the output of the function `adoption`. The commands `print` and `str` give some nice output. The command `print` additionally returns the output within a list.

Usage

```
## S3 method for class 'adoption'
print(x,..., level=0)
## S3 method for class 'adoption'
str(object, ..., give.attr=FALSE)
```

Arguments

`x,object`	objects of S3 class `"adoption"`
`level`	integer. If `level<=0` only a verbal description is given. If `level=1` the important parameters of the models are returned. If `level>1` simulation results for the models are also returned where they are available.
`...`	optional arguments that are ignored
`give.attr`	logical. If `TRUE` the attributes are also printed.

Value

print The higher the `level`, the more details are printed. The print out is also returned within an invisible list. So, `z <- print(adoption(), level=1)` might make sense.

str It uses essentially the basic str function. `str` returns `NULL`

Author(s)

Martin Schlather, <schlather@math.uni-mannheim.de>, http://ms.math.uni-mannheim.de

Examples

```
RFoptions(cores=2)  ## see package RandomFieldsUtils

## only the model definitions and the simulation result for the
## first model (Bass, '_set_') are returned; no pictures are drawn
str(adoption(gui=FALSE, printlevel=0))

## pictures are drawn and the result returned by 'adoption' is
## reduced to most revelant information (level=1). 'print' also
## returns this information in a list
z <- print(adoption(gui=FALSE), level=1)
str(z, give.attr=FALSE)
```

RFoptions *Setting control arguments*

Description

RFoptions sets and returns control arguments for the analysis and the simulation of random fields. See RFoptions for the definition of RFoptions(..., no.readonly = TRUE).

Details

Note that this function can only be used after library(RandomFieldsUtils) has been made available explicitely.

The parameter for **adoption** are

buttons2right logical. The gui has many buttons and sliders. If buttons2right=TRUE all buttons are placed on the right of the graphics, else about half of the stuff is placed below the graphics which gives a more compact view. if buttons2right is not given, it is TRUE for Windows sytems, else FALSE. For Windows systems buttons2right=FALSE does not work (The author is happy to get any hint why).

Default: NA

cores Number of cores for multicore algorithms; currently only used for the Cholesky decomposition.

Default : 1

cumfit Logical variable that directs the model fitting by least squares. If TRUE the model is fitted to the cummulative distribution function of the data, if FALSE to the density function.

Default : TRUE

extension string. The extension name R data files. Default: "rda"

factr control parameter of optim Default: 1e14

filename base name of the pdf files when the images are stored by mean of the button 'Images -> pdf'. The user may change the name in the gui.

Only the basic name should be given, no extensio. Then a bundle of pictures is created when the button 'Images -> pdf' is pressed. Also an rda file is created that contains the whole session information.

Default: `"adoption"`

`fit_m` logical. if `TRUE` the market size `m` is also estimated. In the case, the estimation time is massively increased.

Default: `FALSE`

`fit_operators` If `FALSE`, what is the default, the parameters `alpha`, `beta`, `gamma` and `Uthreshold` are not suggested to be fitted.

`fit_repetitions` Positive integer for the precision of the fitting. The actual number of repetitions used in the model fitting is the maximum of `fit_repetitions` and the value of the slider 'repetitions'.

Default : 10

fontsize integer between 6 and 12 or NA. If `font.size` is `NA`, it chosen 7 for Windows sytems, else 8.

Default: `NA`

gui logical. If `TRUE` the gui is opened. If `FALSE` the calculations for the first model are performed. The results are returned in model form. Additionally if `printlevel`> 0 (what is the default) all the graphics are drawn on the default graphical device.

Default: TRUE

join_models logical. If `TRUE` the model(s) passed by `user` are joined with the list of standard models. If it is `FALSE` the list of models in the gui are replaced by the `user` models. If it is `NA` and `user` contains a single model then it behaves as `join_models = TRUE`

Default: `NA`

max_increasing integer. The fitting of the complete fitting procedure is stopped if no improvement is observed in `max_increasing` subsequent global iteration steps.

Default: `3`

numberSteps integer. Each slider is divided into `numberSteps` parts. When one of the borders is crossed a new simulation is calculated. If `numberSteps` is large enough, this leaves the impression that the figures are continuously updated.

Default: `25`

pgtol control parameter of `optim`

Default: 1e-1

ratio Logical. Graphical parameter. If `TRUE` then density functions and cumulative distribution functions are shown, multiplied by 100. If `FALSE` then frequencies and cumulative frequencies are shown. If `NA` then actual value of `ratio` is `TRUE` iff no data are given.

`ratio` does not have an influence how parameters are fitted to data; the fitting is always based on frequency data.

Default: `TRUE`

screen.shot string giving the system command to create a screen shot.

Default: `"xfce4-screenshooter -w -s ."`

showNindiv integer scalar or vector. If it is a vector, it specifies the individuals, for which the utility functions should be shown. If it is a single number, it plots the utilities of the individuals `1:show.n.indiv`.

Default: 10

simuOnTheFly logical or integer. This option controls the behavior of entry boxes. If it has `1` the simulations are updated by the tcltk binding "<FocusOut>", i.e. whenever another entry box is entered. values greater than 1 then the binding is "<KeyRelease>", i.e. simulations are updated whenever a key is pressed. If `FALSE` or `0` no binding happens; so an update does not happen and updates must be foreced through the button 'new simulation'

sliderColumn Relative position of the sliders on the right handside of the graphics.

Default: Windows:50' Linux:38

startwith integer. the nth model within the list `included.model` to start with. This option is only considered if `user` is not a filename.

Default: 1

tracefit internal logical or integer value.

Tstart `Tstart` and `Tend` give start and end point, respectively, of the simulation period. The time step is given in the gui.

Default : 1

wait if `wait` is negative, the prompt reappears after the gui is launched. The current session model is stored in `.adoption.exit` in the `.GlobalEnv` when leaving the gui.

If `wait` is non-negative, the system checks every `wait` milli seconds whether the gui has finished and returns the current session model.

Default: 5000

`windows` logical. If `TRUE` the fitting progress is shown in a separate window. If `NA` the value is set to `TRUE` iff the operation system is Windows.

Default: `NA`.

ymax Vector of 5 numbers that determines the rescaling of the graphs for dN, so that the same scale is kept as long as the values of dN are not too small and too large relative to the current scale.

Let c be the current upper limit of the graph and n the maximum value of dN for the next graph to be plotted. Then the following rules are applied.

1. While $n > c*$`ymax[1]` do $c \leftarrow c*$`ymax[2]`
2. If $n < c/$`ymax[3]` and $c \geq$ `ymax[4] * m / 100` then $c \leftarrow c/$ `ymax[5]`.

Default: `c(1.3, 3, 6.7, 0.02, 6)`

Value

`NULL` if any argument is given, and the full list of arguments, otherwise.

Author(s)

Martin Schlather, <schlather@math.uni-mannheim.de>, http://ms.math.uni-mannheim.de

References

- N.N., Schlather, M., N.N., (2019) Toward a Generalized Adoption Modeling Framework. Manuscript.
- Schlather, M. (2018) Introduction to the Gui of the R package 'adoption'. Technical Report. Attached with the package.

See Also

RFoptions,

Examples

```
library(RandomFieldsUtils)
RFoptions(GETOPTIONS="adoption")
RFoptions(ymax=c(1.2, 2, 0.25, 0.02, 4))
adoption(gui=interactive())
```

Technology *Technology Adoption*

Description

Technology adoption by households in the United States, available from ourworldindata.org/technology-adoption, published by Hannah Ritchie and Max Roser.

NOTE THAT THE DATA ARE PUBLISHED UNDER THE CC-BY LICENCE (2019), https://ourworldindata.org/technology-adoption, WHOSE POLICY MUST BE STRICTLY FOLLOWED, SEE ALSO THE NOTE BELOW.

Usage

```
data(technology)
```

Format

The data is a list of data frames, each data frame contains the percentage of adoption and the year.

Details

The list elements are

Automatic.transmission Automatic transmission vehicle in percentage of car output.

Automobile Percentage of US households that own an automobile.

Cable.TV Percentage of US households with cable TV.

Cellular.phone Percentage of US households with a cellular phone.

Central.heating Percentage of American dwelling units with central heating.

Colour.TV Percentage of US households with colour TV.

Computer Computer: Adoption rates of computers by US households.

Dishwasher Adoption rates of dishwashers in US households.

Disk.brakes Disk brakes in the percentage of car output.

Dryer Adoption rates of dryers in US households.

Ebook.reader Percentage of US adults who own an Ebook reader.

Electric.Range Adoption rates of electric ranges in US households.

Electric.power Percentage of US households with electric power.

Electronic.ignition Cars with electronic ignition in percentage of car output.

Flush.toilet American households with access to a flush toilet.

Freezer Diffusion rates of freezers in the US economy.

Home.air.conditioning Home air conditioning: Percentage of US households with home air conditioning.

Household.refrigerator Percentage of US households that own a refrigerator.

Internet Percentage of US households with access to the internet.

Iron Diffusion rates of ironers in the US economy.

Landline Percentage of US households with a landline.

Microcomputer Percentage of US households with microcomputers.

Microwave Diffusion rates of microwaves in the US economy.

Nox.pollution.controls Percentage of boilers adopting Nox pollution control technologies.

Podcasting Percentage of Americans aged 12 or older who have listened to a podcast (ever)

Power.steering Power steering in vehicles in percentage of car output

RTGS.adoption Adoption rate of RTGS technology.

Radial.tires Cars with radial tires in percentage of car output.

Radio Percentage of US households that own a radio.

Refrigerator Diffusion rates of refrigerators in the US economy.

Running.water Percentage of households with running water

Shipping.container.port (Shipping container port infrastructure) Percentage adoption of port infrastructure.

Smartphone.usage Percentage of US adults who own a smartphone.

Social.media.usage Percentage of US adults who use at least one social media site.

Stove Percentage of US households with a stove.

Tablet Percentage of US adults who own a tablet.

Television Adoption rates of TV by US households.

Vacuum Diffusion rates of vacuums in the US economy.

Videocassette.recorder Adoption rates of videocassette recorders by US households.

Washer Diffusion rates of washers in the US economy.

Washing.machine Percentage of US households that own a washing machine.

Water.Heater Diffusion rates of water heaters in the US economy.

Note

For citing any of the data sets, usually two sources have to be given, namely https://ourworldindata.org/technology-adoption and the original source, see https://ourworldindata.org/grapher/technology-adoption-by-households-in-the-united-states?time=1860..2016&country=Automatic%20transmission+Automobile+Cable%20TV+Cellular%20phone+Central%20heating+Colour%20TV+Computer+Dishwasher+Disk%20brakes+Dryer+Ebook%20reader+Electric%20Range+Electric%20power+Electronic%20ignition+Flush%20toilet+Freezer+Home%20air%20conditioning+Household%20refrigerator+Internet+Iron+Landline+Microcomputer+Microwave+Nox%20pollution%20controls%20(boilers)+Podcasting+Power%20steering+RTGS%20adoption+Radial%20tires+Radio+Refrigerator+Running%20water+Shipping%20container%20port%20infrastructure+Smartphone%20usage+Social%20media%20usage+Stove+Tablet+Television+Vacuum+Videocassette%20recorder+Washer+Washing%20machine+Water%20Heater . See also the general instructions at https://ourworldindata.org.

Source

https://ourworldindata.org/technology-adoption

References

General

- N.N., Schlather, M., N.N., (2019) Toward a Generalized Adoption Modeling Framework. Manuscript.
- Ritchie, H., Roser, M. (2019) Technology Adoption https://ourworldindata.org/technology-adoption. Accessed 5 March 2019.
- Roser, M., Ortiz-Ospina, E. (2019) Global Rise of Education. OurWorldInData.org. https://ourworldindata.org/technology-adoption

According to the licence, the references given by Max Roser and co-workers are repeated and completed where possible:

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- Rua, G. (2013) Fixed costs, network effects, and the diffusion of container shipping. Federal Reserve Board. as.vanderbilt.edu/econ/sempapers/Rua.pdf
- The New York Times (2008) How Americans spend their money. http://www.nytimes.com/imagepages/2008/02/10/opinion/10op.graphic.ready.html
- US Census Bureau's data (1992–2011) https://www.census.gov/programs-surveys/decennial-census/data/datasets.2010.html

Examples

```
data(technology)
D <- technology$Microwave
indviduals <- 500
if (interactive())
  adoption(startwith=1, cumdata=round(indviduals * D$adoption / 100),
           dt=1, Tstart=D$year[1])
```

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