Package ‘exuber’

May 12, 2020

Type Package

Title Econometric Analysis of Explosive Time Series

Version 0.4.1

Description Testing for and dating periods of explosive
dynamics (exuberance) in time series using the univariate and panel
recursive unit root tests proposed by Phillips et al. (2015)
algorithm utilizes the matrix inversion lemma to avoid matrix
inversion which results in significant speed improvements. Simulation
of a variety of periodically-collapsing bubble processes.

License GPL-3

URL https://github.com/kvasilopoulos/exuber

BugReports https://github.com/kvasilopoulos/exuber/issues

Depends R (>= 3.2)

Imports cli (>= 1.1.0), doRNG (>= 1.8.2), doSNOW (>= 1.0.16), dplyr
(>= 0.8.0.1), foreach (>= 1.4.4), generics (>= 0.0.2), ggplot2
(>= 3.1.1), glue (>= 1.3.1), lubridate (>= 1.7.4), parallel,
purrr (>= 0.3.2), Rcpp (>= 0.12.17), rlang (>= 0.3.4), tibble
(>= 2.1.1), tidyR (>= 0.8.3), vctrs (>= 0.2.4)

Suggests magrittr (>= 1.5), clisymbols (>= 1.2.0), covr (>= 3.2.1),
exuberdata (>= 0.1.0), forcats (>= 0.5.0), gridExtra (>= 2.3),
knitr (>= 1.22), rmarkdown (>= 1.12), spelling (>= 2.1),
stringr (>= 1.4.0), testthat (>= 2.1.1), withr (>= 2.1.2)

LinkingTo Rcpp (>= 1.0.1), RcppArmadillo (>= 0.9.400.2.0)

VignetteBuilder knitr

Additional_repositories https://kvasilopoulos.github.io/drat

Encoding UTF-8

Language en-US

LazyData true
RoxygenNote 7.1.0

NeedsCompilation yes

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Repository CRAN

Date/Publication 2020-05-12 17:00:07 UTC

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### autoplot.ds_radf

**Plotting a ds_radf object**

#### Description

Takes a ds_radf object and returns a ggplot2 object, with a `geom_segment()` layer.

#### Usage

```r
## S3 method for class 'ds_radf'
autoplot(object, trunc = TRUE, ...)
```

#### Arguments

- **object**
  - An object of class `ds_radf`. The output of `datestamp()`
- **trunc**
  - Whether to remove the period of the minimum window from the plot (default = `TRUE`).
- **...**
  - Further arguments passed to methods. Not used.

#### Value

A `ggplot2::ggplot()`

#### Examples

```r
sim_data_wdate %>%
  radf() %>%
  datestamp() %>%
  autoplot() +
  ggplot2::scale_colour_manual(values = rep("black", 4))
```

```r
# Change the colour manually
sim_data_wdate %>%
  radf() %>%
  datestamp() %>%
  autoplot() +
  ggplot2::scale_colour_manual(values = rep("black", 4))
```
autoplot.radf_distr  
Plotting a radf_distr object

Description
Takes a radf_distr object and returns a ggplot2 object.

Usage
```r
## S3 method for class 'radf_distr'
autoplot(object, ...)
```

Arguments
- **object**: An object of class radf_distr.
- **...**: Further arguments passed to methods, used only in wb_distr facet options.

Value
A `ggplot2::ggplot()`

autoplot.radf_obj  
Plotting radf models

Description
`autoplot.radf_obj` takes radf_obj and radf_cv and returns a faceted ggplot object. shade is used as an input to shape_opt. shade modifies the geom_rect layer that demarcates the exuberance periods.

Usage
```r
## S3 method for class 'radf_obj'
autoplot(
  object,
  cv = NULL,
  option = c("gsadf", "sadf"),
  min_duration = 0L,
  select_series = NULL,
  include_negative = FALSE,
  shade_opt = shade(),
  include = "DEPRECATED",
  select = "DEPRECATED",
  ...)
)

shade(fill = "grey70", opacity = 0.5, ...)
```
Arguments

- **object**
  - An object of class `obj`.
- **cv**
  - An object of class `cv`.
- **option**
  - Whether to apply the "gsadf" or "sadf" methodology (default = "gsadf").
- **min_duration**
  - The minimum duration of an explosive period for it to be reported (default = 0).
- **select_series**
  - A vector of column names or numbers specifying the series to be used in plotting. Note that the order of the series does not alter the order used in plotting.
- **include_negative**
  - If TRUE, plot all variables regardless of rejecting the NULL at the 5 percent significance level.
- **shade_opt**
  - Shading options, typically set using `shade` function.
- **include**
  - Argument name is deprecated and substituted with `include_negative`.
- **select**
  - Argument name is deprecated and substituted with `select_series`.
- **...**
  - Further arguments passed to `ggplot2::facet_wrap` and `ggplot2::geom_rect` for shade.
- **fill**
  - The shade color that indicates the exuberance periods.
- **opacity**
  - The opacity of the shade color aka alpha.

Value

A `ggplot2::ggplot()`

Examples

```r
rsim_data <- radf(sim_data_wdate)

autoplot(rsim_data)

# Modify facet_wrap options through ellipsis
autoplot(rsim_data, scales = "free_y", dir = "v")

autoplot(rsim_data, shade_opt = shade(fill = "pink", opacity = 0.5))

# We will need ggplot2 from here on out
library(ggplot2)

# Change (overwrite) color, size or linetype
autoplot(rsim_data) +
  scale_color_manual(values = c("black", "black")) +
  scale_size_manual(values = c(0.9, 1)) +
  scale_linetype_manual(values = c("solid", "solid"))

# Change names through labeller (first way)
custom_labels <- c("psy1" = "new_name_for_psy1", "psy2" = "new_name_for_psy2")
autoplot(rsim_data, labeller = labeller(.default = label_value, id = as_labeller(custom_labels)))
```
# Change names through labeller (second way)
custom_labels2 <- series_names(rsim_data)
names(custom_labels2) <- custom_labels2
custom_labels2[c(3, 5)] <- c("Evans", "Blanchard")
autoplot(rsim_data, labeller = labeller(id = custom_labels2))

# Or change names before plotting
series_names(rsim_data) <- LETTERS[1:5]
autoplot(rsim_data)

# Change Theme options
autoplot(rsim_data) +
  theme(legend.position = "right")

calc_pvalue

Calculate p-values from distr object

Description

Calculate p-values from distr object

Usage

calc_pvalue(x, distr = NULL)

Arguments

x A radf_obj object.
distr A radf_distr object.

Examples

## Not run:
radf_psy1 <- radf(sim_psy1(100))
calc_pvalue(radf_psy1)

# Using the Wild-Bootstrapped
wb_psy1 <- wb_distr(sim_psy1(100))
calc_pvalue(radf_psy1, wb_psy1)

## End(Not run)
**datestamp**  

*Date-stamping periods of mildly explosive behavior*

---

**Description**

Computes the origination, termination and duration of episodes during which the time series display explosive dynamics.

**Usage**

```
datestamp(object, cv = NULL, min_duration = 0L, ...)  

## S3 method for class 'radf_obj'  
datestamp(  
  object,  
  cv = NULL,  
  min_duration = 0L,  
  option = c("gsadf", "sadf"),  
  ...  
)
```

**Arguments**

- **object**: An object of class `obj`.
- **cv**: An object of class `cv`.
- **min_duration**: The minimum duration of an explosive period for it to be reported (default = 0).
- **option**: Whether to apply the "gsadf" or "sadf" methodology (default = "gsadf").
- **...**: further arguments passed to methods.

**Details**

Datestamp also stores a vector whose elements take the value of 1 when there is a period of explosive behaviour and 0 otherwise. This output can serve as a dummy variable for the occurrence of exuberance.

**Value**

Returns a list containing the estimated origination and termination dates of episodes of explosive behaviour and the corresponding duration.

**References**

Examples

```r
dsim_data <- radf(sim_data)
d_data <- datestamp(rsim_data)
d_data

# Choose minimum window
datestamp(rsim_data, min_duration = psy_ds(nrow(sim_data)))

autoplot(ds_data)
```

---

**diagnostics**

*Diagnostics on hypothesis testing*

**Description**

Provides information on whether the null hypothesis of a unit root is rejected against the alternative of explosive behaviour for each series in a dataset.

**Usage**

```r
diagnostics(object, cv = NULL, ...)
```

```r
## S3 method for class 'radf_obj'
diagnostics(object, cv = NULL, option = c("gsadf", "sadf"), ...)
```

**Arguments**

- `object`: An object of class `obj`.
- `cv`: An object of class `cv`.
- `...`: Further arguments passed to methods.
- `option`: Whether to apply the "gsadf" or "sadf" methodology (default = "gsadf").

**Details**

Diagnostics also stores a vector whose elements take the value of 1 when there is a period of explosive behaviour and 0 otherwise.

**Value**

Returns a list with the series that reject (positive) and the series that do not reject (negative) the null hypothesis, and at what significance level.
Examples

rsim_data <- radf(sim_data)
diagnostics(rsim_data)

diagnostics(rsim_data, option = "sadf")

---

Description

Retrieve or replace the index of an object.

Usage

index(x, ...)

index(x) <- value

Arguments

x An object.
...
value An ordered vector of the same length as the 'index' attribute of x.

Details

If the user does not specify an index for the estimation a pseudo-index is generated which is a sequential numeric series. After the estimation, the user can use index to retrieve or `index<-` to replace the index. The index can be either numeric or Date.

---

Description

This function wraps the install.packages function and offers a faster and more convenient way to install exuberdata.

Usage

install_exuberdata()
Examples

```r
if("exuberdata" %in% loadedNamespaces()) {
  exuberdata::radf_crit2
}
```

---

`psy_minw` *Helper functions in accordance to PSY(2015)*

**Description**

`psy_minw` and `psy_ds` use the rules-of-thumb proposed by Phillips et al. (reference) to compute the minimum window size and the minimum duration of an episode of exuberance, respectively.

**Usage**

```r
psy_minw(n)

psy_ds(n, rule = 1, delta = 1)
```

**Arguments**

- `n`: A positive integer. The sample size.
- `rule`: Rule 1 corresponds to \( \log(T) \), while rule 2 \( \log(T)/T \)
- `delta`: Frequency-dependent parameter. See details.

**Details**

For the minimum duration period, `psy_ds` allows the user to choose from two rules:

\[
 rule_1 = \delta \log(n) \quad \& \quad rule_2 = \delta \log(n)/n
\]

`delta` depends on the frequency of the data and the minimal duration condition.

**References**


**Examples**

```r
psy_minw(100)
psy_ds(100)
```
Description

`radf` returns the recursive univariate and panel Augmented Dickey-Fuller test statistics.

Usage

```r
radf(data, minw = NULL, lag = 0L)
```

Arguments

- `data`: A univariate or multivariate numeric time series object, a numeric vector or matrix, or a data.frame. The object should not have any NA values.
- `minw`: A positive integer. The minimum window size (default = \((0.01 + 1.8/\sqrt{T})T\), where \(T\) denotes the sample size).
- `lag`: A non-negative integer. The lag length of the Augmented Dickey-Fuller regression (default = 0L).

Details

The `radf()` function is vectorized, i.e., it can handle multiple series at once, to improve efficiency. This property also enables the computation of panel statistics internally as a by-product of the univariate estimations with minimal additional cost incurred.

Value

A list that contains the unit root test statistics (sequence):

- `adf`: Augmented Dickey-Fuller
- `badf`: Backward Augmented Dickey-Fuller
- `sadf`: Supremum Augmented Dickey-Fuller
- `bsadf`: Backward Supremum Augmented Dickey-Fuller
- `gsadf`: Generalized Supremum Augmented Dickey-Fuller
- `bsadf_panel`: Panel Backward Supremum Augmented Dickey-Fuller
- `gsadf_panel`: Panel Generalized Supremum Augmented Dickey-Fuller

References


Examples

```r
# We will use simulated data that are stored as data
sim_data

rsim <- radf(sim_data)
str(rsim)

# We would also use data that contain a Date column
sim_data_wdate

rsim_wdate <- radf(sim_data_wdate)
tidy(rsim_wdate)
augment(rsim_wdate)
tidy(rsim_wdate, panel = TRUE)
head(index(rsim_wdate))

# For lag = 1 and minimum window = 20
rsim_20 <- radf(sim_data, minw = 20, lag = 1)
```

---

**radf_crit**  
*Stored Monte Carlo Critical Values*

**Description**

A dataset containing Monte Carlo critical values for up to 600 observations generated using the default minimum window. The critical values have been simulated and stored as data to save computation time for the user. The stored critical values can be obtained with the `radf_mc_cv()` function, using nrep = 2000 and the seed = 123.

**Usage**

`radf_crit`

**Format**

A list with lower level lists that contain

- `adf_cv`: Augmented Dickey-Fuller
- `badf_cv`: Backward Augmented Dickey-Fuller
- `sadf_cv`: Supremum Augmented Dickey-Fuller
- `bsadf_cv`: Backward Supremum Augmented Dickey-Fuller
- `gsadf_cv`: Generalized Supremum Augmented Dickey Fuller
Source

Simulated from exuber package function `radf_mc_cv()`.

Examples

```r
## Not run:
all.equal(radf_crit[[50]], radf_mc_cv(50, nrep = 2000, seed = 123))
## End(Not run)
```

### `radf_mc_cv`

#### Monte Carlo Critical Values

**Description**

`radf_mc_cv` computes Monte Carlo critical values for the recursive unit root tests. `radf_mc_distr` computes the distribution.

**Usage**

```r
radf_mc_cv(n, minw = NULL, nrep = 1000L, seed = NULL)
radf_mc_distr(n, minw = NULL, nrep = 1000L, seed = NULL)
```

**Arguments**

- `n`: A positive integer. The sample size.
- `minw`: A positive integer. The minimum window size (default = \((0.01 + 1.8/\sqrt{T})T\), where \(T\) denotes the sample size).
- `nrep`: A positive integer. The number of Monte Carlo simulations.
- `seed`: An object specifying if and how the random number generator (rng) should be initialized. Either NULL or an integer will be used in a call to `set.seed` before simulation. If set, the value is saved as "seed" attribute of the returned value. The default, NULL, will not change rng state, and return `.Random.seed` as the "seed" attribute. Results are different between the parallel and non-parallel option, even if they have the same seed.

**Value**

For `radf_mc_cv` a list that contains the critical values for ADF, BADF, BSADF and GSADF test statistics. For `radf_mc_distr` a list that contains the ADF, SADF and GSADF distributions.

**See Also**

- `radf_wb_cv` for wild bootstrap critical values
- `radf_sb_cv` for sieve bootstrap critical values

```r
```
Examples

```r
# Default minimum window
cmp <- radf_mc_cv(n = 100)
tidy(m)

# Change the minimum window and the number of simulations
mc2 <- radf_mc_cv(n = 100, nrep = 600, minw = 20)
tidy(m)

mdist <- radf_mc_distr(n = 100, nrep = 1000)
autoplot(m)
```

---

### Description

`radf_sb_cv` computes critical values for the panel recursive unit root test using the sieve bootstrap procedure outlined in Pavlidis et al. (2016). `radf_sb_distr` computes the distribution.

### Usage

```r
radf_sb_cv(data, minw = NULL, lag = 0L, nboot = 500L, seed = NULL)

radf_sb_distr(data, minw = NULL, lag = 0L, nboot = 500L, seed = NULL)
```

### Arguments

- **data**: A univariate or multivariate numeric time series object, a numeric vector or matrix, or a data.frame. The object should not have any NA values.
- **minw**: A positive integer. The minimum window size (default = $0.01 + 1.8 / \sqrt{T}$, where T denotes the sample size).
- **lag**: A non-negative integer. The lag length of the Augmented Dickey-Fuller regression (default = 0L).
- **nboot**: A positive integer. Number of bootstraps (default = 500L).
- **seed**: An object specifying if and how the random number generator (rng) should be initialized. Either NULL or an integer will be used in a call to set.seed before simulation. If set, the value is saved as "seed" attribute of the returned value. The default, NULL, will not change rng state, and return .Random.seed as the "seed" attribute. Results are different between the parallel and non-parallel option, even if they have the same seed.
Value

For `radf_sb_cv` a list A list that contains the critical values for the panel BSADF and panel GSADF test statistics. For `radf_wb_dist` a numeric vector that contains the distribution of the panel GSADF statistic.

References


See Also

`radf_mc_cv` for Monte Carlo critical values and `radf_wb_cv` for wild Bootstrap critical values

Examples

```r
rsim_data <- radf(sim_data, lag = 1)

# Critical values should have the same lag length with \code{radf()}
sb <- radf_sb_cv(sim_data, lag = 1)

tidy(sb)

summary(rsim_data, cv = sb)

autoplot(rsim_data, cv = sb)

# Simulate distribution
sdist <- radf_sb_distr(sim_data, lag = 1, nboot = 1000)

autoplot(sdist)
```

---

### Wild Bootstrap Critical Values

**Description**

`radf_wb_cv` performs the Harvey et al. (2016) wild bootstrap re-sampling scheme, which is asymptotically robust to non-stationary volatility, to generate critical values for the recursive unit root tests. `radf_wb_distr` computes the distribution.

**Usage**

```r
radf_wb_cv(data, minw = NULL, nboot = 500L, dist_rad = FALSE, seed = NULL)

radf_wb_distr(data, minw = NULL, nboot = 500L, dist_rad = FALSE, seed = NULL)
```
Arguments

- **data**: A univariate or multivariate numeric time series object, a numeric vector or matrix, or a data.frame. The object should not have any NA values.
- **minw**: A positive integer. The minimum window size (default = $(0.01 + 1.8/\sqrt{T})T$, where $T$ denotes the sample size).
- **nboot**: A positive integer. Number of bootstraps (default = 500L).
- **dist_rad**: Logical. If TRUE then the Rademacher distribution will be used.
- **seed**: An object specifying if and how the random number generator (rng) should be initialized. Either NULL or an integer will be used in a call to set.seed before simulation. If set, the value is saved as "seed" attribute of the returned value. The default, NULL, will not change rng state, and return .Random.seed as the "seed" attribute. Results are different between the parallel and non-parallel option, even if they have the same seed.

Details

This approach involves applying a wild bootstrap re-sampling scheme to construct the bootstrap analogue of the Phillips et al. (2015) test which is asymptotically robust to non-stationary volatility.

Value

For `radf_wb_cv` a list that contains the critical values for the ADF, BADF, BSADF and GSADF tests. For `radf_wb_distr` a list that contains the ADF, SADF and GSADF distributions.

References


See Also

`radf_mc_cv` for Monte Carlo critical values and `radf_sb_cv` for sieve bootstrap critical values.

Examples

```r
# Default minimum window
wb <- radf_wb_cv(sim_data)
tidy(wb)

# Change the minimum window and the number of bootstraps
wb2 <- radf_wb_cv(sim_data, nboot = 600, minw = 20)
tidy(wb2)
```
# Simulate distribution
wdist <- radf_wdistr(sim_data)

autoplot(wdist)

---

**scale_exuber_manual**  
*Exuber scale and theme functions*

**Description**

`scale_exuber_manual` allows specifying the color, size and linetype in `autoplot.radf_obj` mappings. `theme_exuber` is a complete theme which control all non-data display.

**Usage**

```r
scale_exuber_manual(
  color_values = c("red", "blue"),
  linetype_values = c(2, 1),
  size_values = c(0.8, 0.7)
)

theme_exuber(
  base_size = 11,
  base_family = "",
  base_line_size = base_size/22,
  base_rect_size = base_size/22
)
```

**Arguments**

- `color_values`  
a set of color values to map data values to.
- `linetype_values`  
a set of linetype values to map data values to.
- `size_values`  
a set of size values to map data values to.
- `base_size`  
base font size
- `base_family`  
base font family
- `base_line_size`  
base size for line elements
- `base_rect_size`  
base size for rect elements
Description

Retrieve or replace the series names of an object.

Usage

```
series_names(x, ...)  
series_names(x) <- value
```

```
## S3 replacement method for class 'radf_obj'
series_names(x) <- value
```

```
## S3 replacement method for class 'wb_cv'
series_names(x) <- value
```

```
## S3 replacement method for class 'sb_cv'
series_names(x) <- value
```

Arguments

- `x`  
  An object.

- `...`  
  Further arguments passed to methods.

- `value`  
  A ordered vector of the same length as the "index" attribute of `x`.

Examples

```
# Simulate bubble processes
dta <- data.frame(psy1 = sim_psy1(n = 100), psy2 = sim_psy2(n = 100))

rfd <- radf(dta)

series_names(rfd) <- c("OneBubble", "TwoBubbles")
```
Description
Simulation of a Blanchard (1979) rational bubble process.

Usage
sim_blan(n, pi = 0.7, sigma = 0.03, r = 0.05, b0 = 0.1, seed = NULL)

Arguments
n A positive integer specifying the length of the simulated output series.
pi A positive value in (0, 1) which governs the probability of the bubble continuing
to grow.
sigma A positive scalar indicating the standard deviation of the innovations.
r A positive scalar that determines the growth rate of the bubble process.
b0 The initial value of the bubble.
seed An object specifying if and how the random number generator (rng) should be
initialized. Either NULL or an integer will be used in a call to set . seed before
simulation. If set, the value is saved as "seed" attribute of the returned value. The
default, NULL, will not change rng state, and return .Random.seed as the "seed"
attribute. Results are different between the parallel and non-parallel option, even
if they have the same seed.

Details
Blanchard’s bubble process has two regimes, which occur with probability \( \pi \) and \( 1 - \pi \). In the first
regime, the bubble grows exponentially, whereas in the second regime, the bubble collapses to a
white noise.

With probability \( \pi \):

\[ B_{t+1} = \frac{1 + r}{\pi} B_t + \epsilon_{t+1} \]

With probability \( 1 - \pi \):

\[ B_{t+1} = \epsilon_{t+1} \]

where \( r \) is a positive constant and \( \epsilon \sim iid(0, \sigma^2) \).

Value
A numeric vector of length \( n \).

References
Blanchard, O. J. (1979). Speculative bubbles, crashes and rational expectations. Economics letters,
3(4), 387-389.
See Also

sim_psy1, sim_psy2, sim_evans

Examples

```r
sim_blan(n = 100, seed = 123) %>%
  autoplot()
```

**Description**

An artificial dataset containing series simulated from data generating processes widely used in the literature on speculative bubbles.

**Usage**

sim_data

sim_data_wdate

**Format**

An object of class `tbl_df` (inherits from `tbl`, `data.frame`) with 100 rows and 5 columns.
An object of class `tbl_df` (inherits from `tbl`, `data.frame`) with 100 rows and 6 columns.

**See Also**

sim_psy1 sim_psy2 sim_evans sim_div sim_blan

**Examples**

```r
## Not run:
# The dataset can be easily replicated with the code below
library(tibble)
set.seed(1122)
sim_data <- tibble(
  sim_psy1 = sim_psy1(100),
  sim_psy2 = sim_psy2(100),
  sim_evans = sim_evans(100),
  sim_div = sim_div(100),
  sim_blan = sim_blan(100)
)
sim_data_wdate <- tibble(
  psy1 = sim_psy1(100),
  psy2 = sim_psy2(100),
  evans = sim_evans(100),
  # Additional columns based on simulations
)
```
### sim_div

Simulation of dividends

#### Description

Simulate (log) dividends from a random walk with drift.

#### Usage

```r
sim_div(
  n,
  mu,
  sigma,
  r = 0.05,
  log = FALSE,
  output = c("pf", "d"),
  seed = NULL
)
```

#### Arguments

- `n`: A positive integer specifying the length of the simulated output series.
- `mu`: A scalar indicating the drift.
- `sigma`: A positive scalar indicating the standard deviation of the innovations.
- `r`: A positive value indicating the discount factor.
- `log`: Logical. If true dividends follow a lognormal distribution.
- `output`: A character string giving the fundamental price("pf") or dividend series("d"). Default is 'pf'.
- `seed`: An object specifying if and how the random number generator (rng) should be initialized. Either NULL or an integer will be used in a call to set.seed before simulation. If set, the value is saved as "seed" attribute of the returned value. The default, NULL, will not change rng state, and return .Random.seed as the "seed" attribute. Results are different between the parallel and non-parallel option, even if they have the same seed.
Details

If log is set to FALSE (default value) dividends follow:

\[ d_t = \mu + d_{t-1} + \epsilon_t \]

where \( \epsilon \sim \mathcal{N}(0, \sigma^2) \). The default parameters are \( \mu = 0.0373, \sigma^2 = 0.1574 \) and \( d[0] = 1.3 \) (the initial value of the dividend sequence). The above equation can be solved to yield the fundamental price:

\[ F_t = \mu(1 + r)^{-2} + r^{-1}d_t \]

If log is set to TRUE then dividends follow a lognormal distribution or log(dividends) follow:

\[ \ln(d_t) = \mu + \ln(d_{t-1}) + \epsilon_t \]

where \( \epsilon \sim \mathcal{N}(0, \sigma^2) \). Default parameters are \( \mu = 0.013, \sigma^2 = 0.16 \). The fundamental price in this case is:

\[ F_t = \frac{1 + g}{r - g}d_t \]

where \( 1 + g = \exp(\mu + \sigma^2/2) \). All default parameter values are those suggested by West (1988).

Value

A numeric vector of length n.

References


Examples

# Price is the sum of the bubble and fundamental components
# 20 is the scaling factor
pf <- sim_div(100, r = 0.05, output = "pf", seed = 123)
pb <- sim_evans(100, r = 0.05, seed = 123)
p <- pf + 20 * pb
autoplot(p)
Description
Simulation of an Evans (1991) rational periodically collapsing bubble process.

Usage
sim_evans(
  n,
  alpha = 1,
  delta = 0.5,
  tau = 0.05,
  pi = 0.7,
  r = 0.05,
  b1 = delta,
  seed = NULL
)

Arguments
n A positive integer specifying the length of the simulated output series.
alpha A positive scalar, with restrictions (see details).
delta A positive scalar, with restrictions (see details).
tau The standard deviation of the innovations.
pi A positive value in (0, 1) which governs the probability of the bubble continuing to grow.
r A positive scalar that determines the growth rate of the bubble process.
b1 A positive scalar, the initial value of the series. Defaults to delta.
seed An object specifying if and how the random number generator (rng) should be initialized. Either NULL or an integer will be used in a call to set.seed before simulation. If set, the value is saved as "seed" attribute of the returned value. The default, NULL, will not change rng state, and return .Random.seed as the "seed" attribute. Results are different between the parallel and non-parallel option, even if they have the same seed.

Details
delta and alpha are positive parameters which satisfy $0 < \delta < (1 + r)\alpha$. delta represents the size of the bubble after collapse. The default value of r is 0.05. The function checks whether alpha and delta satisfy this condition and will return an error if not.
The Evans bubble has two regimes. If $B_t \leq \alpha$ the bubble grows at an average rate of $1 + r$:

\[ B_{t+1} = (1 + r)B_t u_{t+1}, \]
When $B_t > \alpha$ the bubble expands at the increased rate of $(1 + r)\pi^{-1}$:

$$B_{t+1} = [\delta + (1 + r)\pi^{-1}\theta_{t+1}(B_t - (1 + r)^{-1}\delta B_t)]u_{t+1},$$

where $\theta$ is a binary variable that takes the value 0 with probability $1 - \pi$ and 1 with probability $\pi$. In the second phase, there is a $(1 - \pi)$ probability of the bubble process collapsing to $\delta$. By modifying the values of $\delta$, $\alpha$ and $\pi$ the user can change the frequency at which bubbles appear, the mean duration of a bubble before collapse and the scale of the bubble.

**Value**

A numeric vector of length $n$.

**References**


**See Also**

sim_psy1, sim_psy2, sim_blan

**Examples**

```r
sim_evans(100, seed = 123) %>%
  autoplot()
```

---

**Description**

The following function generates a time series which switches from a martingale to a mildly explosive process and then back to a martingale.

**Usage**

```r
sim_psy1(
  n, 
  te = 0.4 * n, 
  tf = 0.15 * n + te, 
  c = 1, 
  alpha = 0.6, 
  sigma = 6.79, 
  seed = NULL
)
```
Arguments

- **n**: A positive integer specifying the length of the simulated output series.
- **te**: A scalar in \((0, tf)\) specifying the observation in which the bubble originates.
- **tf**: A scalar in \((te, n)\) specifying the observation in which the bubble collapses.
- **c**: A positive scalar determining the autoregressive coefficient in the explosive regime.
- **alpha**: A positive scalar in \((0, 1)\) determining the value of the expansion rate in the autoregressive coefficient.
- **sigma**: A positive scalar indicating the standard deviation of the innovations.
- **seed**: An object specifying if and how the random number generator (rng) should be initialized. Either NULL or an integer will be used in a call to set.seed before simulation. If set, the value is saved as "seed" attribute of the returned value. The default, NULL, will not change rng state, and return .Random.seed as the "seed" attribute. Results are different between the parallel and non-parallel option, even if they have the same seed.

Details

The data generating process is described by the following equation:

\[
X_t = X_{t-1}1\{t < \tau_e\} + \delta_T X_{t-1}1\{\tau_e \leq t \leq \tau_f\} + \left( \sum_{k=\tau_f+1}^{t} \epsilon_k + X_{\tau_f} \right) 1\{t > \tau_f\} + \epsilon_t 1\{t \leq \tau_f\}
\]

where the autoregressive coefficient \(\delta_T\) is given by:

\[
\delta_T = 1 + cT^{-\alpha}
\]

with \(c > 0, \alpha \in (0, 1), \epsilon \sim iid(0, \sigma^2)\) and \(X_{\tau_f} = X_{\tau_e} + X'\) with \(X' = O_p(1)\), \(\tau_e = \lfloor Tr_e \rfloor\) dates the origination of the bubble, and \(\tau_f = \lfloor Tr_f \rfloor\) dates the collapse of the bubble. During the pre- and post- bubble periods, \([1, \tau_e)\), \(X_t\) is a pure random walk process. During the bubble expansion period \([\tau_e, \tau_f]\) becomes a mildly explosive process with expansion rate given by the autoregressive coefficient \(\delta_T\); and, finally during the post-bubble period, \((\tau_f, \tau]\) \(X_t\) reverts to a martingale.

For further details see Phillips et al. (2015) p. 1054.

Value

A numeric vector of length n.

References


See Also

sim_psy2, sim_blan, sim_evans
Examples

# 100 periods with bubble origination date 40 and termination date 55
sim_psy1(n = 100, seed = 123) %>%
  autoplot()

# 200 periods with bubble origination date 80 and termination date 110
sim_psy1(n = 200, seed = 123) %>%
  autoplot()

# 200 periods with bubble origination date 100 and termination date 150
sim_psy1(n = 200, te = 100, tf = 150, seed = 123) %>%
  autoplot()

---

sim_psy2 Simulation of a two-bubble process

Description

The following data generating process is similar to `sim_psy1`, with the difference that there are two episodes of mildly explosive dynamics.

Usage

```r
sim_psy2(
  n,
  te1 = 0.2 * n,
  tf1 = 0.2 * n + te1,
  te2 = 0.6 * n,
  tf2 = 0.1 * n + te2,
  c = 1,
  alpha = 0.6,
  sigma = 6.79,
  seed = NULL
)
```

Arguments

- **n**: A positive integer specifying the length of the simulated output series.
- **te1**: A scalar in (0, n) specifying the observation in which the first bubble originates.
- **tf1**: A scalar in (te1, n) specifying the observation in which the first bubble collapses.
- **te2**: A scalar in (tf1, n) specifying the observation in which the second bubble originates.
- **tf2**: A scalar in (te2, n) specifying the observation in which the second bubble collapses.
- **c**: A positive scalar determining the autoregressive coefficient in the explosive regime.
alpha  A positive scalar in (0, 1) determining the value of the expansion rate in the autoregressive coefficient.
sigma  A positive scalar indicating the standard deviation of the innovations.
seed  An object specifying if and how the random number generator (rng) should be initialized. Either NULL or an integer will be used in a call to \texttt{set.seed} before simulation. If set, the value is saved as "seed" attribute of the returned value. The default, NULL, will not change rng state, and return \texttt{.Random.seed} as the "seed" attribute. Results are different between the parallel and non-parallel option, even if they have the same seed.

Details
The two-bubble data generating process is given by (see also \texttt{sim_psy1}):

\[
X_t = X_{t-1}\mathbb{1}\{t \in N_0\} + \delta_T X_{t-1}\mathbb{1}\{t \in B_1 \cup B_2\} + \left( \sum_{k=\tau_f+1}^{t} \epsilon_k + X_{\tau_f} \right) \mathbb{1}\{t \in N_1\}
\]

\[
+ \left( \sum_{l=\tau_f+1}^{t} \epsilon_l + X_{\tau_f} \right) \mathbb{1}\{t \in N_2\} + \epsilon_t \mathbb{1}\{t \in N_0 \cup B_1 \cup B_2\}
\]

where the autoregressive coefficient \(\delta_T\) is:

\[
\delta_T = 1 + c T^{-\alpha}
\]

with \(c > 0, \alpha \in (0, 1), \epsilon \sim iid(0, \sigma^2)\). \(N_0 = [1, \tau_e], B_1 = [\tau_e, \tau_{1f}], N_1 = (\tau_{1f}, \tau_{2e}), B_2 = [\tau_{2e}, \tau_{2f}], N_2 = (\tau_{2f}, \tau)\), where \(\tau\) is the last observation of the sample. The observations \(\tau_e = [Tr_{1e}]\) and \(\tau_{1f} = [Tr_{1f}]\) are the origination and termination dates of the first bubble; \(\tau_{2e} = [Tr_{2e}]\) and \(\tau_{2f} = [Tr_{2f}]\) are the origination and termination dates of the second bubble. After the collapse of the first bubble, \(X_t\) resumes a martingale path until time \(\tau_{2e} - 1\), and a second episode of exuberance begins at \(\tau_{2e}\). Exuberance lasts lasts until \(\tau_{2f}\) at which point the process collapses to a value of \(X_{\tau_{2f}}\). The process then continues on a martingale path until the end of the sample period \(\tau\). The duration of the first bubble is assumed to be longer than that of the second bubble, i.e. \(\tau_{1f} - \tau_e > \tau_{2f} - \tau_{2e}\).


Value
A numeric vector of length \(n\).

References
See Also

sim_psy1, sim_blan, sim_evans

Examples

# 100 periods with bubble origination dates 20/60 and termination dates 40/70
sim_psy2(n = 100, seed = 123) %>%
  autoplot()

# 200 periods with bubble origination dates 40/120 and termination dates 80/140
sim_psy2(n = 200, seed = 123) %>%
  autoplot()

summary.radf_obj  Summarizing radf models

Description

summary method for radf models that consist of radf_obj and radf_cv.

Usage

## S3 method for class 'radf_obj'
summary(object, cv = NULL, ...)

Arguments

object    An object of class radf_obj. The output of radf().
cv        An object of class radf_cv. The output of radf_mc_cv(), radf_wb_cv() or radf_sb_cv().
...       Further arguments passed to methods. Not used.

Value

Returns a list of summary statistics, which include the estimated ADF, SADF, and GSADF test
statistics and the corresponding critical values

Examples

# Simulate bubble processes, compute the test statistics and critical values
rsim_data <- radf(sim_data)

# Summary, diagnostics and datestamp (default)
summary(rsim_data)

#Summary, diagnostics and datestamp (wild bootstrap critical values)
tidy.ds_radf

wb <- radf_wb_cv(sim_data)
summary(rsim_data, cv = wb)

tidy.ds_radf  Tidy a ds_radf object

Description
Summarizes information about ds_radf object.

Usage
## S3 method for class 'ds_radf'
tidy(x, ...)

Arguments
x  An object of class ds_radf.
... Further arguments passed to methods. Not used.

tidy.radf_cv  Tidy a radf_cv object

Description
Summarizes information about radf_cv object.

Usage
## S3 method for class 'radf_cv'
tidy(x, format = c("wide", "long"), ...)

## S3 method for class 'radf_cv'
augment(x, format = c("wide", "long"), ...)

Arguments
x  An object of class radf_cv.
format  Long or wide format (default = "wide").
... Further arguments passed to methods. Not used.
Value

A `tibble::tibble()`

- **id**: The series names.
- **sig**: The significance level.
- **name**: The name of the series (when format is "long").
- **crit**: The critical value (when format is "long").

Examples

```r
mc <- radf_mc_cv(100)
# Get the critical values
tidy(mc)
# Get the critical value sequences
augment(mc)
```

### tidy.radf_distr

*Tidy a radf_distr object*

**Description**

Summarizes information about `radf_distr` object.

**Usage**

```r
## S3 method for class 'radf_distr'
tidy(x, ...)
```

**Arguments**

- **x**: An object of class `radf_distr`.
- **...**: Further arguments passed to methods. Not used.

**Value**

A `tibble::tibble()`
### Examples

```r
## Not run:
mc <- mc_cv(n = 100)
tidy(mc)
## End(Not run)
```

---

**tidy.radf_obj**  
*Tidy a radf_obj object*

---

### Description

Summarizes information about radf_obj object.

### Usage

```r
## S3 method for class 'radf_obj'
tidy(x, format = c("wide", "long"), panel = FALSE, ...)
```

```r
## S3 method for class 'radf_obj'
augment(x, format = c("wide", "long"), panel = FALSE, ...)
```

### Arguments

- **x**  
  An object of class radf_obj.

- **format**  
  Long or wide format (default = "wide").

- **panel**  
  If TRUE then returns the panel statistics

- **...**  
  Further arguments passed to methods. Not used.

### Value

A `tibble::tibble()`

### Examples

```r
dta <- data.frame(psy1 = sim_psy1(n = 100), psy2 = sim_psy2(n = 100))

rfd <- radf(dta)

# Get the test statistic
tidy(rfd)

# Get the test statistic sequences
augment(rfd)

# Get the panel test statistic
```
tidy(rfd, panel = TRUE)

tidy_join

**Tidy into a joint model**

**Description**
Tidy or augment and then join objects.

**Usage**

```r
 tidy_join(x, y, ...)
 augment_join(x, y, ...)
```

**Arguments**

- `x`: An object of class `obj`.
- `y`: An object of class `cv`.
- `...`: Further arguments passed to methods.

**Details**
tidy_join also calls augment_join when cv is of class sb_cv.
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