Package 'atRisk'

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Title At-Risk

Version 0.2.0

Description The at-Risk (aR) approach is based on a two-step parametric estimation procedure that allows to forecast the full conditional distribution of an economic variable at a given horizon, as a function of a set of factors. These density forecasts are then be used to produce coherent forecasts for any downside risk measure, e.g., value-at-risk, expected shortfall, downside entropy. Initially introduced by Adrian et al. (2019) <doi:10.1257/aer.20161923> to reveal the vulnerability of economic growth to financial conditions, the aR approach is currently extensively used by international financial institutions to provide Value-at-Risk (VaR) type forecasts for GDP growth (Growth-at-Risk) or inflation (Inflation-at-Risk). This package provides methods for estimating these models. Datasets for the US and the Eurozone are available to allow testing of the Adrian et al. (2019) model. This package constitutes a useful toolbox (data and functions) for private practitioners, scholars as well as policymakers.

Depends R (>= 3.5.0)

License GPL-3

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Contents

`data_euro` *Historical data for the eurozone (GDP and Financial Conditions) from 2008:Q4 to 2022:Q3*

Description

data_euro contains: - Quarterly annualized GDP, from 2008:Q4 to 2022:Q3 - Financial Condition Index of the euro Area, from 2008:Q4 to 2022:Q3 - Composite Indicator of Systemic Stress, from 2008:Q4 to 2022:Q3 Sources : https://sdw.ecb.europa.eu/browseExplanation.do?node=9689686 https://webstat.banque-france.fr/ws_wsen/browseSelection.do?node=DATASETS_FCI https://fred.stlouisfed.org/series/CLVMEURSCAB1GQEA1

Usage

```
data("data_euro")
```

Format

A data frame with 56 observations on the following 4 variables.

`DATE` Vector of dates.

`GDP` Vector of annualized PIB.

`FCI` Historical values of the Financial Condition Index (FCI).

`CISS` Historical values of the Composite Indicator of Systemic Stress (CISS).

data_param_histo_US *Historical parameters (skew-t) for the US from 1973:Q1 to 2020:Q1*

Description

Data corresponding to historical parameters estimated over the period 1973:Q1 to 2020:Q1, based on the data_US file in the matrisk package, with the skew-t distribution, and calculated with the f_param_histo function. data_param_histo_US has been calculated using c(0.05,0.25,0.75,0.95) for the qt_trgt parameter, PIB_us_forward_1 as the dependent variable, NFCI_us_lag_1 as the explanatory variable, "skew-t" for the type_function parameter and c(0, 1, -0.5, 1.3) for the starting_values.

Usage

```
data("data_param_histo_US")
```

Format

A matrix with 188 rows and 4 columns for the four parameters of the skew-t distribution).

data_US *Historical data for the US (GDP and Financial Conditions) from 1973:Q1 to 2020:Q1*

Description

data_euro contains: - Quarterly annualized GDP, from 1973:Q1 to 2020:Q1 - National Financial Condition Index of the US, from 1973:Q1 to 2020:Q1 Sources : https://www.chicagofed.org/research/data/nfci/current-data https://fred.stlouisfed.org/series/A191RL1Q225SBEA

Usage

```
data("data_US")
```

Format

A data frame with 189 observations on the following 3 variables.

`DATE` Vector of dates.

`GDP` Vector of annualized PIB.

`NFCI` Historical values of the National Financial Condition Index (NFCI).

`f_compile_quantile` *Estimation of quantiles*

Description

Predicted values based on each quantile regression (Koenker and Basset, 1978), at time=t_trgt, for each quantile in qt_trgt.

Usage

```
f_compile_quantile(qt_trgt, v_dep, v_expl, newdata = NULL)
```

Arguments

`qt_trgt`	Numeric vector, dim k, of k quantiles for different qt-estimations
`v_dep`	Numeric vector of the dependent variable
`v_expl`	Numeric vector or matrix of the (k) explanatory covariate(s)
`newdata`	Numeric optional vector of the (k) out of sample explanatory covariate(s)

Value

A list with the following elements:

`quantile_target`	Numeric vector, dim k, of k quantiles for different qt-estimations.
`results_qt`	Numeric matrix with all the predicted values based on each quantile regression, where each column corresponds to a quantile target. This matrix includes out-of-sample values of the dependent variable if 'newdata' is specified.

References

Koenker, Roger, and Gilbert Bassett Jr. "Regression quantiles." Econometrica: journal of the Econometric Society (1978): 33-50.

Examples

```
# Import data
data("data_euro")

# Data process
PIB_euro_forward_4 = data_euro["GDP"][c(5:length(data_euro["GDP"][,1])),]
FCI_euro_lag_4 = data_euro["FCI"][c(1:(length(data_euro["GDP"][,1]) - 4)),]
CISS_euro_lag_4 = data_euro["CISS"][c(1:(length(data_euro["GDP"][,1]) - 4)),]

quantile_target <- as.vector(c(0.10,0.25,0.75,0.90))
results_quantile_reg <- f_compile_quantile(qt_trgt=quantile_target,
v_dep=PIB_euro_forward_4,
v_expl=as.matrix(cbind(FCI_euro_lag_4, CISS_euro_lag_4)))
```

f_distrib *Distribution*

Description

This function is used to estimate the parameters of the distribution for each period (mean and standard deviation for Gaussian Distribution, xi, omega and alpha for Skew-Normal Distribution, and xi, omega, alpha, and nu for t-student Distribution) based on the quantile regression results (Koenker and Basset, 1978). See Adrian et al. (2019) and Adrian et al. (2022) for more details on the estimation steps.

Usage

```
f_distrib(type_function, compile_qt, starting_values, tolerance = 1e-06)
```

Arguments

type_function	String argument : "gaussian" for Normal Distribution, "skew-gaussian" for Skew-Normal Distribution or "skew-t" for t-student Distribution
compile_qt	List containing the results of f_compile_quantile function
starting_values	Numeric vector with initial values for optimization
tolerance	Numeric optional for the convergence tolerance. Iteration is terminated when the absolute difference in function value between successive iteration is below tol (default value = 1.e-06).

Value

Dataframe with the parameters of the distribution for each period. This dataframe includes out of sample values of the paramateres if newdata has been specified in f_compile_quantile.

References

Adrian, Tobias, Nina Boyarchenko, and Domenico Giannone. "Vulnerable growth." American Economic Review 109.4 (2019): 1263-89.

Adrian, Tobias, et al. "The term structure of growth-at-risk." American Economic Journal: Macroeconomics 14.3 (2022): 283-323.

Koenker, Roger, and Gilbert Bassett Jr. "Regression quantiles." Econometrica: journal of the Econometric Society (1978): 33-50.

Azzalini, Adelchi. "The skew-normal and related families." Vol. 3. Cambridge University Press (2013).

Examples

```
# Import data
data("data_euro")

# Data process
PIB_euro_forward_4 = data_euro["GDP"][c(5:length(data_euro["GDP"][,1])),]
FCI_euro_lag_4 = data_euro["FCI"][c(1:(length(data_euro["GDP"][,1]) - 4)),]
CISS_euro_lag_4 = data_euro["CISS"][c(1:(length(data_euro["GDP"][,1]) - 4)),]

# for a gaussian
quantile_target <- as.vector(c(0.25,0.75))
results_quantile_reg <- f_compile_quantile(qt_trgt=quantile_target,
v_dep=PIB_euro_forward_4,
v_expl=cbind(FCI_euro_lag_4, CISS_euro_lag_4))

results_g <- f_distrib(type_function="gaussian",
compile_qt=results_quantile_reg,
starting_values=c(0, 1))

# for a skew-t
quantile_target <- as.vector(c(0.10,0.25,0.75,0.90))
results_quantile_reg <- f_compile_quantile(qt_trgt=quantile_target,
v_dep=PIB_euro_forward_4,
v_expl=cbind(FCI_euro_lag_4, CISS_euro_lag_4))

results <- f_distrib(type_function="skew-t",
compile_qt=results_quantile_reg,
starting_values=c(0, 0.5, 0, 2), tolerance=1e-05)
```

---

f_ES *Expected Shortfall*

Description

The function allows to calculate Expected-shortfall for a given distribution. It takes as parameters alpha (risk level), a distribution and the parameters associated with this distribution. For example, for a normal distribution, the user must enter the mean and the standard deviation. Currently, the function can calculate the Expected-shortfall for the normal distribution, the skew-normal distribution and for the skew-t distribution (Azzalini and Capitianio, 2003)

Usage

```
f_ES(alpha, type_function, params, accuracy = 0.005)
```

Arguments

alpha	Numeric argument for Expected-Shortfall, between 0 and 1
type_function	String argument : "gaussian" for normal distribution, "skew-gaussian" for Skew-Normal Distribution or "skew-t" for t-student distribution
params	Numeric vector containing parameters of the distribution
accuracy	Scalar value which regulates the accuracy of the ES (default value 1e-05)

Value

Numeric value for the expected-shortfall given the distribution and the alpha risk.

References

Azzalini, Adelchi, and Antonella Capitanio. "Distributions generated by perturbation of symmetry with emphasis on a multivariate skew t-distribution." Journal of the Royal Statistical Society: Series B (Statistical Methodology) 65.2 (2003): 367-389.

Azzalini, Adelchi, and Maintainer Adelchi Azzalini. "Package 'sn'." The skew-normal and skew-t distributions (2015): 1-3.

Examples

```
f_ES(0.95, "gaussian", params=c(0,1))
f_ES(0.95, "gaussian", params=c(0,1), accuracy=1e-05)
f_ES(0.95, "gaussian", params=c(0,1), accuracy=1e-04)
```

---

f_histo_RM *Historical parameters*

Description

This function allows to calculate historical historical parameters and the VaR and ES for each historical period.

Usage

```
f_histo_RM(param_histo, type_function, alpha)
```

Arguments

param_histo	Dataframe with the parameters of the distribution for each period.
type_function	String argument : "gaussian" for Normal Distribution, "skew-gaussian" for Skew-Normal Distribution or "skew-t" for t-student distribution
alpha	Numeric argument for Expected-Shortfall, between 0 and 1

Value

A list with historical estimated coefficients, VaR(alpha) and ES(alpha)

Examples

```
data("data_euro")

# Data process
PIB_euro_forward_4 = data_euro["GDP"][c(5:length(data_euro["GDP"][,1])),]
FCI_euro_lag_4 = data_euro["FCI"][c(1:(length(data_euro["GDP"][,1]) - 4)),]
CISS_euro_lag_4 = data_euro["CISS"][c(1:(length(data_euro["GDP"][,1]) - 4)),]

results_quantile_reg <- f_compile_quantile(qt_trgt=as.vector(c(0.10,0.25,0.75,0.90)),
v_dep=PIB_euro_forward_4,
v_expl=cbind(FCI_euro_lag_4, CISS_euro_lag_4))

histo_param <- f_distrib(type_function="skew-t",
compile_qt=results_quantile_reg,
starting_values=c(0, 1, -0.5, 1.3))

# for a skew-t
results_s <- f_histo_RM(param_histo = histo_param,
type_function="skew-t",
alpha=0.95)
```

---

f_nadaraya_watson_quantile

Estimation of quantiles using the Nadaraya-Watson estimator with a product kernel

---

Description

This function performs quantile regression using the Nadaraya-Watson estimator with a product kernel. It computes the weights using a Gaussian kernel for each dimension of the explanatory variables and then estimates the quantile using a weighted average of the observed responses.

Usage

```
f_nadaraya_watson_quantile(v_dep, v_expl, qt_trgt, bandwidth)
```

Arguments

v_dep	Numeric vector of the dependent variable
v_expl	Numeric vector or matrix of the (k) explanatory covariate(s)
qt_trgt	Numeric vector, dim k, of k quantiles for different qt-estimations
bandwidth	Numeric value specifying the bandwidth for the Gaussian kernel

Value

Numeric matrix with all the predicted values based on each quantile regression, where each column corresponds to a quantile target.

Examples

```
# Data process
set.seed(123)
Y <- as.vector(rnorm(100))
X <- matrix(rnorm(200), ncol = 2)
quantile_target <- c(0.1, 0.5, 0.9)
bandwidth_value <- 0.5

results_qt <- f_nadaraya_watson_quantile(v_dep=Y,
v_expl=X,
qt_trgt=quantile_target,
bandwidth=bandwidth_value)
```

---

f_plot_distrib_2D *Plot of historical distributions in 2D*

Description

This function allows to create a plot in 2D of historical distributions.

Usage

```
f_plot_distrib_2D(
  m_param_histo,
  type_function,
  v_date = NULL,
  v_var_dep,
  x_lab,
  y_lab,
  x_min = NULL,
  x_max = NULL,
  color_theme = c("#bd8e42", "gray30", "#876b3a", "khaki1")
)
```

Arguments

m_param_histo	Numeric matrix containing the parameters of the f_param_histo function
type_function	String argument specifying the distribution type (gaussian, skew-gaussian or skew-t)
v_date	Vector optional of dates containing the full sample's dates (default value : daily dates starting from "1970-01-01")

v_var_dep	Numeric vector containing the realization of the dependent variable
x_lab	String optional argument for the x axis title (default value = x)
y_lab	String optionalargument for the y axis title (default value = y)
x_min	Numeric optional argument (default value = VaR 97.5)
x_max	Numeric optional argument (default value = VaR 2.5)
color_theme	A character vector specifying the color theme to use (default value c("#bd8e42","gray30","#876b3a","khal

Value

A plot of historical distributions with the median, four quantiles (5th, 25th, 75th, 95th) and the realized dependent variable.

Examples

```
# Import data
data(data_US)
data(data_param_histo_US)

results_plot_2D <- f_plot_distrib_2D(m_param_histo=data_param_histo_US,
type_function="skew-t",
v_date=data_US[,1],
v_var_dep=data_US[,2],
x_lab="US GDP variation",
y_lab="Year")
```

---

f_plot_distrib_3D *Plot of historical distributions in 3D*

Description

This function allows to create a plot in 3D of historical distributions.

Usage

```
f_plot_distrib_3D(
  m_param_histo,
  type_function,
  v_date = NULL,
  n_samples = 10000,
  x_min = NULL,
  x_max = NULL,
  x_lab,
  y_lab,
  color_theme = c("#bd8e42", "#bebfbf")
)
```

Arguments

m_param_histo	Numeric matrix containing the parameters of the f_param_histo function
type_function	String argument specifying the distribution type ("gaussian", "skew-gaussian" or "skew-t")
v_date	Vector optional of dates containing the full sample's dates (default value : daily dates starting from "1970-01-01")
n_samples	Number optional of samples for the plot (default value = 1000)
x_min	Numeric optional argument (default value = VaR 97.5)
x_max	Numeric optional argument (default value = VaR 2.5)
x_lab	String optional argument for the x axis title (default value = x)
y_lab	String optional argument for the y axis title (default value = y)
color_theme	A character vector specifying the color theme to use (default value c("#bd8e42", "#bebfbf"))

Value

A plot in 3D of historical distributions

Examples

```
# Import data
data(data_US)

data(data_param_histo_US)

results_plot_3D <- f_plot_distrib_3D(m_param_histo=data_param_histo_US,
type_function="skew-t",
v_date=data_US[,1],
x_lab="US GDP variation",
y_lab="Year")
```

---

f_VaR *Value-at-Risk*

Description

The function allows to calculate Value-at-Risk for a given distribution. It takes as parameters alpha (risk level), a distribution and the parameters associated with this distribution. For example, for a normal distribution, the user must enter the mean and the standard deviation. Currently, the function can calculate the Value-at-Risk for the normal distribution and for the skew-t distribution (Azzalini and Capitianio, 2003)

Usage

```
f_VaR(alpha, type_function, params)
```

Arguments

alpha	Numeric argument for Expected-Shortfall, between 0 and 1
type_function	String argument : "gaussian" for Normal Distribution, "skew-gaussian" for Skew-Normal Distribution or "skew-t" for T-student Distribution
params	Numeric vector containing parameters of the distribution

Value

Numeric value for the Value-at-Risk given the distribution and the alpha risk

References

Azzalini, Adelchi, and Antonella Capitanio. "Distributions generated by perturbation of symmetry with emphasis on a multivariate skew t-distribution." Journal of the Royal Statistical Society: Series B (Statistical Methodology) 65.2 (2003): 367-389.

Azzalini, Adelchi, and Maintainer Adelchi Azzalini. "Package 'sn'." The skew-normal and skew-t distributions (2015): 1-3.

Examples

```
f_VaR(0.95, "gaussian", params=c(0,1))
```

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