

Package ‘smqf’

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Description

Provides data and functions used in the book “Statistical Methods in Quantitative Finance” by David Ardia (2026).

License GPL-3

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BugReports <https://github.com/ArdiaD/smqf-package/issues>

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Author David Ardia [aut, cre] (ORCID: <<https://orcid.org/0000-0003-2823-782X>>),
Marius Hofert [ctb, cph] (Original author of qrmdata, from which 14
market datasets were ported under GPL-2 | GPL-3),
Kurt Hornik [ctb, cph] (Original author of qrmdata, from which 14
market datasets were ported under GPL-2 | GPL-3),
Alexander J. McNeil [ctb, cph] (Original author of qrmdata, from which
14 market datasets were ported under GPL-2 | GPL-3)

Maintainer David Ardia <david.ardia.ch@gmail.com>

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CAC

CAC 40 Index (Daily, xts)

Description

Daily adjusted close prices of the Cotation Assistée en Continu (CAC 40) stock index (ticker symbol ^FCHI), from its first date of availability on Yahoo Finance to 2015-12-31.

Usage

```
data("CAC")
```

Format

An xts object with 6549 daily observations and a single column ^FCHI containing adjusted close prices in index points. The time index spans from 1990-03-01 to 2015-12-31.

Details

Originally distributed as CAC in the **qrmdata** package (Hofert, Hornik, & McNeil), ported into **smqf** so that the book's examples remain reproducible without an extra dependency. The data is redistributed here under the same GPL (≥ 2) license as **qrmdata**.

Source

Yahoo Finance, downloaded on 2016-01-03 via `qrmtools::get_data()`.

References

Hofert, M., Hornik, K., & McNeil, A. J. *qrmdata: Data Sets for Quantitative Risk Management Practice*, <https://CRAN.R-project.org/package=qrmdata>.

Examples

```
data("CAC")
class(CAC)      # "xts" "zoo"
dim(CAC)
head(CAC)
```

DAX

DAX Index (Daily, xts)

Description

Daily adjusted close prices of the Deutscher Aktienindex (DAX) stock index (ticker symbol ^GDAXI), from its first date of availability on Yahoo Finance to 2015-12-30.

Usage

```
data("DAX")
```

Format

An xts object with 6355 daily observations and a single column ^GDAXI containing adjusted close prices in index points. The time index spans from 1990-11-26 to 2015-12-30.

Details

Originally distributed as DAX in the **qrmdata** package (Hofert, Hornik, & McNeil), ported into **smqf** so that the book's examples remain reproducible without an extra dependency. The data is redistributed here under the same GPL (≥ 2) license as **qrmdata**.

Source

Yahoo Finance, downloaded on 2016-01-03 via `qrmtools::get_data()`.

References

Hofert, M., Hornik, K., & McNeil, A. J. *qrmdata: Data Sets for Quantitative Risk Management Practice*, <https://CRAN.R-project.org/package=qrmdata>.

Examples

```
data("DAX")
class(DAX)      # "xts" "zoo"
dim(DAX)
head(DAX)
```

DJ

Dow Jones Industrial Average Index (Daily, xts)

Description

Daily adjusted close prices of the Dow Jones Industrial Average (ticker symbol `^DJI`), from its first date of availability on Yahoo Finance to 2015-12-31.

Usage

```
data("DJ")
```

Format

An `xts` object with 7797 daily observations and a single column `^DJI` containing adjusted close prices in index points. The time index spans from 1985-01-29 to 2015-12-31.

Details

Originally distributed as `DJ` in the `qrmdata` package (Hofert, Hornik, & McNeil), ported into `smqf` so that the book's examples remain reproducible without an extra dependency. The data is redistributed here under the same GPL (≥ 2) license as `qrmdata`.

Source

Yahoo Finance, downloaded on 2016-01-03 via `qrmtools::get_data()`.

References

Hofert, M., Hornik, K., & McNeil, A. J. *qrmdata: Data Sets for Quantitative Risk Management Practice*, <https://CRAN.R-project.org/package=qrmdata>.

Examples

```
data("DJ")
class(DJ)      # "xts" "zoo"
dim(DJ)
head(DJ)
```

| | |
|----------|---|
| DJ_const | <i>Dow Jones Industrial Average Constituents (Daily, xts)</i> |
|----------|---|

Description

Daily adjusted close prices for the 30 constituents of the Dow Jones Industrial Average as of 2016-01-03.

Usage

```
data("DJ_const")
```

Format

An xts object with 13595 daily observations and 30 columns, one per constituent (e.g., AAPL, IBM, JPM, XOM). Missing values appear before the first date at which a given constituent was available. The time index spans from 1962-01-02 to 2015-12-31.

Details

Originally distributed as DJ_const in the **qrmdata** package (Hofert, Hornik, & McNeil), ported into **smqf** so that the book's examples remain reproducible without an extra dependency. The data is redistributed here under the same GPL (≥ 2) license as **qrmdata**.

Source

Yahoo Finance, downloaded on 2016-01-03 via `qrmtools::get_data()`.

References

Hofert, M., Hornik, K., & McNeil, A. J. *qrmdata: Data Sets for Quantitative Risk Management Practice*, <https://CRAN.R-project.org/package=qrmdata>.

Examples

```
data("DJ_const")
class(DJ_const)      # "xts" "zoo"
dim(DJ_const)
head(colnames(DJ_const))
```

| | |
|----------|---|
| EURSTOXX | <i>Euro Stoxx 50 Index (Daily, xts)</i> |
|----------|---|

Description

Daily adjusted close prices of the Euro Stoxx 50 stock index (ticker symbol `^STOXX50E`), from its first date of availability on Yahoo Finance to 2015-12-23.

Usage

```
data("EURSTOXX")
```

Format

An `xts` object with 7445 daily observations and a single column `^STOXX50E` containing adjusted close prices in index points. The time index spans from 1986-12-31 to 2015-12-23.

Details

Originally distributed as `EURSTOXX` in the `qrmdata` package (Hofert, Hornik, & McNeil), ported into `smqf` so that the book's examples remain reproducible without an extra dependency. The data is redistributed here under the same GPL (≥ 2) license as `qrmdata`.

Source

Yahoo Finance, downloaded on 2016-01-03 via `qrmtools::get_data()`.

References

Hofert, M., Hornik, K., & McNeil, A. J. *qrmdata: Data Sets for Quantitative Risk Management Practice*, <https://CRAN.R-project.org/package=qrmdata>.

Examples

```
data("EURSTOXX")
class(EURSTOXX)      # "xts" "zoo"
dim(EURSTOXX)
head(EURSTOXX)
```

EURSTX_const

Euro Stoxx 50 Constituents (Daily, xts)

Description

Daily adjusted close prices for the 50 constituents of the Euro Stoxx 50 stock index as of 2016-01-03.

Usage

```
data("EURSTX_const")
```

Format

An xts object with 4174 daily observations and 50 columns, one per constituent (e.g., SAP.DE, BNP.PA, SAN.MC). Missing values appear before the first date at which a given constituent was available. The time index spans from 2000-01-03 to 2015-12-31.

Details

Originally distributed as EURSTX_const in the **qrmdata** package (Hofert, Hornik, & McNeil), ported into **smqf** so that the book's examples remain reproducible without an extra dependency. The data is redistributed here under the same GPL (≥ 2) license as **qrmdata**.

Source

Yahoo Finance, downloaded on 2016-01-03 via `qrmtools::get_data()`.

References

Hofert, M., Hornik, K., & McNeil, A. J. *qrmdata: Data Sets for Quantitative Risk Management Practice*, <https://CRAN.R-project.org/package=qrmdata>.

Examples

```
data("EURSTX_const")
class(EURSTX_const)      # "xts" "zoo"
dim(EURSTX_const)
head(colnames(EURSTX_const))
```

FamaFrenchMonthly *Fama–French Factors (Monthly, xts)*

Description

Monthly time series of the three Fama–French equity risk factors and the risk-free rate, as provided by Kenneth French’s data library. Values are expressed in **percentage points** (e.g., -1.20 means a return of -1.20%).

Usage

```
data("FamaFrenchMonthly")
```

Format

An xts object with 360 monthly observations (from 1969-01-01 to 1998-12-01) and 4 columns:

mkt_rf Excess return on the market (market return minus risk-free rate), in %.

smb Small-Minus-Big size factor return, in %.

hml High-Minus-Low value factor return, in %.

rf Risk-free rate (monthly), in %.

Details

The time index is set to the first calendar day of each month. Divide by 100 to convert to decimal returns before use in calculations. For the weekly version of this dataset see [FamaFrenchWeekly](#).

Source

Kenneth R. French Data Library, https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

References

Fama, E. F., & French, K. R. (1993). Common Risk Factors in the Returns on Stocks and Bonds. *Journal of Financial Economics*, 33(1), 3–56.

See Also

[FamaFrenchWeekly](#) for the higher-frequency (weekly, 1926-2019) companion dataset built from the same Kenneth French source. The two datasets are pedagogically complementary: the monthly version is convenient for low-frequency factor-model illustrations, while the weekly version offers a much longer sample for time-series exercises.

Examples

```
data("FamaFrenchMonthly")
class(FamaFrenchMonthly)      # "xts" "zoo"
dim(FamaFrenchMonthly)       # 360 x 4
head(FamaFrenchMonthly)

# Convert to decimal and extract the three equity factors
ff <- FamaFrenchMonthly[, c("mkt_rf", "smb", "hml")] / 100
rf <- FamaFrenchMonthly[, "rf"] / 100
```

| | |
|------------------|--|
| FamaFrenchWeekly | <i>Fama–French Factors (Weekly, xts)</i> |
|------------------|--|

Description

Weekly time series of the three Fama–French equity risk factors and the risk-free rate, as provided by Kenneth French’s data library. Values are expressed in **percentage points** (e.g., 1.60 means a return of 1.60%).

Usage

```
data("FamaFrenchWeekly")
```

Format

An xts object with 4,834 weekly observations (from 1926-07-02 to 2019-02-22) and 4 columns:

mkt_rf Excess return on the market (market return minus risk-free rate), in %.

smb Small-Minus-Big size factor return, in %.

hml High-Minus-Low value factor return, in %.

rf Risk-free rate (weekly), in %.

Details

Divide by 100 to convert to decimal returns before use in calculations. For the monthly version of this dataset see [FamaFrenchMonthly](#).

Source

Kenneth R. French Data Library, https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

References

Fama, E. F., & French, K. R. (1993). Common Risk Factors in the Returns on Stocks and Bonds. *Journal of Financial Economics*, 33(1), 3–56.

See Also

[FamaFrenchMonthly](#) for the lower-frequency (monthly, 1969-1998) companion dataset built from the same Kenneth French source. The two datasets are pedagogically complementary: the weekly version offers a much longer sample for time-series exercises, while the monthly version is convenient for low-frequency factor-model illustrations.

Examples

```
data("FamaFrenchWeekly")
class(FamaFrenchWeekly)      # "xts" "zoo"
dim(FamaFrenchWeekly)       # 4834 x 4
head(FamaFrenchWeekly)

# Convert to decimal and extract the three equity factors
ff <- FamaFrenchWeekly[, c("mkt_rf", "smb", "hml")] / 100
rf <- FamaFrenchWeekly[, "rf"] / 100
```

| | |
|------|---|
| Fred | <i>FRED-MD Macro Factors and Dow Jones Returns (Monthly, 2015–2019)</i> |
|------|---|

Description

A list containing a matrix of 128 FRED-MD macroeconomic predictors and a vector of monthly Dow Jones Industrial Average log-returns, aligned over the period 2015-01 to 2019-12. Used to illustrate high-dimensional regularised regression (Lasso, Ridge) in a return-prediction context.

Usage

```
data("Fred")
```

Format

A named list with two components:

- X** A 60×128 numeric matrix of standardised FRED-MD macro variables (monthly, January 2015 to December 2019). Row names are "YYYY-MM-01" strings; column names are FRED-MD series codes (e.g., "INDPRO", "CPIAUCSL", "GS10"). The series have been transformed (differenced or log-differenced) to achieve stationarity following the FRED-MD transformation codes.
- y** A 60×1 numeric matrix of one-month-ahead Dow Jones Industrial Average log-returns (column name "DJI.Adjusted"), shifted so that row t of X predicts row t of y .

Details

The predictors in X were downloaded from the McCracken–Ng FRED-MD database and transformed according to the recommended stationarity codes. The target y was obtained from Yahoo Finance via `quantmod::getSymbols("^DJI")` and converted to monthly log-returns. Both series are restricted to the 60-month window 2015-01 to 2019-12 and temporally aligned so that $X[t,]$ can be used to predict $y[t]$.

Source

- McCracken, M. W., & Ng, S. FRED-MD database, <https://www.stlouisfed.org/research/economists/mccracken/fred-databases>.
- Dow Jones daily prices via `quantmod::getSymbols("^DJI")`, Yahoo Finance.

References

McCracken, M. W., & Ng, S. (2016). FRED-MD: A Monthly Database for Macroeconomic Research. *Journal of Business & Economic Statistics*, 34(4), 574–589.

See Also

The book chapter on *Dimension Reduction* (Chapter 4 of *Statistical Methods in Quantitative Finance*) introduces Lasso and Ridge regression on the lower-dimensional [GoyalWelch](#) dataset; Fred provides a complementary high-dimensional ($p \gg n$) test bed for the same regularised-regression workflow.

Examples

```
data("Fred")
X <- Fred$X # 60 x 128 macro predictors
y <- Fred$y # 60 x 1 DJ log-returns
dim(X)
head(rownames(X))

# Lasso with cross-validation (requires glmnet)
if (requireNamespace("glmnet", quietly = TRUE)) {
  set.seed(1234)
  fit <- glmnet::cv.glmnet(X, y, alpha = 1)
  coef(fit, s = "lambda.min")[coef(fit, s = "lambda.min")[,1] != 0, , drop = FALSE]
}
```

 FTSE

FTSE 100 Index (Daily, xts)

Description

Daily adjusted close prices of the FTSE 100 stock index (ticker symbol ^FTSE), from its first date of availability on Yahoo Finance to 2015-12-31.

Usage

```
data("FTSE")
```

Format

An xts object with 8333 daily observations and a single column `^FTSE` containing adjusted close prices in index points. The time index spans from 1984-01-03 to 2015-12-31.

Details

Originally distributed as FTSE in the **qrmdata** package (Hofert, Hornik, & McNeil), ported into **smqf** so that the book's examples remain reproducible without an extra dependency. The data is redistributed here under the same GPL (≥ 2) license as **qrmdata**.

Source

Yahoo Finance, downloaded on 2016-01-03 via `qrmtools::get_data()`.

References

Hofert, M., Hornik, K., & McNeil, A. J. *qrmdata: Data Sets for Quantitative Risk Management Practice*, <https://CRAN.R-project.org/package=qrmdata>.

Examples

```
data("FTSE")
class(FTSE)      # "xts" "zoo"
dim(FTSE)
head(FTSE)
```

FTSE_const

FTSE 100 Constituents (Daily, xts)

Description

Daily adjusted close prices for 98 constituents of the FTSE 100 stock index as of 2016-01-03.

Usage

```
data("FTSE_const")
```

Format

An xts object with 7198 daily observations and 98 columns, one per constituent (e.g., HSBA.L, BP.L, VOD.L). Missing values appear before the first date at which a given constituent was available. The time index spans from 1988-05-03 to 2015-12-31.

Details

Originally distributed as `FTSE_const` in the **qrmdata** package (Hofert, Hornik, & McNeil), ported into **smqf** so that the book's examples remain reproducible without an extra dependency. The data is redistributed here under the same GPL (≥ 2) license as **qrmdata**. Only 98 of the 100 constituents were available at the time of the download.

Source

Yahoo Finance, downloaded on 2016-01-03 via `qrmtools::get_data()`.

References

Hofert, M., Hornik, K., & McNeil, A. J. *qrmdata: Data Sets for Quantitative Risk Management Practice*, <https://CRAN.R-project.org/package=qrmdata>.

Examples

```
data("FTSE_const")
class(FTSE_const)      # "xts" "zoo"
dim(FTSE_const)
head(colnames(FTSE_const))
```

FungHsieh

Fung–Hsieh Factors (Monthly, xts)

Description

Monthly time series of commonly used Fung–Hsieh style and macro factors. The object is an `xts` matrix with a monthly index and the columns listed below. Typical use cases include hedge-fund replication and factor attribution.

Usage

```
data("FungHsieh")
```

Format

An `xts` object with 276 monthly observations (from 1994-01 to 2016-12) and 8 columns:

EMKT Equity market factor (broad market return / excess return).

RF Risk-free rate (monthly).

SS Size or related equity style spread (e.g., small–minus–big).

CST10Y Change in the 10-year U.S. Treasury constant-maturity yield.

BAA Change in a BAA credit spread / yield (credit conditions).

PTFSBD Fung–Hsieh trend-following factor: bond.

PTFSCOM Fung–Hsieh trend-following factor: commodity.

PTFSFX Fung–Hsieh trend-following factor: currency (FX).

Details

Columns are provided as in the original Fung–Hsieh factor construction. Units may appear as percentage points or basis points depending on source/ vintage; treat the series consistently within your analysis. The time index is monthly and stored in UTC; the object class is `c("xts", "zoo")`.

Source

Compiled from public factor sources commonly used in the Fung–Hsieh literature (e.g., Hsieh’s data library, FRED/H.15, and Fama–French style factors). If you distribute the data, include a `data-raw/` script that reproduces this object from original sources.

References

Fung, W., & Hsieh, D. A. (2004). Hedge Fund Benchmarks: A Risk-Based Approach. *Financial Analysts Journal*, 60(5), 65–80. Fung, W., & Hsieh, D. A. (2001). The Risk in Hedge Fund Strategies: Theory and Evidence from Trend Followers. *Review of Financial Studies*, 14(2), 313–341.

Examples

```
data("FungHsieh")
class(FungHsieh)      # "xts" "zoo"
head(FungHsieh)
colnames(FungHsieh)
# Quick plot of the three PTFS factors
if (requireNamespace("zoo", quietly = TRUE)) {
  zoo::plot.zoo(FungHsieh[, c("PTFSBD", "PTFSCOM", "PTFSFX")], screens = 1, col = 1:3)
}
```

f_clayton_copula_2d_pdf

Clayton Copula PDF (2-Dimensional)

Description

Computes the value of the bivariate Clayton copula probability density function (PDF) at a specified point (u_1, u_2) for a given dependence parameter θ .

Usage

```
f_clayton_copula_2d_pdf(u, theta)
```

Arguments

| | |
|-------|---|
| u | Numeric vector of length 2, containing values in the interval $(0, 1]$ representing the evaluation point (u_1, u_2) . |
| theta | Numeric scalar giving the dependence parameter $(\theta \geq 0)$. The value $\theta = 0$ is the independence limit. |

Details

The Clayton copula is an Archimedean copula with lower-tail dependence $\lambda_L = 2^{-1/\theta}$ and no upper-tail dependence ($\lambda_U = 0$). When $\theta = 0$, the copula reduces to the independence copula, whose PDF equals 1 for all $(u_1, u_2) \in [0, 1]^2$.

The PDF is given by:

$$c(u_1, u_2; \theta) = (1 + \theta) (u_1 u_2)^{-(1+\theta)} (u_1^{-\theta} + u_2^{-\theta} - 1)^{-2-1/\theta}.$$

Numerical computation may lose precision for large θ (typically above about 34).

Value

A numeric value corresponding to the Clayton copula PDF evaluated at the specified point.

References

- Joe, H. (1997). *Multivariate Models and Dependence Concepts*. Chapman & Hall. - Patton, A. (2006). Modelling Asymmetric Exchange Rate Dependence. *International Economic Review*, 47(2), 527–556.

See Also

[f_gumbel_copula_2d_pdf](#), [f_normal_copula_pdf](#), [f_student_copula_pdf](#)

Examples

```
# Example: Evaluate Clayton copula PDF at (u1, u2) = (0.5, 0.5)
f_clayton_copula_2d_pdf(c(0.5, 0.5), theta = 2)
```

f_display_copula

Display a Bivariate Copula Surface

Description

Evaluates and displays a bivariate copula function (typically a PDF or CDF) on a 2D grid, producing a static 3D surface via base R's `persp()`.

Usage

```
f_display_copula(my_copula, grid_1, grid_2, plot = TRUE)
```

Arguments

| | |
|----------------|--|
| my_copula | A function that takes a numeric vector $c(u_1, u_2)$ as input and returns a scalar value (e.g., a copula PDF or CDF). |
| grid_1, grid_2 | Numeric vectors defining the evaluation grid for u_1 and u_2 in the interval $[0, 1]$. |
| plot | Logical; if TRUE (the default), a 3D surface is drawn via <code>graphics::persp()</code> . If FALSE, no graphics device is opened and only the evaluated matrix is returned (useful for testing or non-interactive use). |

Details

This function provides a simple way to visualize the surface of a bivariate copula (e.g., Clayton, Gumbel, Gaussian). The copula function should accept a vector of two uniform values (u_1, u_2) and return its density or CDF value.

Value

Invisibly returns the matrix of evaluated copula values f_U , with rows corresponding to `grid_1` and columns to `grid_2`.

Examples

```
# Example: Display the Clayton copula PDF surface
grid <- seq(0.05, 0.95, length.out = 25)
f_display_copula(
  my_copula = function(u) f_clayton_copula_2d_pdf(u, theta = 2),
  grid_1 = grid,
  grid_2 = grid
)
```

f_efficient_frontier *Compute a Long-Only Mean-Variance Efficient Frontier*

Description

Solves a sequence of quadratic programs to trace the long-only, fully-invested Markowitz efficient frontier between the minimum-variance portfolio and the maximum-return (corner) portfolio.

Usage

```
f_efficient_frontier(mu, Sigma, n_ptf)
```

Arguments

| | |
|-------|--|
| mu | Numeric vector of length N : expected asset returns. |
| Sigma | Numeric $N \times N$ covariance matrix. Only the symmetric part is used internally. |
| n_ptf | Integer ≥ 2 : number of portfolios along the frontier (including the minimum-variance and maximum-return portfolios). |

Details

Portfolios are obtained by minimizing variance for a grid of target returns under the constraints $\sum_i w_i = 1$ and $w_i \geq 0$.

Each QP solves

$$\min_w w^\top \Sigma w \quad \text{s.t. } \mathbf{1}^\top w = 1, w \geq 0$$

and, for interior points on the frontier, additionally

$$\mu^\top w = \mu^*,$$

where μ^* spans a linear grid between the min-variance portfolio return and the single-asset maximum-return portfolio.

Requires **pracma** for quadprog. Numerical issues can arise if Sigma is not positive semidefinite or if target returns are infeasible under the long-only constraint.

Value

A list with components:

weights Numeric matrix $N \times n_{ptf}$: portfolio weights.

volatility Numeric length- n_{ptf} : portfolio standard deviations.

expected_returns Numeric length- n_{ptf} : portfolio expected returns.

frontier Data frame with columns point (integer index), expected_return, and volatility for each frontier portfolio.

targets Numeric vector of length n_{ptf} : the target-return grid used to trace the frontier.

References

Markowitz, H. (1952). Portfolio Selection. *Journal of Finance*, 7(1), 77–91.

See Also

[quadprog](#)

Examples

```
set.seed(1)
N <- 4
mu <- c(0.08, 0.10, 0.12, 0.09)
M <- matrix(rnorm(N*N), N); Sigma <- crossprod(M) / N # PSD covariance
ef <- f_efficient_frontier(mu, Sigma, n_ptf = 20)
# Inspect end points
ef$expected_returns[c(1, 20)]
ef$volatility[c(1, 20)]
```

 f_gumbel_copula_2d_cdf

Gumbel Copula CDF (2-Dimensional)

Description

Computes the bivariate Gumbel copula cumulative distribution function (CDF) at (u_1, u_2) for dependence parameter $\theta \geq 1$.

Usage

```
f_gumbel_copula_2d_cdf(u, theta)
```

Arguments

u Numeric vector of length 2 with entries in $(0, 1]$: the evaluation point (u_1, u_2) .
theta Numeric scalar, the Gumbel dependence parameter $\theta \geq 1$.

Details

The Gumbel copula exhibits upper-tail dependence $\lambda_U = 2 - 2^{1/\theta}$ and no lower-tail dependence ($\lambda_L = 0$). When $\theta = 1$, it reduces to the independence copula with $C(u_1, u_2) = u_1 u_2$.

The CDF is

$$C(u_1, u_2; \theta) = \exp\left(-\left[(-\log u_1)^\theta + (-\log u_2)^\theta\right]^{1/\theta}\right), \quad \theta \geq 1.$$

Value

A numeric scalar: $C(u_1, u_2; \theta)$.

References

Joe, H. (1997). *Multivariate Models and Dependence Concepts*. Chapman & Hall.
 Nelsen, R. B. (2006). *An Introduction to Copulas* (2nd ed.). Springer.

See Also

[f_gumbel_copula_2d_pdf](#), [f_clayton_copula_2d_pdf](#), [f_normal_copula_pdf](#), [f_student_copula_pdf](#)

Examples

```
f_gumbel_copula_2d_cdf(c(0.5, 0.8), theta = 2)
f_gumbel_copula_2d_cdf(c(0.7, 0.7), theta = 1) # independence: ~0.49
```

 f_gumbel_copula_2d_pdf

Gumbel Copula PDF (2-Dimensional)

Description

Computes the bivariate Gumbel copula probability density function (PDF) at (u_1, u_2) for dependence parameter $\theta \geq 1$.

Usage

```
f_gumbel_copula_2d_pdf(u, theta)
```

Arguments

u Numeric vector of length 2 with entries in $(0, 1]$: the evaluation point (u_1, u_2) .
theta Numeric scalar, the Gumbel dependence parameter $\theta \geq 1$.

Details

The PDF can be written as

$$c(u_1, u_2; \theta) = C(u_1, u_2; \theta) \frac{\{[-\log u_1] [-\log u_2]\}^{\theta-1}}{u_1 u_2} ((-\log u_1)^\theta + (-\log u_2)^\theta)^{1/\theta-2} \left(\{(-\log u_1)^\theta + (-\log u_2)^\theta\}^{\theta-1} \right)$$

When $\theta = 1$, $c(u_1, u_2; 1) \equiv 1$ (independence).

Value

A numeric scalar: $c(u_1, u_2; \theta)$.

Note

Numerical stability may degrade as $u_i \rightarrow 0^+$ (large $-\log u_i$).

References

Joe, H. (1997). *Multivariate Models and Dependence Concepts*. Chapman & Hall. Nelsen, R. B. (2006). *An Introduction to Copulas* (2nd ed.). Springer.

See Also

[f_gumbel_copula_2d_cdf](#), [f_clayton_copula_2d_pdf](#), [f_normal_copula_pdf](#), [f_student_copula_pdf](#)

Examples

```
f_gumbel_copula_2d_pdf(c(0.5, 0.8), theta = 2)
f_gumbel_copula_2d_pdf(c(0.7, 0.7), theta = 1) # independence: 1
```

f_normal_copula_pdf *Multivariate Normal Copula PDF*

Description

Computes the probability density function (PDF) of the Gaussian (normal) copula at a specified point $u \in [0, 1]^N$, given mean vector μ and covariance matrix Σ of the underlying multivariate normal distribution.

Usage

```
f_normal_copula_pdf(u, mu, Sigma)
```

Arguments

| | |
|-------|---|
| u | Numeric vector of length N with entries in $(0, 1)$: the copula evaluation point. |
| mu | Numeric vector of length N , the mean of the corresponding multivariate normal distribution (usually zeros for a copula). |
| Sigma | Numeric positive-definite $N \times N$ covariance matrix. |

Details

The Gaussian copula density is

$$c(u; \mu, \Sigma) = \frac{\phi_N(\Phi^{-1}(u); \mu, \Sigma)}{\prod_{i=1}^N \phi_1(\Phi^{-1}(u_i); \mu_i, \sigma_i^2)},$$

where ϕ_N and ϕ_1 are multivariate and univariate normal densities respectively, and Φ^{-1} denotes the inverse normal CDF applied componentwise. The resulting function is a valid copula density on the unit hypercube $[0, 1]^N$.

Typically, the copula is defined for $\mu = 0$ and correlation matrix R , but the implementation here generalizes to arbitrary mean and covariance.

Value

A numeric scalar: the value of the Gaussian copula density $c(u; \mu, \Sigma)$ at the point u . The value is returned as a plain numeric scalar (not a 1×1 matrix).

References

Joe, H. (1997). **Multivariate Models and Dependence Concepts.** Chapman & Hall. Nelsen, R. B. (2006). **An Introduction to Copulas** (2nd ed.). Springer. McNeil, A. J., Frey, R., & Embrechts, P. (2015). **Quantitative Risk Management.** Princeton University Press.

See Also

[f_student_copula_pdf](#), [f_clayton_copula_2d_pdf](#), [f_gumbel_copula_2d_pdf](#)

Examples

```
# Example: 2D Gaussian copula
Sigma <- matrix(c(1, 0.7, 0.7, 1), 2, 2)
mu <- c(0, 0)
f_normal_copula_pdf(c(0.5, 0.8), mu, Sigma)

# Compare with independence (Sigma = I)
f_normal_copula_pdf(c(0.5, 0.8), mu, diag(2))
```

f_portfolio_moments *Portfolio Co-Moments (Variance, Co-Skewness, Co-Kurtosis)*

Description

Compute the portfolio's centred 2nd, 3rd and 4th moments (variance, co-skewness, co-kurtosis) from the asset-level co-moment matrices and a weight vector.

Usage

```
f_portfolio_moments(w, M2 = NULL, M3 = NULL, M4 = NULL)
```

Arguments

| | |
|----|---|
| w | Numeric vector of length d of portfolio weights. |
| M2 | Optional $d \times d$ covariance matrix of the assets (as returned by <code>PerformanceAnalytics::M2.MM()</code>). If NULL, the second moment is not computed. |
| M3 | Optional $d \times d^2$ co-skewness matrix (<code>PerformanceAnalytics::M3.MM()</code>). If NULL, the third moment is not computed. |
| M4 | Optional $d \times d^3$ co-kurtosis matrix (<code>PerformanceAnalytics::M4.MM()</code>). If NULL, the fourth moment is not computed. |

Details

The three quantities are defined as

$$m_2(w) = w' M_2 w, \quad m_3(w) = w' M_3 (w \otimes w), \quad m_4(w) = w' M_4 (w \otimes w \otimes w),$$

where \otimes denotes the Kronecker product. These are the building blocks of the mean-variance-skewness-kurtosis (MVSK) framework of Jondeau, Poon and Rockinger (2007).

The function is a thin, exported wrapper around the package's internal helpers `.portm2`, `.portm3`, `.portm4` (which themselves replace the unexported `PerformanceAnalytics:::portm*` family). It exists so the textbook can demonstrate co-moment computation without reaching into non-exported symbols of the package via `:::`.

Value

A named list with components m2, m3, m4 (NULL for any component whose corresponding co-moment matrix was not supplied).

References

Jondeau, E., Poon, S.-H., & Rockinger, M. (2007). *Financial Modeling Under Non-Gaussian Distributions*. Springer.

Examples

```
set.seed(1)
R <- matrix(rnorm(200 * 4), 200, 4)
d <- ncol(R)
M2 <- cov(R)
w <- rep(1 / d, d)
# Variance of the equal-weighted portfolio:
f_portfolio_moments(w, M2 = M2)$m2

# Co-skewness / co-kurtosis matrices in d x d^2 / d x d^3 form (e.g. from
# PerformanceAnalytics::M3.MM() / M4.MM()) can be passed as M3, M4.
```

f_ptf_max_U

Maximize Truncated MVSK Utility with Box & Budget Constraints

Description

Solves for portfolio weights that (approximately) maximize expected utility using a fourth-order moment expansion in mean–variance–skewness–kurtosis (MVSK). The problem is solved via SLSQP with the constraints $\sum_i w_i = 1$ and $0 \leq w_i \leq w_{max}$.

Usage

```
f_ptf_max_U(gamma, w_max, M1, M2, M3, M4)
```

Arguments

| | |
|-------|--|
| gamma | Non-negative numeric scalar risk-aversion parameter. |
| w_max | Numeric scalar in $(0, 1]$ giving the per-asset upper bound: $0 \leq w_i \leq w_{max}$. |
| M1 | Numeric vector of expected returns (length d). |
| M2 | Numeric $d \times d$ covariance matrix. |
| M3 | Numeric $d \times d^2$ co-moment matrix, as returned by <code>M3.MM()</code> from the PerformanceAnalytics package. |
| M4 | Numeric $d \times d^3$ co-moment matrix, as returned by <code>M4.MM()</code> from the PerformanceAnalytics package. |

Details

The objective implemented is the negative of the truncated MVSK utility series, so minimizing it is equivalent to maximizing the utility:

$$EU(w) \approx \mu_p - \frac{\gamma}{2} \sigma_p^2 + \frac{\gamma(\gamma+1)}{6} S_p - \frac{\gamma(\gamma+1)(\gamma+2)}{24} K_p,$$

where $\mu_p, \sigma_p^2, S_p, K_p$ are the portfolio's first four centralized moments and $\gamma \geq 0$ is a risk-aversion parameter.

The equality constraint is enforced via `eval_g_eq` and box constraints via `lb/ub`. Gradients are supplied analytically using internal helper functions `‘.derportm2‘`, `‘.derportm3‘`, and `‘.derportm4‘` defined in `‘portfolio-moments.R‘`.

Value

A list with:

`w` Numeric vector of optimal portfolio weights (length d).

`EU` Scalar: value of the (approximate) expected utility at `w` (sign-corrected).

Implementation note

Portfolio moment calculations (`portm2/3/4` and their gradients) are performed by internal helpers in `‘R/portfolio-moments.R‘`, vendored from the standard kronecker-product formulas (Jondeau et al., 2007). `M3` and `M4` must be co-moment matrices ($d \times d^2$ and $d \times d^3$), not higher-dimensional arrays.

References

Jondeau, E., Poon, S.-H., & Rockinger, M. (2007). *Financial Modeling Under Non-Gaussian Distributions*. Harvey, C. R., Liechty, J. C., Liechty, M. W., & Müller, P. (2010). Portfolio selection with higher moments.

Examples

```
set.seed(1)
d <- 3
M1 <- c(0.06, 0.08, 0.07)
A <- matrix(rnorm(d*d), d); M2 <- crossprod(A)/d
M3 <- matrix(0, d, d^2)
M4 <- matrix(0, d, d^3)
res <- f_ptf_max_U(gamma = 5, w_max = 0.8, M1, M2, M3, M4)
res$w; res$EU
```

f_student_copula_pdf *Multivariate Student-t Copula PDF*

Description

Computes the probability density function (PDF) of the multivariate Student- t copula at a specified point $u \in [0, 1]^N$, given location vector μ , scatter matrix Σ , and degrees of freedom ν .

Usage

```
f_student_copula_pdf(u, mu, Sigma, nu)
```

Arguments

| | |
|-------|---|
| u | Numeric vector of length N with entries in $(0, 1)$: the evaluation point in the copula's domain. |
| mu | Numeric vector of length N , the location (mean) vector of the underlying multivariate Student- t distribution. |
| Sigma | Numeric $N \times N$ positive-definite scatter matrix. Typically a correlation matrix when defining a copula. |
| nu | Positive numeric scalar: degrees of freedom of the Student- t distribution ($\nu > 0$). |

Details

The multivariate Student- t copula density is given by

$$c(u; \mu, \Sigma, \nu) = \frac{t_N(t_\nu^{-1}(u); \mu, \Sigma, \nu)}{\prod_{i=1}^N t_1(t_\nu^{-1}(u_i); \mu_i, \sigma_i^2, \nu)},$$

where t_N and t_1 denote the multivariate and univariate Student- t densities, respectively, and t_ν^{-1} is the quantile function of the univariate Student- t with ν degrees of freedom.

For $\nu \rightarrow \infty$, this copula converges to the Gaussian copula.

Value

A numeric scalar: the value of the Student- t copula density $c(u; \mu, \Sigma, \nu)$ at u . The value is returned as a plain numeric scalar (not a 1×1 matrix).

References

Demarta, S., & McNeil, A. J. (2005). The t Copula and Related Copulas. **International Statistical Review**, 73(1), 111–129. Joe, H. (1997). **Multivariate Models and Dependence Concepts**. Chapman & Hall. Nelsen, R. B. (2006). **An Introduction to Copulas** (2nd ed.). Springer.

See Also

[f_normal_copula_pdf](#), [f_clayton_copula_2d_pdf](#), [f_gumbel_copula_2d_pdf](#)

Examples

```
# Example: 2D t-copula density
mu <- c(0, 0)
Sigma <- matrix(c(1, 0.7, 0.7, 1), 2, 2)
f_student_copula_pdf(c(0.6, 0.8), mu, Sigma, nu = 5)

# Compare to Gaussian copula (nu large)
f_student_copula_pdf(c(0.6, 0.8), mu, Sigma, nu = 100)
```

f_tail_dependence *Empirical Tail Dependence and Exceedance Correlation*

Description

Estimates the empirical tail-dependence coefficient and the exceedance correlation between two series at a given quantile threshold α for either the lower or upper tail.

Usage

```
f_tail_dependence(x, y, alpha, side = c("lower", "upper"))
```

Arguments

| | |
|-------|--|
| x | Numeric vector of length n , first variable or return series. |
| y | Numeric vector of length n , second variable or return series. |
| alpha | Numeric scalar in $(0, 1)$, the tail probability level (e.g. 0.05 for the 5% tail). |
| side | Character string, either "lower" (default) or "upper", indicating which tail to analyse. "lower" conditions on $X < F_X^{-1}(\alpha)$; "upper" conditions on $X > F_X^{-1}(1 - \alpha)$. |

Details

The function classifies observations in the α -quantile tail of each margin and computes:

- the standard empirical tail-dependence coefficient: the proportion of joint tail events *conditional on x being in its tail* (lambda), and
- the sample correlation between the values of x and y for which both lie in their respective tails (excorr).

If no joint tail events are found, lambda = 0 and excorr = NA. If fewer than two joint-tail observations are available, excorr is also NA (the sample correlation is undefined). When the joint-tail subset is degenerate (e.g., x and y are identical so that the subset has zero variance), cor returns NA with a warning.

Value

A list with components:

lambda Empirical tail-dependence coefficient. For side = "lower":

$$\hat{\lambda}_L = \frac{\#\{X < q_\alpha^X \text{ and } Y < q_\alpha^Y\}}{\#\{X < q_\alpha^X\}}.$$

For side = "upper":

$$\hat{\lambda}_U = \frac{\#\{X > q_{1-\alpha}^X \text{ and } Y > q_{1-\alpha}^Y\}}{\#\{X > q_{1-\alpha}^X\}}.$$

excorr Exceedance correlation between x and y in the joint tail (computed only if there are joint exceedances).

References

Joe, H. (1997). *Multivariate Models and Dependence Concepts*. Chapman & Hall. Embrechts, P., McNeil, A. J., & Straumann, D. (2002). Correlation and dependence in risk management. *Risk Management: Value at Risk and Beyond*. Cambridge University Press.

See Also

[f_efficient_frontier](#)

Examples

```
set.seed(1)
x <- rnorm(1000)
y <- 0.7 * x + sqrt(1 - 0.7^2) * rnorm(1000)

f_tail_dependence(x, y, alpha = 0.05)
f_tail_dependence(x, y, alpha = 0.05, side = "upper")
```

GOLD

Gold Price (Daily, xts)

Description

Daily World Gold Council gold price in USD per troy ounce, from 1970-01-01 to 2015-12-31.

Usage

```
data("GOLD")
```

Format

An xts object with 9691 daily observations and a single column GOLD containing USD prices per troy ounce.

Details

Originally distributed as GOLD in the **qrmdata** package (Hofert, Hornik, & McNeil), ported into **smqf** so that the book's examples remain reproducible without an extra dependency. The data is redistributed here under the same GPL (≥ 2) license as **qrmdata**.

Source

Federal Reserve Economic Data (FRED) via Quandl, downloaded on 2016-01-03 with `qrmtools::get_data()`.

References

Hofert, M., Hornik, K., & McNeil, A. J. *qrmdata: Data Sets for Quantitative Risk Management Practice*, <https://CRAN.R-project.org/package=qrmdata>.

Examples

```
data("GOLD")
class(GOLD)      # "xts" "zoo"
dim(GOLD)
head(GOLD)
```

GoyalWelch

Goyal–Welch Predictive Variables (Monthly, U.S.)

Description

Monthly time series of equity predictors and bond/credit variables commonly used in return predictability studies following Goyal & Welch (2008). Stored as an xts object with a monthly Date index (UTC).

Usage

```
data("GoyalWelch")
```

Format

An xts object with monthly observations (1980–2018 in this snapshot) and 15 variables:

Index Broad U.S. equity price index level (e.g., S&P 500).

D12 Trailing 12-month cash dividends on the index (level).

E12 Trailing 12-month earnings on the index (level).

b/m Aggregate book-to-market ratio.

tbl 3-month Treasury bill rate (monthly).

AAA Moody's AAA corporate bond yield.

BAA Moody's BAA corporate bond yield.

lty Long-term government bond yield.

ntis Net equity expansion: shares issued less repurchases scaled by total equity (a supply measure).

Rfree Risk-free rate (monthly).

infl Inflation (monthly change in price level).

ltr Long-term government bond total return (monthly).

corpr Corporate bond total return (monthly).

svar Stock market variance proxy (e.g., rolling sum of daily squared returns).

csp Corporate bond *return* spread: $\text{corpr} - \text{ltr}$.

Details

This object mirrors the variables used in Goyal & Welch (2008) and subsequent updates. From these levels you can form the standard ratios used in the literature, for example $\text{dp} = \log(\text{D12}/\text{Index})$, $\text{ep} = \log(\text{E12}/\text{Index})$, $\text{dfy} = \text{BAA} - \text{AAA}$, and $\text{tms} = \text{lty} - \text{tbl}$.

Source

Compiled from the public Goyal–Welch data library (predictable stock returns) and standard fixed-income sources (e.g., FRED). If you distribute this data, include a `data-raw/` script that reproduces the object from originals.

References

Goyal, A., & Welch, I. (2008). A Comprehensive Look at The Empirical Performance of Equity Premium Prediction. *Review of Financial Studies*, 21(4), 1455–1508.

Examples

```
data("GoyalWelch")
class(GoyalWelch)      # "xts" "zoo"
head(GoyalWelch)

# Construct common predictors:
dp <- log(GoyalWelch[, "D12"] / GoyalWelch[, "Index"]) # dividend-price
ep <- log(GoyalWelch[, "E12"] / GoyalWelch[, "Index"]) # earnings-price
dfy <- GoyalWelch[, "BAA"] - GoyalWelch[, "AAA"]        # default yield spread
tms <- GoyalWelch[, "lty"] - GoyalWelch[, "tbl"]        # term spread
```

| | |
|-----|-------------------------------------|
| HSI | <i>Hang Seng Index (Daily, xts)</i> |
|-----|-------------------------------------|

Description

Daily adjusted close prices of the Hang Seng stock index (ticker symbol ^HSI), from its first date of availability on Yahoo Finance to 2015-12-31.

Usage

```
data("HSI")
```

Format

An xts object with 7214 daily observations and a single column ^HSI containing adjusted close prices in index points. The time index spans from 1986-12-31 to 2015-12-31.

Details

Originally distributed as HSI in the **qrmdata** package (Hofert, Hornik, & McNeil), ported into **smqf** so that the book's examples remain reproducible without an extra dependency. The data is redistributed here under the same GPL (≥ 2) license as **qrmdata**.

Source

Yahoo Finance, downloaded on 2016-01-03 via `qrmtools::get_data()`.

References

Hofert, M., Hornik, K., & McNeil, A. J. *qrmdata: Data Sets for Quantitative Risk Management Practice*, <https://CRAN.R-project.org/package=qrmdata>.

Examples

```
data("HSI")
class(HSI)      # "xts" "zoo"
dim(HSI)
head(HSI)
```

| | |
|--------|--------------------------------------|
| NIKKEI | <i>NIKKEI 225 Index (Daily, xts)</i> |
|--------|--------------------------------------|

Description

Daily adjusted close prices of the NIKKEI 225 stock index (ticker symbol ^N225), from its first date of availability on Yahoo Finance to 2015-12-30.

Usage

```
data("NIKKEI")
```

Format

An xts object with 7880 daily observations and a single column ^N225 containing adjusted close prices in index points. The time index spans from 1984-01-04 to 2015-12-30.

Details

Originally distributed as NIKKEI in the **qrmdata** package (Hofert, Hornik, & McNeil), ported into **smqf** so that the book's examples remain reproducible without an extra dependency. The data is redistributed here under the same GPL (≥ 2) license as **qrmdata**.

Source

Yahoo Finance, downloaded on 2016-01-03 via `qrmtools::get_data()`.

References

Hofert, M., Hornik, K., & McNeil, A. J. *qrmdata: Data Sets for Quantitative Risk Management Practice*, <https://CRAN.R-project.org/package=qrmdata>.

Examples

```
data("NIKKEI")
class(NIKKEI)      # "xts" "zoo"
dim(NIKKEI)
head(NIKKEI)
```

SMI *Swiss Market Index (Daily, xts)*

Description

Daily adjusted close prices of the Swiss Market Index (SMI) stock index (ticker symbol ^SSMI), from its first date of availability on Yahoo Finance to 2015-12-30.

Usage

```
data("SMI")
```

Format

An xts object with 6350 daily observations and a single column ^SSMI containing adjusted close prices in index points. The time index spans from 1990-11-09 to 2015-12-30.

Details

Originally distributed as SMI in the **qrmdata** package (Hofert, Hornik, & McNeil), ported into **smqf** so that the book's examples remain reproducible without an extra dependency. The data is redistributed here under the same GPL (≥ 2) license as **qrmdata**. Note: the **MSGARCH** package ships a different dataset also named SMI (SMI log-returns); to use that one, load it explicitly with `data("SMI", package = "MSGARCH")`.

Source

Yahoo Finance, downloaded on 2016-01-03 via `qrmtools::get_data()`.

References

Hofert, M., Hornik, K., & McNeil, A. J. *qrmdata: Data Sets for Quantitative Risk Management Practice*, <https://CRAN.R-project.org/package=qrmdata>.

Examples

```
data("SMI")
class(SMI)      # "xts" "zoo"
dim(SMI)
head(SMI)
```

SP500 *S&P 500 Index (Daily, xts)*

Description

Daily adjusted close prices of the Standard & Poor's 500 stock index (ticker symbol ^GSPC), from its first date of availability on Yahoo Finance to 2015-12-31.

Usage

```
data("SP500")
```

Format

An xts object with 16607 daily observations and a single column ^GSPC containing adjusted close prices in index points. The time index spans from 1950-01-03 to 2015-12-31.

Details

Originally distributed as SP500 in the **qrmdata** package (Hofert, Hornik, & McNeil), ported into **smqf** so that the book's examples remain reproducible without an extra dependency. The data is redistributed here under the same GPL (≥ 2) license as **qrmdata**.

Source

Yahoo Finance, downloaded on 2016-01-03 via `qrmtools::get_data()`.

References

Hofert, M., Hornik, K., & McNeil, A. J. *qrmdata: Data Sets for Quantitative Risk Management Practice*, <https://CRAN.R-project.org/package=qrmdata>.

Examples

```
data("SP500")
class(SP500)      # "xts" "zoo"
dim(SP500)
head(SP500)
```

| | |
|---------------|--------------------------------------|
| TermStructure | <i>Daily Term Structure (1m–30y)</i> |
|---------------|--------------------------------------|

Description

A compact term–structure object holding daily yield curves across 11 standard maturities from mid-2006 to late-2008. The object is a named list with the observation dates, the maturity grid (in years), and a rates matrix (rows = dates, columns = maturities).

Usage

```
data("TermStructure")
```

Format

A list with three components:

time Character vector of ISO-8601 calendar dates (e.g., "2006-05-12"). Length equals the number of rows in rates.

tau Numeric vector of maturities in years: c(1/12, 1/4, 1/2, 1, 2, 3, 5, 7, 10, 20, 30).

rates Numeric matrix of annualized yields (percent, not decimals) with dimension $T \times 11$. Column names: X1mo, X3mo, X6mo, X1yr, X2yr, X3yr, X5yr, X7yr, X10yr, X20yr, X30yr.

Details

Dates run from 2006-05-12 to 2008-10-31 (about 622 business days in this snapshot). Yields are curve levels for each maturity on each date and can be used directly for fitting/parsing term-structure models (e.g., Nelson–Siegel or Svensson), computing spreads (term, slope, butterfly), or building zero curves.

Examples

```
data("TermStructure")
str(TermStructure)

# Convert 'time' to Date and build an xts for quick plotting
dts <- as.Date(TermStructure$time)
y.mat <- TermStructure$rates
colnames(y.mat)

# Example: 10Y vs 2Y term spread (in percentage points)
sprd_10y2y <- y.mat[, "X10yr"] - y.mat[, "X2yr"]
head(sprd_10y2y)

# Example: maturity grid (years)
TermStructure$tau
```

VIX*CBOE Volatility Index VIX (Daily, xts)*

Description

Daily close values of the Chicago Board Options Exchange (CBOE) volatility index VIX (ticker symbol ^VIX), from its first date of availability on Yahoo Finance to 2015-12-31.

Usage

```
data("VIX")
```

Format

An `xts` object with 6553 daily observations and a single column `^VIX` containing the VIX level in percent (annualized implied volatility). The time index spans from 1990-01-02 to 2015-12-31.

Details

Originally distributed as `VIX` in the **qrmdata** package (Hofert, Hornik, & McNeil), ported into **smqf** so that the book's examples remain reproducible without an extra dependency. The data is redistributed here under the same GPL (≥ 2) license as **qrmdata**. The VIX is typically used as a market-based measure of volatility, expressed in percent.

Source

Yahoo Finance, downloaded on 2016-01-03 via `qrmtools::get_data()`.

References

Hofert, M., Hornik, K., & McNeil, A. J. *qrmdata: Data Sets for Quantitative Risk Management Practice*, <https://CRAN.R-project.org/package=qrmdata>.

Examples

```
data("VIX")
class(VIX)      # "xts" "zoo"
dim(VIX)
head(VIX)
```

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