Package: smqf (via r-universe)

June 2, 2026

Title Statistical Methods for Quantitative Finance

Version 1.1-3

Description Provides data and functions used in the book ``Statistical Methods for Quantitative Finance'' by David Ardia (2026).

License GPL-3

LazyData true

LazyDataCompression xz

Encoding UTF-8

Depends R (>= 4.1.0), xts

URL https://github.com/ArdiaD/smqf-package

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

Suggests zoo, testthat (>= 3.0.0), PerformanceAnalytics, glmnet

Config/testthat/edition 3

Imports graphics, stats, nloptr, pracma

Config/roxygen2/version 8.0.0

Config/pak/sysreqs cmake

Repository https://ardiad.r-universe.dev

Date/Publication 2026-05-29 22:22:12 UTC

RemoteUrl https://github.com/ardiad/smqf-package

RemoteRef HEAD

RemoteSha 3631a2b19c29c4e6975ccd839485c17e10814693

Contents

`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 ($\geq$ 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 ($\geq$ 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 ($\geq$ 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 — *Dow Jones Industrial Average Constituents (Daily, xts)*

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 *Euro Stoxx 50 Index (Daily, xts)*

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 ($\geq$ 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))
```

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:

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

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(u1, u2)` 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 `graphics::persp()`. 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

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

where $\mu^\star$ 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

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

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

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

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 $u_i \to 0^+$ (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

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

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 PerformanceAnalytics::M2.MM()). If NULL, the second moment is not computed.
M3	Optional $d \times d^2$ co-skewness matrix (PerformanceAnalytics::M3.MM()). If NULL, the third moment is not computed.
M4	Optional $d \times d^3$ co-kurtosis matrix (PerformanceAnalytics::M4.MM()). 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: $0 \leq w_i \leq w_m ax$.
- `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 `M3.MM()` from the **PerformanceAnalytics** package.
- `M4` Numeric $d \times d^3$ co-moment matrix, as returned by `M4.MM()` 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:

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

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

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

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 $\nu \to \infty$, 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")
```

FamaFrench *Fama–French Factors (Weekly, xts)*

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("FamaFrench")
```

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

The time index is a weekly `Date`. Divide by 100 to convert to decimal returns before use in calculations. To work at monthly frequency, downsample with, for example, `FamaFrench[xts::endpoints(FamaFrench, "months"), ]`.

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.

Examples

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

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

`Fred` *FRED-MD Macro Factors and Dow Jones Returns (Monthly, 2015–2019)*

Description

An `xts` object holding 128 FRED-MD macroeconomic predictors and the 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

An `xts` object with 60 monthly observations (index Jan 2015 to Dec 2019, class `zoo::yearmon`) and 129 columns:

columns 1 to 128 Standardised FRED-MD macro variables, transformed (differenced or log-differenced) to achieve stationarity following the FRED-MD transformation codes. Column names are FRED-MD series codes (e.g., `"INDPRO"`, `"CPIAUCSL"`, `"GS10"`).

`DJI.Adjusted` **(final column)** One-month-ahead Dow Jones Industrial Average log-returns, aligned so that row t of the predictors corresponds to row t of the response.

Details

The 128 macro predictors (columns 1 to 128) were downloaded from the McCracken–Ng FRED-MD database and transformed according to the recommended stationarity codes. The target column `DJI.Adjusted` was obtained from Yahoo Finance via `quantmod::getSymbols("^DJI")` and converted to monthly log-returns. All series are restricted to the 60-month window 2015-01 to 2019-12 and temporally aligned so that the predictor columns in row t can be used to predict `DJI.Adjusted` in row 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 for 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")
class(Fred)                                # "xts" "zoo"
y <- Fred[, "DJI.Adjusted"]                # response (60 x 1)
X <- Fred[, colnames(Fred) != "DJI.Adjusted"]  # 128 macro predictors
dim(X)

# Lasso with cross-validation (requires glmnet, which expects matrices)
if (requireNamespace("glmnet", quietly = TRUE)) {
  set.seed(1234)
  fit <- glmnet::cv.glmnet(as.matrix(X), as.numeric(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 ($\geq$ 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 indexed by month (class `zoo::yearmon`) with 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 (Jan 1994 to Dec 2016), indexed by `zoo::yearmon`, 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 of class `zoo::yearmon` (a calendar month with no day-of-month), so the series aligns with other monthly data by month, irrespective of any day-of-month convention.

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)
}
```

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 ($\geq$ 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 indexed by month (class `zoo::yearmon`).

Usage

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

Format

An `xts` object with monthly observations (Dec 1979 to Dec 2018 in this snapshot), indexed by `zoo::yearmon`, 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: `corpr - 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 `dp = log(D12/Index)`, `ep = log(E12/Index)`, `dfy = BAA - AAA`, and `tms = lty - 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` *Hang Seng Index (Daily, xts)*

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 ($\geq$ 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` *NIKKEI 225 Index (Daily, xts)*

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 ($\geq$ 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)
```

SP500_const *S&P 500 Constituents (Weekly, xts)*

Description

Weekly adjusted close prices for the 505 constituents of the S&P 500 index (membership as of the 2016-01-03 snapshot).

Usage

```
data("SP500_const")
```

Format

An `xts` object with 2818 weekly observations (the last available trading day of each week) and 505 columns, one per constituent (e.g., `AAPL`, `MSFT`, `XOM`). Missing values are common, especially in the early part of the sample, since a given name only has data once it became available. The time index spans from 1962-01-05 to 2015-12-31.

Unlike the `DJ_const`, `FTSE_const` and `EURSTX_const` panels (which are daily), this dataset is stored at **weekly** frequency to keep the package within the CRAN size limit. Weekly data is sufficient for the high-dimensional covariance and factor-model examples in the book, where a three-year window already has more constituents than observations.

Details

Originally distributed as `SP500_const` in the **qrmdata** package (Hofert, Hornik, & McNeil), thinned to weekly frequency and ported into **smqf** so that the book's examples remain reproducible without an extra dependency. The data is redistributed here under the same GPL ($\geq$ 2) license as **qrmdata**. The panel reflects index membership at the snapshot date and is therefore subject to survivorship bias.

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_const")
class(SP500_const)        # "xts" "zoo"
dim(SP500_const)
head(colnames(SP500_const))
```

`TermStructure` *Daily Term Structure (1m–30y)*

Description

A compact term-structure object holding daily yield curves across 11 standard maturities from mid-2006 to late-2008. The object is an `xts` matrix of annualized yields (rows = dates, columns = maturities); the maturity grid in years is attached as the `"tau"` entry of `xts::xtsAttributes()`.

Usage

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

Format

An `xts` object of annualized yields (percent, not decimals) with dimension 622×11. The index runs daily from `2006-05-12` to `2008-10-31`; columns are the 11 maturities: `X1mo`, `X3mo`, `X6mo`, `X1yr`, `X2yr`, `X3yr`, `X5yr`, `X7yr`, `X10yr`, `X20yr`, `X30yr`.

The maturity grid in years, `c(1/12, 1/4, 1/2, 1, 2, 3, 5, 7, 10, 20, 30)`, is stored as a user attribute and retrieved with `xts::xtsAttributes(TermStructure)$tau`.

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")
class(TermStructure)         # "xts" "zoo"
dts <- index(TermStructure)  # observation dates
colnames(TermStructure)

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

# Maturity grid (years), stored as a user attribute
xts::xtsAttributes(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 ($\geq$ 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)
```

Index