Rmetrics

An Environment for Teaching
Financial Engineering and Computational Finance
with R Rmetrics Built 201.10059

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Rmetrics *is a collection of several hundreds of functions which may be useful for teaching "Financial Engineering" and "Computational Finance". This R port was initiated 1999 as an outcome of my lectures held on topics in econophysics at ETH Zürich. The family of the Rmetrics packages includes currently six members dealing with the following subjects:* ***fBasics*** *- Markets, Basic Statistics, Date and Time,* ***fSeries*** *- The Dynamical Process Behind Financial Markets,* ***fMultivar*** *- Multivariate Data Analysis,* ***fExtremes*** *- Beyond the Sample, Dealing with Extreme Values,* ***fOptions*** *– The Valuation of Options, and* ***fPortfolio*** *- Portfolio Selection and Optimization*

fBasics

The package fBasics covers the management of economic and financial market data. Included are functions to download economic indicators and financial market data from the Internet. Distribution functions relevant in finance are added like the asymmetric stable, the hyperbolic and the inverse normal gaussian distribution function to compute densities, probabilities, quantiles and random deviates. Estimators to fit the distributional parameters are also available. Some additional hypothesis tests for the investigation of correlations, dependencies and other stylized facts of financial time series can also be found in this package. Furthermore, for date and time management a holiday database for all ecclesiastical and public holidays in the G7 countries and Switzerland is provided together with a database of daylight saving times for financial centers around the world. Special calendar management functions were implemented to create easily business calendars for exchanges. A collection of functions for filtering and outlier detection of high frequency foreign exchange data records collected from Reuters' data feed can also be found together with functions for devolatilization and de-seasonalization of the data. A S4 "timeDate" class is included for managing date and time around the globe for any financial center. The concept allows for dealing with time zones, day light saving time and holiday calendars independent of

the date and time specifications of the operating system implemented on your computer. This is an important issue especially for R running under Microsoft's Windows operating system. The time zone concept is replaced by the "Financial Center" concept. The financial center specifies where you are living and working. With the specification of the financial center the system knows what rules for day light saving times should be applied or what is your holiday calendar So one can distinguish between Frankfurt and Zurich, which both belong to the same time zone, but differed in DST changes in the eighties and have different holiday calendars. Another important feature is the fact that Rmetrics uses internally the ISO-8601 standard for date and time notations. The S4 "timeSeries" class manages regular and irregular time series objects. Dates and times are implemented as "timeDate" objects. Included are functions and methods for the generation, representation and mathematical manipulation of time series objects.

fSeries

This package covers topics from the field of financial time series analysis including ARIMA, GARCH, long memory modelling, and chaotic time series analysis . This library tries to bring together the content of existing R-packages with additional new functionality on a common platform. The collection comes with functions for simulations, parameter estimation, diagnostic analysis and hypothesis testing of financial time series. The tests include methods for testing unit roots, independence, normality of the distribution, trend stationary, and neglected non-linearities. In addition functions for testing for higher serial correlations, for heteroskedasticity, for autocorrelations of disturbances, for linearity, and functional relations are provided. Furthermore, distribution functions for GARCH modelling like the normalized Student-t and the GED together with their skewed versions have been added which require for their computation Heaviside and related functions. The demonstration directory includes also a R-interface for the GarchOx software package.

fMultivar

This library deals mainly with multivariate aspects of time series analysis. Offered are algorithms for regression analysis including neural network modelling with feedforward networks. Furthermore functions for sytem equation modelling are available. Technical analysis and benchmarking is another major issue of this package. The collection offers a set of the most common technical indicators together with functions for charting and benchmark measurements. For the technical analysis of markets several trading functions are implemented and also tools are availalble for a rolling market analysis. A matrix addon with many functions which allow an easy use of matrix manipulations is also part of this package. This addon includes functions to generate several kind of standard matrixes, to extract subsets of a matrix, and some function from linear algebra. This matrix addon is thought to be used to manipulate easily the data of multivariate time series objects.

fExtremes

This package covers topics from the field what is known as extreme value theory. The package has functions for the exploratory data analysis of extreme values in insurance, economics, and finance applications. Included are plot functions for empirical distributions, quantile plots, graphs exploring the properties of exceedences over a threshold, plots for mean/sum ratio and for the development of records. Furthermore functions for preprocessing data for extreme value analysis are available offering tools to separate data beyond a threshold value, to compute blockwise data like block maxima, and to de-cluster point process data. One major aspect of this package is to bring together the content of the already existing

R-packages, *evir* and *ismev* with additional new functionality for financial engineers on a common platform investigating fluctuations of maxima, extremes via point processes, and the extremal index.

fOptions

This package covers the valuation of options including topics like the basics of option pricing in the framework of Black and Scholes, including almost 100 functions for exotic options pricing, including the Heston-Nandi option pricing approach mastering stochastic volatility, and Monte Carlo simulations together with generators for low discrepancy sequences. Beside the Black and Scholes option pricing formulas, functions to valuate other plain vanilla options on commodities and futures, and function to approximate American options are available. Some binomial tree models are also implemented. The exotic options part comes with a large number of functions to valuate multiple exercise options, multiple asset options, lookback options, barrier options, binary options, Asian options, and currency translated options. Parts for a new additional chapter on exponential Brownian motion including functions dealing with moment matching methods, PDE solvers, Laplace inversion methods, and spectral expansion approaches for option are already present. They include additional distribution functions, moment statistics and specical mathematical functions like the gamma and the confluent hypergeometric functions.

fPortfolio

This library has just been started. The topics cover multivariate distributions, assets modelling, drawdown statistics, value-at-risk modelling, Markowitz portfolios, two assets. The multivariate distribution functions allow to compute multivariate densities and probabilities from skew normal and skew Student-t distribution functions. Furthermore, multivariate random daviates can be generated, and for multivariate data, the parameters of the underlying distribution can be estimated by the maximum log-likelihood estimation. The functions for assets modelling can be used togenerate multivariate artficial data sets of assets, which fit the parameters to a multivariate normal, skew normal, or (skew) Student-t distribution. Included in the library are also functions to compute some benchmark statistics. In addition a function is provided which allows for the selection and clustering of individual assets from portfolios using hierarchical and k-means clustering approaches. Tools are provided to evaluate dtawdown statistics. Availalble are functions for the density, distribution function, and random number generation for the maximum drawdown distribution. In addition the expectation of drawdowns for Brownian motion can be computed. Value-at-Risk Modelling is another topic which is consider in this library. Value-at-Risk and related risk measures for a portfolio of assets can be evaluated. A group of functions is dedicated to the Markowitz portfolio optimization problem. Functions for the computation of the efficient frontier, for the market line, for the tangency portfolio and for Monte Carlo simulations are part of the library. Analytical formulas for the Markowitz and for the Condition VaR Portfolio approach are implemented.

Outlook

A further packages is under current The library **fBonds**. is just at the beginning and deals with bond arithmetic, with yield curve modelling, with interest rate instruments, and with replicating portfolios.

Summary

Rmetrics is a collection of R functions having its source in algorithms and functions written by many authors. The aim is to bring the software together under a common platform and to make it public available for

teaching financial engineering and computational finance. The packages are documented in *User Guides* and *Reference Guides*, currently about 800 pages.

The most recent source packages of Rmetrics and the compiled Windows binaries can be obtained from the Rmetrics Server. The reason is that I develop Rmetrics under MS Windows XP since in the financial community Windows is the mostly used operating system. Stable source packages for Linux and binaries for Mac OSX and MS Windows are downloadable from the CRAN Server. In addition Debian packages for Rmetrics are also available and they are part of the Knoppix Qantian CD.

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References

R/CRAN Server: cran.r-project.org

Debian Server: www.debian.org

Knoppix Server: www.knoppix.org

Quantian Server: www.quantian.org

Rmetrics Server: www.rmetrics.org