

Rmetrics

An Environment for Teaching Financial Engineering and Computational Finance with R Rmetrics Built 200.10058

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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 four members dealing with the following subjects: **fBasics** - Markets, Basic Statistics, Date and Time, **fSeries** - The Dynamical Process Behind Financial Markets, **fExtremes** - Beyond the Sample, Dealing with Extreme Values, and **fOptions** – The Valuation of Options.*

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 de-volatilization 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, Regression, and Feedforward Neural Network modelling. Furthermore functions for equation modelling and the simulation of long memory behavior are included. 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 testing various aspects of financial time series, including unit roots, independence, normality of the distribution, trend stationary, co-integration 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. 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 building trading models functions for a rolling market analysis are available. 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 slot of multivariate time series objects. 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 furthermore some functions from chaos theory and a R-interface for the GarchOx software package.

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 value 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 value 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 special mathematical functions like the gamma and the confluent hypergeometric functions.

Outlook

Two other packages are currently implemented: **fPortfolio** and **fBonds**. The first package offers functions for the cluster analysis of market data based on already available R functions and new functions for modern portfolio selection and optimization. Beyond the Markowitz approach we are currently implementing modern risk concepts based on conditional Value-at-Risk and conditional Drawdown-at-Risk for the investigation of hedge funds. Several graphical utility functions like heatmaps and others to display multivariate data sets will become also part of this package. The second package 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 plat-

form 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 Quantian 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