

## Rmetrics



# An Environment for Teaching Financial Engineering and Computational Finance with R

Rmetrics Built 221.10065

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*Rmetrics is a collection of several hundreds of functions designed and written for teaching "Financial Engineering" and "Computational Finance". Rmetrics was initiated in 1999 as an outcome of my lectures held on topics in econophysics at ETH Zürich. The family of the Rmetrics packages build on top of the statistical software environment R includes members dealing with the following subjects: **fBasics** - Markets and Basic Statistics, **fCalendar** - Date, Time and Calendar Management, **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.*

**Rmetrics** has become the premier open source solution for financial market analysis and valuation of financial instruments. With hundreds of functions build on modern and powerful methods Rmetrics combines explorative data analysis and statistical modeling with object oriented rapid prototyping. Rmetrics is embedded in R, both building an environment which creates especially for students and researchers in the third world a first class system for applications in statistics and finance.

### **fBasics**

The package **fBasics** covers the basic management of economic and financial market data. Included are example data sets and S functions for collecting, archiving and characterizing economic and financial time series. Especially the S functions should be mentioned which allow

to download data sets from the Internet. The major concern is given to financial return series and their stylized facts. Distribution functions relevant in finance are added like the stable, the hyperbolic, or the normal inverse Gaussian distribution function to compute densities, probabilities, quantiles and random deviates. Estimators to fit the distributional parameters are also available. Furthermore, hypothesis tests for the investigation of distributional properties, of correlations, of dependencies and of other stylized facts of financial time series returns can also be found in this package.

### **fCalendar**

The core **fCalendar** functions are the S4 "timeDate" and "timeSeries" classes to manage 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. 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. An important feature is the fact that Rmetrics uses the ISO-8601 standard for date and time notations but also makes date transformations possible. The S4 "timeSeries" class manages regular and irregular time series objects. Included are functions and methods for the generation, representation and mathematical manipulation of time series objects. For local 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 and holiday calendars.

## **fSeries**

This package covers topics from the field of financial time series analysis including ARIMA, GARCH, long memory modelling, and chaotic time series analysis. The package 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 modeling like the normalized Student-t and the GED together with their skewed versions have been added. It is also worth to mention that an R-interface for the Ox/GARCH software package is available.

## **fMultivar**

This package deals mainly with multivariate aspects of economic and financial time series

analysis. Offered are algorithms for regression analysis including neural network modelling with feedforward networks. Furthermore, functions for system equation modelling in the context of demand and supply models 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 performance measurements. For the technical analysis of markets several trading functions are implemented and also tools are available for a rolling market analysis. A matrix add-on with many functions which allow an easy use of matrix manipulations is also part of this package. This add-on includes functions to generate several kind of standard matrixes, to extract subsets of a matrix, and some function from linear algebra. This matrix add-on 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**

The fOptions 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. Furthermore, S functions are provided to investigate and analyze exponential Brownian motion including functions dealing with moment matching methods, PDE solvers, Laplace inversion methods, and spectral expansion approaches.

## fPortfolio

The fPortfolio package deals with portfolio selection, optimization and benchmarking. Included are S functions for multivariate distributions, for assets modeling, for Value-at-Risk computation, and for performance measures including drawdown statistics. S functions for the modeling of assets allow to compute fat-tailed and skewed multivariate densities and probabilities. Furthermore, the distributional parameters of assets can be estimated and artificial sets with the same statistical properties can be generated. In addition assets can be selected and grouped using hierarchical and k-means clustering approaches. Value-at-Risk Modeling is considered as another important topic and additional VaR related risk measures can be evaluated. S functions are included to solve the Markowitz portfolio optimization problem, the conditional Value-at-Risk and the conditional Drawdown-at-Risk portfolio problems. S Functions for the computation of the efficient frontier, for the market line, for the tangency portfolio and for Monte Carlo simulations are also part of the package. Analytical formulas for two-assets portfolios are implemented from the educational point of view.

## Outlook

Further packages are under current development. This includes the packages **fCopulae**, **fTickdata**, **fBonds**, **fActuar**, and **fAgents**.

## 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 Quantian CD.

## Acknowledgement:

Many thanks to the members of the R development team for their support and continuous help, to all the authors who made their programs and R-packages available under the GNU General Public License so that they could be used or included to Rmetrics, and to Dirk Eddelbuettel for creating the Debian Packages and including Rmetrics to the Quantian CD.

## References

R and Rmetrics –An Environment for “Teaching Financial Engineering and Computational Finance with R”, Reference Card, 2006

R/CRAN Server: [cran.r-project.org](http://cran.r-project.org)

Debian Server: [www.debian.org](http://www.debian.org)

Knoppix Server: [www.knoppix.org](http://www.knoppix.org)

Quantian Server: [www.quantian.org](http://www.quantian.org)

Rmetrics Server: [www.rmetrics.org](http://www.rmetrics.org)

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