

Rmetrics

www.rmetrics.org

An Environment for Teaching Financial Engineering and Computational Finance

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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.

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 ecclestial 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 new additional chapter with synonyme functions for Splus like time, date, and time series objects is scheduled for April 2004.

The package **fSeries** covers topics from the field of financial time series analysis including ARIMA, GARCH, Regression, and Feedforward Neural Network modelling. 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. Furthermore functions for testing for higher serial correlations, for heteroskedasticity, for autocorrelations of disturbances, for linearity, and functional relations are also 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 new additional chapter on modeling long memory behavior including moment methods, periodgram analysis, whittle estimator, and wavelet analysis is scheduled for May 2004.

The package **fExtremes** 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 already existing R-packages with additional new functionality for financial engineers on a common platform investigating fluctuations of maxima, extremes via point processes, and the extremal index. – A new additional chapter on risk measures, stress testing and copulae is scheduled for October 2004.

The package **fOptions** 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. – 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 pricing is scheduled for August 2004.

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 have implemented 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 are also part of this package. The second package is just at the beginning and deals with bond arithmetic, with the yield curve, with interest rate instruments, and with replicating portfolios. – The portfolio optimization functions for hedge funds will be available end of March 2004, the remaining parts of the two packages are scheduled for 2005.

The packages are documented in *User Guides* and *Reference Guides*, currently about 800 pages. The packages are made for R under the operating system MS Windows. *Why using R?* To make the software in an academic environment "free" available for everybody, we decided to implement the functions in the framework of R. This offers the possibility, that everybody can modify the existing functions and can contribute additional functions and datasets. Furthermore, in most cases the functions can be ported to SPlus. *Why using MS Windows?* In the financial community Windows is the mostly used operating system. For a broad distribution and acceptance of *Rmetrics*, we decided to develop the software under Windows 2000/XP. But nevertheless, since all source code is available it may be straightforward to adapt and compile the software for other operating systems.

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.