Portfolio Optimization with R/Rmetrics

Diethelm Würtz
Yohan Chalabi, Andrew Ellis, Dominik Locher

ETH Zurich, Rmetrics Association, Theta Fundmanagement

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Portfolio Optimization Problem

… return, risk, performance ratio

For a given set of financial assets let us find the composition

1) which minimizes the risk for a given return (reward),

2) which maximizes the return for a given risk,

3) which optimizes a reward/risk performance ratio,

4) which finds the global minimum risk,

subject to certain constraints and preferences.

How to quantify Risk ?

Stone 1973

$$R_S[Y_0, k, A](f) = \left(\int_{-\infty}^{A} |y - Y_0|^k f(y)\, dy \right)^{1/k}$$

y are the financial returns,
f ( ) their multivariate distribution
A, Y_0, and k parameters

$$R_{SD}(f) = R_S[\mu_y, 2, \infty](f) \qquad R_{SSD}(f) = R_S[\mu_y, 2, 0](f)$$

$$R_{SVM}(f) = R_S[\mu_y, 2, 0]^2(f) \qquad R_{\alpha-t}(f) = R_S[t, \alpha, t]^{\alpha}(f)$$

Pederson and Satchell 1998

$$R[A,\ b,\ \alpha,\ \theta,\ W(\cdot)] = \left[\int_{-\infty}^{A} |y - b|^{\alpha} W[F(y)] f(y)\, dy \right]^{\theta}$$

for some bounded function W ( )

(*BP*1) (*Nonnegativity*): $R[\tilde{y}] \geq 0$.
(*BP*2) (*Homogeneity*): $R[\lambda\tilde{y}] = |\lambda|\, R[\tilde{y}]$ *for* $\lambda \geq 0$.
(*BP*3) (*Subadditivity*): $R[\tilde{y}_1 + \tilde{y}_2] \leq R[\tilde{y}_1] + R[\tilde{y}_2]$.
(*BP*4) (*Shift-invariance*): $R[\tilde{y} + \lambda] \leq R[\tilde{y}]$ *for all* λ.

Artzner, Delbaen, Eber, Heath 1999

(ADEH 3) (translation invariance) $R(X + c) = R(X) - c$ for all c

(ADEH 4) (monotonicity) $X \leq Y \Rightarrow R(Y) \leq R(X)$.

… this makes a coherent risk measure

Axiomatic Risk Measures

(a) *Stone's Class for* $k > 1$ *and* $Y_0 = \mu_y$ *and* $A = \mu_y$ *or* $A = \infty$

- *Standard deviation*
- *Mean absolute deviation*
- *Fishburn's* $\alpha - t$ *measures for* $t = \mu_y$ *raised to power* $\frac{1}{k}$
- *Semistandard deviation* (3)
- *The first Kijima-Ohnishi measure*
- *Generalized lower partial moment*

(b) *The range*

(c) *The piecewise linear measures*

- *The Gini coefficient*
- *The L-moments for* $r + s < 2$

(d) *Kijima and Ohsniki's second measure*

Pederson and Satchell 1998

… note

Covariance Risk Measure:	$(Standard\ deviation)^2$
CVaR Measure:	$k = 1, A = VaR, Y_0 = 0$
new Developments:	*Spectral Risk Measures*

Mean – Variance Portfolios

Markowitz 1952, QP1:

Minimize Risk for a given Return:

$$\begin{aligned} \min \quad & w^\top \hat{\Sigma} w \\ s.t. \quad & \\ & w^\top \hat{\mu} = \overline{r} \\ & w^\top 1 = 1 \\ & Aw \leq b \end{aligned}$$

QP1 Solution:
„Quadratic Programming Solvers“
Goldfarb and Idnani, 1982

QP2:

Maximize Return for a given Risk:

$$\begin{aligned} \max_w \quad & w^\top \hat{\mu} \\ s.t. \quad & w^\top 1 = 1 \\ & Aw \leq b \\ & w^\top \hat{\Sigma} w \leq \sigma \\ & w^\top B w \leq c \end{aligned}$$

QP2 Solution:
„Second Order Cone Programming Solver“
Nesterov and Nemirovski, 1994

… **do not forget the critical line algorithms**

Mean – QLPM Portfolios

Nawrocki, 1992:

$$LPM = E[\{\max(0, \tau - y)\}^a]$$

τ	*Benchmark*
0 < a < 1	*Risk seeking behavior*
a = 1	*Risk neutrality*
a > 1	*Risk aversion*

$$\min_w \; w^\top L w$$
$$s.t.$$
$$Aw \leq b$$

Quadratic Lower Partial Moments:

Co-Lower Partial Moments

$$CLPM_{ij} = \frac{1}{k}\sum_{t=1}^{k}\left[MAX\{0,(\tau_t - x_{it})\}\right]^{a-1}(\tau_t - x_{jt}), \quad \text{for} \quad a > 1$$

$$CLPM_{ij} = \frac{1}{k}\sum_{t=1}^{k} I_{\{MAX[0,(\tau_T - x_{it})]\}} \cdot (\tau_t - x_{jt}), \quad \text{for} \quad a = 1$$

$$L = \begin{pmatrix} CLPM_{11} & \cdots & CLPM_{1n} \\ \vdots & \ddots & \vdots \\ CLPM_{n1} & \cdots & CLPM_{nn} \end{pmatrix}$$

Mean – QLPM Solution: For a > 1 formaly equivalent to QP1

… **note there is also a symmetrized QLPM version**

Mean - CVaR Poertfolios

Rockafeller and Uryasev 1992:

$$e_s = \max\left[0, VaR - \sum_{i=1}^{n} w_i r_{i,s}\right]$$

$$CVaR = VaR - \left(\frac{1}{m}\sum_{s=1}^{m} e_s\right) / \alpha$$

Note if the assets are elliptically distributed, we will get the same set of weights as for the Mean-Variance Markowitz Portfolio!

CVAR:

$$\max_{w_i, e_s, VaR} \; VaR - \left(\frac{1}{m}\sum_{s=1}^{m} e_s\right) / \alpha$$

$$\sum_{i=1}^{n} w_i \mu_i \geq \bar{\mu}$$

$$e_s \geq VaR - \sum_{i=1} w_i r_{i,s}$$

$$e_s \geq 0$$

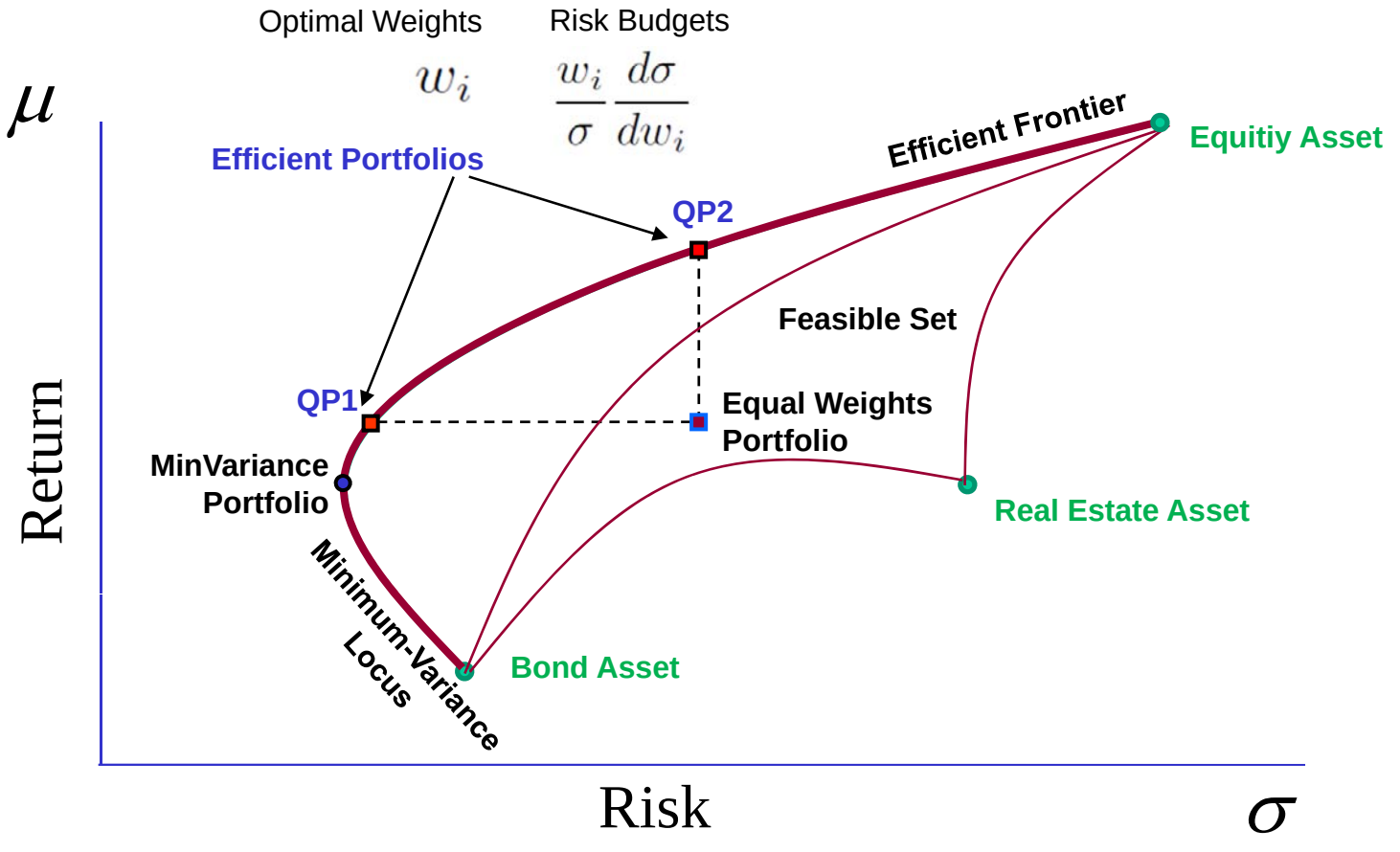
$$w_i \geq 0$$

$$\ldots$$

Mean - CVaR Solution: Linear Programming Problem

… **note Conditional Drawdown at Risk Portfolios can be solved in the same way**

Risk vs. Return

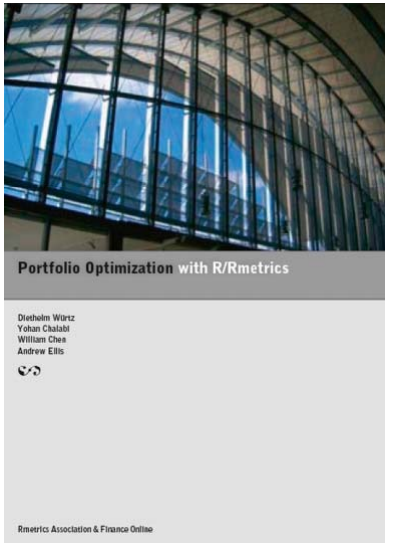


fPortfolio Models

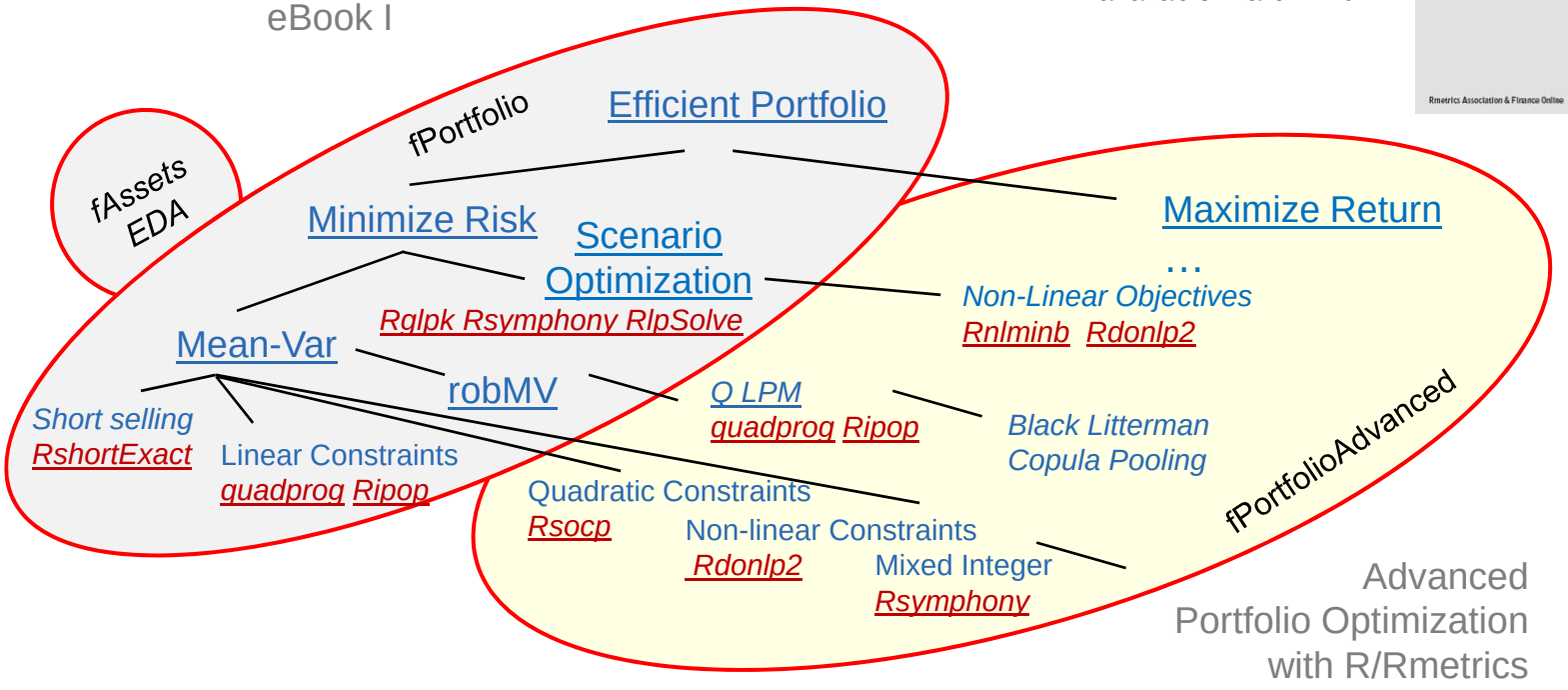
fPortfolio Zoo:
Rmetrics Software

Topics
Managing Data Sets of Assets
Exploratory Data Analysis of Assets
Portfolio Framework
Mean-Variance Portfolios
Mean-CVaR Portfolios
Portfolio Backtesting

462 p 88 CHF
see Example Text on
www.rmetrics.org
available March 11th



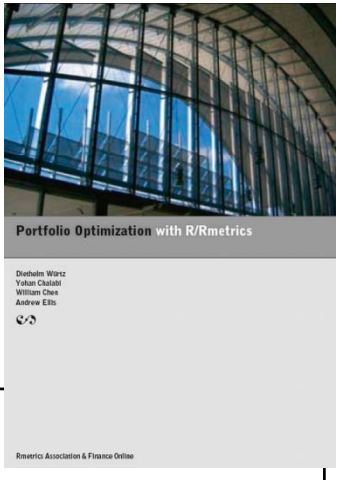
Portfolio Optimization
with R/Rmetrics
eBook I



Advanced
Portfolio Optimization
with R/Rmetrics
eBook II

Rmetrics Packages

Chronological Objects
in R/Rmetrics
eBook, available in July



timeDate* ❶
timeSeries* ❶

datafeed* ❸

❶ CRAN Repository
❷ r-forge Repository
❸ Rmetrics Repository

* Rmetrics Packages
and/or Interfaces

fPortfolio* ❶ ❷
quadprog ❶
Rglpk ❶
Rsymphony ❶
fAssets* ❶ ❷
robustbase ❶
corpcor ❶
fPortfolioBacktest* ❶ ❷
fPortfolioPerformance* ❸

fPortfolioAdvanced* ❸
fPortfolioSolver* ❷
Ripop* ❸
Rnlminb* ❸
RlpSolve* ❷
RlpSolveAPI* ❷
Rsocp* ❷
Rdonlp2 ❷
… commercial solvers ❸
BLCOP ❶ ❷

Rmetrics Packages: fEcofin, fBasics, timeDate, timeSeries, fImport, datafeed, fArma, fArmaOx, fGarch, fGarchOx, fNonlinear, fMultivar, fUnitRoots, fTrading, fOptions, fExoticOptions, fAsianOptions, fTrading, fAssets, fPortfolio, fPortfolioSolver, fPortfolioBacktesting, fPortfolioPerformance, Rquadprog, Ripop, Rsimplex, Rsocp, RlpSolve, RlpSolveAPI, Rnlminb, Rsoplex, Rcplex, …

Portfolio Structure …

Portfolio Model

Portfolio Functions

Portfolio Data

Portfolio Specification

Portfolio Constraints

Default Portfolio:

Constrained MV Portfolio
with LongOnly constraints

```
portfolioFrontier()
   efficientPortfolio()
   minriskPortfolio()
   maxratioPortfolio()
     feasiblePortfolio()

portfolioData()
```
timeSeries

```
portfolioSpec()
```
setType() = “MV”
setEstimator() = “covEstimator”
setOptimize() = “minRisk”
setSolver() = “solveRquadprog”
…

```
portfolioConstraints()
```
“LongOnly”

CVaR Example:

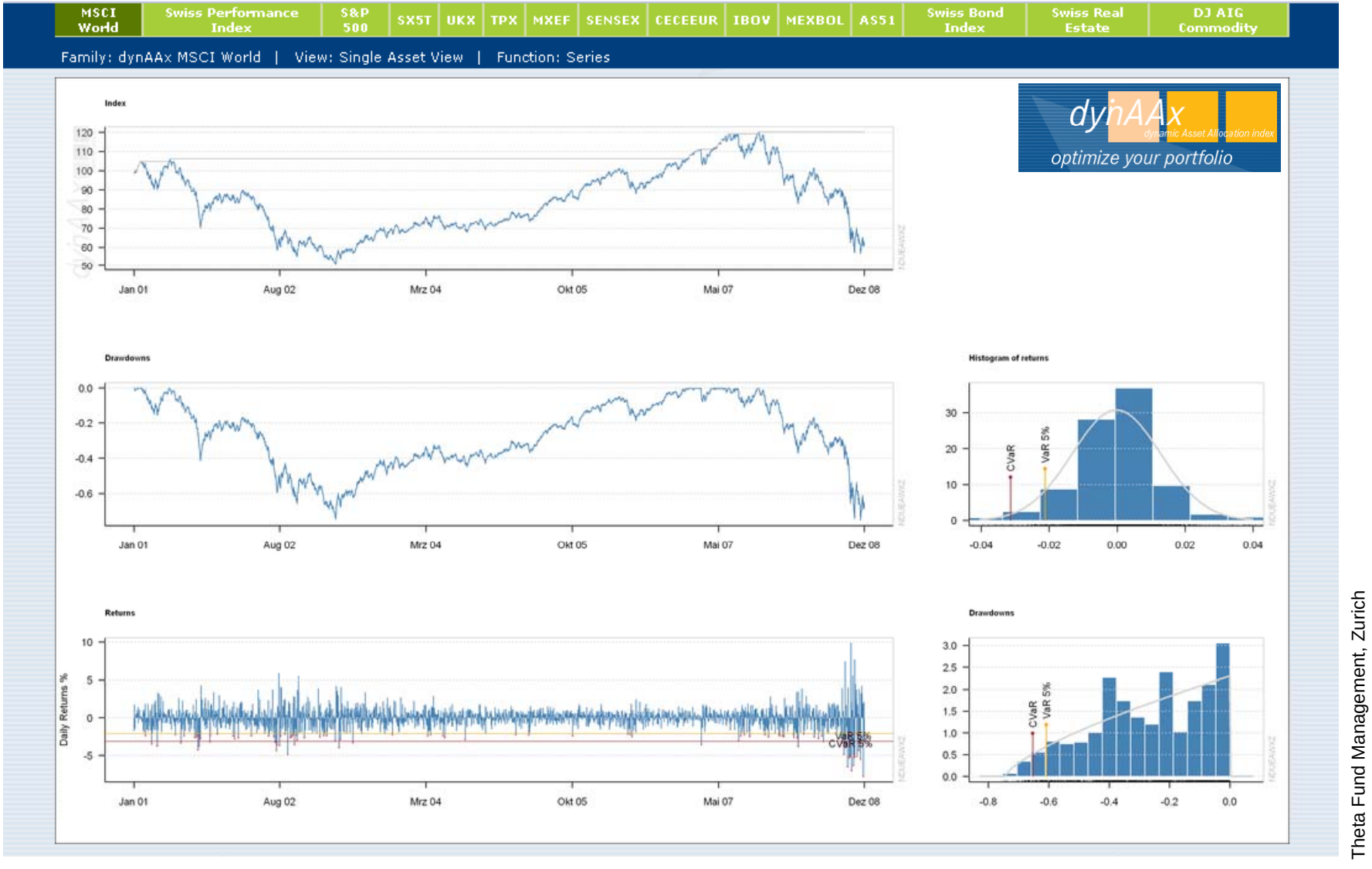
Mean-CVaR Portfolio
with alternative constraints

```
portfolioFrontier()
   efficientPortfolio()
   minriskPortfolio()
   maxratioPortfolio()
     feasiblePortfolio()

portfolioData()
```
timeSeries

```
portfolioSpec()
```
setType() = “CVaR”
setAlpha() = 0.05
setOptimize() = “minRisk”
setSolver ()= “solveRsymphony”
…

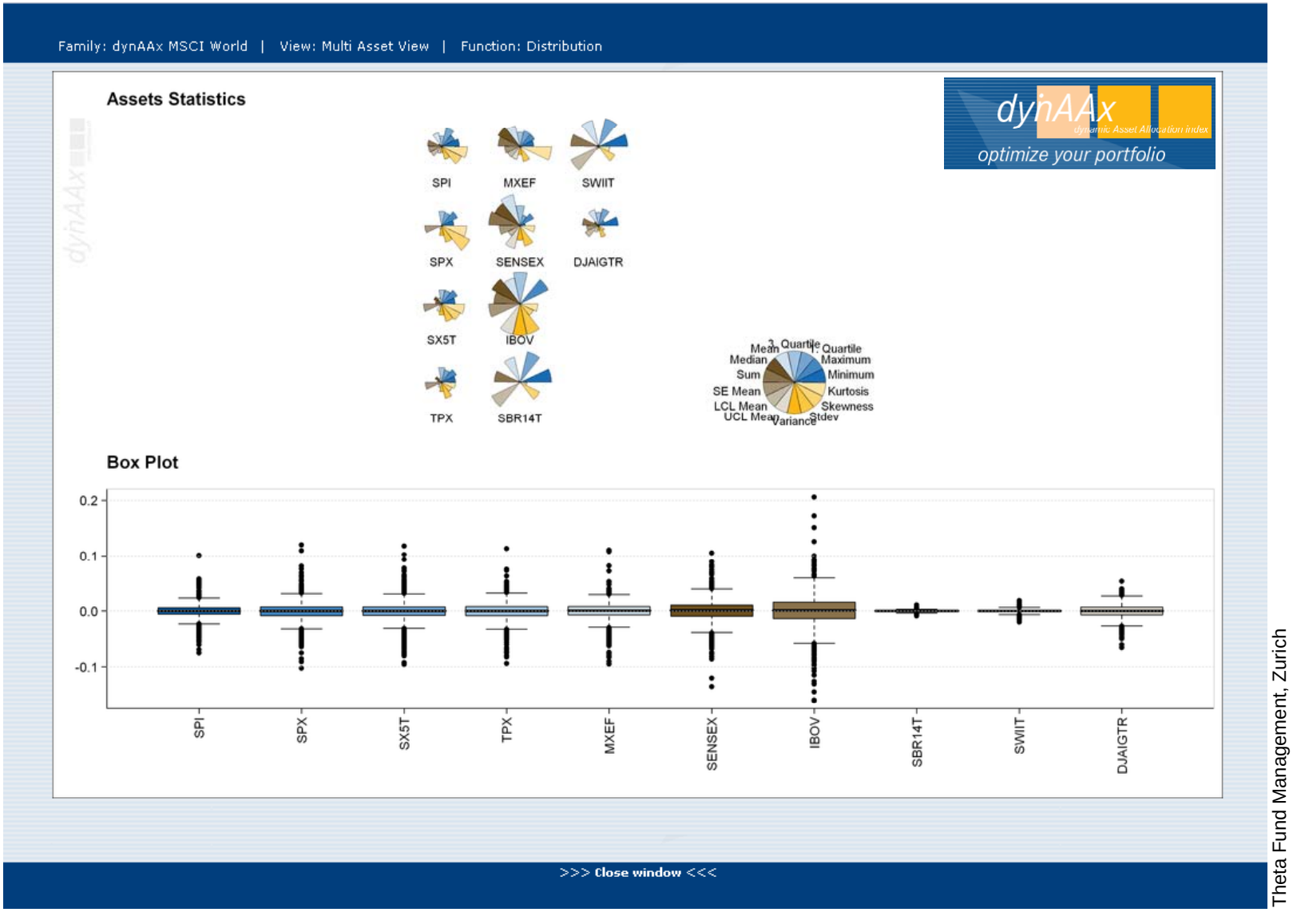
```
portfolioConstraints()
```
“LongOnly”, “Short”, “Partial”,
minW, maxW,
minsumW, maxSumW, eqsumW,
minsumB, maxSumB, eqsumB,
listFun, minFun, maxFun, …

Explorative Data Analysis ...



Theta Fund Management, Zurich

Asset Selection



Theta Fund Management, Zurich

Optimizing MV Portfolios ...

Load Data Set, Specification and Constraints
Pictet Swiss Pension Fund Benchmark
LPP2005

```
# LPP Portfolio Example:
> Data = LPP2005.RET[, 1:6]
> Spec = portfolioSpec()
> Cons = "LongOnly"

# Portfolio Frontier:
> portfolioFrontier(Data, Spec, Cons)
```

Compute the efficient frontier

Output:

```
Title:
 MV Portfolio Frontier:
 Estimator:         covEstimator
 Solver:            solveRquadprog
 Optimize:          minRisk
 Constraints:       LongOnly
 Portfolio Points:  5 of 50
```

The portfolio weights

```
Portfolio Weights:
      SBI   SPI    SII    LMI    MPI    ALT  LPP25  LPP40  LPP60
1  1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
13 0.0327 0.0000 0.1458 0.6594 0.0000 0.1621 0.0000 0.0000 0.0000
25 0.0000 0.0081 0.2492 0.3528 0.0000 0.3899 0.0000 0.0000 0.0000
37 0.0000 0.0197 0.3516 0.0120 0.0000 0.6168 0.0000 0.0000 0.0000
50 0.0000 0.0000 0.0000 0.0000 0.0000 1.0000 0.0000 0.0000 0.0000
```

The covariance risk budgets

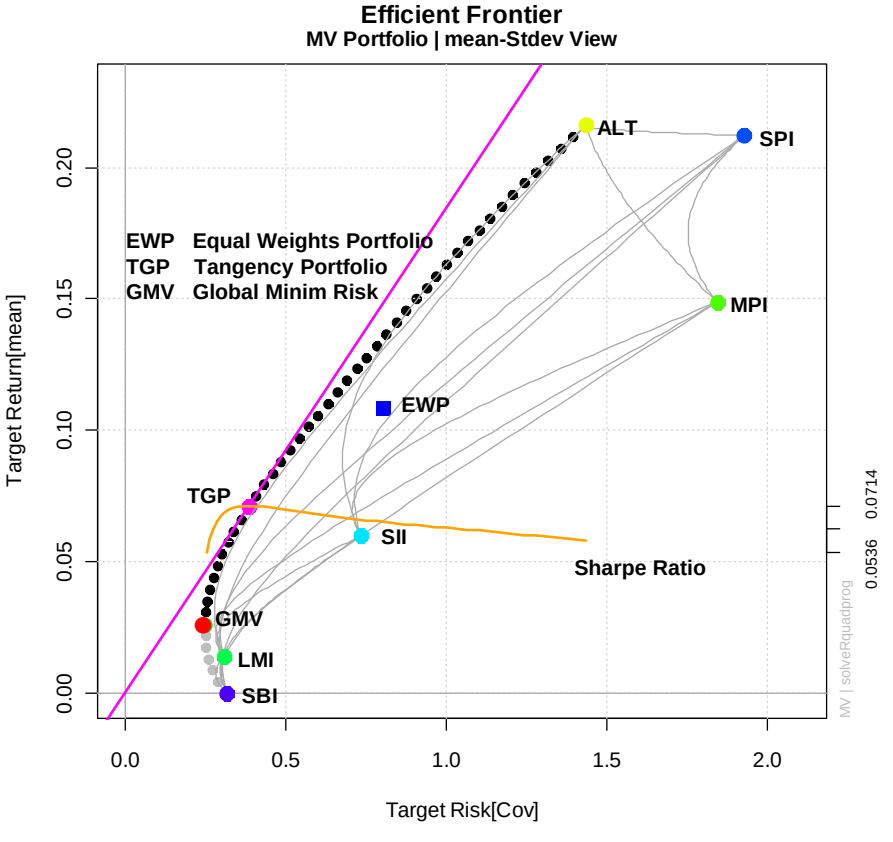
```
Covariance Risk Budgets:
       SBI     SPI     SII     LMI     MPI     ALT   LPP25   LPP40   LPP60
1   1.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
13  0.0116  0.0000  0.1586  0.3456  0.0000  0.4841  0.0000  0.0000  0.0000
25  0.0000  0.0176  0.1225 -0.0083  0.0000  0.8683  0.0000  0.0000  0.0000
37  0.0000  0.0274  0.0954 -0.0008  0.0000  0.8780  0.0000  0.0000  0.0000
50  0.0000  0.0000  0.0000  0.0000  0.0000  1.0000  0.0000  0.0000  0.0000
```

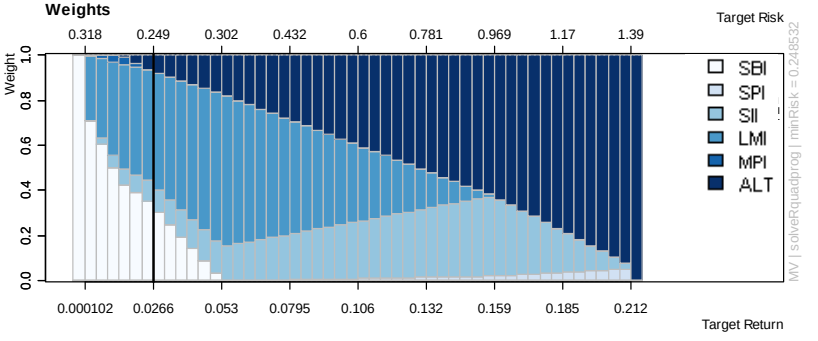
The target returns and target risks

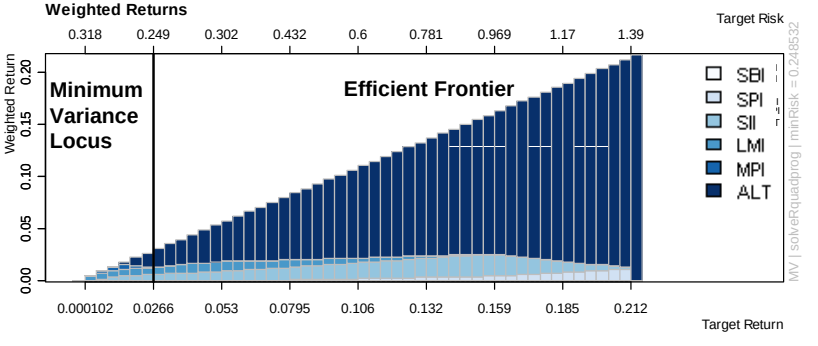
```
Target Return and Risks:
     mean     mu    Cov  Sigma   CVaR    VaR
1  0.0000 0.0000 0.1261 0.1261 0.2758 0.2177
13 0.0210 0.0210 0.1198 0.1198 0.2329 0.1708
25 0.0420 0.0420 0.2381 0.2381 0.5135 0.3348
37 0.0630 0.0630 0.3845 0.3845 0.8577 0.5714
50 0.0858 0.0858 0.5684 0.5684 1.3343 0.8978
```

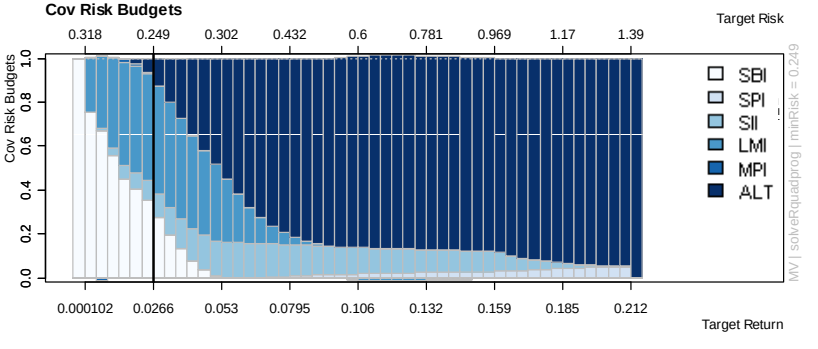
Plotting Frontiers and Weights ...

LPP 2005 Benchmark Portfolio



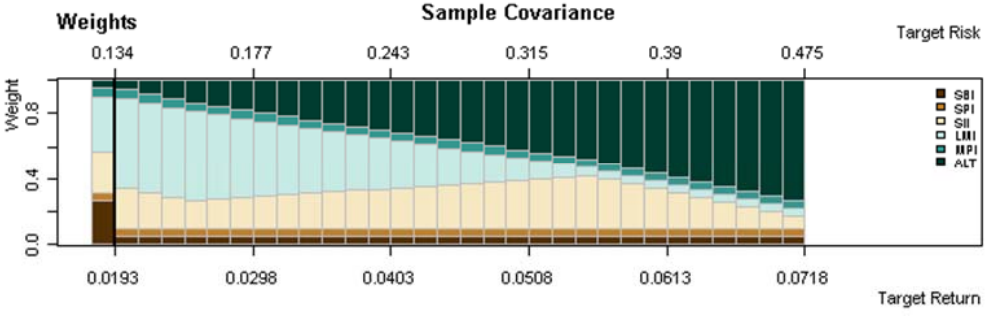






Adding Box/Group Constraints ...

```
# Example:
Cons = c(
  "minW[1:nAssets] = 0.05",
  "maxsumW[c('SBI','LMI'] = 0.6")


# Mean-Variance:
frontier = portfolioFrontier(Data,Spec,Cons)


# Weights Plot:
weightsPlot(frontier)
```

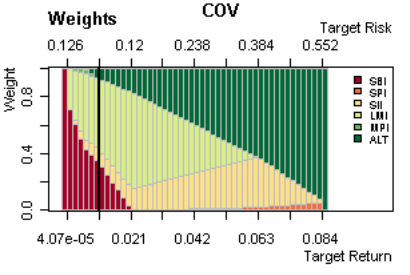


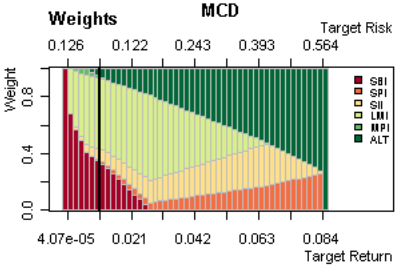
Reducing Estimation Errors ...

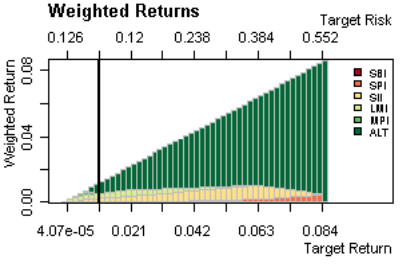
Functions:

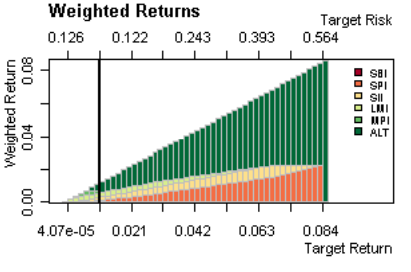
```
covEstimator
kendallEstimator
spearmanEstimator
mcdEstimator
mveEstimator
covMcdEstimator
covOGKEstimator
shrinkEstimator
baggedEstimator
```

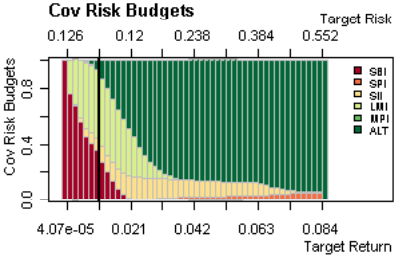
```
# MV Sample Estimator:
covFrontier = portfolioFrontier(Data, Spec)

# MV MCD Estimator:
setEstimator(Spec) <- "covMcdEstimator"
mcdFrontier <- portfolioFrontier(Data, Spec)

# Weights Plot:
weightsPlot(covFrontier)
weightsPlot(mcdFrontier)

...
```

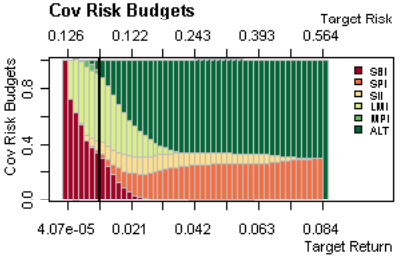


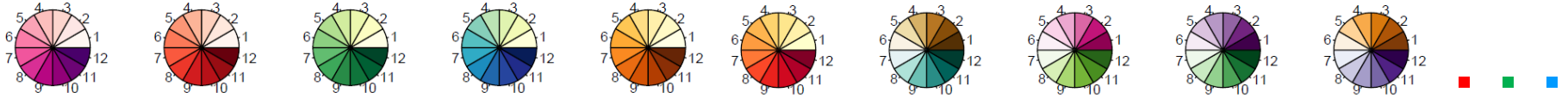






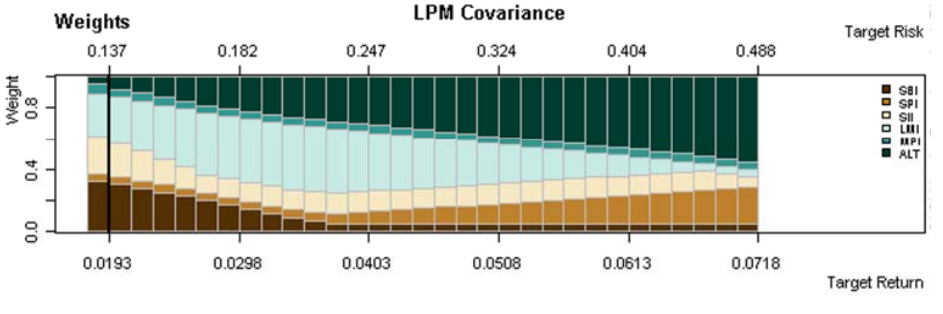






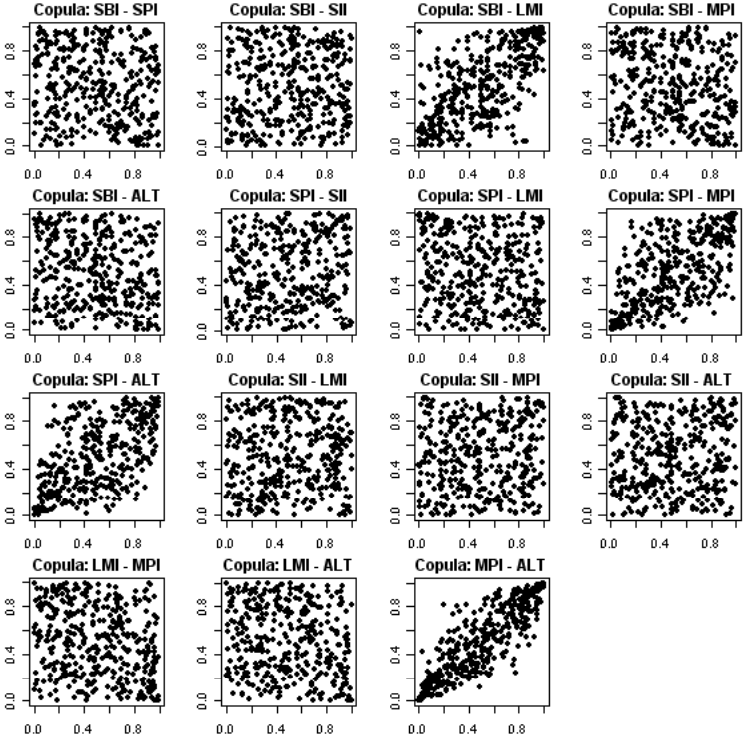
Q Lower Partial Moments ...

```
# Example:
Cons = c(
  "minW[1:nAssets] = 0.05",
  "maxsumW[c('SBI','LMI'] = 0.60")

# Quadratic Lower Partial Moments:
setEstimator(Spec) <- "lpmEstimator"
Spec@model$param$a <- 1.25
Spec@model$param$tau <- "colMeans"
frontier <- portfolioFrontier(Data,Spec,Cons)

# Weights Plot:
weightsPlot(frontier)
```



Copulae Tail Risks …

Copulae Lower Tail Risk Dependence Budgets



SBI CH Bonds
SPI CH Stocks
SII CH Immo
LMI World Bonds
MPI World Stocks
ALT World AltInvest

Tail Dependence:

	Lower
SBI SPI	0
SBI SII	0.055
SBI LMI	0.064
SBI MPI	0
SBI ALT	0
SPI SII	0
SPI LMI	0
SPI MPI	0.352
SPI ALT	0.273
SII LMI	0.075
SII MPI	0
LMI MPI	0
LMI ALT	0
MPI ALT	0.124

$$\lambda_{lower} = \lim_{u \to 0} \left[\Pr\left(Y \le F_Y^{-1}(u) \mid X \le F_X^{-1}(u) \right) \right]$$
$$= \lim_{u \to 0} \left[\frac{C(u,u)}{u} \right]$$

$$\min \quad w^\top \hat{\Sigma} w$$
$$s.\ t.$$
$$w^\top \hat{\mu} = \bar{r}$$
$$w^\top 1 = 1$$
$$\mathcal{L}_i^{lower} \le \frac{w_i}{\lambda} \frac{d\lambda}{dw_i} \le \mathcal{L}_i^{upper}$$
$$\ldots$$

… Quadratic Constraints use Rsocp
(not yet fully implemented)

Handling Nonlinear Constraints ...

```
# Specification:
spec <- portfolioSpec()
setTargetReturn(spec) <- 4*mean(data) # 17.2%
setObjective(spec) = c("Objective", "Return", "Risk")
Return <- function(weights)
   (getMu(Data) %*% weights)
Risk <- function(weights)
   (sqrt(weights %*% getSigma(Data) %*% weights))
Objective <- function(weights) Risk(weights)
setSolver(spec) <- "solveRdonlp2"

# 130/30 Extension Constraints:
lowerExtension <- function(w) sum(w[w<0])
upperExtension <- function(w) sum(w[w>0])
cons <- c(
   "minW[1:nAssets] = rep(-0.30, times = nAssets)",
   "maxW[1:nAssets] = rep( 1.30, times = nAssets)",
   "minsumW[1:nAssets] = -0.30",
   "maxsumW[1:nAssets] =  1.30",
   "listF = list(lowerExtension, upperExtension),
   "minF = c(-0.30, 0.00)",
   "maxF = c( 0.00, 1.30)")

# Portfolio:
efficientPortfolio(data, spec, cons)
```

```
Title:
 MV Efficient Portfolio
 Estimator:     covEstimator
 Solver:        solveRdonlp2
 Optimize:      minRisk
 Constraints:   minW maxW minsumW maxsumW

Portfolio Weights:
   SBI    SPI    SII    LMI    MPI    ALT
-0.293  0.001 -0.000 -0.006  0.000  1.243

Covariance Risk Budgets:
   SBI    SPI    SII    LMI    MPI    ALT
0.0121 0.0009 0.0000 0.0003 0.0003 0.9864

Target Return and Risks:
  mean     mu    Cov  Sigma   CVaR    VaR
0.1067 0.1067 0.7157 0.7157 1.6843 1.1471
```

Other non-linear Constraints:
Value at Risk, Tracking Error, Drawdowns, ...

Mixed Integer Programming ...

Buy-In Threshold Constraints:

These constraints define the minimum level at which an asset can be purchased. Its eliminates the problem of unrealistically small trades.

Cardinality Constraints:

These constraints restrict the number of stocks allowed in the portfolio

Roundlot Constraints:

Roundlots are used to define the basic unit of investment. Investors are allowed only to make transactions in multiples of the roundlots.

```
...
setSolver(spec) <- "solveRsymphony"
cons <- ...
```

is currently under implementation in Package fPortfolioAdvanced.

BLCOP

BLCOP

is a contributed Package written by Francisco Gochez for Black-Litterman and Copula Opinion Pooling in Portfolio Optimization.

Black-Litterman

Fisher Black and Robert Litterman's 1992 goal wasto create a systematic method of specifying and then incorporating analyst/portfolio manager views into the estimation of market parameters for portfolio optimization.

Copula Opinion Pooling

is an alternative way with several advantages compared with Black-Litterman, Attilio Meucci 2005.

```
...
setType(spec) <- "BLCOP"
setViews(spec) <- ...
```

an interface is currently under implementation in Package fPortfolioAdvanced .

Rolling Portfolio Backtests ...

fPortfolioBacktest

Portfolio Model

Example: Rolling Tangency CVaR Portfolio with box/group constraints

Specification the Backtest Settings

```
backtestSpec <-
portfolioBacktest(
  windows,
  strategy,
  smoother, ... )
```

Run the Backtests

```
rollingBacktest <-
portfolioBacktesting(
   formula,
   data, spec, constraints,
   backtest = backtestSpec, ...)
```

Smooth the Weights

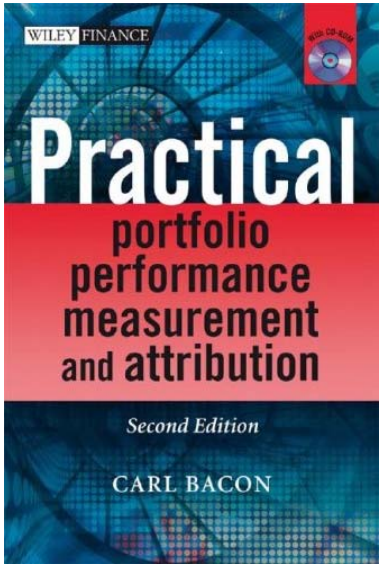
```
portfolioSmoothing(
   object = rollingBacktest,
   backtest = backtestSpec, ...)
```

Analyze the Performance

```
portfolioPerformance(...)
```

Rolling Performance Analysis ..

fPortfolioPerformance



Implements more than 100 traditional portfolio risk and performance measures from Carl Bacon's book, plus some more, e.g. robust risk measures, extreme value measures, copulae measures, …

Preliminary version (without documentation) is available on demand.

GCC Country Rotation

MSCI GCC
Gulf Cooperation Council
Countries Indices

Rolling Windows:

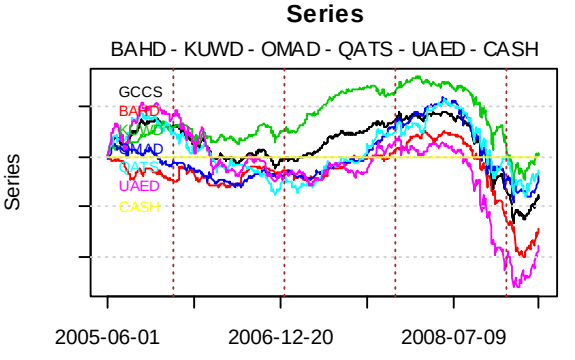
- Horizon 12m
- Shift 1m

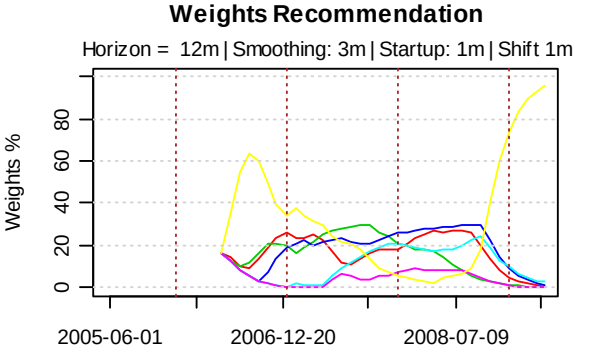
Portfolio Strategy:

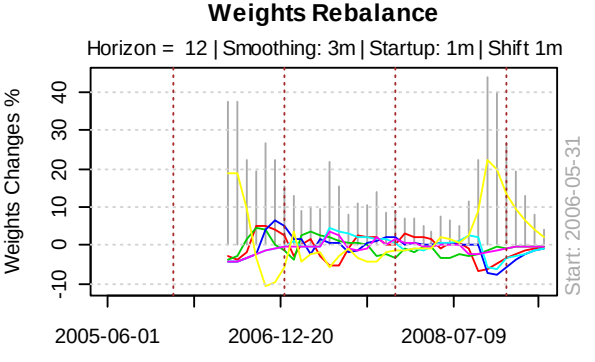
- MV Tangency Portfolio
- Dynamic Horizon < 12M
- Optimal Shrinkage Estimator
  - best of $\lambda = 0 \ldots 1$
- Partial Cash Position
- Max 30% Box Constraints

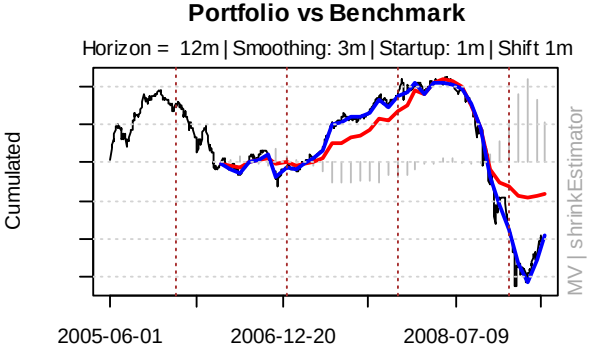
Weights Smoothing:

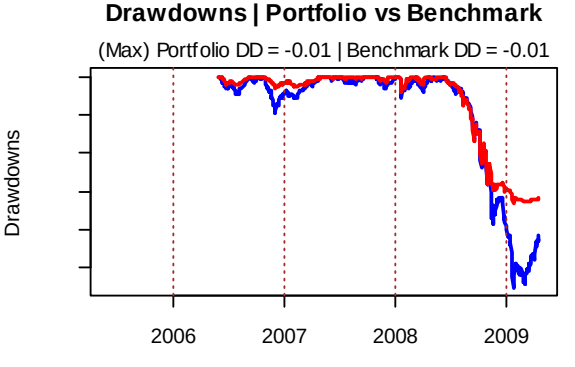
- 3m Double EMA



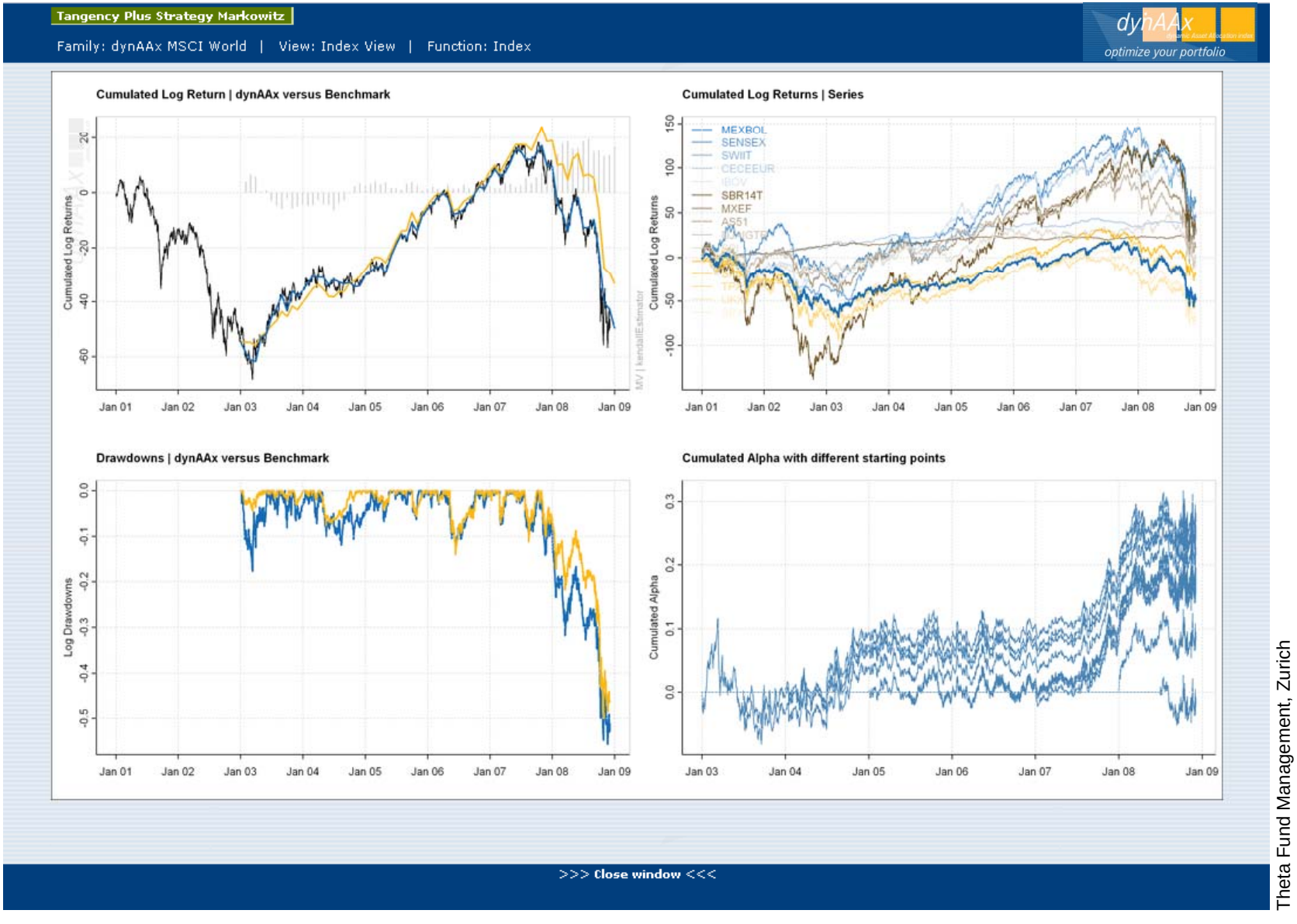








Backtesting Results ...

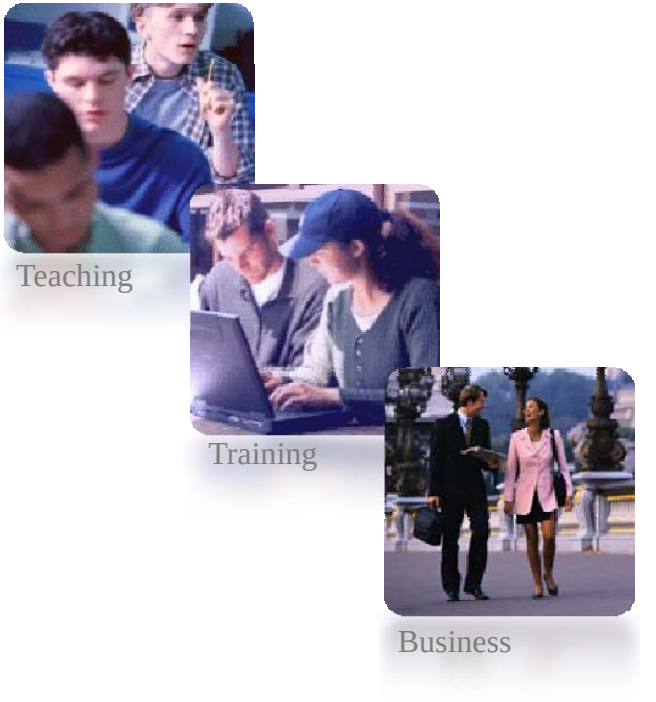


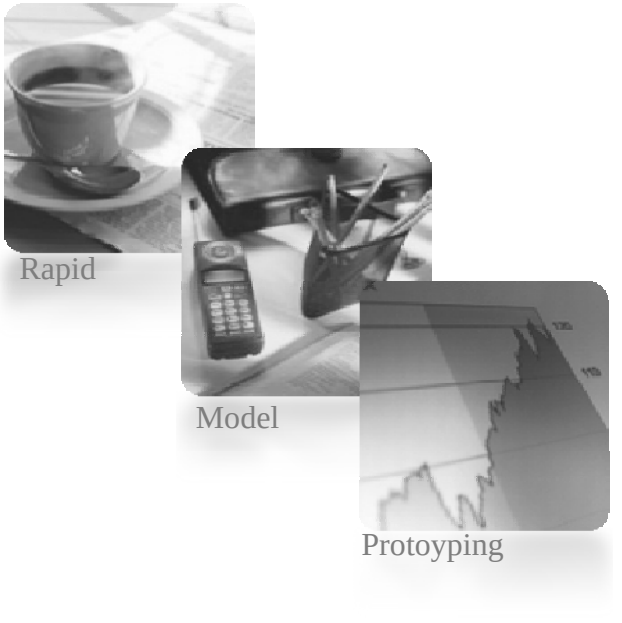
Theta Fund Management, Zurich

Backtesting Results

Theta Fund Management, Zurich

open source software for computational finance and financial engineering





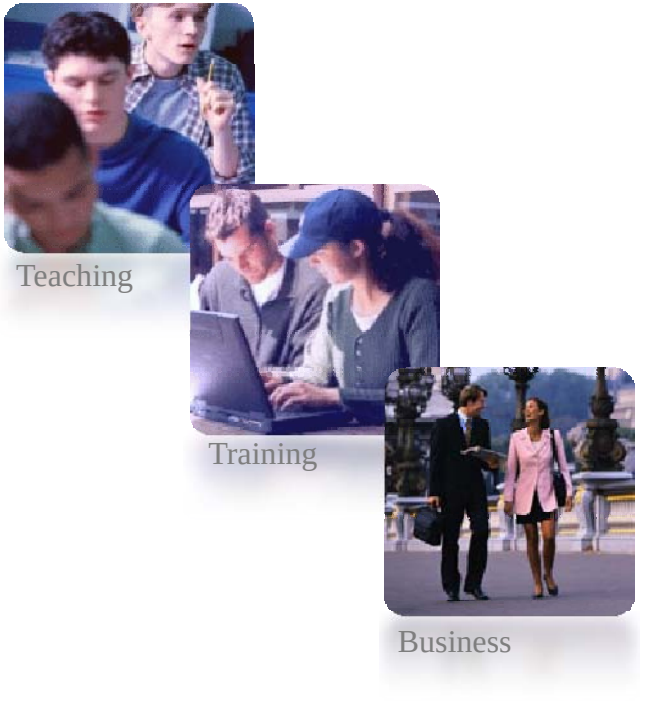
Thank you

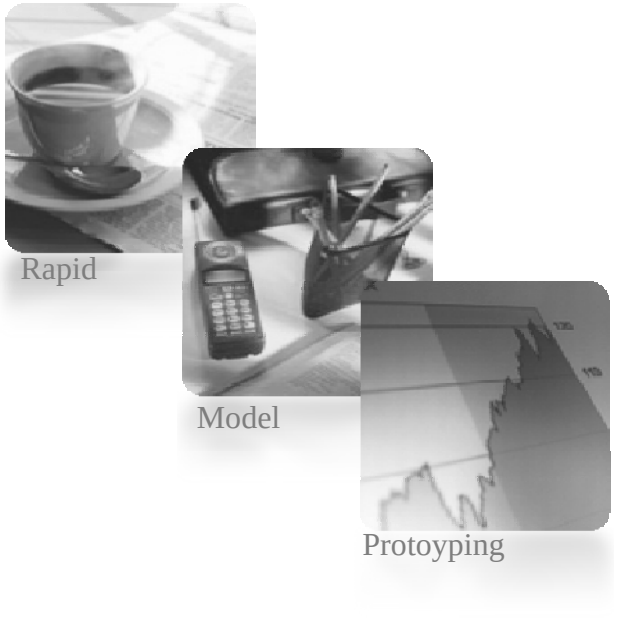
wuertz@phys.ethz.ch

Rmetrics Packages: fEcofin, fBasics, timeDate, timeSeries, fImport, datafeed, fArma, fArmaOx, fGarch, fGarchOx, fNonlinear, fMultivar, fUnitRoots, fTrading, fOptions, fExoticOptions, fAsianOptions, fTrading, fAssets, fPortfolio, fPortfolioSolver, fPortfolioBacktesting, fPortfolioPerformance, Rquadprog, Ripop, Rsimplex, Rsocp, RlpSolve, RlpSolveAPI, Rnlminb, Rsoplex, Rcplex, …

Rmetrics Packages: fEcofin, fBasics, timeDate, timeSeries, fImport, datafeed, fArma, fArmaOx, fGarch, fGarchOx, fNonlinear, fMultivar, fUnitRoots, fTrading, fOptions, fExoticOptions, fAsianOptions, fTrading, fAssets, fPortfolio, fPortfolioSolver, fPortfolioBacktesting, fPortfolioPerformance, Rquadprog, Ripop, Rsimplex, Rsocp, RlpSolve, RlpSolveAPI, Rnlminb, Rsoplex, Rcplex, …

open source software for computational finance and financial engineering





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About Rmetrics ...

Rmetrics
is a collection of R packages for computational finance and financial engineering.
It is based on the R language and the R run-time environment.

Rmetrics
is designed
as an Open Source Environment – you can look at any piece of the code
as a Rapid Model Prototyping System – do in one day where others need one week
as a Teaching Tool for “Computational Finance and Financial Engineering”,
but also a Code Archive for business use – copy and paste for free what you need

Rmetrics
tries to cover all major aspects of computational finance and financial engineering
Time and Date Management of Financial Time Series
Pricing and Valuation of Financial Instruments and Derivatives
Volatilty Modeling and Forecasting including GARCH Processes
Risk Management including Extreme Value Theory and Copulae
Asset Management and Portfolio Optimization together with Performance Analysis
…

Time Line …

1997 Starting with a Collection of SPlus Functions

1999 Moving to R

2001 Creating Rmetrics Packages

2002 Adding to CRAN Packages

2003 Introducing R-sig-Finance / Private Repository – Martin Mächler

2004 Providing Debian Packages – Dirk Eddelbüttel

2007 Organizing the1st Rmetrics User and Developer Workshop

2008 Founding the Rmetrics Association / Offering Student Internships

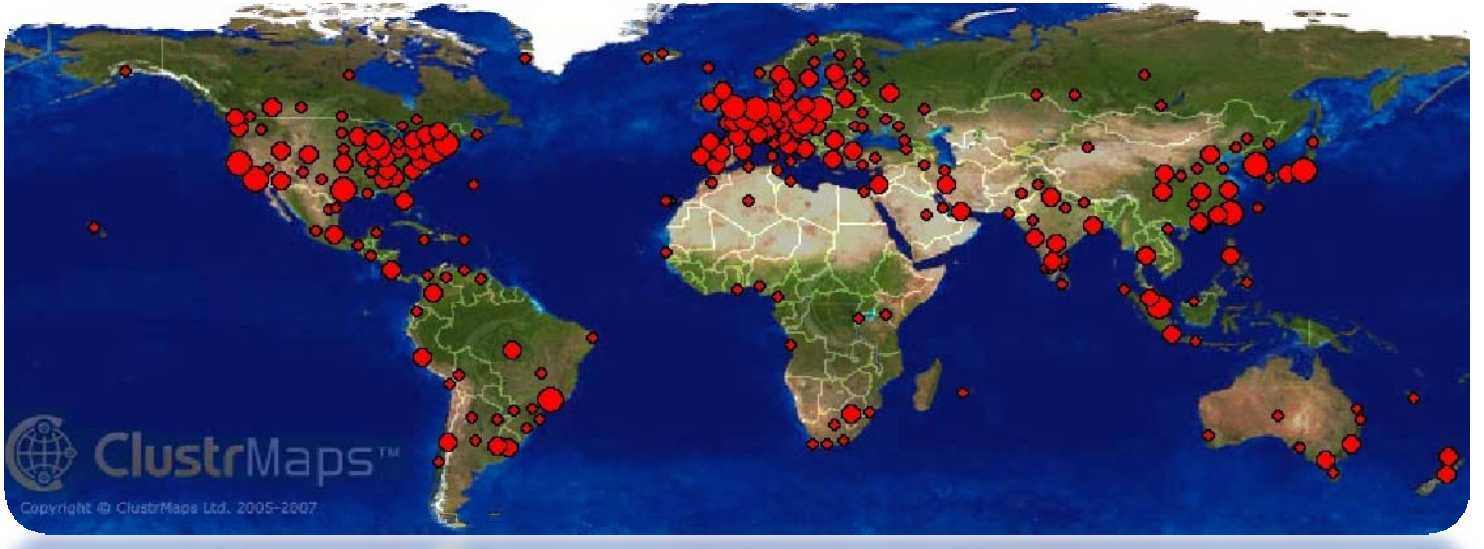
2008 2nd Rmetrics Developer Workshop

2008 Joining R-forge / Rmetrics Repository

2009 3rd Rmetrics User and Developer Workshop

2009 First Rmetrics eBook “Portfolio Optimization with R/Rmetrics”

Rmetrics Users Worldwide …



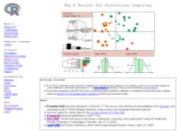
People use it in Education

Chicago Business School, University of Chicago
University of Economics, Vienna
Swiss Federal Administration, Berne
Institute for Advanced Studies, Vienna
Swiss Economic Institute, KOF ETH Zurich
Swiss Banking Institute, University of Zurich
...

and in Business …

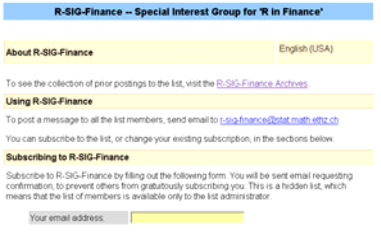
Bank Clariden, Zurich
Bank of America, Chicago
Credit Suisse, Madrid,
European Central Bank, Frankfurt
Government Investment Corp, Singapore
Lippers – Reuters, Dallas
…

R/Rmetrics Links ...



Download R Run-Time Environment and Rmetrics Packages:
www.r-project.org

Get most recent updates from the Rmetrics Repository:
https://r-forge.r-project.org



Find help from the Special Interest Group of R inFinance:
https://stat.ethz.ch/mailman/listinfo/rmetrics-core
https://stat.ethz.ch/mailman/listinfo/r-sig-finance

Visit the home of Rmetrics Association for Financial Computing:
www.rmetrics.org

Rmetrics Association …

The “Rmetrics Association” is a not-for-profit organization working in the public interest. It was founded May, 2008 as an association under Swiss law and has its seat in Zurich.

Rmetrics was born 1997 in the econphysics group of Dr. Diethelm Würtz at the Institute of Theoretical Physics. When Rmetrics was introduced it served as a teaching environment in computational finance and financial engineering.

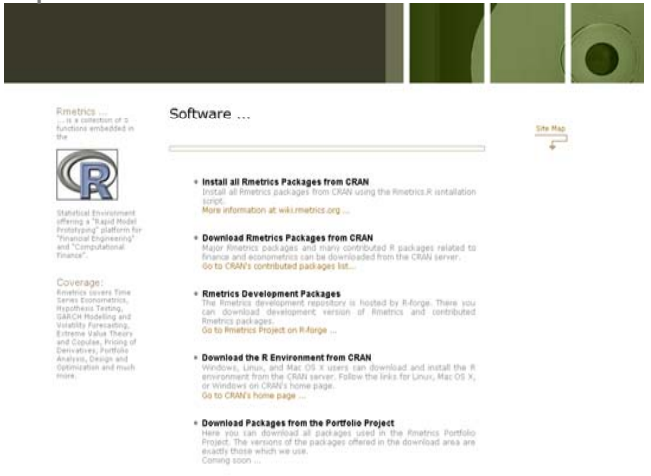
Diethelm Würtz is Senior Scientist and Private Lecturer at the Physics Department and at the Curricuilum for Computational Science at the Swiss Federal Institute of Technology in Zurich.

The Rmetrics Association …

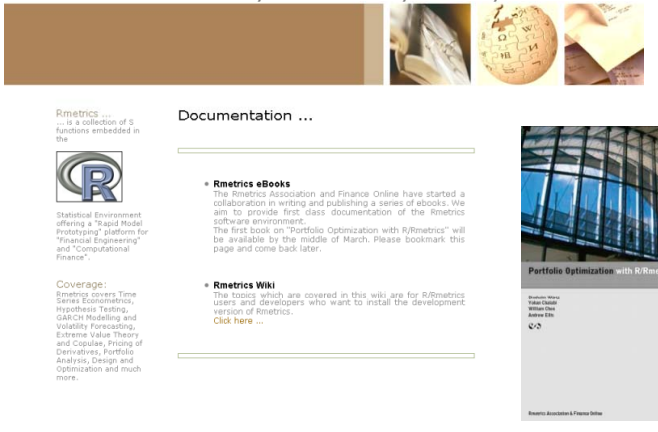
- supports the Rmetrics project and other innovations in financial computing,
- ensures the continued development of the Rmetrics software packages,
- provides a reference point for individuals, institutions or commercial enterprises, that want to support or interact with the Rmetrics development community,
- encourages students to participate in internships,
- publishes eBooks covering user and programming guides,
- offers traineeships, and organizes meetings and workshops.

Rmetrics Activities …

Open Source Software …



Documentation, eBooks, Wiki, …



Conferences, Workshops, Lectures, Seminars …

Meielisalp User and Developer Workshop

Rmetrics Support ...



Donations ...

The non-profit Rmetrics Association supports the open source Rmetrics Software in the public interest. Rmetrics has expenses and it is hoped that businesses that use it and make money through it will contribute back to help make Rmetrics the best open source software in computational finance and financial engineering.

https://www.rmetrics.org