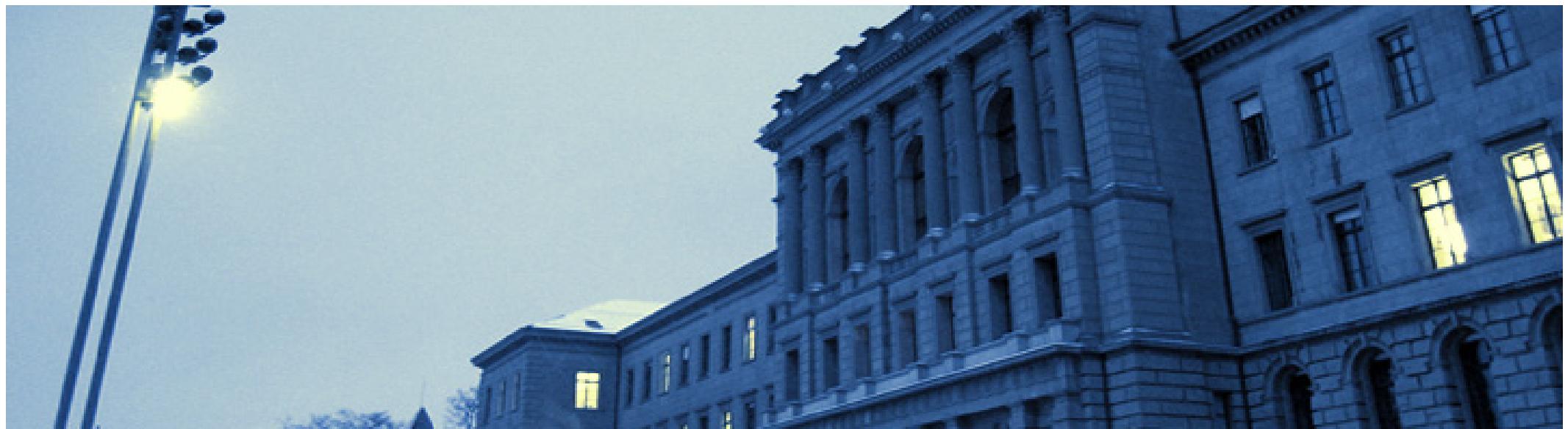


# *Computational Finance and Financial Engineering: The R/Rmetrics Software Environment*

Diethelm Würtz and Yohan Chalabi  
ITP ETH Zürich, Finance Online GmbH Zürich

*useR! 2008*



## What is Rmetrics ?

... Open Source Software Development for Statistical and Financial Computing

### Rmetrics

is a system 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 and as a  
Rapid Model Prototyping System for  
Teaching “Computational Finance and Financial Engineering”.

# Rmetrics Packages

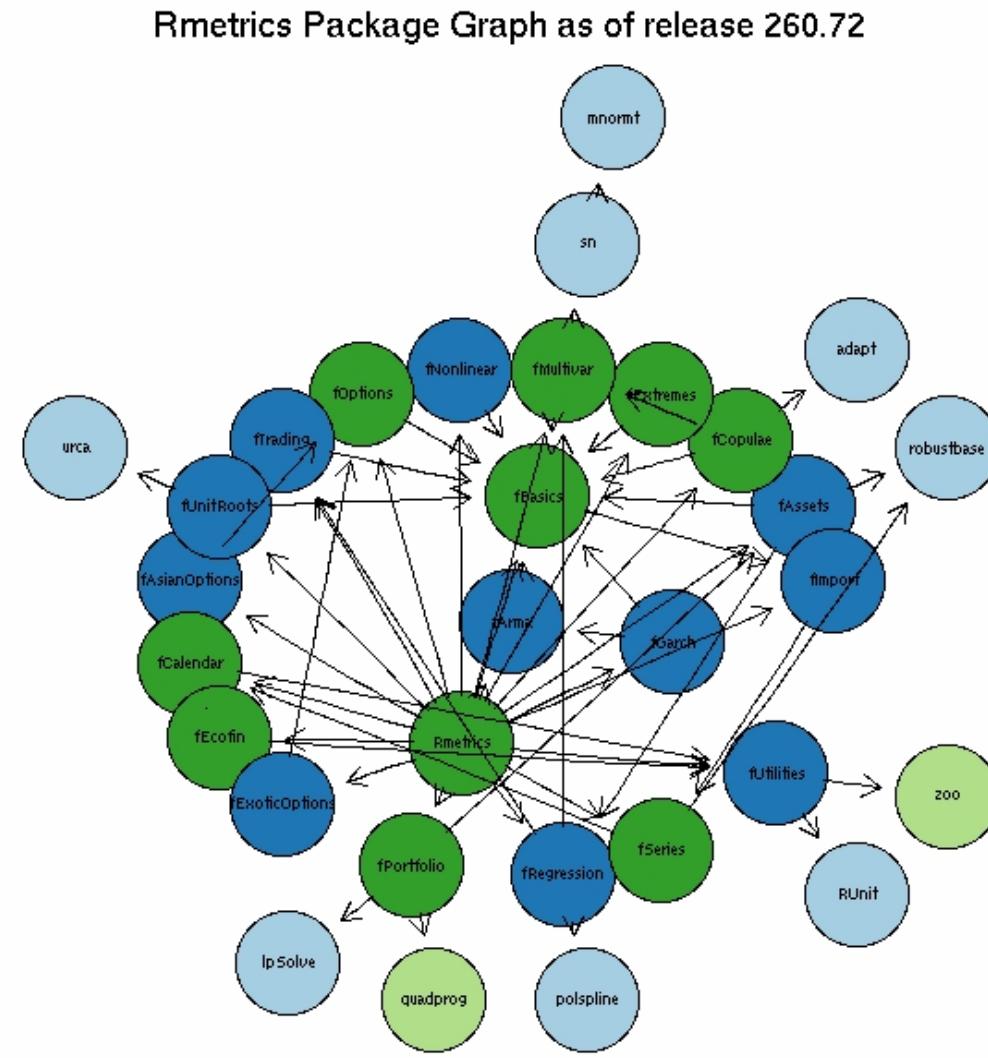
Which Packages are Coming with Rmetrics ?

... 20 R Packages, 1'600 R Functions, 80'000 lines of R Code

## Rmetrics

- fUtilities
- fEcofin
- fCalendar / timeDate**
- fSeries / timeSeries**
- fImport
- fBasics
- fArma
- fGarch**
- fNonlinear
- fUnitRoots
- fTrading
- fMultivar
- fRegression
- fExtremes**
- fCopulae**
- fOptions
- fExoticOptions
- fAsianOptions
- fAssets**
- fPortfolio**

## Rmetrics Package Graph by Dirk Eddelbuettel



## From where I can get Information on R / Rmetrics ?

... visit the CRAN and Rmetrics Servers

The image contains two side-by-side screenshots of web browser windows.

**Left Browser Screenshot:** Displays the "The R Project for Statistical Computing" website. The URL is <http://www.r-project.org/>. The page features a large R logo on the left, a navigation menu at the top, and a main content area with a PCA plot titled "PCA 5 vars". The plot shows data points colored by group (orange and green) and has axes labeled "Fertility", "Catholic", "Examination", and "Education". Below the plot is a "Getting Started" section with bullet points about R being free, its availability on various platforms, and links to answers for common questions. There's also a "News" section listing recent R releases and a "Misc" section with links to Bioconductor, Related Projects, and Links.

**Right Browser Screenshot:** Displays the "Rmetrics" website for "Learning Computational Finance". The URL is <http://www.itp.phys.ethz.ch/econophysics/R/>. The page has a dark header with the Rmetrics logo and the text "open Learning Computational Finance". It features a banner image of people working on laptops. Below the banner is a navigation menu with links to Home, About, Course, Documentation, Benchmarks, Download, Links, and Contact. A "Rmetrics ..." section describes it as a collection of functions for financial engineering and computational finance. A "Support Rmetrics & Donate Books - Have a look on our Wish List" link is present. A "Welcome to Rmetrics ..." section includes a quote from Diethelm Wuertz: "I hope you enjoy Rmetrics! Diethelm Wuertz".

Download the Rmetrics Packages from CERAN  
[www.r-project.org](http://www.r-project.org)

Visit the home of  
**Rmetrics:**  
[www.rmetrics.org](http://www.rmetrics.org)

Where I can get help for R/Rmetrics' Financial Applications ?  
... join the R-sig-finance – Special Interest Group for 'R in Finance'

The screenshot shows a Microsoft Internet Explorer window displaying the R-sig-finance info page. The title bar reads "R-sig-finance Info Page - Microsoft Internet Explorer". The address bar shows the URL "https://stat.ethz.ch/mailman/listinfo/r-sig-finance". The main content area has a blue header bar with the text "R-sig-finance -- Special Interest Group for 'R in Finance'". Below this, there are several sections with headings: "About R-sig-finance" (highlighted in orange), "Using R-sig-finance", and "Subscribing to R-sig-finance". The "About R-sig-finance" section contains the text "English (USA)". The "Using R-sig-finance" section contains the text "To see the collection of prior postings to the list, visit the [R-sig-finance Archives](#). To post a message to all the list members, send email to [r-sig-finance@stat.math.ethz.ch](mailto:r-sig-finance@stat.math.ethz.ch). You can subscribe to the list, or change your existing subscription, in the sections below." The "Subscribing to R-sig-finance" section contains the text "Subscribe to R-sig-finance by filling out the following form. You will be sent email requesting confirmation, to prevent others from gratuitously subscribing you. This is a hidden list, which means that the list of members is available only to the list administrator." At the bottom, there is a text input field labeled "Your email address:".

Where to  
discuss and find help on  
**R/Rmetrics** ?

[https://stat.ethz.ch/mailman/  
listinfo/r-sig-finance](https://stat.ethz.ch/mailman/listinfo/r-sig-finance)

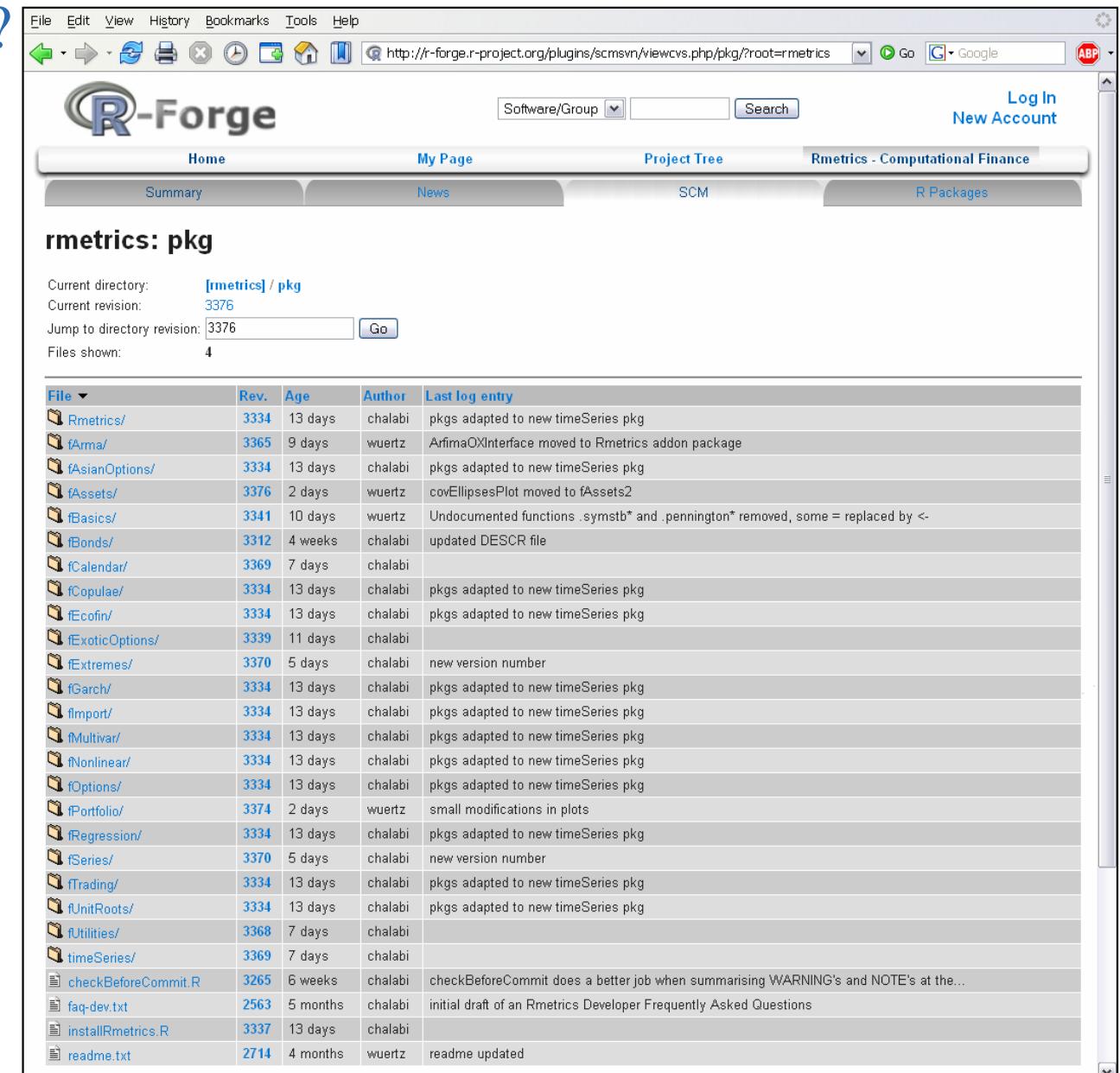
Thanks to Martin Mächler

The most recent Rmetrics ?  
 ... get it from the R-forge Server

Where to get the most recent  
 versions of the **Rmetrics**  
 Packages?

Goto to the SVN repository of  
**Rmetrics**, part of

<https://r-forge.r-project.org>



The screenshot shows a web browser window displaying the R-Forge SVN repository for the 'Rmetrics' package. The URL in the address bar is <http://r-forge.r-project.org/plugins/scmsvn/viewcvs.php/pkg/?root=rmetrics>. The page title is 'rmetrics: pkg'. The top navigation bar includes links for Home, My Page, Project Tree, and Rmetrics - Computational Finance. Below the title, there are tabs for Summary, News, SCM, and R Packages. The main content area displays a table of file revisions:

File	Rev.	Age	Author	Last log entry
Rmetrics/	3334	13 days	chalabi	pkgs adapted to new timeSeries pkg
fArma/	3365	9 days	wuertz	ArfimaOXInterface moved to Rmetrics addon package
fAsianOptions/	3334	13 days	chalabi	pkgs adapted to new timeSeries pkg
fAssets/	3376	2 days	wuertz	covEllipsesPlot moved to fAssets2
fBasics/	3341	10 days	wuertz	Undocumented functions .symstb* and .pennington* removed, some = replaced by <-
fBonds/	3312	4 weeks	chalabi	updated DESCRI file
fCalendar/	3369	7 days	chalabi	
fCopulae/	3334	13 days	chalabi	pkgs adapted to new timeSeries pkg
fEcofin/	3334	13 days	chalabi	pkgs adapted to new timeSeries pkg
fExoticOptions/	3339	11 days	chalabi	
fExtremes/	3370	5 days	chalabi	new version number
fGarch/	3334	13 days	chalabi	pkgs adapted to new timeSeries pkg
fImport/	3334	13 days	chalabi	pkgs adapted to new timeSeries pkg
fMultivar/	3334	13 days	chalabi	pkgs adapted to new timeSeries pkg
fNonlinear/	3334	13 days	chalabi	pkgs adapted to new timeSeries pkg
fOptions/	3334	13 days	chalabi	pkgs adapted to new timeSeries pkg
fPortfolio/	3374	2 days	wuertz	small modifications in plots
fRegression/	3334	13 days	chalabi	pkgs adapted to new timeSeries pkg
fSeries/	3370	5 days	chalabi	new version number
fTrading/	3334	13 days	chalabi	pkgs adapted to new timeSeries pkg
fUnitRoots/	3334	13 days	chalabi	pkgs adapted to new timeSeries pkg
fUtilities/	3368	7 days	chalabi	
timeSeries/	3369	7 days	chalabi	
checkBeforeCommit.R	3265	6 weeks	chalabi	checkBeforeCommit does a better job when summarising WARNING's and NOTE's at the...
faq-dev.txt	2563	5 months	chalabi	initial draft of an Rmetrics Developer Frequently Asked Questions
installRmetrics.R	3337	13 days	chalabi	
readme.txt	2714	4 months	wuertz	readme updated

Thanks to Kurt Hornik, Stefan Theussl for R-forge, and Martin Mächler and Yohan Chalabi for the move to R-forge

# Rmetrics - Workshop

**Next Workshop  
June 28th – July 2nd 2009**

**Organization:**

Swiss Rmetrics Foundation

**Co-Organizers:**

Swiss Federal Institute of Technology,  
Zurich, University of Economics and  
Business Administration, Vienna,  
University of Auckland

**Conference Chairs:**

Diethelm Würz, ETH Zurich  
Kurt Hornik, University of Vienna  
David J. Scott, University of Auckland

**Topics:**

Econometrics, Finance and Insurance  
Financial Time Series, Volatility Forecasts  
Trading and Decision Making Systems  
Portfolio Selection and Optimization  
Valuation of Financial Derivatives  
Extreme Value Theory and Copulae  
FX High Frequency, Time&Sales Data  
Monte Carlo Simulation and Pricing  
Robust Statistics in Finance

**Important Dates:**

Registration starts on February 1<sup>st</sup>, 2008  
Paper Submission ends on May 31<sup>st</sup> 2008

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

The workshop is limited to 80 participants



View from Meielisalp on Lake Thun

## Second R/Rmetrics User and Developer Workshop June 29<sup>th</sup> – July 3<sup>rd</sup>, 2008, Meielisalp, Lake Thun, Switzerland

The workshop focuses on ...

- \* using R/Rmetrics as the premier open source solution for financial market analysis, valuation of financial instruments, and insurance tasks,
- \* providing a platform for R/Rmetrics users to discuss and exchange ideas how R and Rmetrics can be used to do computations, data analysis, and visualization in finance and insurance,
- \* giving an overview of the new features of the rapidly evolving R/Rmetrics project.

The program consists of ...

- \* presentations of new R/Rmetrics directions and developments through keynote lectures,
- \* user-contributed presentations reflecting the wide range of fields in which R and Rmetrics are used in finance and insurance to analyze and model data,
- \* bringing together developers, practitioners, and users from finance and insurance providing a platform for common discussions and exchange of ideas.

# Volatility Forecasting

## Example 1: ARMA-GARCH Modeling

### Modeling and Forecasting Volatility

fGARCH

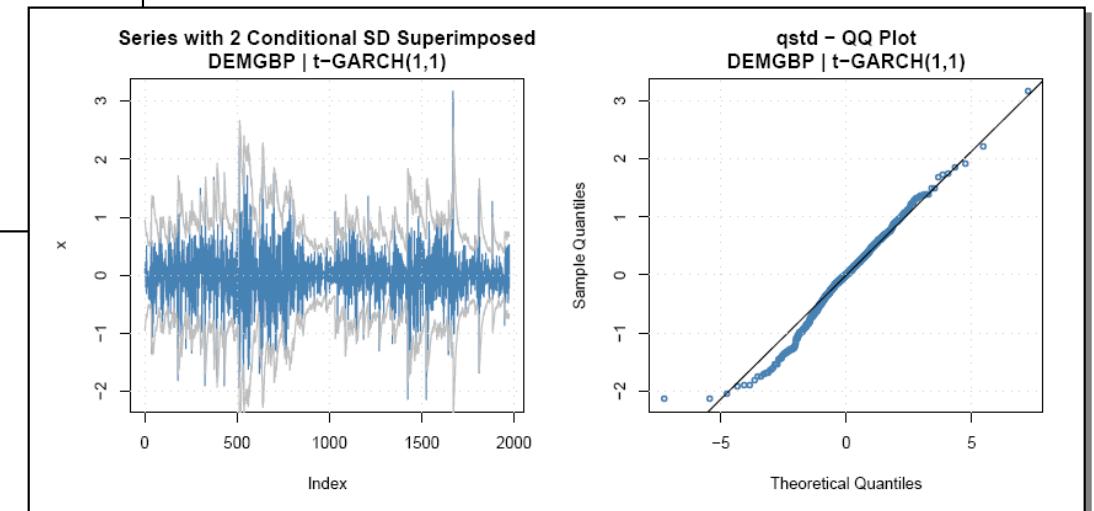
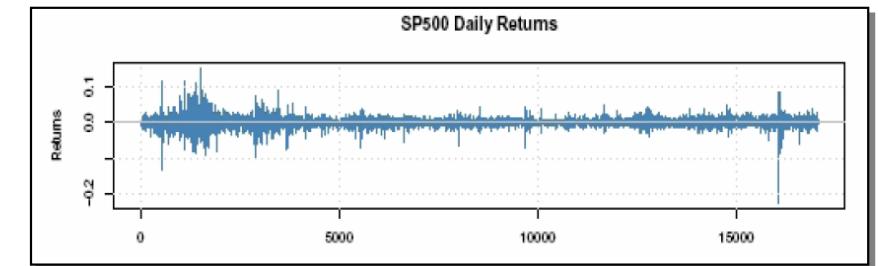
```
# DGE MA(1)-GARCH(1,1) Model Parameter Estimation:
> data(sp500dge)
# Percentual returns result in better scaling and faster convergence ...
> x = 100*sp500dge[, 1]

# R/Rmetrics:
> garchFit(~arma(0,1), ~aparch(1,1))
    Estimate Std. Error   t value Pr(>|t|)    
mu      0.020646  0.006346    3.253  0.00114 ** 
ma1     0.144745  0.008357   17.319 < 2e-16 *** 
omega   0.009988  0.001085    9.203 < 2e-16 *** 
alpha1   0.083803  0.004471   18.742 < 2e-16 *** 
gamma1  0.373092  0.027995   13.327 < 2e-16 *** 
beta1    0.919401  0.004093  224.622 < 2e-16 *** 
delta    1.435124  0.067200   21.356 < 2e-16 ***
```

### Diagnostic Analysis:

### Volatility Forecasts:

### SP500 ARMA -APARCH Modeling



### Residual Tests, ARCH Tests, IC Statistics, 11 Diagnostic Plots

Steps:	R/Rmetrics		Splus/Finmetrics		Ox/G@RCH	
	Mean	StDev	Mean	StDev	Mean	StDev
1	-0.006190	0.3834	-0.006053	0.3838	-0.006183	0.3834
2	-0.006190	0.3895	-0.006053	0.3900	-0.006183	0.3895
3	-0.006190	0.3953	-0.006053	0.3959	-0.006183	0.3953
4	-0.006190	0.4008	-0.006053	0.4014	-0.006183	0.4007
5	-0.006190	0.4060	-0.006053	0.4067	-0.006183	0.4060

## Example 2: Extreme Value Theory

## Robust Estimation of VaR and Expected Shortfall

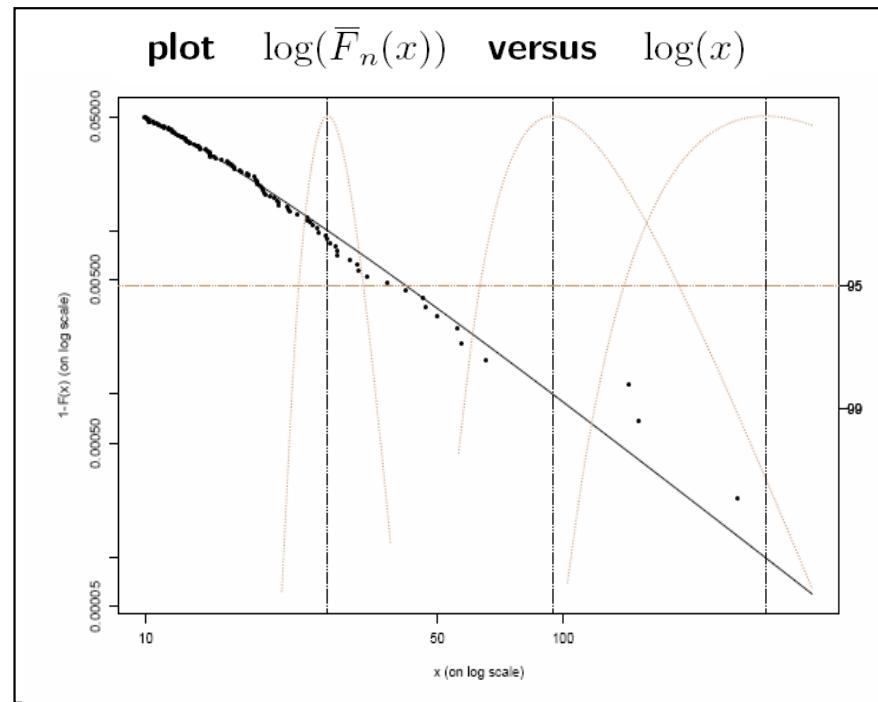
Extreme Value Theory: Value-at-Risk and Expected Shortfall are estimated from the GPD

$$\widehat{\text{VaR}}_q = u + \frac{\hat{\beta}}{\hat{\xi}} \left( \left( \frac{n}{N_u} (1 - q) \right)^{-\hat{\xi}} - 1 \right).$$

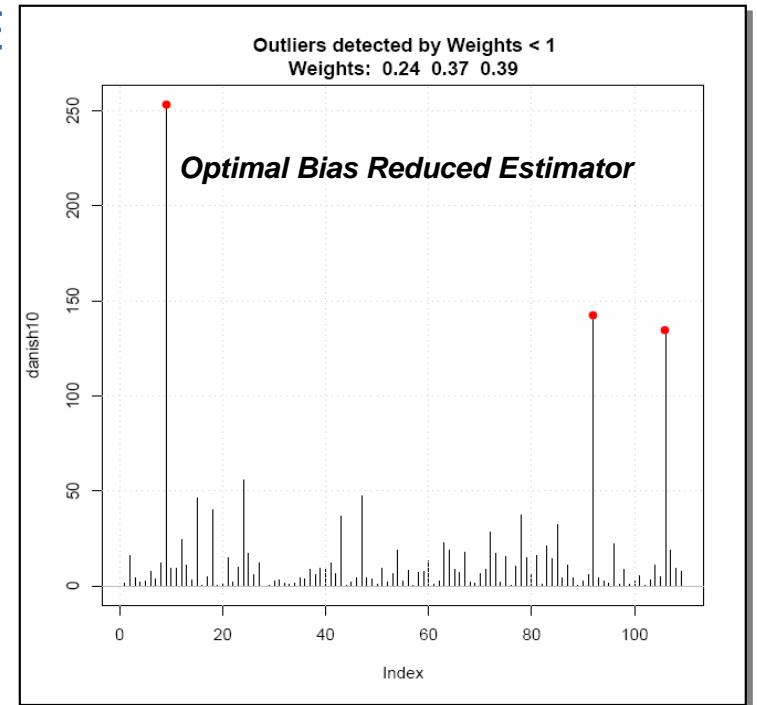
$$\widehat{\text{ES}}_q = \frac{\widehat{\text{VaR}}_q}{1 - \hat{\xi}} + \frac{\hat{\beta} - \hat{\xi}u}{1 - \hat{\xi}}.$$

## Danish Fire Losses

GPD



OBRE



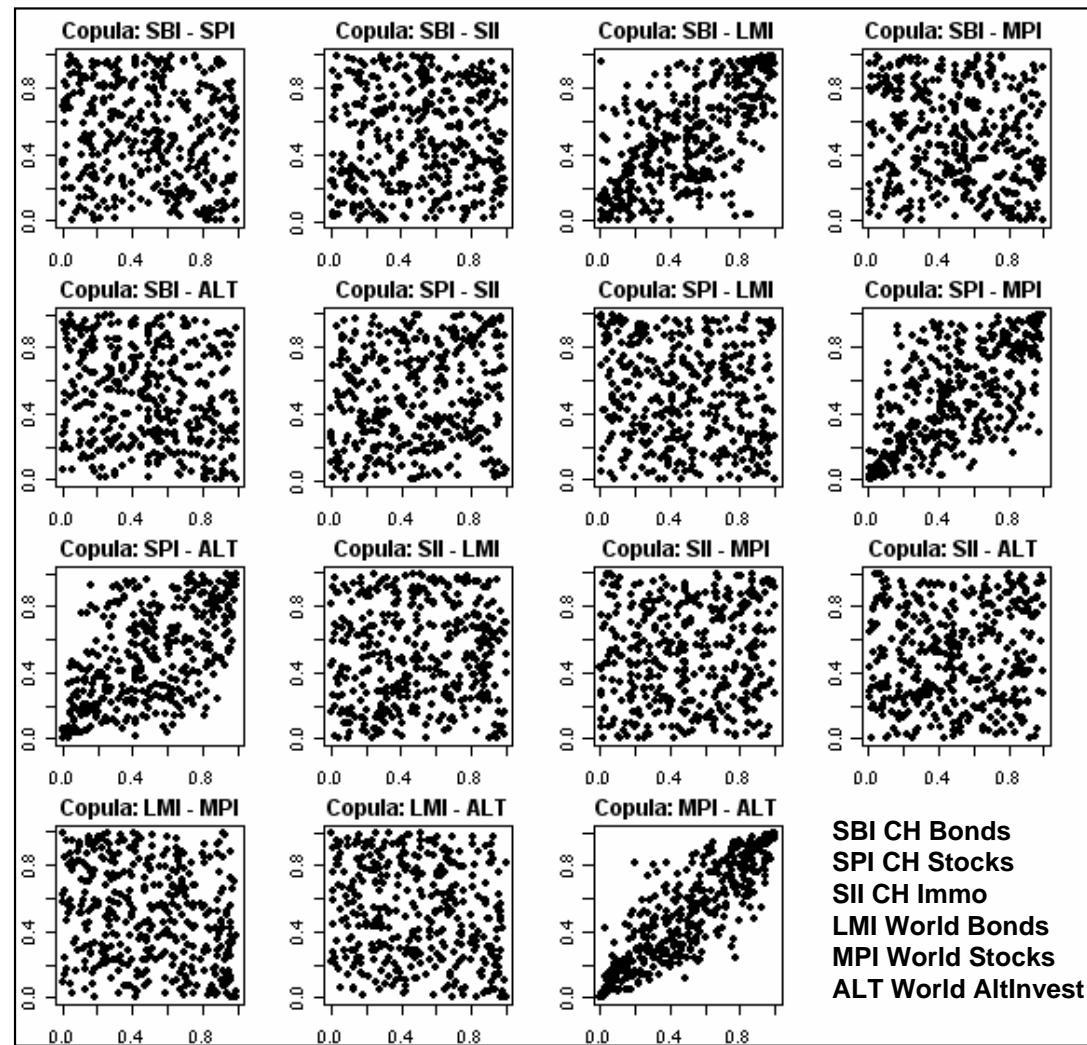
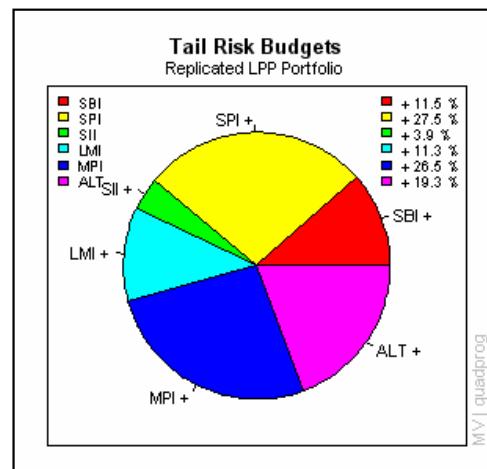
## Example 3: Bivariate Copulae

### Estimating Pairwise Lower Tail Dependence

fCopulae

### Pictet Swiss Pension Fund Portfolio

	Lower	Upper
SBI SPI	0	0
SBI SII	0.055	0
SBI LMI	0.064	0.069
SBI MPI	0	0
SBI ALT	0	0
SPI SII	0	0.064
SPI LMI	0	0.072
SPI MPI	0.352	0.214
SPI ALT	0.273	0.048
SII LMI	0.075	0
SII MPI	0	0.164
LMI MPI	0	0
LMI ALT	0	0
MPI ALT	0.124	0.012



## Example 4: Term Structure Modeling

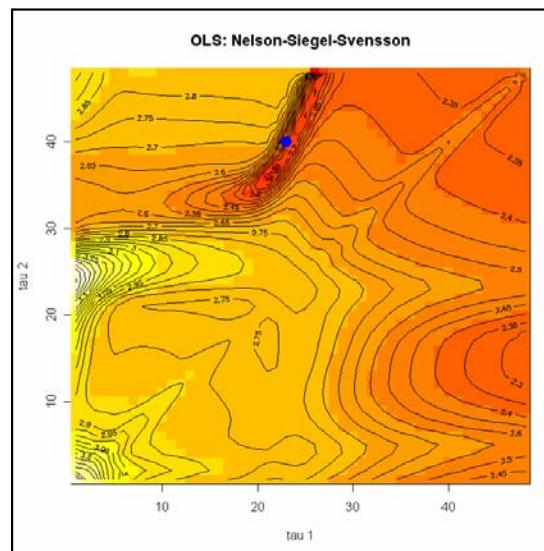
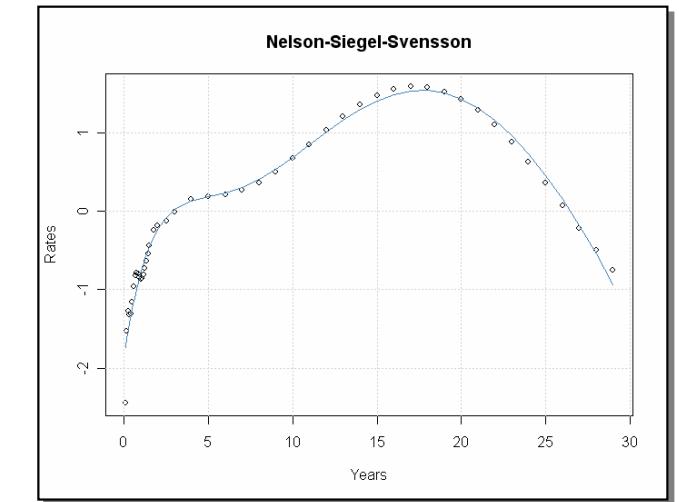
... Nelsen-Siegel-Svensson Estimation for the Zero Rates

fBonds

$$y(m) = \beta_0 + \beta_1 \frac{1 - e^{-m/\tau_1}}{m/\tau_1} + \beta_2 \left[ \frac{1 - e^{-m/\tau_1}}{m/\tau_1} - e^{-m/\tau_1} \right] \\ + \beta_3 \left[ \frac{1 - e^{-m/\tau_2}}{m/\tau_2} - e^{-m/\tau_2} \right].$$

Objective Function: non-convex!

Search for the Global Minimum



## Calibration

- Find for all maturities  $\tau_{1,2}$  the best solution for the coefficients  $\beta$
- Take this value as starting point for the nonlinear (least square) solver.

## Example 5: Vontobel German Sector Rotation Index ISIN CH0026834058

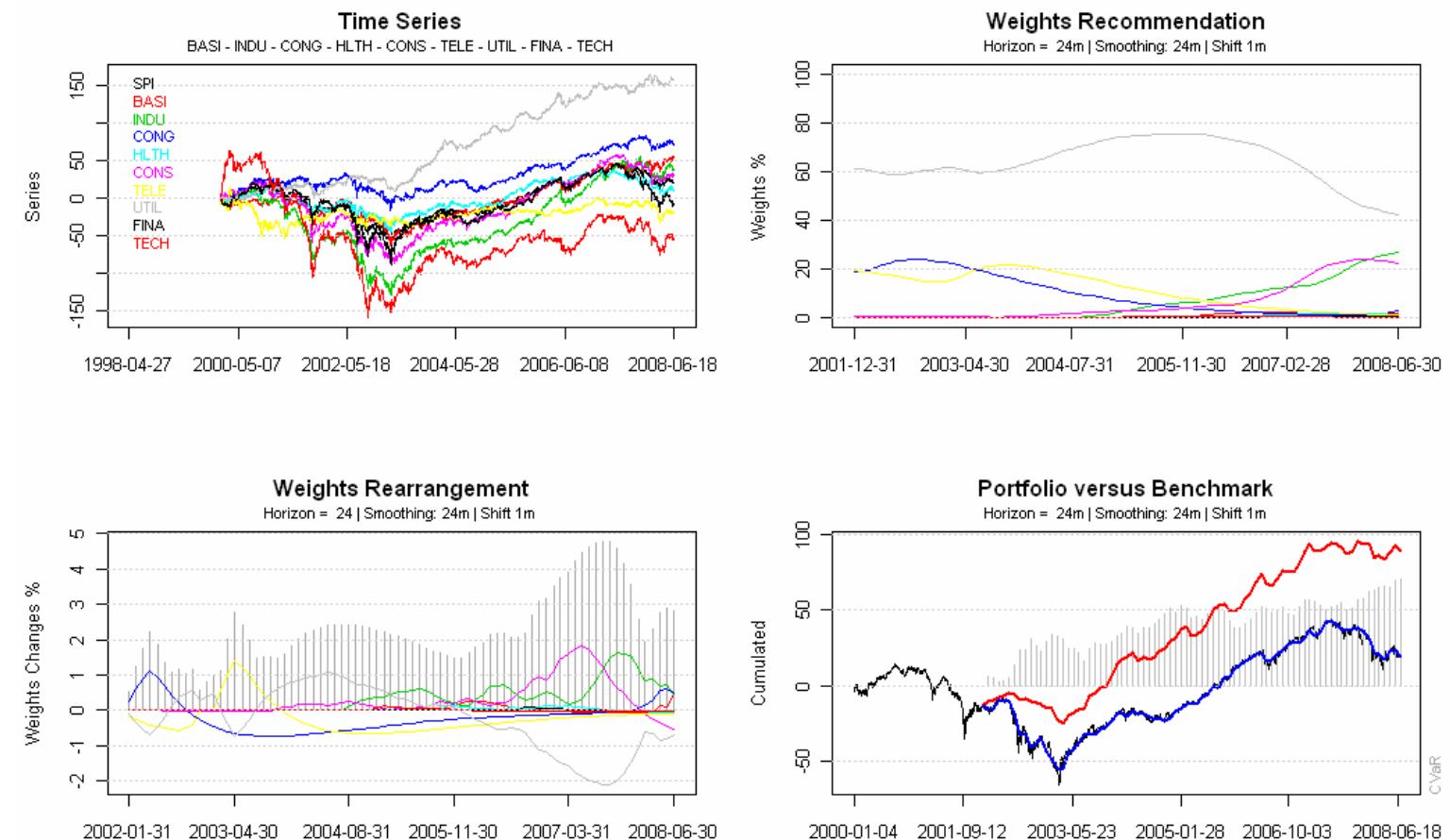
fPortfolio

Sectors: Auto, Banks, Chemicals, Basic Resources, Food & Beverage, Insurance, Transport & Logistics, Industrial, Construction Performance, Pharmacy & Healthcare Utilities

Rebalancing: Quarterly

**Build a Portfolio on  
 the SPI Universe:**

ISIN	Security
CH0022635152	SWX ID ENERGY TR
CH0022635194	SWX ID BASICMAT TR
CH0022635210	SWX ID INDUSTRY TR
CH0022635301	SWX ID CONGOODS TR
CH0022647017	SWX ID HLTHCARE TR
CH0022647256	SWX ID CONSERV TR
CH0022647405	SWX ID TELECOM TR
CH0022647835	SWX ID UTILITIES TR
CH0022647934	SWX ID FINANCE TR
CH0022652785	SWX ID TECH TR



# Dynamic Asset Allocation

**dynAAx**   
*dynamic Asset Allocation index*

## Theta Fund Management, Zürich Dominik Locher

### *dynAAx FIX*

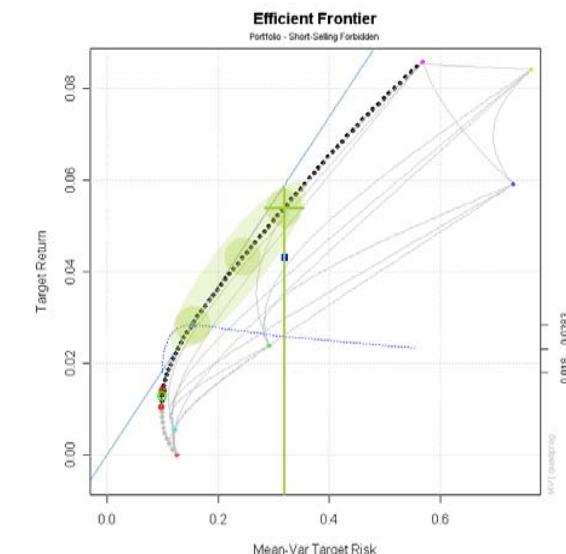
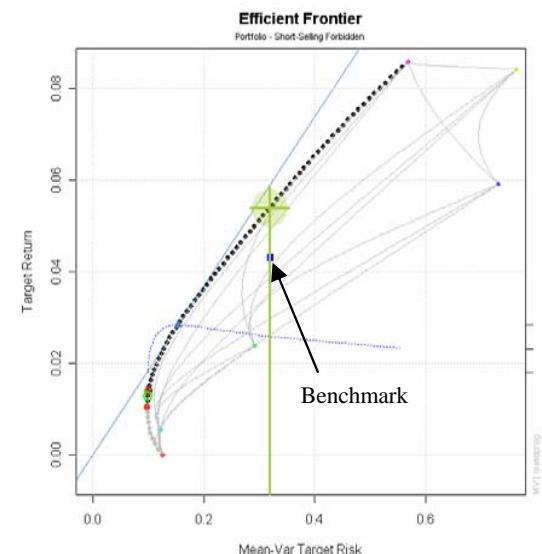
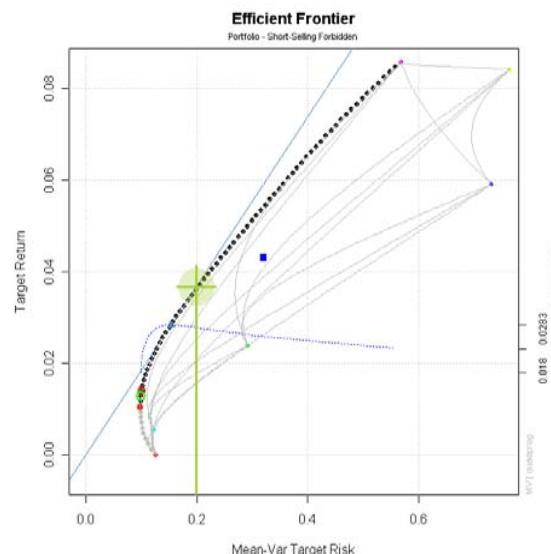
- Constant risk Index

### *dynAAx TRACKER*

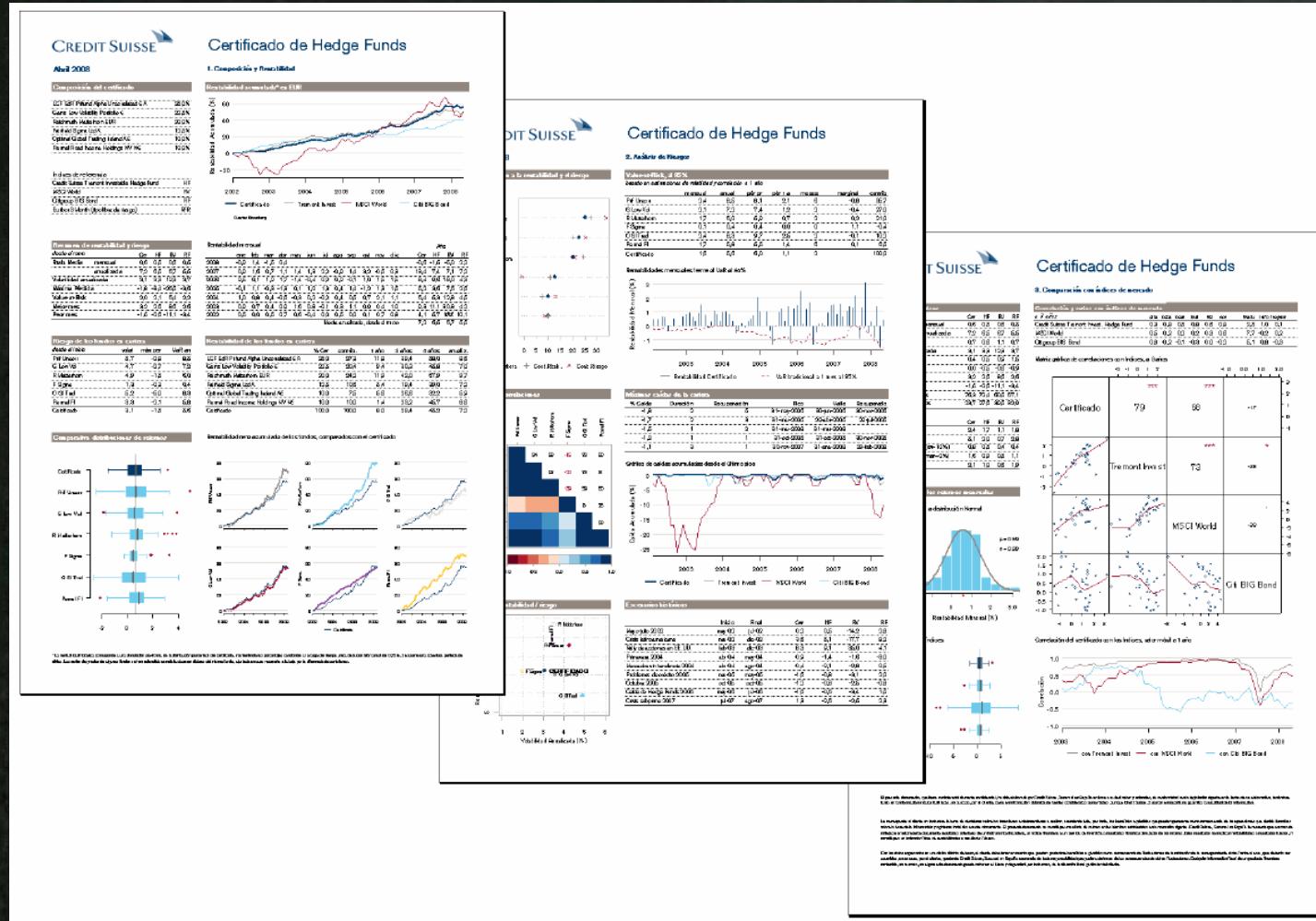
- Tracking the risk or return of a known benchmark

### *dynAAx FLEX*

- An Index following an investment strategy ...



# Advisory Services



Delivering Private Banking  
Advisory Services with R

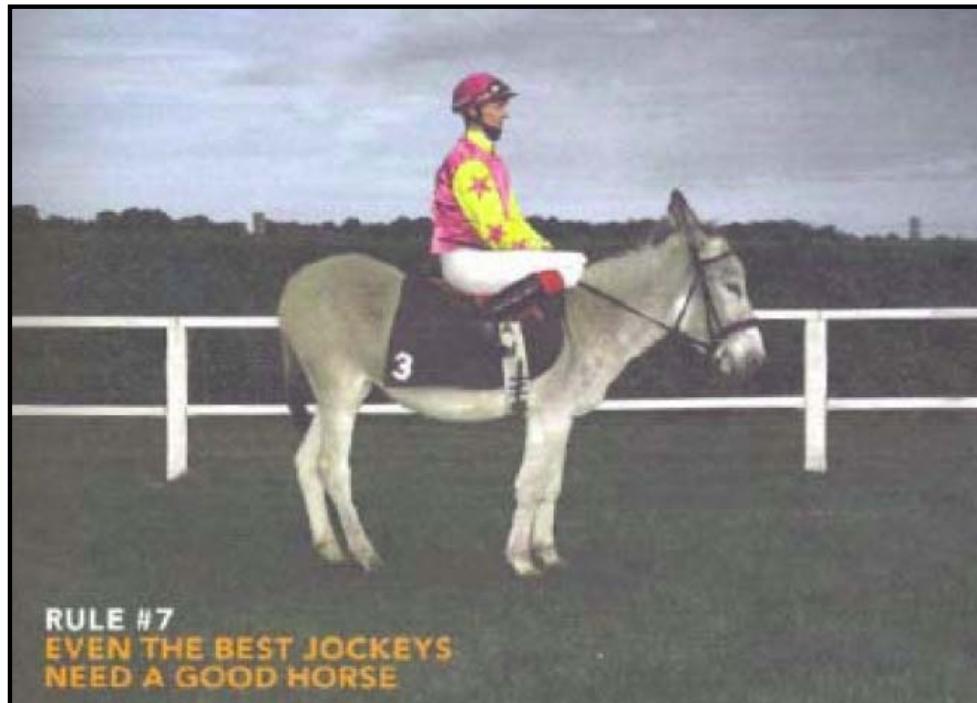
Enrique Bengoechea

enrique.bengoechea@credit-suisse.com  
Credit Suisse Madrid

2nd R/Rmetrics Summer Workshop  
3rd July 2008

## Summary

Consider **R/Rmetrics** as a competitive and unique rapid model prototyping environment in education and even for business applications



Thank You

Diethelm Würtz  
*wuertz@ethz.ch*