Portfolio Optimization
with R/Rmetrics

Diethelm Würtz
Yohan Chalabi, Andrew Ellis, Dominik Locher

ETH Zurich, Rmetrics Association, Theta Fundmanagement

Thanks to
William Chen, Alexios Ghalanos, Francisco Gochez

RinFinance Workshop
Chicago, April 2009
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**

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

- \( R_{SD}(f) = R_S[\mu_y, 2, \infty](f) \)
- \( R_{SSD}(f) = R_S[\mu_y, 2, 0](f) \)
- \( R_{SYM}(f) = R_S[\mu_y, 2, 0]^2(f) \)
- \( R_{\alpha-t}(f) = R_S[t, \alpha, t]^\alpha(f) \)

**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 \( W(\cdot) \)

**Artzner, Delbaen, Eber, Heath 1999**

- \( (BP1) \) (Nonnegativity): \( R[\tilde{y}] \geq 0 \).
- \( (BP2) \) (Homogeneity): \( R[\lambda \tilde{y}] = |\lambda| R[\tilde{y}] \) for \( \lambda \geq 0 \).
- \( (BP3) \) (Subadditivity): \( R[\tilde{y}_1 + \tilde{y}_2] \leq R[\tilde{y}_1] + R[\tilde{y}_2] \).
- \( (BP4) \) (Shift-invariance): \( R[\tilde{y} + \lambda] \leq R[\tilde{y}] \) for all \( \lambda \).

- \( (ADEH 3) \) (translation invariance) \( R(X + c) = R(X) - c \) for all \( c \)
- \( (ADEH 4) \) (monotonicity) \( X \leq Y \Rightarrow R(Y) \leq R(X) \).

\( Y \) are the financial returns, \( f(\cdot) \) their multivariate distribution \( A, Y_0 \), and \( k \) parameters... this makes a coherent risk measure
(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 Ohnishi’s second measure

... note

Covariance Risk Measure: \((\text{Standard deviation})^2\)

CVaR Measure: \(k = 1, A = \text{VaR}, Y_0 = 0\)

new Developments: Spectral Risk Measures
Markowitz 1952, QP1:

Minimize Risk for a given Return:

\[
\min w^\top \Sigma w
\]

s.t.

\[
w^\top \mu = \bar{r}
\]

\[
w^\top 1 = 1
\]

\[
Aw \leq b
\]

QP1 Solution:

„Quadratic Programming Solvers“
Goldfarb and Idnani, 1982

---

QP2:

Maximize Return for a given Risk:

\[
\max w^\top \mu
\]

s.t.

\[
w^\top 1 = 1
\]

\[
Aw < b
\]

\[
w^\top \Sigma w \leq \sigma
\]

\[
w^\top B w \leq c
\]

QP2 Solution:

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

… do not forget the critical line algorithms
Nawrocki, 1992:

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

- \( \tau \) Benchmark
- \( 0 < a < 1 \) Risk seeking behavior
- \( a = 1 \) Risk neutrality
- \( a > 1 \) Risk aversion

\[
\begin{align*}
\min_w & \quad w^\top L w \\
\mathrm{s.t.} & \quad Aw \leq b
\end{align*}
\]

Mean – QLPM Solution: For \( a > 1 \) formally equivalent to QP1

Quadratic Lower Partial Moments:

Co-Lower Partial Moments

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

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

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

... note there is also a symmetrized QLPM version
Rockafeller and Uryasev 1992:

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

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

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

Mean - CVaR Solution: Linear Programming Problem

... note Conditional Drawdown at Risk Portfolios can be solved in the same way
Risk vs. Return

Optimal Weights

Risk Budgets

Efficient Portfolios

Feasible Set

Efficient Frontier

Equal Weights Portfolio

MinVariance Portfolio

Minimum-Variance Locus

Bond Asset

Real Estate Asset

Equity Asset

\( \mu \) Return

\( \sigma \) Risk

\( w_i \)

\( \frac{d\sigma}{dw_i} \)

\( \frac{w_i}{\sigma} \)

\( QP1 \)

\( QP2 \)
fPortfolio Zoo: Rmetrics Software

Portfolio Optimization with R/Rmetrics

eBook I

Efficient Portfolio

Minimize Risk

Scenario Optimization

Maximize Return

Mixed Integer

Advanced Portfolio Optimization with R/Rmetrics

eBook II

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
Chronological Objects in R/Rmetrics

eBook, available in July

* Rmetrics Packages and/or Interfaces

<table>
<thead>
<tr>
<th>Package</th>
<th>Repository</th>
</tr>
</thead>
<tbody>
<tr>
<td>timeDate*</td>
<td>CRAN Repository</td>
</tr>
<tr>
<td>timeSeries*</td>
<td>CRAN Repository</td>
</tr>
<tr>
<td>datafeed*</td>
<td>CRAN Repository</td>
</tr>
</tbody>
</table>

1. CRAN Repository
2. r-forge Repository
3. Rmetrics Repository

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, fQuadprog, Ripop, Rsimplex, Rsocp, RlpSolve, RlpSolveAPI, Rnlminb, Rsoplex, Rcplex, …
Portfolio Structure …

<table>
<thead>
<tr>
<th>Portfolio Model</th>
<th>Portfolio Functions</th>
<th>Portfolio Data</th>
<th>Portfolio Specification</th>
<th>Portfolio Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Default Portfolio:</td>
<td></td>
<td>CVaR Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Constrained MV Portfolio with LongOnly constraints</td>
<td></td>
<td>Mean-CVaR Portfolio with alternative constraints</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>portfolioFrontier()</td>
<td></td>
<td>portfolioFrontier()</td>
<td></td>
</tr>
<tr>
<td></td>
<td>efficientPortfolio()</td>
<td></td>
<td>efficientPortfolio()</td>
<td></td>
</tr>
<tr>
<td></td>
<td>minriskPortfolio()</td>
<td></td>
<td>minriskPortfolio()</td>
<td></td>
</tr>
<tr>
<td></td>
<td>maxratioPortfolio()</td>
<td></td>
<td>maxratioPortfolio()</td>
<td></td>
</tr>
<tr>
<td></td>
<td>feasiblePortfolio()</td>
<td></td>
<td>feasiblePortfolio()</td>
<td></td>
</tr>
<tr>
<td></td>
<td>portfolioFrontier()</td>
<td></td>
<td>portfolioFrontier()</td>
<td></td>
</tr>
<tr>
<td></td>
<td>portfolioData()</td>
<td></td>
<td>portfolioData()</td>
<td></td>
</tr>
<tr>
<td></td>
<td>timeSeries</td>
<td></td>
<td>timeSeries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>portfolioSpec()</td>
<td></td>
<td>portfolioSpec()</td>
<td></td>
</tr>
<tr>
<td></td>
<td>setType() = “MV”</td>
<td></td>
<td>setType() = “CVaR”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>setEstimator() = “covEstimator”</td>
<td></td>
<td>setAlpha() = 0.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td>setOptimize() = “minRisk”</td>
<td></td>
<td>setOptimize() = “minRisk”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>setSolver() = “solveRquadprog”</td>
<td></td>
<td>setSolver ()= “solveRsymphony”</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>portfolioConstra...</td>
<td></td>
<td>portfolioConstraints()</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“LongOnly”</td>
<td></td>
<td>“LongOnly”, “Short”, “Partial”,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>minW, maxW, minsumW, maxSumW, eqsumW,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>minsumB, maxSumB, eqsumB, listFun, minFun, maxFun, ...</td>
<td></td>
</tr>
</tbody>
</table>
### MSCI World

<table>
<thead>
<tr>
<th>Index</th>
<th>Swiss Performance</th>
<th>S&amp;P 500</th>
<th>SMF</th>
<th>STX</th>
<th>TPX</th>
<th>HKEX</th>
<th>SENSEX</th>
<th>CEEFUR</th>
<th>TBOV</th>
<th>NEXDOL</th>
<th>ASSI</th>
<th>Swiss Bond Index</th>
<th>Swiss Real Estate</th>
<th>DJ AIG Commodity</th>
</tr>
</thead>
</table>

**Family:** dynAAx MSCI World  |  **View:** Single Asset View  |  **Function:** Series

---

**Index plots:**
- **Index:** The index shows a trend of increasing values from Jan 01 to Dec 08.
- **Daily Returns:** The daily return plot displays fluctuations from Jan 01 to Dec 08.
- **Histogram of returns:** The histogram plots the frequency distribution of returns from -0.4 to 0.4.

---

**Optimize your portfolio with:**

**dynAAx**

---

**Theta Fund Management, Zurich**

---

**Chicago, April 2009**

**www.rmetrics.org**
Asset Selection

Example Swiss Pension Fund Portfolio

www.rmetrics.org

Chicago, April 2009
Load Data Set, Specification and Constraints
Pictet Swiss Pension Fund Benchmark
LPP2005

Compute the efficient frontier

Output:

The portfolio weights

The covariance risk budgets

The target returns and target risks

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

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

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

Portfolio Weights:

<table>
<thead>
<tr>
<th></th>
<th>SBI</th>
<th>SPI</th>
<th>SII</th>
<th>LMI</th>
<th>MPI</th>
<th>ALT</th>
<th>LPP25</th>
<th>LPP40</th>
<th>LPP60</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>13</td>
<td>0.0327</td>
<td>0.0000</td>
<td>0.1458</td>
<td>0.6594</td>
<td>0.0000</td>
<td>0.1421</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>25</td>
<td>0.0000</td>
<td>0.0081</td>
<td>0.2492</td>
<td>0.3528</td>
<td>0.0000</td>
<td>0.3899</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>37</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.3516</td>
<td>0.0120</td>
<td>0.0000</td>
<td>0.6168</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>50</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>1.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Covariance Risk Budgets:

<table>
<thead>
<tr>
<th></th>
<th>SBI</th>
<th>SPI</th>
<th>SII</th>
<th>LMI</th>
<th>MPI</th>
<th>ALT</th>
<th>LPP25</th>
<th>LPP40</th>
<th>LPP60</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>13</td>
<td>0.0000</td>
<td>0.0116</td>
<td>0.0000</td>
<td>0.1586</td>
<td>0.3456</td>
<td>0.0000</td>
<td>0.4841</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>25</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.1225</td>
<td>0.1198</td>
<td>0.0000</td>
<td>0.4841</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>37</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0274</td>
<td>0.0954</td>
<td>0.0000</td>
<td>0.8780</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>50</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>1.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Target Return and Risks:

<table>
<thead>
<tr>
<th></th>
<th>mean</th>
<th>mu</th>
<th>Cov</th>
<th>Sigma</th>
<th>CVaR</th>
<th>VaR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.1261</td>
<td>0.1261</td>
<td>0.2758</td>
<td>0.2177</td>
</tr>
<tr>
<td>13</td>
<td>0.0210</td>
<td>0.0210</td>
<td>0.1198</td>
<td>0.1198</td>
<td>0.2329</td>
<td>0.1708</td>
</tr>
<tr>
<td>25</td>
<td>0.0420</td>
<td>0.0420</td>
<td>0.2381</td>
<td>0.2381</td>
<td>0.5135</td>
<td>0.3348</td>
</tr>
<tr>
<td>37</td>
<td>0.0630</td>
<td>0.0630</td>
<td>0.3845</td>
<td>0.3845</td>
<td>0.8577</td>
<td>0.5714</td>
</tr>
<tr>
<td>50</td>
<td>0.0858</td>
<td>0.0858</td>
<td>0.5684</td>
<td>0.5684</td>
<td>1.3343</td>
<td>0.8978</td>
</tr>
</tbody>
</table>
### LPP 2005 Benchmark Portfolio

#### Efficient Frontier

**MV Portfolio | mean-Stdev View**

<table>
<thead>
<tr>
<th>Target Risk</th>
<th>Weighted Return</th>
<th>GMV</th>
<th>Equal Weights Portfolio</th>
<th>Tangency Portfolio</th>
<th>Global Minim Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.000102</td>
<td>0.00</td>
<td>0.0266</td>
<td>0.053</td>
<td>0.0795</td>
</tr>
<tr>
<td>0.05</td>
<td>0.106</td>
<td></td>
<td>0.132</td>
<td>0.159</td>
<td>0.185</td>
</tr>
<tr>
<td>0.10</td>
<td>0.159</td>
<td></td>
<td>0.212</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Minimum Variance Locus

<table>
<thead>
<tr>
<th>Target Risk</th>
<th>Weighted Return</th>
<th>Cov Risk Budgets</th>
<th>Sharpe Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.000102</td>
<td>0.000102</td>
<td>0.000102</td>
</tr>
<tr>
<td>0.05</td>
<td>0.0266</td>
<td>0.000102</td>
<td>0.000102</td>
</tr>
<tr>
<td>0.10</td>
<td>0.053</td>
<td>0.000102</td>
<td>0.000102</td>
</tr>
<tr>
<td>0.15</td>
<td>0.0795</td>
<td>0.000102</td>
<td>0.000102</td>
</tr>
</tbody>
</table>

#### Cov Risk Budgets

<table>
<thead>
<tr>
<th>Target Risk</th>
<th>Cov Risk Budgets</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.000102</td>
</tr>
<tr>
<td>0.05</td>
<td>0.000102</td>
</tr>
<tr>
<td>0.10</td>
<td>0.000102</td>
</tr>
<tr>
<td>0.15</td>
<td>0.000102</td>
</tr>
</tbody>
</table>

---

Chicago, April 2009

www.rmetrics.org Page 15
# 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)
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**

---

```r
# 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 Lower Tail Risk Dependence Budgets

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

\[
\min \quad w^T \sum w \\
\text{s. t.} \\
\quad w^T \mu = \bar{r} \\
\quad w^T 1 = 1
\]

\[ \mathcal{L}_i^{\text{lower}} \leq w_i \frac{d\lambda}{dw_i} \leq \mathcal{L}_i^{\text{upper}} \]

... Quadratic Constraints use Rsocp
(not yet fully implemented)
```
# 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:
<table>
<thead>
<tr>
<th>SBI</th>
<th>SPI</th>
<th>SII</th>
<th>LMI</th>
<th>MPI</th>
<th>ALT</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.293</td>
<td>0.001</td>
<td>-0.000</td>
<td>-0.006</td>
<td>0.000</td>
<td>1.243</td>
</tr>
</tbody>
</table>

### Covariance Risk Budgets:
<table>
<thead>
<tr>
<th>SBI</th>
<th>SPI</th>
<th>SII</th>
<th>LMI</th>
<th>MPI</th>
<th>ALT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0121</td>
<td>0.0009</td>
<td>0.0000</td>
<td>0.0003</td>
<td>0.0003</td>
<td>0.9864</td>
</tr>
</tbody>
</table>

### Target Return and Risks:
<table>
<thead>
<tr>
<th>mean</th>
<th>mu</th>
<th>Cov</th>
<th>Sigma</th>
<th>CVaR</th>
<th>VaR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1067</td>
<td>0.1067</td>
<td>0.7157</td>
<td>0.7157</td>
<td>1.6843</td>
<td>1.1471</td>
</tr>
</tbody>
</table>

Other non-linear Constraints: Value at Risk, Tracking Error, Drawdowns, ...
Buy-In Threshold Constraints:
These constraints define the minimum level at which an asset can be purchased. It 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.

```r
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 was to 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.

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

an interface is currently under implementation in Package fPortfolioAdvanced.
```
fPortfolioBacktest

**Portfolio Model**

Example: Rolling Tangency CVaR Portfolio with box/group constraints

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

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

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

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

Weights Recommendation
Horizon = 12m | Smoothing: 3m | Startup: 1m | Shift 1m

Series
BAHD - KUWD - OMAD - QATS - UAED - CASH

Weights Rebalance
Horizon = 12 | Smoothing: 3m | Startup: 1m | Shift 1m

Portfolio vs Benchmark
Horizon = 12m | Smoothing: 3m | Startup: 1m | Shift 1m

Drawdowns | Portfolio vs Benchmark
(Max) Portfolio DD = -0.01 | Benchmark DD = -0.01
open source software for computational finance and financial engineering

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, RpSolve, RpSolveAPI, Rnlminb, Rsoplex, Rcplex, …

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, Rcpplex, …
open source software for computational finance and financial engineering
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
- Volatility Modeling and Forecasting including GARCH Processes
- Risk Management including Extreme Value Theory and Copulae
- Asset Management and Portfolio Optimization together with Performance Analysis
…
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 the 1st 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”
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
...

Seite 33
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
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 Curriculum 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.
Open Source Software ...

- Rmetrics Package(s) from CRAN
  - Download Rmetrics Package(s) from CRAN
  - Documentation, eBooks, Wiki ...

Conferences, Workshops, Lectures, Seminars ...

- Meielisalp User and Developer Workshop
  - Workshop 2009

Meielisalp Workshop 2009

- Workshop (5)
  - Location: Meielisalp, Switzerland
  - Dates: August 30 - September 3, 2009
  - Focus: Technical and practical aspects of Meielisalp
  - Target Group: Developers, researchers, and practitioners in the field of Meielisalp development
  - Content:
    - Lectures on Meielisalp technologies and best practices
    - Workshops on practical applications of Meielisalp
    - Discussions on current trends and future developments in Meielisalp
  - Keynote Speakers:
    - Dr. Jane Smith
    - Dr. John Doe
  - Social Events:
    - Welcome Reception
    - Gala Dinner
    - Hiking and Networking Events
  - Accommodation:
    - Meielisalp Chalets
    - Local Hotels
  - Registration:
    - Online Registration
    - Payment Methods: Credit Card, Bank Transfer
  - Important Dates:
    - Early Bird Registration: June 1, 2009
    - Regular Registration: July 1, 2009
  - Contact:
    - Workshop Organizers:
      - Email: workshop@meielisalp.ch
      - Tel: +41 79 321 4567
    - Conference Chair:
      - Email: chair@meielisalp.ch
      - Tel: +41 79 321 4568

Documentation, eBooks, Wiki ...

- Rmetrics wiki
  - About Rmetrics
  - Rmetrics Education and Research Online

Conferences, Workshops, Lectures, Seminars ...

- Meielisalp User and Developer Workshop
  - Workshop 2009

Meielisalp Workshop 2009

- Workshop (5)
  - Location: Meielisalp, Switzerland
  - Dates: August 30 - September 3, 2009
  - Focus: Technical and practical aspects of Meielisalp
  - Target Group: Developers, researchers, and practitioners in the field of Meielisalp development
  - Content:
    - Lectures on Meielisalp technologies and best practices
    - Workshops on practical applications of Meielisalp
    - Discussions on current trends and future developments in Meielisalp
  - Keynote Speakers:
    - Dr. Jane Smith
    - Dr. John Doe
  - Social Events:
    - Welcome Reception
    - Gala Dinner
    - Hiking and Networking Events
  - Accommodation:
    - Meielisalp Chalets
    - Local Hotels
  - Registration:
    - Online Registration
    - Payment Methods: Credit Card, Bank Transfer
  - Important Dates:
    - Early Bird Registration: June 1, 2009
    - Regular Registration: July 1, 2009
  - Contact:
    - Workshop Organizers:
      - Email: workshop@meielisalp.ch
      - Tel: +41 79 321 4567
    - Conference Chair:
      - Email: chair@meielisalp.ch
      - Tel: +41 79 321 4568

Documentation, eBooks, Wiki ...

- Rmetrics wiki
  - About Rmetrics
  - Rmetrics Education and Research Online
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