Exploratory Data Analysis in Finance Using PerformanceAnalytics

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Outline

Visualization

Methods

Summary

Appendix: Set Up PerformanceAnalytics
Overview

- Exploratory data analysis with finance data often starts with visual examination to:
  - examine properties of asset returns
  - compare an asset to other similar assets
  - compare an asset to one or more benchmarks

- Application of performance and risk measures can build a set of statistics for comparing possible investments

- Examples are developed using data for six (hypothetical) managers, a peer index, and an asset class index

- Hypothetical manager data was developed from real manager timeseries using `accuracy` and `perturb` packages to disguise the data while maintaining some of the statistical properties of the original data.
Draw a Performance Summary Chart.

> charts.PerformanceSummary(managers[, c(manager.col, indexes.cols)],
+   colorset = rich6equal, lwd = 2, ylog = TRUE)
Show Calendar Performance.

```r
> t(table.CalendarReturns(managers[, c(manager.col, indexes.cols)]))

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
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<th></th>
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<tbody>
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<td>Jan</td>
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<td>-1.0</td>
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</tr>
<tr>
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<td>0.9</td>
<td>3.6</td>
<td>4.6</td>
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<tr>
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<td>0.8</td>
<td>0.4</td>
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<tr>
<td>Jun</td>
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<td>1.2</td>
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<td>1.2</td>
<td>0.2</td>
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<td>2.2</td>
</tr>
<tr>
<td>Jul</td>
<td>-2.3</td>
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<td>0.5</td>
<td>2.1</td>
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<td>0.9</td>
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<td>4.0</td>
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<td>0.5</td>
<td>1.1</td>
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<td>Sep</td>
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<td>2.5</td>
<td>-0.4</td>
<td>0.1</td>
<td>-3.1</td>
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<tr>
<td>Oct</td>
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<td>5.6</td>
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<td>-0.1</td>
<td>-1.9</td>
<td>4.3</td>
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<td>Nov</td>
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<td>2.5</td>
<td>1.3</td>
<td>0.4</td>
<td>1.0</td>
<td>3.4</td>
<td>6.6</td>
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<td>3.9</td>
<td>2.3</td>
<td>1.2</td>
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<tr>
<td>Dec</td>
<td>1.8</td>
<td>1.1</td>
<td>1.0</td>
<td>1.5</td>
<td>-0.7</td>
<td>6.8</td>
<td>-3.2</td>
<td>2.8</td>
<td>4.4</td>
<td>2.6</td>
<td>1.1</td>
</tr>
<tr>
<td>HAM1</td>
<td>13.6</td>
<td>20.4</td>
<td>6.1</td>
<td>16.1</td>
<td>17.7</td>
<td>22.4</td>
<td>-8.0</td>
<td>23.7</td>
<td>14.9</td>
<td>7.8</td>
<td>20.5</td>
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<tr>
<td>EDHEC LS EQ</td>
<td>NA</td>
<td>21.4</td>
<td>14.6</td>
<td>31.4</td>
<td>12.0</td>
<td>-1.2</td>
<td>-6.4</td>
<td>19.3</td>
<td>8.6</td>
<td>11.3</td>
<td>11.7</td>
</tr>
<tr>
<td>SP500 TR</td>
<td>23.0</td>
<td>33.4</td>
<td>28.6</td>
<td>21.0</td>
<td>-9.1</td>
<td>-11.9</td>
<td>-22.1</td>
<td>28.7</td>
<td>10.9</td>
<td>4.9</td>
<td>15.8</td>
</tr>
</tbody>
</table>
```
Calculate Statistics.

```r
> table.Stats(managers[, c(manager.col, peers.cols)])

<table>
<thead>
<tr>
<th></th>
<th>HAM1</th>
<th>HAM2</th>
<th>HAM3</th>
<th>HAM4</th>
<th>HAM5</th>
<th>HAM6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations</td>
<td>132.0000</td>
<td>125.0000</td>
<td>132.0000</td>
<td>132.0000</td>
<td>77.0000</td>
<td>64.0000</td>
</tr>
<tr>
<td>NAs</td>
<td>0.0000</td>
<td>7.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>55.0000</td>
<td>68.0000</td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.0944</td>
<td>-0.0371</td>
<td>-0.0718</td>
<td>-0.1759</td>
<td>-0.1320</td>
<td>-0.0404</td>
</tr>
<tr>
<td>Quartile 1</td>
<td>0.0000</td>
<td>-0.0098</td>
<td>-0.0054</td>
<td>-0.0198</td>
<td>-0.0164</td>
<td>-0.0016</td>
</tr>
<tr>
<td>Median</td>
<td>0.0112</td>
<td>0.0082</td>
<td>0.0102</td>
<td>0.0138</td>
<td>0.0038</td>
<td>0.0128</td>
</tr>
<tr>
<td>Arithmetic Mean</td>
<td>0.0111</td>
<td>0.0141</td>
<td>0.0124</td>
<td>0.0110</td>
<td>0.0041</td>
<td>0.0111</td>
</tr>
<tr>
<td>Geometric Mean</td>
<td>0.0108</td>
<td>0.0135</td>
<td>0.0118</td>
<td>0.0096</td>
<td>0.0031</td>
<td>0.0108</td>
</tr>
<tr>
<td>Quartile 3</td>
<td>0.0248</td>
<td>0.0252</td>
<td>0.0314</td>
<td>0.0460</td>
<td>0.0309</td>
<td>0.0255</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.0692</td>
<td>0.1556</td>
<td>0.1796</td>
<td>0.1508</td>
<td>0.1747</td>
<td>0.0583</td>
</tr>
<tr>
<td>SE Mean</td>
<td>0.0022</td>
<td>0.0033</td>
<td>0.0032</td>
<td>0.0046</td>
<td>0.0052</td>
<td>0.0030</td>
</tr>
<tr>
<td>LCL Mean (0.95)</td>
<td>0.0067</td>
<td>0.0076</td>
<td>0.0062</td>
<td>0.0019</td>
<td>-0.0063</td>
<td>0.0051</td>
</tr>
<tr>
<td>UCL Mean (0.95)</td>
<td>0.0155</td>
<td>0.0206</td>
<td>0.0187</td>
<td>0.0202</td>
<td>0.0145</td>
<td>0.0170</td>
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<tr>
<td>Variance</td>
<td>0.0007</td>
<td>0.0013</td>
<td>0.0013</td>
<td>0.0028</td>
<td>0.0021</td>
<td>0.0006</td>
</tr>
<tr>
<td>Stdev</td>
<td>0.0256</td>
<td>0.0367</td>
<td>0.0365</td>
<td>0.0532</td>
<td>0.0457</td>
<td>0.0238</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.6514</td>
<td>1.4406</td>
<td>0.7819</td>
<td>-0.4262</td>
<td>0.0724</td>
<td>-0.2735</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.2807</td>
<td>2.2937</td>
<td>2.5972</td>
<td>0.8049</td>
<td>2.1772</td>
<td>-0.4311</td>
</tr>
</tbody>
</table>
```
Compare Distributions.

> chart.Boxplot(managers[trailing36.rows, c(manager.col, peers.cols, + indexes.cols)], main = "Trailing 36-Month Returns")

![Boxplot of Trailing 36-Month Returns](image)
Compare Distributions.

```r
> layout(rbind(c(1, 2), c(3, 4)))
> chart.Histogram(managers[, 1, drop = F], main = "Plain", methods = NULL)
> chart.Histogram(managers[, 1, drop = F], main = "Density", breaks = 40,
+ methods = c("add.density", "add.normal"))
> chart.Histogram(managers[, 1, drop = F], main = "Skew and Kurt",
+ methods = c("add.centered", "add.rug"))
> chart.Histogram(managers[, 1, drop = F], main = "Risk Measures",
+ methods = c("add.risk"))
```

![Histograms of managers returns](image1)

Plain

```
Plots of returns distribution for managers using different methods:
- Plain
- Density
- Skew and Kurt
- Risk Measures
```

Density

```
Plots of returns distribution for managers using different methods:
- Density
```

Skew and Kurt

```
Plots of returns distribution for managers using different methods:
- Skew and Kurt
```

Risk Measures

```
Plots of returns distribution for managers using different methods:
- Risk Measures
```

![Histograms of managers returns](image2)
Show Relative Return and Risk.

```r
> chart.RiskReturnScatter(managers[trailing36.rows, 1:8], Rf = 0.03/12,
+   main = "Trailing 36-Month Performance", colorset = c("red",
+   rep("black", 5), "orange", "green"))
```

![Trailing 36-Month Performance](chart.png)
Examine Performance Consistency.

```r
> charts.RollingPerformance(managers[, c(manager.col, peers.cols, +    indexes.cols)], Rf = 0.03/12, colorset = c("red", rep("darkgray", +    5), "orange", "green"), lwd = 2)
```

![Rolling 12 month Performance](chart)
Display Relative Performance.

```r
> chart.RelativePerformance(managers[, manager.col, drop = FALSE],
    + managers[, c(peers.cols, 7)], colorset = tim8equal[-1], lwd = 2,
    + legend.loc = "topleft")
```

![Relative Performance Chart](chart.png)
Compare to a Benchmark.

```r
> chart.RelativePerformance(managers[, c(manager.col, peers.cols)],
+   managers[, 8, drop = F], colorset = rainbow8equal, lwd = 2,
+   legend.loc = "topleft")
```

**Relative Performance**

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAM1.SP500.TR</td>
<td></td>
</tr>
<tr>
<td>HAM2.SP500.TR</td>
<td></td>
</tr>
<tr>
<td>HAM3.SP500.TR</td>
<td></td>
</tr>
<tr>
<td>HAM4.SP500.TR</td>
<td></td>
</tr>
<tr>
<td>HAM5.SP500.TR</td>
<td></td>
</tr>
<tr>
<td>HAM6.SP500.TR</td>
<td></td>
</tr>
</tbody>
</table>

**Date**

Jan 96  Jul 97  Jan 99  Jul 00  Jan 02  Jul 03  Jan 05  Jul 06
Compare to a Benchmark.

```r
> table.CAPM(managers[trailing36.rows, c(manager.col, peers.cols)],
+    managers[trailing36.rows, 8, drop = FALSE], Rf = managers[trailing36.rows,
+    Rf.col, drop = F])
```

<table>
<thead>
<tr>
<th></th>
<th>HAM1 to SP500 TR</th>
<th>HAM2 to SP500 TR</th>
<th>HAM3 to SP500 TR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td>0.0051</td>
<td>0.0020</td>
<td>0.0020</td>
</tr>
<tr>
<td>Beta</td>
<td>0.6267</td>
<td>0.3223</td>
<td>0.6320</td>
</tr>
<tr>
<td>Beta+</td>
<td>0.8227</td>
<td>0.4176</td>
<td>0.8240</td>
</tr>
<tr>
<td>Beta-</td>
<td>1.1218</td>
<td>-0.0483</td>
<td>0.8291</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.3829</td>
<td>0.1073</td>
<td>0.4812</td>
</tr>
<tr>
<td>Annualized Alpha</td>
<td>0.0631</td>
<td>0.0247</td>
<td>0.0243</td>
</tr>
<tr>
<td>Correlation</td>
<td>0.6188</td>
<td>0.3276</td>
<td>0.6937</td>
</tr>
<tr>
<td>Correlation p-value</td>
<td>0.0001</td>
<td>0.0511</td>
<td>0.0000</td>
</tr>
<tr>
<td>Tracking Error</td>
<td>0.0606</td>
<td>0.0426</td>
<td>0.0042</td>
</tr>
<tr>
<td>Active Premium</td>
<td>0.0373</td>
<td>-0.0254</td>
<td>-0.0021</td>
</tr>
<tr>
<td>Information Ratio</td>
<td>0.6157</td>
<td>-0.5973</td>
<td>-0.5051</td>
</tr>
<tr>
<td>Treynor Ratio</td>
<td>0.1741</td>
<td>0.1437</td>
<td>0.1101</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>HAM4 to SP500 TR</th>
<th>HAM5 to SP500 TR</th>
<th>HAM6 to SP500 TR</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.0009</td>
<td>0.0002</td>
<td>0.0022</td>
</tr>
<tr>
<td>Beta</td>
<td>1.1282</td>
<td>0.8755</td>
<td>0.8150</td>
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<tr>
<td>Beta+</td>
<td>1.8430</td>
<td>1.0985</td>
<td>0.9993</td>
</tr>
<tr>
<td>Beta-</td>
<td>1.2223</td>
<td>0.5283</td>
<td>1.1320</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.3444</td>
<td>0.5209</td>
<td>0.4757</td>
</tr>
<tr>
<td>Annualized Alpha</td>
<td>0.0109</td>
<td>0.0030</td>
<td>0.0271</td>
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<tr>
<td>Correlation</td>
<td>0.5868</td>
<td>0.7218</td>
<td>0.6897</td>
</tr>
<tr>
<td>Correlation p-value</td>
<td>0.0002</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>Tracking Error</td>
<td>0.0353</td>
<td>0.0105</td>
<td>0.0236</td>
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<tr>
<td>Active Premium</td>
<td>0.0149</td>
<td>-0.0075</td>
<td>0.0134</td>
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<tr>
<td>Information Ratio</td>
<td>0.4232</td>
<td>-0.7121</td>
<td>0.5684</td>
</tr>
<tr>
<td>Treynor Ratio</td>
<td>0.0768</td>
<td>0.0734</td>
<td>0.1045</td>
</tr>
</tbody>
</table>
Calculate Returns.

- The single-period arithmetic return, or simple return, can be calculated as

\[
R_t = \frac{P_t}{P_{t-1}} - 1 = \frac{P_t - P_{t-1}}{P_{t-1}} \tag{1}
\]

- Simple returns, cannot be added together. A multiple-period simple return is calculated as:

\[
R_t = \frac{P_t}{P_{t-k}} - 1 = \frac{P_t - P_{t-k}}{P_{t-k}} \tag{2}
\]

- The natural logarithm of the simple return of an asset is referred to as the continuously compounded return, or log return:

\[
r_t = \ln(1 + R_t) = \ln\frac{P_t}{P_{t-1}} = p_t - p_{t-1} \tag{3}
\]

- Calculating log returns from simple gross return, or vice versa:

\[
r_t = \ln(1 + R_t), \quad R_t = \exp(r_t) - 1. \tag{4}
\]

- *Return.calculate* or *CalculateReturns* (now deprecated) may be used to compute discrete and continuously compounded returns for data containing asset prices.
Return\textsuperscript{annualized} — Annualized return using
\[
prod(1 + R_a)^{\frac{\text{scale}}{n}} - 1 = \sqrt[n]{\prod(1 + R_a)^\text{scale}} - 1
\tag{5}
\]

TreynorRatio — ratio of asset’s Excess Return to Beta $\beta$ of the benchmark
\[
\frac{(R_a - R_f)}{\beta_{a,b}}
\tag{6}
\]

ActivePremium — investment’s annualized return minus the benchmark’s annualized return

Tracking Error — A measure of the unexplained portion of performance relative to a benchmark, given by
\[
\text{TrackingError} = \sqrt{\sum \frac{(R_a - R_b)^2}{\text{len}(R_a) \sqrt{\text{scale}}}}
\tag{7}
\]

InformationRatio — ActivePremium/TrackingError
Compare to a Benchmark.

```r
> charts.RollingRegression(managers[, c(manager.col, peers.cols),
+    drop = FALSE], managers[, 8, drop = FALSE], Rf = 0.03/12,
+    colorset = redfocus, lwd = 2)
```

![Rolling 12-month Regressions](image)

- **Alpha**
- **Beta**
- **R-Squared**

Jan 96 Jan 97 Jan 98 Jan 99 Jan 00 Jan 01 Jan 02 Jan 03 Jan 04 Jan 05 Jan 06 Dec 06

Date
Calculate Downside Risk.

```r
> table.DownsideRisk(managers[, 1:6], Rf = 0.03/12)

<table>
<thead>
<tr>
<th></th>
<th>HAM1</th>
<th>HAM2</th>
<th>HAM3</th>
<th>HAM4</th>
<th>HAM5</th>
<th>HAM6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi Deviation</td>
<td>0.0270</td>
<td>0.0258</td>
<td>0.0319</td>
<td>0.0576</td>
<td>0.0456</td>
<td>0.0260</td>
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<tr>
<td>Gain Deviation</td>
<td>0.0169</td>
<td>0.0347</td>
<td>0.0290</td>
<td>0.0311</td>
<td>0.0313</td>
<td>0.0149</td>
</tr>
<tr>
<td>Loss Deviation</td>
<td>0.0211</td>
<td>0.0107</td>
<td>0.0191</td>
<td>0.0365</td>
<td>0.0324</td>
<td>0.0128</td>
</tr>
<tr>
<td>Downside Deviation (MAR=10%)</td>
<td>0.0273</td>
<td>0.0226</td>
<td>0.0313</td>
<td>0.0585</td>
<td>0.0464</td>
<td>0.0253</td>
</tr>
<tr>
<td>Downside Deviation (Rf=3%)</td>
<td>0.0281</td>
<td>0.0190</td>
<td>0.0295</td>
<td>0.0562</td>
<td>0.0463</td>
<td>0.0238</td>
</tr>
<tr>
<td>Downside Deviation (0%)</td>
<td>0.0291</td>
<td>0.0171</td>
<td>0.0291</td>
<td>0.0548</td>
<td>0.0451</td>
<td>0.0229</td>
</tr>
<tr>
<td>Maximum Drawdown</td>
<td>-0.1518</td>
<td>-0.2399</td>
<td>-0.2894</td>
<td>-0.2874</td>
<td>-0.3405</td>
<td>-0.0788</td>
</tr>
<tr>
<td>Historical VaR (95%)</td>
<td>-0.0258</td>
<td>-0.0294</td>
<td>-0.0425</td>
<td>-0.0799</td>
<td>-0.0733</td>
<td>-0.0341</td>
</tr>
<tr>
<td>Historical ES (95%)</td>
<td>-0.0513</td>
<td>-0.0331</td>
<td>-0.0555</td>
<td>-0.1122</td>
<td>-0.1023</td>
<td>-0.0392</td>
</tr>
<tr>
<td>Modified VaR (95%)</td>
<td>-0.0342</td>
<td>-0.0276</td>
<td>-0.0368</td>
<td>-0.0815</td>
<td>-0.0676</td>
<td>-0.0298</td>
</tr>
<tr>
<td>Modified ES (95%)</td>
<td>-0.0610</td>
<td>-0.0614</td>
<td>-0.0440</td>
<td>-0.1176</td>
<td>-0.0974</td>
<td>-0.0390</td>
</tr>
</tbody>
</table>
```
Semivariance and Downside Deviation

- Downside Deviation as proposed by Sharpe is a generalization of semivariance which calculates bases on the deviation below a Minimum Acceptable Return (MAR)

\[ \delta_{MAR} = \sqrt{\frac{\sum_{t=1}^{n}(R_t - \text{MAR})^2}{n}} \] (8)

- Downside Deviation may be used to calculate semideviation by setting $\text{MAR} = \text{mean}(R)$ or may also be used with $\text{MAR} = 0$

- Downside Deviation (and its special cases semideviation and semivariance) is useful in several performance to risk ratios, and in several portfolio optimization problems.
Value at Risk

- Value at Risk (VaR) has become a required standard risk measure recognized by Basel II and MiFID
- Traditional mean-VaR may be derived historically, or estimated parametrically using

\[ z_c = q_p = qnorm(p) \]  
\[ VaR = \bar{R} - z_c \cdot \sqrt{\sigma} \]  

- Even with robust covariance matrix or Monte Carlo simulation, mean-VaR is not reliable for non-normal asset distributions
- For non-normal assets, VaR estimates calculated using GPD (as in VaR.GPD) or Cornish Fisher perform best
- Modified Cornish Fisher VaR takes higher moments of the distribution into account:

\[ z_{cf} = z_c + \left( \frac{z_c^2 - 1}{6} \right) S + \left( \frac{z_c^3 - 3z_c}{24} \right) K + \left( \frac{2z_c^3 - 5z_c}{36} \right) S^2 \]  
\[ modVaR = \bar{R} - z_{cf} \sqrt{\sigma} \]  

- Modified VaR also meets the definition of a coherent risk measure per Artzner, et.al. (1997)
Risk/Reward Ratios in *PerformanceAnalytics*

- **SharpeRatio** — return per unit of risk represented by variance, may also be annualized by
  \[
  \sqrt[\frac{n}{\text{prod}}(1 + R_a)^{\text{scale}} - 1] \quad \frac{\sqrt{\text{scale}} \cdot \sqrt{\sigma}}{1}
  \]  
  \[(13)\]

- **Sortino Ratio** — improvement on Sharpe Ratio utilizing downside deviation as the measure of risk
  \[
  \frac{(R_a - \text{MAR})}{\delta_{\text{MAR}}}
  \]  
  \[(14)\]

- **Calmar and Sterling Ratios** — ratio of annualized return (Eq. 1) over the absolute value of the maximum drawdown

- **Sortino’s Upside Potential Ratio** — upside semdiviation from MAR over downside deviation from MAR
  \[
  \sum_{t=1}^{n}(R_t - \text{MAR})
  \frac{1}{\delta_{\text{MAR}}}
  \]  
  \[(15)\]

- **Favre’s modified Sharpe Ratio** — ratio of excess return over Cornish-Fisher VaR
  \[
  \frac{(R_a - R_f)}{\text{modVaR}_{R_a,p}}
  \]  
  \[(16)\]
Summary

- Performance and risk analysis are greatly facilitated by the use of charts and tables.
- The display of your information is in many cases as important as the analysis.
- *PerformanceAnalytics* contains several tools for measuring and visualizing data that may be used to aid investment decision making.

Further Work

- Additional parameterization to make charts and tables more useful.
- Pertrac or Morningstar-style sample reports.
- Functions and graphics for more complicated topics such as factor analysis and optimization.
Install PerformanceAnalytics.

- As of version 0.9.4, PerformanceAnalytics is available in CRAN
- Version 0.9.5 was released at the beginning of July
- Install with:
  ```r
  > install.packages("PerformanceAnalytics")
  ```
- Required packages include Hmisc, zoo, and Rmetrics packages such as fExtremes.
- Load the library into your active R session using:
  ```r
  > library("PerformanceAnalytics")
  ```
Load and Review Data.

```r
> data(managers)
> head(managers)

<table>
<thead>
<tr>
<th></th>
<th>HAM1</th>
<th>HAM2</th>
<th>HAM3</th>
<th>HAM4</th>
<th>HAM5</th>
<th>HAM6</th>
<th>EDHEC</th>
<th>LS</th>
<th>EQ</th>
<th>SP500</th>
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<td>NA</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```
Set Up Data for Analysis.

```r
> dim(managers)
[1] 132  10

> managers.length = dim(managers)[1]
> colnames(managers)

[1] "HAM1"  "HAM2"  "HAM3"  "HAM4"  "HAM5"
[6] "HAM6"  "EDHEC LS EQ" "SP500 TR" "US 10Y TR" "US 3m TR"

> manager.col = 1
> peers.cols = c(2, 3, 4, 5, 6)
> indexes.cols = c(7, 8)
> Rf.col = 10
> trailing12.rows = ((managers.length - 11):managers.length)
> trailing12.rows

[1] 121 122 123 124 125 126 127 128 129 130 131 132

> trailing36.rows = ((managers.length - 35):managers.length)
> trailing60.rows = ((managers.length - 59):managers.length)
> frInception.rows = (length(managers[, 1]) - length(managers[, +
   1][!is.na(managers[, 1])]) + 1):length(managers[, 1])
```
Draw a Performance Summary Chart.

```r
> charts.PerformanceSummary(managers[, c(manager.col, indexes.cols)],
+   colorset = rich6equal, lwd = 2, ylog = TRUE)
```

![Performance Summary Chart](chart.png)