Overview of PerformanceAnalytics' Charts and Tables

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Outline

Overview

- Utilize charts and tables to display and analyze data:
  - asset returns
  - compare an asset to other similar assets
  - compare an asset to one or more benchmarks
- Utilize common performance and risk measures to aid the investment decision
- Examples developed using data for six (hypothetical) managers, a peer index, and an asset class index
- Hypothetical manager data developed from real manager timeseries using *accuracy* and *perturb* packages to perturb data maintaining the statistical distribution properties of the original data.

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:

  ```
  > install.packages("PerformanceAnalytics")
  ```
- Required packages include `Hmisc`, `zoo`, and Rmetrics packages such as `fExtremes`.
- Load the library into your active R session using:

  ```
  > library("PerformanceAnalytics").
  ```

Load and Review Data.

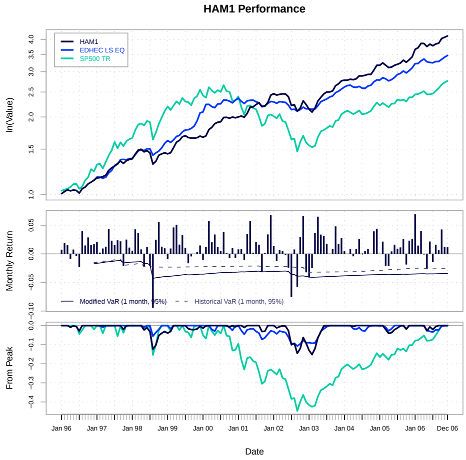
```
> data(managers)
> head(managers)

              HAM1 HAM2    HAM3    HAM4 HAM5 HAM6 EDHEC LS EQ SP500 TR
1996-01-30  0.0074   NA  0.0349  0.0222   NA   NA          NA    0.0340
1996-02-28  0.0193   NA  0.0351  0.0195   NA   NA          NA    0.0093
1996-03-30  0.0155   NA  0.0258 -0.0098   NA   NA          NA    0.0096
1996-04-29 -0.0091   NA  0.0449  0.0236   NA   NA          NA    0.0147
1996-05-30  0.0076   NA  0.0353  0.0028   NA   NA          NA    0.0258
1996-06-29 -0.0039   NA -0.0303 -0.0019   NA   NA          NA    0.0038
           US 10Y TR US 3m TR
1996-01-30   0.00380  0.00456
1996-02-28  -0.03532  0.00398
1996-03-30  -0.01057  0.00371
1996-04-29  -0.01739  0.00428
1996-05-30  -0.00543  0.00443
1996-06-29   0.01507  0.00412
```

Set Up Data for Analysis.

```
> 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.

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



Show Calendar Performance.

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

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Jan	0.7	2.1	0.6	-0.9	-1.0	0.8	1.4	-4.1	0.5	0.0	6.9
Feb	1.9	0.2	4.3	0.9	1.2	0.8	-1.2	-2.5	0.0	2.1	1.5
Mar	1.6	0.9	3.6	4.6	5.8	-1.1	0.6	3.6	0.9	-2.1	4.0
Apr	-0.9	1.3	0.8	5.1	2.0	3.5	0.5	6.5	-0.4	-2.1	-0.1
May	0.8	4.4	-2.3	1.6	3.4	5.8	-0.2	3.4	0.8	0.4	-2.7
Jun	-0.4	2.3	1.2	3.3	1.2	0.2	-2.4	3.1	2.6	1.6	2.2
Jul	-2.3	1.5	-2.1	1.0	0.5	2.1	-7.5	1.8	0.0	0.9	-1.4
Aug	4.0	2.4	-9.4	-1.7	3.9	1.6	0.8	0.0	0.5	1.1	1.6
Sep	1.5	2.2	2.5	-0.4	0.1	-3.1	-5.8	0.9	0.9	2.6	0.7
Oct	2.9	-2.1	5.6	-0.1	-0.8	0.1	3.0	4.8	-0.1	-1.9	4.3
Nov	1.6	2.5	1.3	0.4	1.0	3.4	6.6	1.7	3.9	2.3	1.2
Dec	1.8	1.1	1.0	1.5	-0.7	6.8	-3.2	2.8	4.4	2.6	1.1
HAM1	13.6	20.4	6.1	16.1	17.7	22.4	-8.0	23.7	14.9	7.8	20.5
EDHEC LS EQ	NA	21.4	14.6	31.4	12.0	-1.2	-6.4	19.3	8.6	11.3	11.7
SP500 TR	23.0	33.4	28.6	21.0	-9.1	-11.9	-22.1	28.7	10.9	4.9	15.8

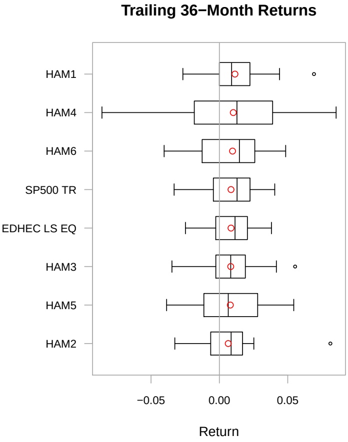
Calculate Statistics.

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

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

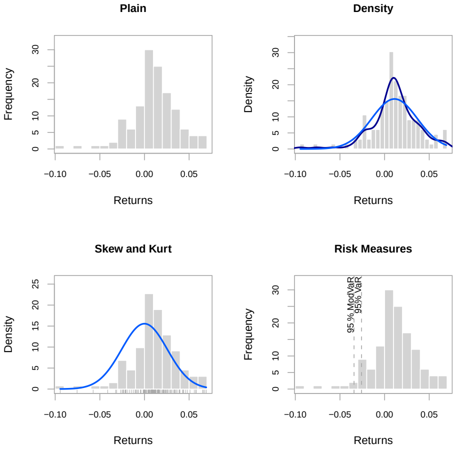
Compare Distributions.

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



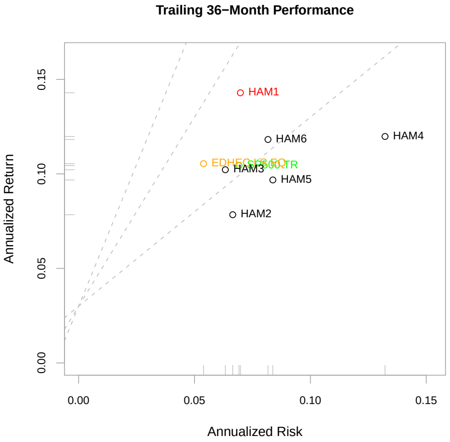
Compare Distributions.

```
> 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"))
```



Show Relative Return and Risk.

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



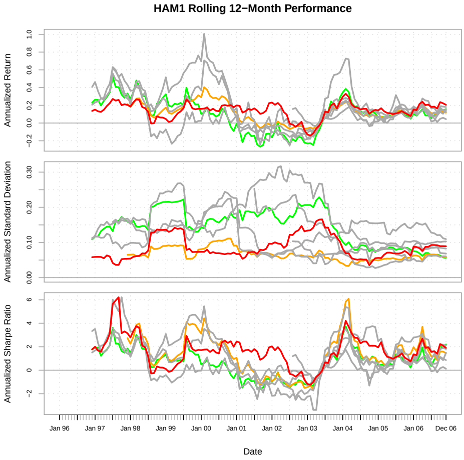
Calculate Statistics.

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

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

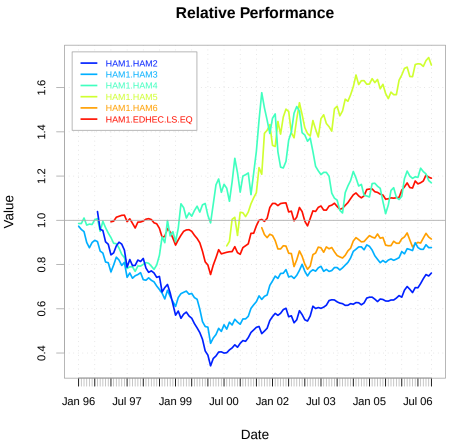
Examine Performance Consistency.

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



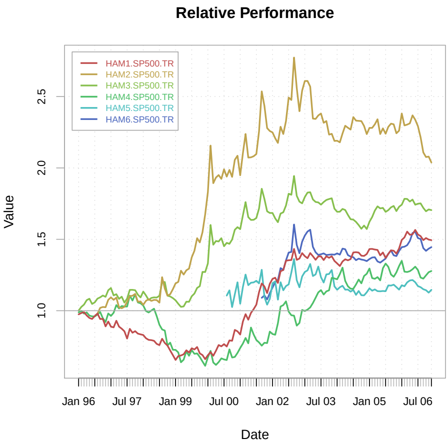
Display Relative Performance.

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



Compare to a Benchmark.

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



Compare to a Benchmark.

```
> table.CAPM(managers[trailing36.rows, c(manager.col, peers.cols)],
+     managers[trailing36.rows, 8, drop = FALSE], Rf = managers[trailing36.rows,
+         Rf.col, drop = F])
                        HAM1 to SP500 TR HAM2 to SP500 TR HAM3 to SP500 TR
Alpha                             0.0051           0.0020           0.0020
Beta                              0.6267           0.3223           0.6320
Beta+                             0.8227           0.4176           0.8240
Beta-                             1.1218          -0.0483           0.8291
R-squared                         0.3829           0.1073           0.4812
Annualized Alpha                  0.0631           0.0247           0.0243
Correlation                       0.6188           0.3276           0.6937
Correlation p-value               0.0001           0.0511           0.0000
Tracking Error                    0.0606           0.0426           0.0042
Active Premium                    0.0373          -0.0254          -0.0021
Information Ratio                 0.6157          -0.5973          -0.5051
Treynor Ratio                     0.1741           0.1437           0.1101
                        HAM4 to SP500 TR HAM5 to SP500 TR HAM6 to SP500 TR
Alpha                             0.0009           0.0002           0.0022
Beta                              1.1282           0.8755           0.8150
Beta+                             1.8430           1.0985           0.9993
Beta-                             1.2223           0.5283           1.1320
R-squared                         0.3444           0.5209           0.4757
Annualized Alpha                  0.0109           0.0030           0.0271
Correlation                       0.5868           0.7218           0.6897
Correlation p-value               0.0002           0.0000           0.0000
Tracking Error                    0.0353           0.0105           0.0236
Active Premium                    0.0149          -0.0075           0.0134
Information Ratio                 0.4232          -0.7121           0.5684
Treynor Ratio                     0.0768           0.0734           0.1045
```

table.CAPM underlying techniques

- Return.annualized — Annualized return using

$$prod(1 + R_a)^{\frac{scale}{n}} - 1 = \sqrt[n]{prod(1 + R_a)^{scale}} - 1 \quad (1)$$

- TreynorRatio — ratio of asset's Excess Return to Beta β of the benchmark

$$\frac{(\overline{R_a - R_f})}{\beta_{a,b}} \quad (2)$$

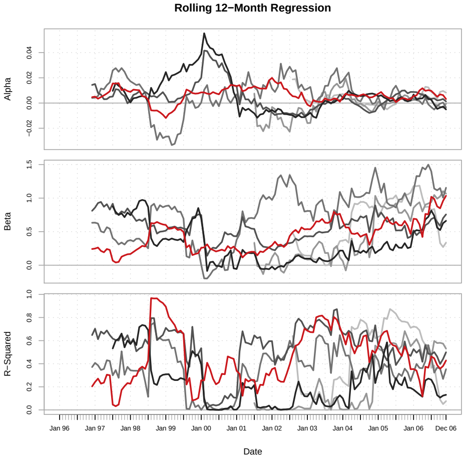
- ActivePremium — investment's annualized return minus the benchmark's annualized return
- Tracking Error — A measure of the unexplained portion of performance relative to a benchmark, given by

$$TrackingError = \sqrt{\sum \frac{(R_a - R_b)^2}{len(R_a)\sqrt{scale}}} \quad (3)$$

- InformationRatio — ActivePremium/TrackingError

Compare to a Benchmark.

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



Calculate Downside Risk.

```
> table.DownsideRisk(managers[, 1:6], Rf = 0.03/12)
                                HAM1    HAM2    HAM3    HAM4    HAM5
Semi Deviation                0.0270  0.0258  0.0319  0.0576  0.0456
Gain Deviation                0.0169  0.0347  0.0290  0.0311  0.0313
Loss Deviation                0.0211  0.0107  0.0191  0.0365  0.0324
Downside Deviation (MAR=10%)  0.0273  0.0226  0.0313  0.0585  0.0464
Downside Deviation (Rf=3%)    0.0281  0.0190  0.0295  0.0562  0.0463
Downside Deviation (0%)       0.0291  0.0171  0.0291  0.0548  0.0451
Maximum Drawdown             -0.1518 -0.2399 -0.2894 -0.2874 -0.3405 -
Historical VaR (95%)         -0.0258 -0.0294 -0.0425 -0.0799 -0.0733 -
Historical ES (95%)          -0.0513 -0.0331 -0.0555 -0.1122 -0.1023 -
Modified VaR (95%)           -0.0342 -0.0276 -0.0368 -0.0815 -0.0676 -
Modified ES (95%)            -0.0610 -0.0614 -0.0440 -0.1176 -0.0974 -
```

Semivariance and Downside Deviation

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

$$\delta_{MAR} = \sqrt{\frac{\sum_{t=1}^{n}(R_t - MAR)^2}{n}} \tag{4}$$

- Downside Deviation may be used to calculate semideviation by setting MAR=mean(R) or may also be used with 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

$$z_c = q_p = qnorm(p) \tag{5}$$

$$VaR = \bar{R} - z_c \cdot \sqrt{\sigma} \tag{6}$$

- 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:

$$z_{cf} = z_c + \frac{(z_c^2 - 1)S}{6} + \frac{(z_c^3 - 3z_c)K}{24} + \frac{(2z_c^3 - 5z_c)S^2}{36} \tag{7}$$

$$modVaR = \bar{R} - z_{cf}\sqrt{\sigma} \tag{8}$$

- 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

$$\frac{\sqrt[n]{prod(1+R_a)^{scale}}-1}{\sqrt{scale}\cdot\sqrt{\sigma}} \tag{9}$$

- Sortino Ratio — improvement on Sharpe Ration utilizing downside deviation as the measure of risk

$$\frac{(\overline{R_a - MAR})}{\delta_{MAR}} \tag{10}$$

- 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

$$\frac{\sum_{t=1}^{n}(R_t - MAR)}{\delta_{MAR}} \tag{11}$$

- Favre's modified Sharpe Ratio — ratio of excess return over Cornish-Fisher VaR

$$\frac{(\overline{R_a - R_f})}{modVaR_{R_a,p}} \tag{12}$$

- *NOTE*: The newest measures such as modified Sharpe and Sortino's UPR are far more reliable than older measures, but everyone still seems to look at older measures.

Summary

- Performance and Risk analysis are greatly facilitated by the use of charts and tables.
- The display of your infomation is in many cases as important as the analysis.
- The observer should have gained a working knowledge of how specific visual techniques may be utilized 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.