

Overview of PerformanceAnalytics' Charts and Tables

Brian G. Peterson

Diamond Management & Technology Consultants
Chicago, IL
brian@braverock.com

R/Rmetrics User and Developer Workshop, 2007

Outline

Introduction

Set Up PerformanceAnalytics

Review Performance

Summary

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"

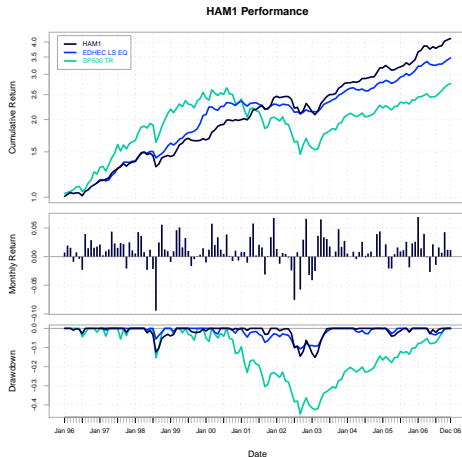
> manager.col = 1
> peers.cols = c(2, 3, 4, 5, 6)
> indexes.cols = c(7, 8)
> Rf.col = 10
> trailing12.rows = (managers.length - 11):managers.length
> trailing12.rows

[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

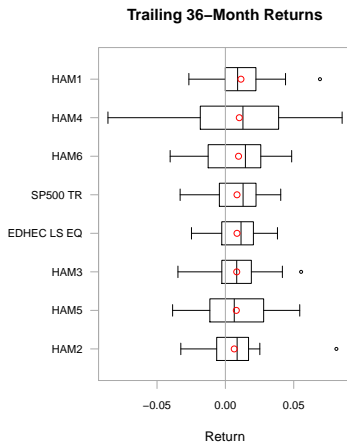
Calculate Statistics.

```
> table.Stats(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.

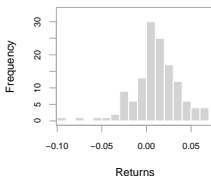
```
> chart.Boxplot(managers[trailing36.rows, c(manager.col, peers.cols,  
+      indexes.cols)], main = "Trailing 36-Month Returns")
```



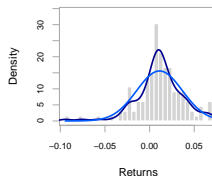
Compare Distributions.

```
> 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"))
```

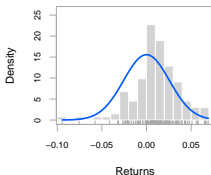
Plain



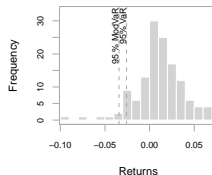
Density



Skew and Kurt

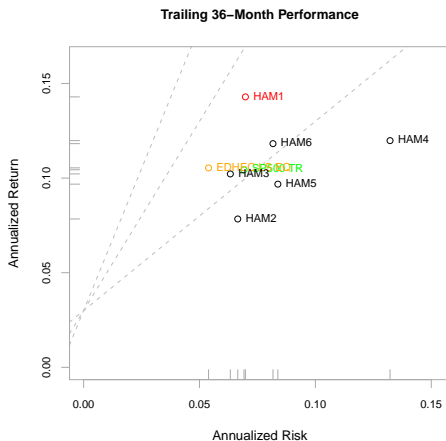


Risk Measures



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"))
```



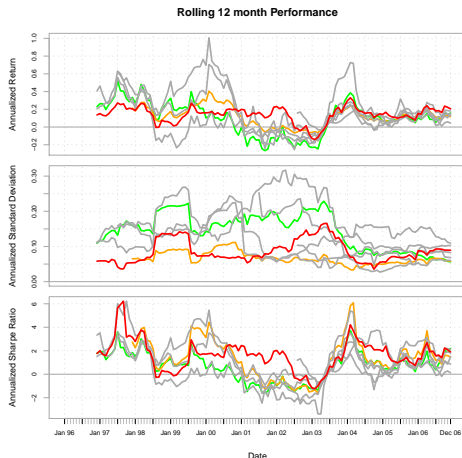
Calculate Statistics.

```
> table.Stats(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

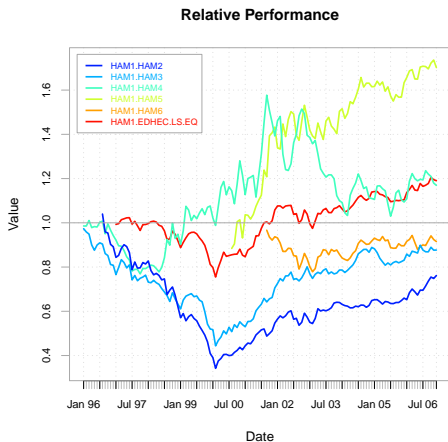
Examine Performance Consistency.

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



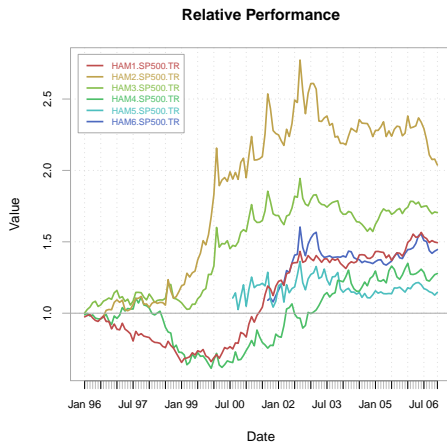
Display Relative Performance.

```
> 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

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

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

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

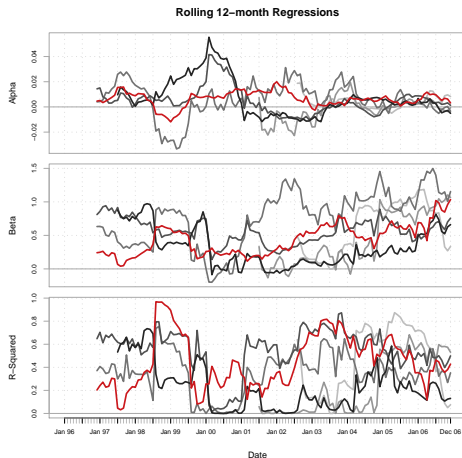
- ▶ ActivePremium — investment's annualized return minus the benchmark's annualized return
- ▶ Tracking Error — A measure of the unexplained portion of performance relative to a benchmark, given by

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

- ▶ 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 Minimum Acceptable Return(MAR)

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

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

$$z_c = q_p = qnorm(p) \quad (5)$$

$$VaR = \bar{R} - z_c \cdot \sqrt{\sigma} \quad (6)$$

- ▶ 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:

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

$$modVaR = \bar{R} - z_{cf}\sqrt{\sigma} \quad (8)$$

- ▶ 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

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

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

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

- ▶ 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

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

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

$$\frac{(\overline{R_a} - R_f)}{\text{modVaR}_{R_a,p}} \quad (12)$$

- ▶ **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 information 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.

