

Umsmooth Return Models Impact

Shubhankit Mohan

September 10, 2013

Abstract

The fact that many hedge fund returns exhibit extraordinary levels of serial correlation is now well-known and generally accepted as fact. Because hedge fund strategies have exceptionally high autocorrelations in reported returns and this is taken as evidence of return smoothing, we first develop a method to completely eliminate any order of serial correlation across a wide array of time series processes. Once this is complete, we can determine the underlying risk factors to the "true" hedge fund returns and examine the incremental benefit attained from using nonlinear payoffs relative to the more traditional linear factors.

Contents

1	Okunev White Model Methodology	1
2	To Remove Up to m Orders of Autocorrelation	2
3	Time Series Characteristics	2
3.1	Performance Summary	3
3.2	Autocorrelation UnSmoothing Impact	4
3.3	Comparing Distributions	6
4	Risk Measure	9
4.1	Mean absolute deviation	9
4.2	Sharpe Ratio	10
4.3	Value at Risk	11
5	Regression analysis	11
5.1	Regression equation	11
5.2	Regression alpha	12
5.3	Regression beta	12

5.4	Jensen's alpha	13
5.5	Systematic Risk	14
5.6	Treynor ratio	15
5.7	Downside Risk	16
6	Relative Risk	16
6.1	Tracking error	16
6.2	Information ratio	17
7	Drawdown	18
7.1	Pain index	18
7.2	Calmar ratio	19
7.3	Sterling ratio	20
7.4	Burke ratio	21
7.5	Modified Burke ratio	22
7.6	Martin ratio	23
7.7	Pain ratio	24
8	Performance Analysis Charts	25
8.1	Show relative return and risk	25
8.2	Examine Performance Consistency	27

1 Okunev White Model Methodology

Given a sample of historical returns (R_1, R_2, \dots, R_T) , the method assumes the fund manager smooths returns in the following manner:

$$r_{0,t} = \sum_i \beta_i r_{0,t-i} + (1 - \alpha) r_{m,t} \quad (1)$$

$$where : \sum_i \beta_i = (1 - \alpha) \quad (2)$$

$r_{0,t}$: is the observed (reported) return at time t (with 0 adjustments' to reported returns),

$r_{m,t}$: is the true underlying (unreported) return at time t (determined by making m adjustments to reported returns).

The objective is to determine the true underlying return by removing the autocorrelation structure in the original return series without making any assumptions regarding the actual time series properties of the underlying process. We are implicitly assuming by this approach that the autocorrelations that arise in reported returns are entirely due to the

smoothing behavior funds engage in when reporting results. In fact, the method may be adopted to produce any desired level of autocorrelation at any lag and is not limited to simply eliminating all autocorrelations.

2 To Remove Up to m Orders of Autocorrelation

To remove the first m orders of autocorrelation from a given return series we would proceed in a manner very similar to that detailed in **Geltner Return**. We would initially remove the first order autocorrelation, then proceed to eliminate the second order autocorrelation through the iteration process. In general, to remove any order, m, autocorrelations from a given return series we would make the following transformation to returns:

$$r_{m,t} = \frac{r_{m-1,t} - c_m r_{m-1,t-m}}{1 - c_m} \quad (3)$$

Where $r_{m-1,t}$ is the series return with the first (m-1) order autocorrelation coefficient's removed. The general form for all the autocorrelations given by the process is :

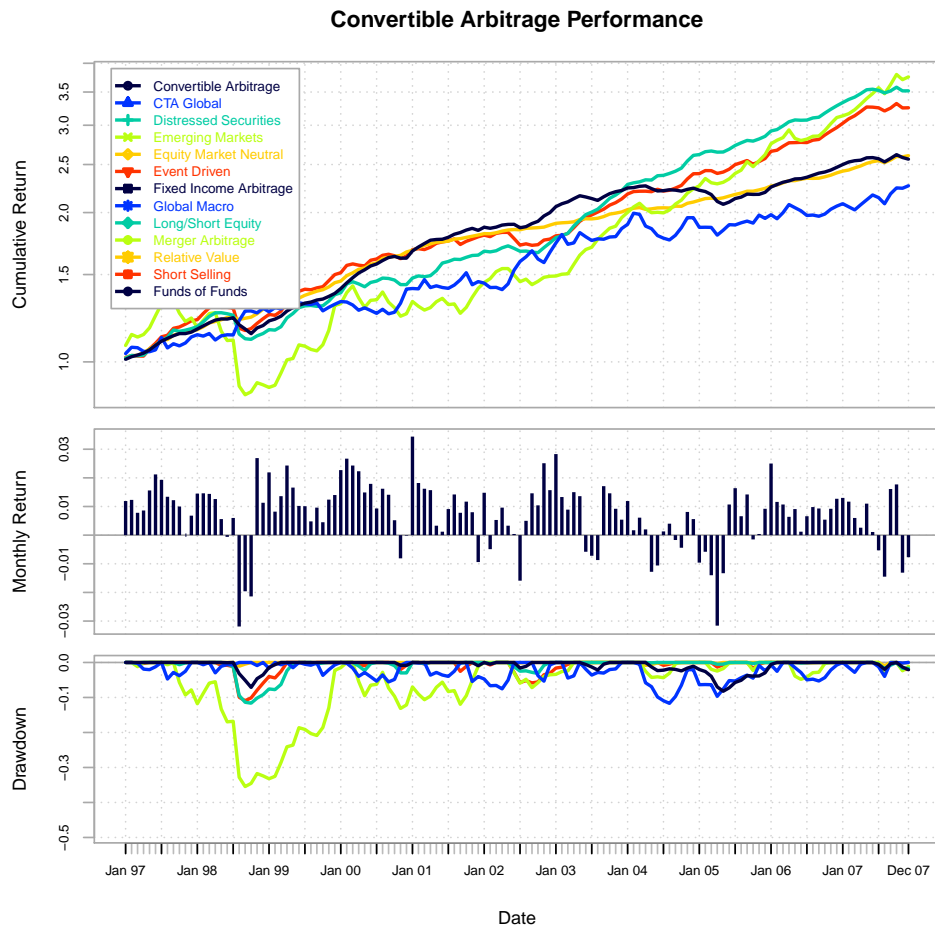
$$a_{m,n} = \frac{a_{m-1,n}(1 + c_m^2) - c_m(1 + a_{m-1,2m})}{1 + c_m^2 - 2c_m a_{m-1,n}} \quad (4)$$

Once a solution is found for c_m to create $r_{m,t}$, one will need to iterate back to remove the first 'm' autocorrelations again. One will then need to once again remove the mth autocorrelation using the adjustment in equation (3). It would continue the process until the first m autocorrelations are sufficiently close to zero.

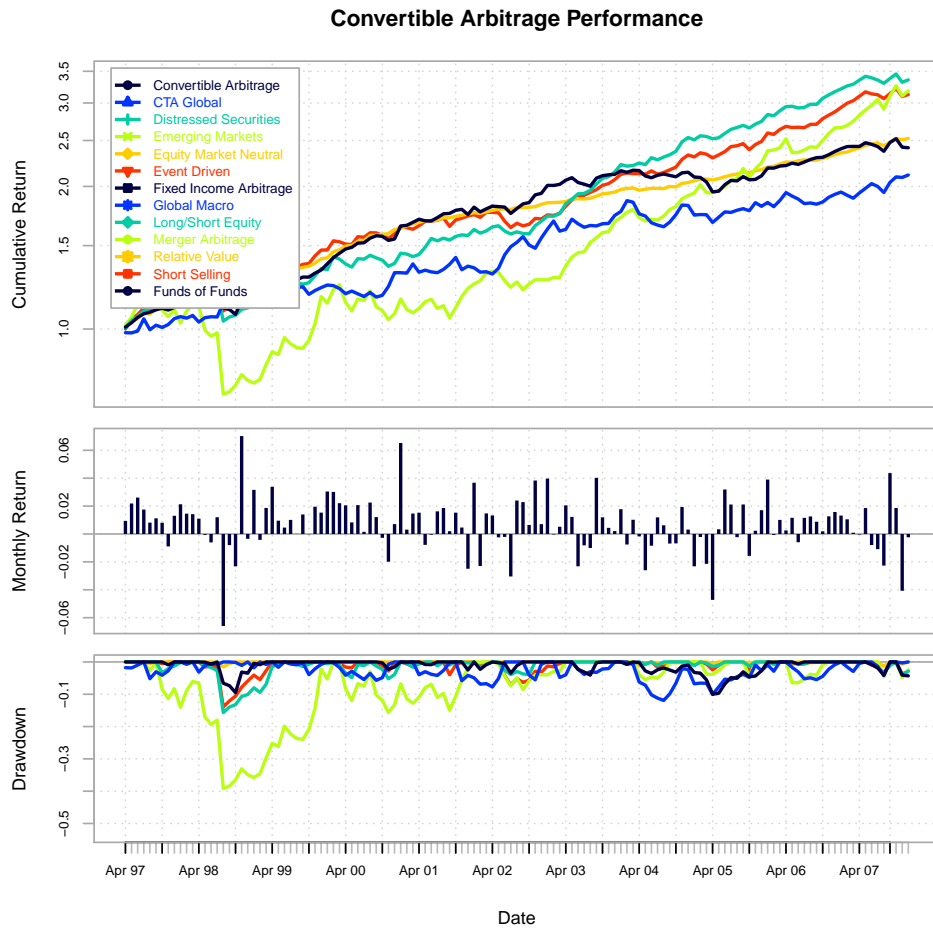
3 Time Series Characteristics

Given a series of historical returns (R_1, R_2, \dots, R_T) from **January-1997** to **January-2008**, create a wealth index chart, bars for per-period performance, and underwater chart for drawdown of the Hedge Funds Indices from EDHEC Database.

3.1 Performance Summary

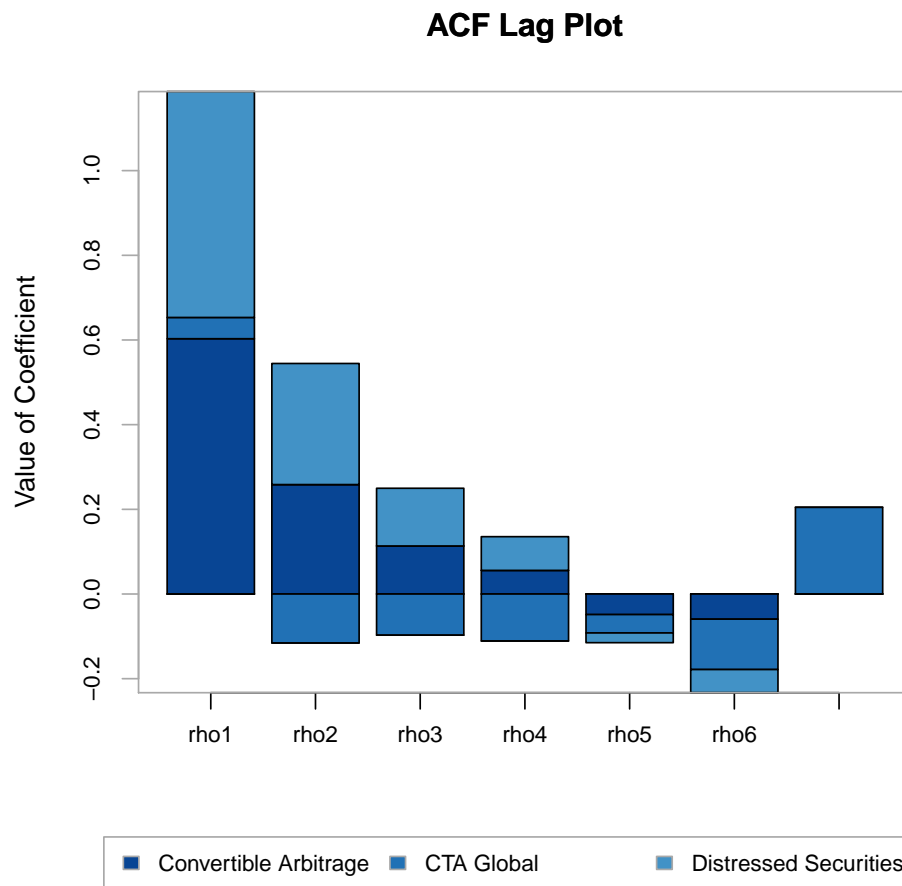


After applying the **Okunev White Model** to remove the serial correlation , we get the following Performance Chart.

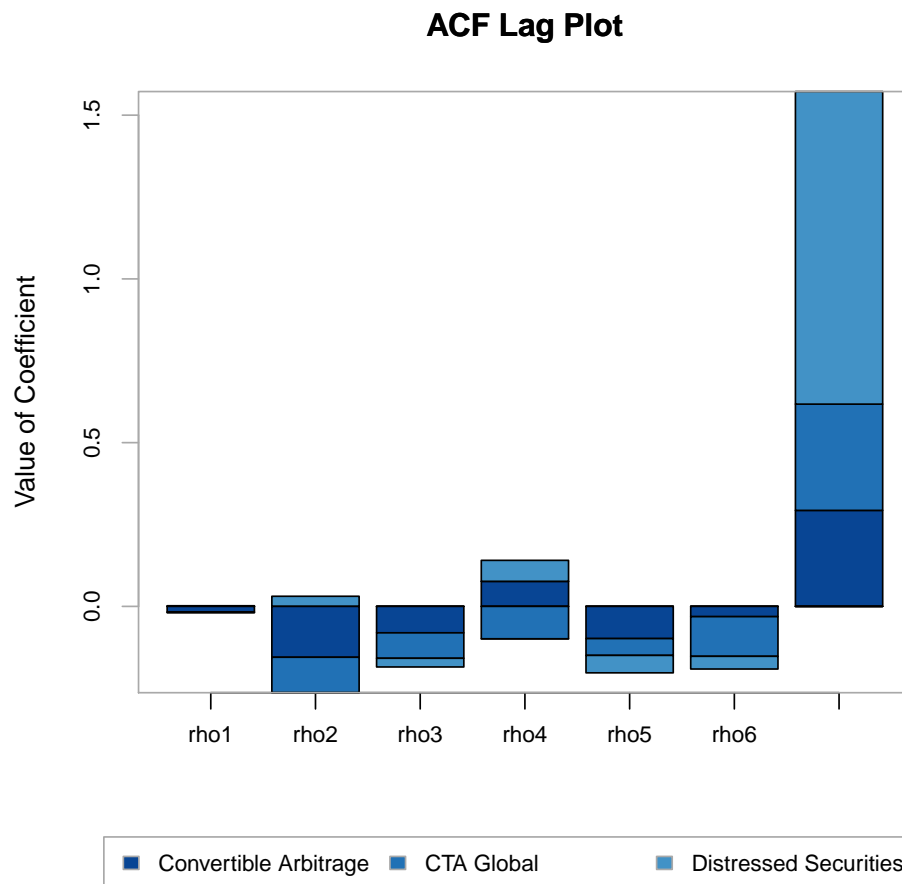


3.2 Autocorrelation UnSmoothing Impact

One prominent feature visible by the summary chart is the removal of **serial autocorrelation** and **unsoomthing** of the return series. The significant drop in autocorrelation, is visible by the following chart based on indices of the CTA global ,Distressed Securities and Ememrging Markets which had the highest autocorrelation .



The change can be evidently seen by the following chart :



3.3 Comparing Distributions

In this example we use edhec database, to compute true Hedge Fund Returns.

```
> library(PerformanceAnalytics)
> data(edhec)
> Returns = Return.Okunev(edhec[,1])
> skewness(edhec[,1])
```

```
[1] -2.683657
```

```
> skewness>Returns)
```

```
[1] -1.19068
```

```

> # Right Shift of Returns Distribution for a negative skewed distribution
> kurtosis(edhec[,1])

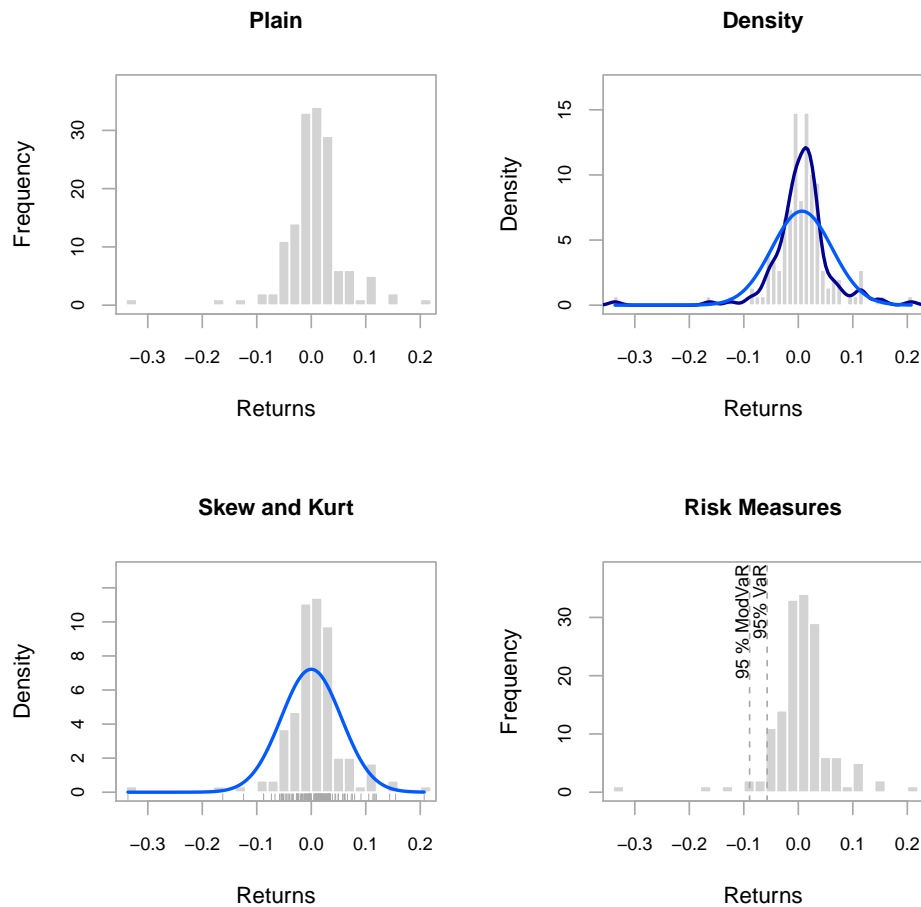
[1] 16.17819

> kurtosis>Returns)

[1] 10.59337

> # Reduction in "peakedness" around the mean
> layout(rbind(c(1, 2), c(3, 4)))
> chart.Histogram>Returns, main = "Plain", methods = NULL)
> chart.Histogram>Returns, main = "Density", breaks = 40,
+ methods = c("add.density", "add.normal"))
> chart.Histogram>Returns, main = "Skew and Kurt",
+ methods = c("add.centered", "add.rug"))
> chart.Histogram>Returns, main = "Risk Measures",
+ methods = c("add.risk"))

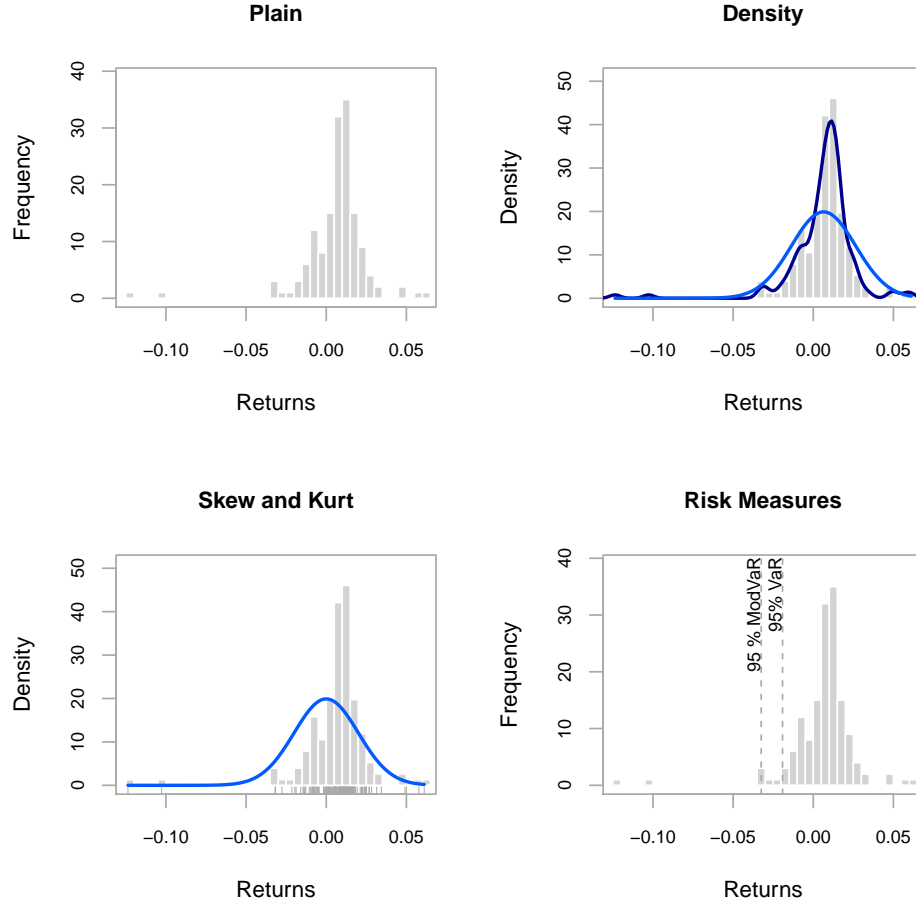
```

The above figure shows the behaviour of the distribution tending to a normal IID distribution. For comparative purpose, one can observe the change in the characteristics of return as compared to the original.

```
> library(PerformanceAnalytics)
> data(edhec)
> Returns = Return.Okunev(edhec[,1])
> layout(rbind(c(1, 2), c(3, 4)))
> chart.Histogram(edhec[,1], main = "Plain", methods = NULL)
> chart.Histogram(edhec[,1], main = "Density", breaks = 40,
+ methods = c("add.density", "add.normal"))
> chart.Histogram(edhec[,1], main = "Skew and Kurt",
+ methods = c("add.centered", "add.rug"))
> chart.Histogram(edhec[,1], main = "Risk Measures",
+ methods = c("add.risk"))
```

>



4 Risk Measure

4.1 Mean absolute deviation

To calculate Mean absolute deviation we take the sum of the absolute value of the difference between the returns and the mean of the returns and we divide it by the number of returns.

$$MeanAbsoluteDeviation = \frac{\sum_{i=1}^n |r_i - \bar{r}|}{n}$$

where n s the number of observations of the entire series, r_i s the return in month i and \bar{r} s the mean return

	Convertible Arbitrage	CTA Global	Distressed Securities
Mean absolute deviation	191.5453	5.581807	89.59503

We can observe than due to the spurious serial autocorrelation, the true **volatility** was hidden, which is **more than 100 %** in case of Distressed Securities to the one apparent to the investor. **CTA Global**, has the lowest change, which is consistent, with the fact with it has the lowest autocorrelation.

4.2 Sharpe Ratio

The Sharpe ratio is simply the return per unit of risk (represented by variability). In the classic case, the unit of risk is the standard deviation of the returns.

$$\frac{(R_a - R_f)}{\sqrt{\sigma(R_a - R_f)}}$$

	Convertible Arbitrage	CTA Global
StdDev Sharpe (Rf=0%, p=95%):	0.31967021	0.2582269
VaR Sharpe (Rf=0%, p=95%):	0.19734443	0.1919833
ES Sharpe (Rf=0%, p=95%):	0.06437672	0.1514751
	Distressed Securities	
StdDev Sharpe (Rf=0%, p=95%):	0.4334711	
VaR Sharpe (Rf=0%, p=95%):	0.2892904	
ES Sharpe (Rf=0%, p=95%):	0.1306556	
	Convertible Arbitrage	CTA Global
StdDev Sharpe (Rf=0%, p=95%):	0.12060647	0.2330569
VaR Sharpe (Rf=0%, p=95%):	0.07461253	0.1689703
ES Sharpe (Rf=0%, p=95%):	0.02832469	0.1328497
	Distressed Securities	
StdDev Sharpe (Rf=0%, p=95%):	0.24494271	
VaR Sharpe (Rf=0%, p=95%):	0.14988705	
ES Sharpe (Rf=0%, p=95%):	0.07186104	

The Sharpe Ratio should expectedly fall, as in UnSmooth Return model, the returns decrease and standard deviation increases simultaneously. **CTA Global**, is the sole index, which does not experience a sharp fall, which can be attributed to the low autocorrelation coefficient (**0.05**).

4.3 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

$$z_c = q_p = qnorm(p)$$

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

```
> data(edhec)
> VaR(edhec, p=.95, method="gaussian")

      Convertible Arbitrage  CTA Global Distressed Securities Emerging Markets
VaR          -0.02645782 -0.03471098          -0.0221269          -0.05498927
      Equity Market Neutral Event Driven Fixed Income Arbitrage Global Macro
VaR          -0.008761813 -0.02246202          -0.01900198 -0.02023018
      Long/Short Equity Merger Arbitrage Relative Value Short Selling
VaR          -0.02859264          -0.01152478          -0.01493049 -0.08617027
      Funds of Funds
VaR          -0.02393888

> VaR(Return.Okunev(edhec), p=.95, method="gaussian")

      Convertible Arbitrage  CTA Global Distressed Securities Emerging Markets
VaR          -0.08394453 -0.03724858          -0.04617951          -0.07864815
      Equity Market Neutral Event Driven Fixed Income Arbitrage Global Macro
VaR          -0.01238121 -0.0372441          -0.04178068 -0.02143809
      Long/Short Equity Merger Arbitrage Relative Value Short Selling
VaR          -0.03983483          -0.01841034          -0.02907754          -0.1026801
      Funds of Funds
VaR          -0.03504775
```

5 Regression analysis

5.1 Regression equation

$$r_P = \alpha + \beta * b + \epsilon$$

5.2 Regression alpha

"Alpha" purports to be a measure of a manager's skill by measuring the portion of the managers returns that are not attributable to "Beta", or the portion of performance attributable to a benchmark.

```
> data(managers)
> CAPM.alpha(edhec, managers[,8,drop=FALSE], Rf=.035/12)
```

	Convertible Arbitrage	CTA	Global Distressed Securities	
Alpha: SP500 TR	0.004471465	0.003821383	0.00636263	
	Emerging Markets Equity	Market Neutral	Event Driven	
Alpha: SP500 TR	0.004841242	0.004170222	0.005182049	
	Fixed Income Arbitrage	Global Macro	Long/Short Equity	
Alpha: SP500 TR	0.002324711	0.004706408	0.005009663	
	Merger Arbitrage	Relative Value	Short Selling Funds of Funds	
Alpha: SP500 TR	0.003935414	0.004268617	0.005397325	0.003917601

```
> CAPM.alpha(Return.Okunev(edhec), managers[,8,drop=FALSE], Rf=.035/12)
```

	Convertible Arbitrage	CTA	Global Distressed Securities	
Alpha: SP500 TR	0.003623436	0.003482153	0.005457597	
	Emerging Markets Equity	Market Neutral	Event Driven	
Alpha: SP500 TR	0.003004784	0.004048946	0.004523336	
	Fixed Income Arbitrage	Global Macro	Long/Short Equity	
Alpha: SP500 TR	0.00184902	0.004405292	0.004630361	
	Merger Arbitrage	Relative Value	Short Selling Funds of Funds	
Alpha: SP500 TR	0.00365762	0.003672505	0.005288907	0.003442342

5.3 Regression beta

CAPM Beta is the beta of an asset to the variance and covariance of an initial portfolio. Used to determine diversification potential.

```
> data(managers)
> CAPM.beta(edhec, managers[, "SP500 TR", drop=FALSE], Rf = managers[, "US 3m TR",
```

	Convertible Arbitrage	CTA	Global Distressed Securities
Beta: SP500 TR	0.04824155	-0.07328212	0.1692722
	Emerging Markets Equity	Market Neutral	Event Driven
Beta: SP500 TR	0.5092851	0.05648291	0.2379033
	Fixed Income Arbitrage	Global Macro	Long/Short Equity

Beta: SP500 TR	-0.009447579	0.1664831	0.3368761
	Merger Arbitrage	Relative Value	Short Selling Funds of Funds
Beta: SP500 TR	0.1357786	0.1356442	-1.000142
			0.2145575

```
> CAPM.beta(Return.Okunev(edhec), managers[, "SP500 TR", drop=FALSE], Rf = manager
```

	Convertible Arbitrage	CTA Global	Distressed Securities
Beta: SP500 TR	0.2324435	-0.08548672	0.3996316
	Emerging Markets	Equity Market Neutral	Event Driven
Beta: SP500 TR	0.7753848	0.07331462	0.4013961
	Fixed Income Arbitrage	Global Macro	Long/Short Equity
Beta: SP500 TR	0.03619617	0.1681044	0.4535646
	Merger Arbitrage	Relative Value	Short Selling Funds of Funds
Beta: SP500 TR	0.199134	0.2684195	-1.177247
			0.318659

This is an **interesting** find of investigation. **Contorary**, to the belief , that *umsmooth-
ing the returns would make it more volatile, with idiosyncratic components*, the regression
shows, that the true returns are **much more** significantly related to Financial Markets, as
compared to the visible returns to the investors. This also weakens the belief, that hedge
funds give returns, irrespective of the market conditions.

5.4 Jensen's alpha

The Jensen's alpha is the intercept of the regression equation in the Capital Asset Pricing
Model and is in effect the exess return adjusted for systematic risk.

$$\alpha = r_p - r_f - \beta_p * (b - r_f)$$

where r_f is the risk free rate, β_r is the regression beta, r_p is the portfolio return and b
is the benchmark return

```
> data(edhec)
> CAPM.jensenAlpha(edhec, managers[, 8], Rf=.03/12)
```

	Convertible Arbitrage	CTA Global
Jensen's Alpha (Risk free = 0.0025)	0.06999936	0.0812573
	Distressed Securities	Emerging Markets
Jensen's Alpha (Risk free = 0.0025)	0.07949484	0.04377234
	Equity Market Neutral	Event Driven
Jensen's Alpha (Risk free = 0.0025)	0.06617577	0.06851869
	Fixed Income Arbitrage	Global Macro

Jensen's Alpha (Risk free = 0.0025)	0.0493231	0.07618595
	Long/Short Equity Merger Arbitrage	
Jensen's Alpha (Risk free = 0.0025)	0.05988859	0.06845796
	Relative Value Short Selling Funds of Funds	
Jensen's Alpha (Risk free = 0.0025)	0.06714829	0.1240347
	0.04870534	

> CAPM.jensenAlpha(Return.Okunev(edhec),managers[,8],Rf=.03/12)

	Convertible Arbitrage CTA Global	
Jensen's Alpha (Risk free = 0.0025)	0.03808553	0.07805832
	Distressed Securities Emerging Markets	
Jensen's Alpha (Risk free = 0.0025)	0.05490376	0.002827883
	Equity Market Neutral Event Driven	
Jensen's Alpha (Risk free = 0.0025)	0.06349135	0.05133152
	Fixed Income Arbitrage Global Macro	
Jensen's Alpha (Risk free = 0.0025)	0.03995779	0.0726611
	Long/Short Equity Merger Arbitrage	
Jensen's Alpha (Risk free = 0.0025)	0.04786047	0.06170853
	Relative Value Short Selling Funds of Funds	
Jensen's Alpha (Risk free = 0.0025)	0.05300399	0.1250439
	0.03648212	

The Jensen's alpha diminish significantly with Okunev Return model. However, with CTA Global, the alpha does not change by more than 3% .

5.5 Systematic Risk

Systematic risk as defined by Bacon(2008) is the product of beta by market risk. Be careful ! It's not the same definition as the one given by Michael Jensen. Market risk is the standard deviation of the benchmark. The systematic risk is annualized

$$\sigma_s = \beta * \sigma_m$$

where σ_s is the systematic risk, β is the regression beta, and σ_m is the market risk

	Convertible Arbitrage CTA Global	
Systematic Risk to SP500 TR (Rf = 0)	382.1817	18.46926
	Distressed Securities Emerging Markets	
Systematic Risk to SP500 TR (Rf = 0)	139.0751	52.54349
	Equity Market Neutral Event Driven	
Systematic Risk to SP500 TR (Rf = 0)	27.61317	68.90475
	Fixed Income Arbitrage Global Macro	

Systematic Risk to SP500 TR (Rf = 0)	157.3361	0.02542014
	Long/Short Equity Merger Arbitrage	
Systematic Risk to SP500 TR (Rf = 0)	34.37248	45.69652
	Relative Value Short Selling	
Systematic Risk to SP500 TR (Rf = 0)	97.82683	17.98637
	Funds of Funds	
Systematic Risk to SP500 TR (Rf = 0)	48.21903	

The above table shows, the increase in % of the market risk σ_m after Okunev White model has been implemented. Concurrent with the investment stlye, **Equity Market Neutral, Short Selling , Global Macro** show least amount of indifference to their market risk exposure.

5.6 Treynor ratio

The Treynor ratio is similar to the Sharpe Ratio, except it uses beta as the volatility measure (to divide the investment's excess return over the beta). It is a performance metric that measures the effective return adjusted for market risk. Well-diversified portfolios should have similar Sharpe and Treynor Ratios because the standard deviation reduces to the beta.

$$TreynorRatio = \frac{\overline{(R_a - R_f)}}{\beta_{a,b}}$$

	Convertible Arbitrage CTA Global Distressed Securities		
Treynor Ratio: SP500 TR	0.8368	-0.5328	0.3644
	Emerging Markets Equity Market Neutral Event Driven		
Treynor Ratio: SP500 TR	0.1119	0.6658	0.2372
	Fixed Income Arbitrage Global Macro Long/Short Equity		
Treynor Ratio: SP500 TR	-1.2009	0.3448	0.1687
	Merger Arbitrage Relative Value Short Selling		
Treynor Ratio: SP500 TR	0.3444	0.3368	0.0029
	Funds of Funds		
Treynor Ratio: SP500 TR	0.1624		

	Convertible Arbitrage CTA Global Distressed Securities		
Treynor Ratio: SP500 TR	0.112	-0.4005	0.145
	Emerging Markets Equity Market Neutral Event Driven		
Treynor Ratio: SP500 TR	0.053	0.505	0.1358
	Fixed Income Arbitrage Global Macro Long/Short Equity		
Treynor Ratio: SP500 TR	0.3037	0.324	0.123

	Merger Arbitrage	Relative Value	Short Selling
Treynor Ratio: SP500 TR	0.2318	0.1639	0.0155
	Funds of Funds		
Treynor Ratio: SP500 TR	0.1017		

CTA Global has a negative value, which imply as risk-free rate is less than the expected return, but the beta is negative. This means that the fund manger has performed well, managing to reduce risk but getting a return better than the risk free rate

5.7 Downside Risk

As we have obtained the true hedge fund returns, what is the actual **VaR,drawdown and downside potential** of the indices, can be illustrated by the following example, where we CTA Global and Distressed Securities indiciies have been taken as sample data sets.

The following table, shows the change in **absolute value** in terms of percentage, when the Okunev White Return model has been implemented as compared to the Orginal model. We can observe, that for the given period , before the 2008 financial crisis, the hedge fund returns have a **100 %** increase in exposure.The result is consistent , when tested on other indicies, which show that true risk was camouflaged under the haze of smoothing in the hedge fund industry.

	CTA Global	Distressed Securities
Semi Deviation	5.780347	75.67568
Gain Deviation	1.775148	70.19231
Loss Deviation	7.407407	48.18653
Downside Deviation (MAR=10%)	6.521739	75.16779
Downside Deviation (Rf=0%)	8.759124	89.07563
Downside Deviation (0%)	8.759124	89.07563
Maximum Drawdown	2.568493	17.88831
Historical VaR (95%)	5.932203	86.24339
Historical ES (95%)	5.518764	77.75176
Modified VaR (95%)	7.988166	96.72727
Modified ES (95%)	8.644860	85.38588

6 Relative Risk

6.1 Tracking error

A measure of the unexplained portion of performance relative to a benchmark.Tracking error is calculated by taking the square root of the average of the squared deviations

between the investment's returns and the benchmark's returns, then multiplying the result by the square root of the scale of the returns.

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

```
> data(managers)
> TrackingError(edhec, managers[,8,drop=FALSE])
```

	Convertible	Arbitrage	CTA	Global	Distressed	Securities
Tracking Error: SP500 TR	0.1543707	0.1685952				0.1539006
	Emerging	Markets	Equity	Market	Neutral	Event Driven
Tracking Error: SP500 TR	0.1950528			0.1423184		0.1517637
	Fixed	Income	Arbitrage	Global	Macro	Long/Short Equity
Tracking Error: SP500 TR	0.1458036			0.1529016		0.157304
	Merger	Arbitrage	Relative	Value	Short	Selling
Tracking Error: SP500 TR	0.1412594			0.1452275		0.2391201
	Funds	of	Funds			
Tracking Error: SP500 TR	0.1524484					

```
> TrackingError(Return.Okunev(edhec), managers[,8,drop=FALSE])
```

	Convertible	Arbitrage	CTA	Global	Distressed	Securities
Tracking Error: SP500 TR	0.2445393	0.1725162				0.187338
	Emerging	Markets	Equity	Market	Neutral	Event Driven
Tracking Error: SP500 TR	0.2375463			0.1474357		0.176381
	Fixed	Income	Arbitrage	Global	Macro	Long/Short Equity
Tracking Error: SP500 TR	0.183249			0.1623801		0.1801033
	Merger	Arbitrage	Relative	Value	Short	Selling
Tracking Error: SP500 TR	0.1551378			0.1655992		0.246828
	Funds	of	Funds			
Tracking Error: SP500 TR	0.1730591					

6.2 Information ratio

The Active Premium divided by the Tracking Error.

InformationRatio = ActivePremium/TrackingError

This relates the degree to which an investment has beaten the benchmark to the consistency with which the investment has beaten the benchmark.

```
> data(managers)
> InformationRatio(edhec, managers[,8,drop=FALSE])
```

	Convertible Arbitrage	CTA Global	
Information Ratio: SP500 TR	0.06641876	-0.05510777	
	Distressed Securities	Emerging Markets	
Information Ratio: SP500 TR	0.2728265	0.1837459	
	Equity Market Neutral	Event Driven	
Information Ratio: SP500 TR	0.05213518	0.2018958	
	Fixed Income Arbitrage	Global Macro	
Information Ratio: SP500 TR	-0.1439689	0.1284569	
	Long/Short Equity	Merger Arbitrage	Relative Value
Information Ratio: SP500 TR	0.2147325	0.06278675	0.09164164
	Short Selling Funds	Funds of Funds	
Information Ratio: SP500 TR	-0.2589545	0.08212568	

```
> abs(InformationRatio(Return.Okunev(edhec), managers[,8,drop=FALSE]))
```

	Convertible Arbitrage	CTA Global	
Information Ratio: SP500 TR	0.01739878	0.08246386	
	Distressed Securities	Emerging Markets	
Information Ratio: SP500 TR	0.2154123	0.08186685	
	Equity Market Neutral	Event Driven	
Information Ratio: SP500 TR	0.04971605	0.1709152	
	Fixed Income Arbitrage	Global Macro	
Information Ratio: SP500 TR	0.1428086	0.09947874	
	Long/Short Equity	Merger Arbitrage	Relative Value
Information Ratio: SP500 TR	0.1907038	0.05806339	0.07847608
	Short Selling Funds	Funds of Funds	
Information Ratio: SP500 TR	0.3250201	0.06674165	

Short Selling has the highest value as the returns produced by this fund have low correlation with the market returns.

7 Drawdown

7.1 Pain index

The pain index is the mean value of the drawdowns over the entire analysis period. The measure is similar to the Ulcer index except that the drawdowns are not squared. Also, it's different than the average drawdown, in that the numerator is the total number of observations rather than the number of drawdowns. Visually, the pain index is the area of the region that is enclosed by the horizontal line at zero percent and the drawdown line in the Drawdown chart.

$$Painindex = \sum_{i=1}^n \frac{|D'_i|}{n}$$

where n is the number of observations of the entire series, D'_i is the drawdown since previous peak in period i

```
> data(edhec)
> print(PainIndex(edhec[,]))
```

```

          Convertible Arbitrage CTA Global Distressed Securities
Pain Index      0.02515669 0.02330895      0.02427166
          Emerging Markets Equity Market Neutral Event Driven
Pain Index      0.08077422      0.008118339 0.02245003
          Fixed Income Arbitrage Global Macro Long/Short Equity
Pain Index      0.01783657 0.01035735      0.03111831
          Merger Arbitrage Relative Value Short Selling Funds of Funds
Pain Index      0.006876259 0.01253914 0.2192711 0.02395462
```

```
> print(PainIndex(Return.Okunev(edhec[,])))
```

```

          Convertible Arbitrage CTA Global Distressed Securities
Pain Index      0.04347953 0.02519844      0.03675718
          Emerging Markets Equity Market Neutral Event Driven
Pain Index      0.0933349 0.009222145 0.02850331
          Fixed Income Arbitrage Global Macro Long/Short Equity
Pain Index      0.02460773 0.01109697 0.03728646
          Merger Arbitrage Relative Value Short Selling Funds of Funds
Pain Index      0.009386586 0.01790537 0.2460317 0.03089789
```

7.2 Calmar ratio

Calmar ratio is another method of creating a risk-adjusted measure for ranking investments similar to the Sharpe ratio.

```
> data(managers)
> CalmarRatio(edhec)
```

```

          Convertible Arbitrage CTA Global Distressed Securities
Calmar Ratio      0.263148 0.6569514 0.4253743
          Emerging Markets Equity Market Neutral Event Driven
```

Calmar Ratio	0.2601868	0.6671512	0.4640555
	Fixed Income Arbitrage	Global Macro Long/Short Equity	
Calmar Ratio	0.2834293	1.189059	0.4308705
	Merger Arbitrage	Relative Value Short Selling Funds of Funds	
Calmar Ratio	1.485945	0.5163909	0.06588579
			0.3461158

```
> CalmarRatio(Return.Okunev(edhec))
```

	Convertible Arbitrage	CTA Global Distressed Securities	
Calmar Ratio	0.1198212	0.6025441	0.3496838
	Emerging Markets Equity	Market Neutral Event Driven	
Calmar Ratio	0.187074	0.55529	0.4050253
	Fixed Income Arbitrage	Global Macro Long/Short Equity	
Calmar Ratio	0.1738416	1.128598	0.3961305
	Merger Arbitrage	Relative Value Short Selling Funds of Funds	
Calmar Ratio	1.026547	0.3803846	0.03089017
			0.3060663

7.3 Sterling ratio

Sterling ratio is another method of creating a risk-adjusted measure for ranking investments similar to the Sharpe ratio.

```
> data(managers)
> SterlingRatio(edhec)
```

	Convertible Arbitrage	CTA Global	
Sterling Ratio (Excess = 10%)	0.1961361	0.353885	
	Distressed Securities	Emerging Markets	
Sterling Ratio (Excess = 10%)	0.2961725	0.2035986	
	Equity Market Neutral	Event Driven	
Sterling Ratio (Excess = 10%)	0.3507009	0.3097907	
	Fixed Income Arbitrage	Global Macro	
Sterling Ratio (Excess = 10%)	0.1817662	0.5256301	
	Long/Short Equity	Merger Arbitrage	Relative Value
Sterling Ratio (Excess = 10%)	0.2954606	0.5355002	0.3173254
	Short Selling Funds of Funds		
Sterling Ratio (Excess = 10%)	0.05482407	0.2329745	

```
> SterlingRatio(Return.Okunev(edhec))
```

	Convertible Arbitrage CTA Global		
Sterling Ratio (Excess = 10%)	0.1005155	0.3284646	
	Distressed Securities Emerging Markets		
Sterling Ratio (Excess = 10%)	0.2552339	0.1507136	
	Equity Market Neutral Event Driven		
Sterling Ratio (Excess = 10%)	0.3148317	0.2805439	
	Fixed Income Arbitrage Global Macro		
Sterling Ratio (Excess = 10%)	0.1257162	0.5028299	
	Long/Short Equity Merger Arbitrage Relative Value		
Sterling Ratio (Excess = 10%)	0.2776743	0.4583353	0.2583881
	Short Selling Funds of Funds		
Sterling Ratio (Excess = 10%)	0.02608718	0.2117567	

7.4 Burke ratio

To calculate Burke ratio we take the difference between the portfolio return and the risk free rate and we divide it by the square root of the sum of the square of the drawdowns.

$$BurkeRatio = \frac{r_P - r_F}{\sqrt{\sum_{t=1}^d D_t^2}}$$

where d is number of drawdowns, r_P the portfolio return, r_F is the risk free rate and D_t the t^{th} drawdown.

```
> data(edhec)
> (BurkeRatio(edhec))
```

	Convertible Arbitrage CTA Global		
Burke ratio (Risk free = 0)	0.2447676	0.3526829	
	Distressed Securities Emerging Markets		
Burke ratio (Risk free = 0)	0.3774068	0.178912	
	Equity Market Neutral Event Driven		
Burke ratio (Risk free = 0)	0.6317512	0.3975819	
	Fixed Income Arbitrage Global Macro		
Burke ratio (Risk free = 0)	0.2264446	0.7490102	
	Long/Short Equity Merger Arbitrage Relative Value		
Burke ratio (Risk free = 0)	0.3681217	0.8688048	0.4618429
	Short Selling Funds of Funds		
Burke ratio (Risk free = 0)	0.05035482	0.3107097	

```
> BurkeRatio(Return.Okunev(edhec))
```

	Convertible Arbitrage CTA Global		
Burke ratio (Risk free = 0)	0.1043484	0.313335	
	Distressed Securities Emerging Markets		
Burke ratio (Risk free = 0)	0.2677291	0.1258649	
	Equity Market Neutral Event Driven		
Burke ratio (Risk free = 0)	0.6975856	0.3278118	
	Fixed Income Arbitrage Global Macro		
Burke ratio (Risk free = 0)	0.1231584	0.6873877	
	Long/Short Equity Merger Arbitrage Relative Value		
Burke ratio (Risk free = 0)	0.2999348	0.6113309	0.3520044
	Short Selling Funds of Funds		
Burke ratio (Risk free = 0)	0.02314389	0.2471398	

7.5 Modified Burke ratio

To calculate the modified Burke ratio we just multiply the Burke ratio by the square root of the number of datas.

$$ModifiedBurkeRatio = \frac{r_P - r_F}{\sqrt{\sum_{t=1}^d \frac{D_t^2}{n}}}$$

where n is the number of observations of the entire series, ds number of drawdowns, r_P is the portfolio return, r_F is the risk free rate and D_t the t^{th} drawdown.

```
> data(edhec)
> BurkeRatio(edhec)
```

	Convertible Arbitrage CTA Global		
Burke ratio (Risk free = 0)	0.2447676	0.3526829	
	Distressed Securities Emerging Markets		
Burke ratio (Risk free = 0)	0.3774068	0.178912	
	Equity Market Neutral Event Driven		
Burke ratio (Risk free = 0)	0.6317512	0.3975819	
	Fixed Income Arbitrage Global Macro		
Burke ratio (Risk free = 0)	0.2264446	0.7490102	
	Long/Short Equity Merger Arbitrage Relative Value		
Burke ratio (Risk free = 0)	0.3681217	0.8688048	0.4618429
	Short Selling Funds of Funds		
Burke ratio (Risk free = 0)	0.05035482	0.3107097	

```
> BurkeRatio(Return.Okunev(edhec))
```

	Convertible Arbitrage CTA Global		
Burke ratio (Risk free = 0)	0.1043484	0.313335	
	Distressed Securities Emerging Markets		
Burke ratio (Risk free = 0)	0.2677291	0.1258649	
	Equity Market Neutral Event Driven		
Burke ratio (Risk free = 0)	0.6975856	0.3278118	
	Fixed Income Arbitrage Global Macro		
Burke ratio (Risk free = 0)	0.1231584	0.6873877	
	Long/Short Equity Merger Arbitrage Relative Value		
Burke ratio (Risk free = 0)	0.2999348	0.6113309	0.3520044
	Short Selling Funds of Funds		
Burke ratio (Risk free = 0)	0.02314389	0.2471398	

7.6 Martin ratio

To calculate Martin ratio we divide the difference of the portfolio return and the risk free rate by the Ulcer index

$$Martinratio = \frac{r_P - r_F}{\sqrt{\sum_{i=1}^n \frac{D_i'^2}{n}}}$$

where r_P is the annualized portfolio return, r_F is the risk free rate, n is the number of observations of the entire series, D_i' is the drawdown since previous peak in period i

```
> data(edhec)
> MartinRatio(edhec) #expected 1.70
```

	Convertible Arbitrage CTA Global Distressed Securities		
Martin Ratio (Rf = 0)	1.188397	2.201226	1.61687
	Emerging Markets Equity Market Neutral Event Driven		
Martin Ratio (Rf = 0)	0.6683931	2.709051	1.778773
	Fixed Income Arbitrage Global Macro Long/Short Equity		
Martin Ratio (Rf = 0)	1.108342	4.64473	1.549726
	Merger Arbitrage Relative Value Short Selling		
Martin Ratio (Rf = 0)	5.881015	2.313093	0.1233799
	Funds of Funds		
Martin Ratio (Rf = 0)	1.238275		

```
> MartinRatio(Return.Okunev(edhec))
```


	Convertible Arbitrage	CTA	Global Distressed Securities
Martin Ratio (Rf = 0)	0.6523562	1.957153	1.275891
	Emerging Markets Equity	Market Neutral	Event Driven
Martin Ratio (Rf = 0)	0.5046302	2.474297	1.520402
	Fixed Income Arbitrage	Global Macro	Long/Short Equity
Martin Ratio (Rf = 0)	0.7965394	4.30898	1.382441
	Merger Arbitrage	Relative Value	Short Selling
Martin Ratio (Rf = 0)	4.470347	1.831024	0.05787034
	Funds of Funds		
Martin Ratio (Rf = 0)	1.052294		

7.7 Pain ratio

To calculate Pain ratio we divide the difference of the portfolio return and the risk free rate by the Pain index

$$Painratio = \frac{r_P - r_F}{\sum_{i=1}^n \frac{|D'_i|}{n}}$$

where r_P is the annualized portfolio return, r_F is the risk free rate, n is the number of observations of the entire series, D'_i is the drawdown since previous peak in period i

```
> data(edhec)
> PainRatio(edhec)
```

	Convertible Arbitrage	CTA	Global Distressed Securities
Pain Ratio (Rf = 0)	3.061626	3.291054	4.017428
	Emerging Markets Equity	Market Neutral	Event Driven
Pain Ratio (Rf = 0)	1.15894	9.107276	4.151015
	Fixed Income Arbitrage	Global Macro	Long/Short Equity
Pain Ratio (Rf = 0)	2.841078	9.095792	3.021203
	Merger Arbitrage	Relative Value	Short Selling
Pain Ratio (Rf = 0)	12.1754	6.564771	0.148922
	Funds of Funds		
Pain Ratio (Rf = 0)	2.97522		

```
> PainRatio(Return.Okunev(edhec))
```

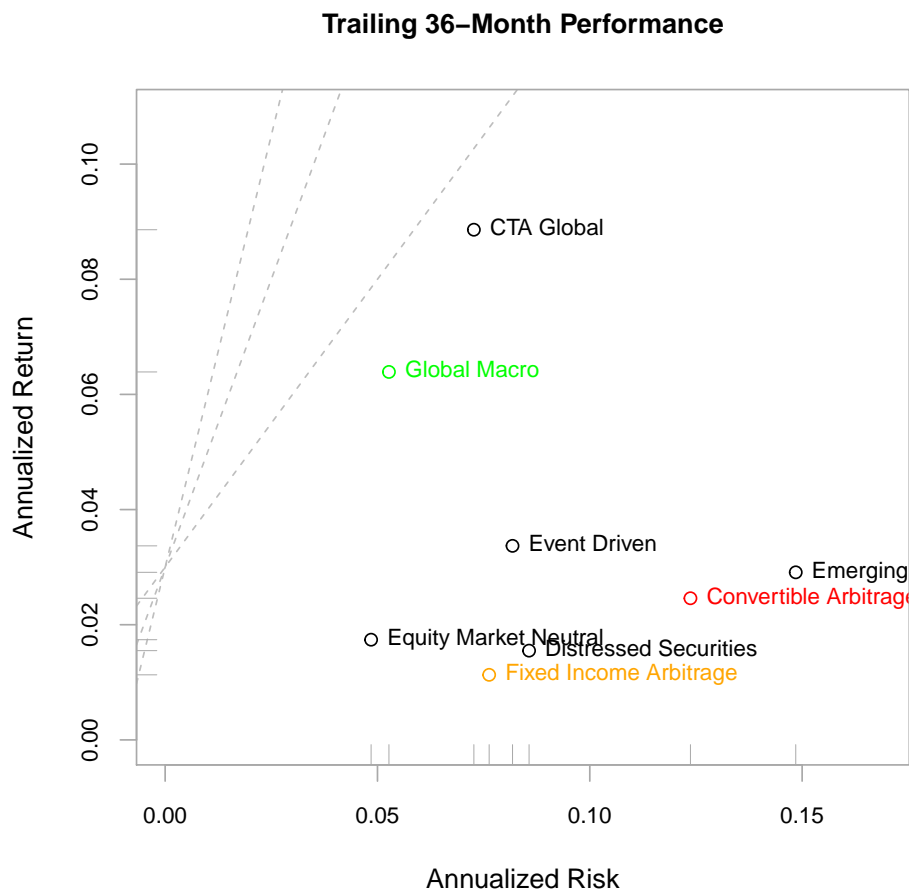
	Convertible Arbitrage	CTA	Global Distressed Securities
Pain Ratio (Rf = 0)	1.434813	2.865677	2.57081
	Emerging Markets Equity	Market Neutral	Event Driven

Pain Ratio ($R_f = 0$)	0.8307953	7.883636	3.202458
	Fixed Income Arbitrage	Global Macro	Long/Short Equity
Pain Ratio ($R_f = 0$)	1.845438	8.17227	2.490376
	Merger Arbitrage	Relative Value	Short Selling
Pain Ratio ($R_f = 0$)	8.821538	4.499503	0.06819378
	Funds of Funds		
Pain Ratio ($R_f = 0$)	2.22417		

8 Performance Analysis Charts

8.1 Show relative return and risk

Returns and risk may be annualized as a way to simplify comparison over longer time periods. Although it requires a bit of estimating, such aggregation is popular because it offers a reference point for easy comparison



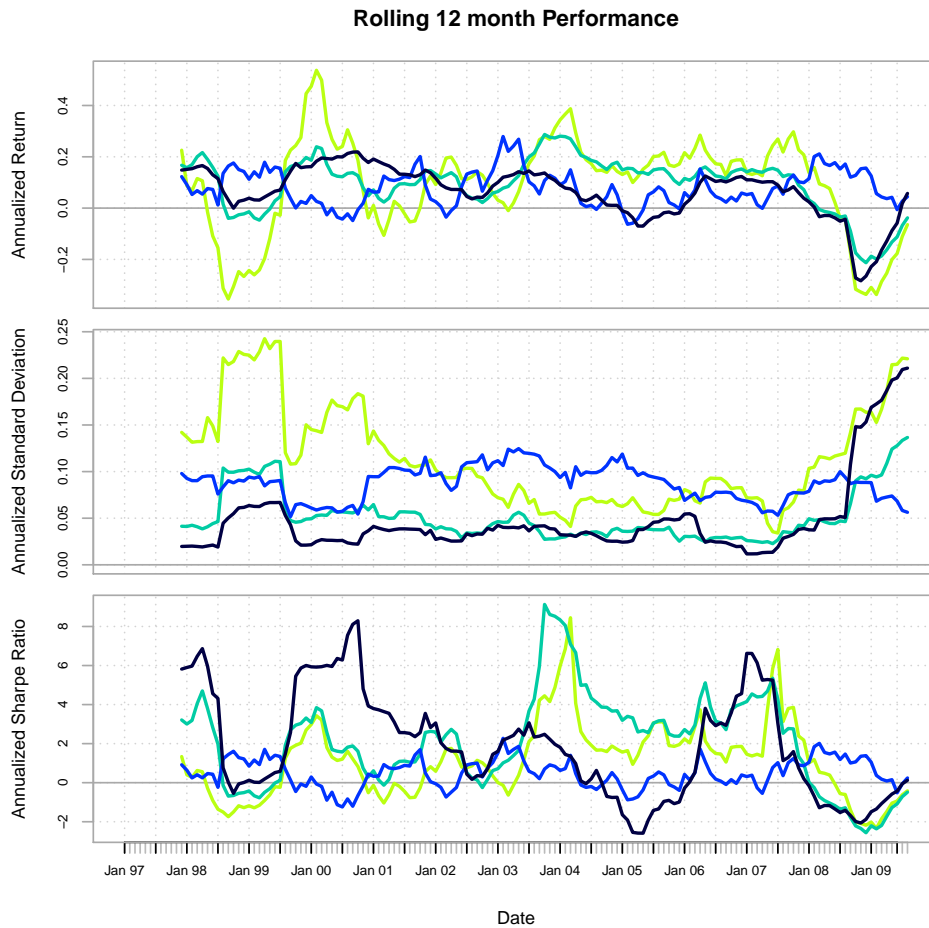
As we can see that, for a given amount of risk, all the funds deliver a positive return. The funds, standing out from the cluster, are the ones which have **lowest autocorrelation**, among the whole group. Also, given their stability, when we unsmooth the returns, it is expectedly seen, that they remain **unaffected**, by the change in model, while the rest of the funds, display a negative characteristic.



8.2 Examine Performance Consistency

Rolling performance is typically used as a way to assess stability of a return stream. Although perhaps it doesn't get much credence in the financial literature because of its roots in digital signal processing, many practitioners use rolling performance to be a useful way to examine and segment performance and risk periods.

```
> charts.RollingPerformance(edhec[,1:4], Rf=.03/12, colorset = rich6equal, lwd = 2)
```



We can observe that **CTA Global** has once again, outperformed it's peer in the 3 charts respectively as well in the case of Okunev Return Model although a steep fall is evident in the end time period for returns and subsequent rise in volatility.

```
> charts.RollingPerformance(Return.Okunev(edhec[,1:4]), Rf=.03/12, colorset = rich)
```

Rolling 12 month Performance

