

Measuring hedge fund risks

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Abstract

This research paper shows that volatility is an incomplete measure of hedge fund risks, so that the Sharpe ratio is not a reliable index of risk-adjusted performance. One uses a dataset of monthly hedge fund index returns provided by TASS to investigate risk and performance. I demonstrate that hedge funds are highly attractive according to the mean-variance approach. However, they lose most of their attraction when skewness and kurtosis are taken into account. Shapiro-Wilk and Jarque-Bera tests of the normality of hedge fund returns reject the hypothesis of normality for all the hedge fund categories except equity market neutral and managed futures. Consequently sharpe ratios are over estimated. I also find that equity market neutral is the best strategy in term of returns, standard deviation, sharpe ratio, skewness and kurtosis.

JEL Classification: G11, G12, G23

Keywords: hedge fund, volatility, sharpe ratio, skewness, kurtosis, sortino ratio

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INTRODUCTION

Since the 1990's, we have observed a substantial growth of hedge funds. According to HFR, in 2006 assets under management accounted for \$1,4 trillion and 10, 500 hedge funds existed. The European hedge fund industry has enjoyed an important development. Assets under management ranged from \$1 trillion in 1995 to \$75 trillion in 2002 (Capocci, 2003). Since 2000, investors have been looking for new investments. They are particularly interested in alternative investments. According to bank of New York and Quirk&Associates LLC, in 2006, investors demand for hedge funds was \$300 trillions against \$60 trillions in 2004.

This craze for hedge fund industry and the absence of regulation emphasize the importance of understanding hedge fund underlying risks. Volatility and Sharpe ratio are the main risk measure and risk-adjusted performance measure used. But, these indicators are not adapted to hedge funds. However they are widely used. ING Private Banking gives to its potential clients commercial pieces of information whereby risk is identified to volatility.

Whereas newspapers inform about hedge funds only when some of them have registered extreme losses, presentations made to investors do not give any information of that kind of risk. According to an Edhec survey (2003), 84% of the 61 multi-managers interviewed confuse risk and volatility.

The literature about hedge fund returns analysis concludes that the mean-variance approach is not adequate to investigate hedge funds risk and performance.

Fung et Hsieh (1997), Brook and Kat (2001) or Amenc, Curtis and Martellini (2003) demonstrated that the monthly returns distribution of hedge fund strategies present negative skewness and excess kurtosis.

Thus, according to Kat (2003), volatility underestimates hedge fund risks. Indeed, volatility does not give any information about asymmetric distribution of returns and extreme losses.

But, as noticed by Scott and Horvath (1980), investors are interested in higher moments of the distribution function. Their satisfaction increases with uneven moments (mean and skewness) and decreases with even moments (standard deviation and kurtosis).

Consequently, as noticed in Kat and Menexe (2002), the hedge fund returns distribution disqualifies the use of sharpe ratio as a risk-adjusted performance measure, because it overestimates hedge funds performance.

This paper shows that volatility is not a thorough measure of hedge fund risk, which makes the Sharpe ratio an inadequate gauge of performance. By the present investigation, those findings concerning hedge fund returns analysis are confused.

Firstly, I present hedge funds data, then I make a comparison between hedge fund returns and market indexes performance. Secondly, I study the normal distribution function to see whether or not hedge fund returns follow it. Finally, I focus on an alternative risk measure and risk-adjusted performance indicator.

1. HEDGE FUNDS DATA

Because of their private nature, hedge funds do not have to disclose their results. Fortunately, some hedge funds accept to provide some information, but not all of them. Consequently, hedge funds databases do not represent the whole universe of hedge funds, they are not thorough. Thus, hedge funds databases are biased. Different sorts of bias have been detected.

Self-reporting bias means that databases are incomplete. As a matter of fact, funds that have enough assets under management do not need to attract further investors. Thus, they are not willing to disclose their results.

Database selection bias exists because databases have their own hedge funds selection criterion. According to Lhabitant (2006), only 3% of funds are reported jointly in Hedge Fund Research (HFR), Morgan Stanley Capital Indices (MSCI), TASS and CISDM (formerly Managed Account Report) databases.

Survivorship bias exists because databases incorporate only existing funds in their indexes calculation. Defunct funds are not taken into account. Subsequently, hedge fund indexes returns are overestimated. Fung and Hsieh (2002) assessed the survivorship bias to 3% for TASS database from 1994 to 1998.

Heterogeneous approaches of data providers generate different hedge fund performance results.

To perform the empirical analysis, we use the 10 CSFB/Tremont monthly performance sub-indexes split by an investment styles and an aggregate index which encompasses all hedge fund strategies and spans the period January 1994 - December 2006.

The CSFB/Tremont indexes are based on the TASS database that tracks 2,600 funds. Then, CSFB/Tremont uses data reported by 650 funds to calculate the 10 indexes. The CSFB/Tremont indexes are asset-weighted indexes and measure the net of fee returns.

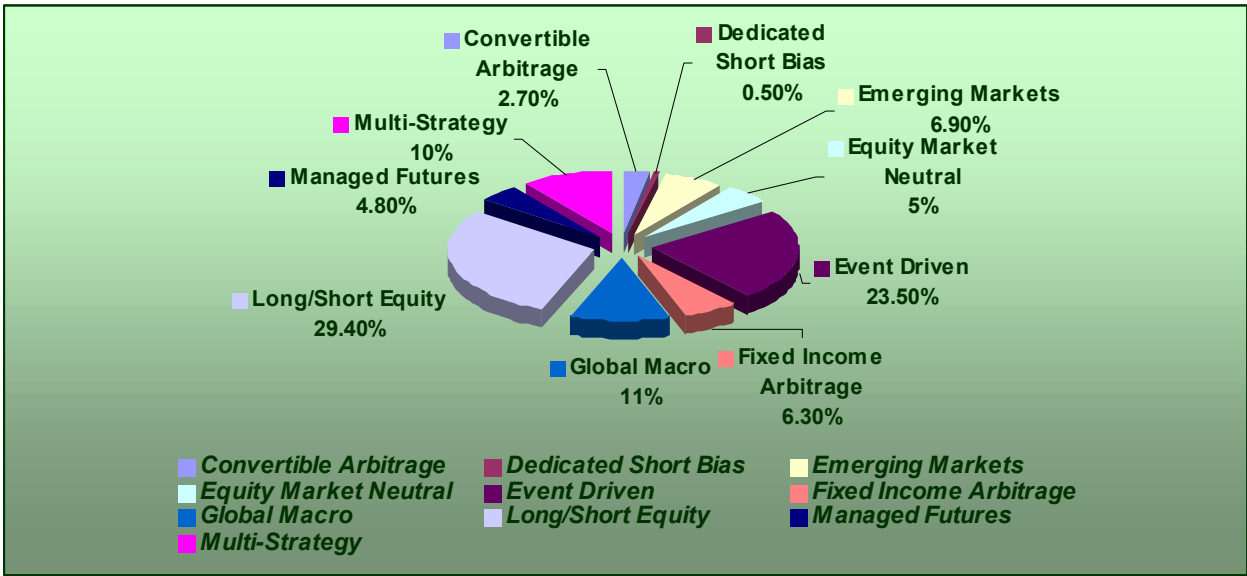
There are three strict rules for fund selection.

1. Funds must have a minimum of \$10 million of assets under management (« AUM »)
2. Funds must have a minimum one-year track record
3. Funds must have a current audited financial statement

The 10 CSFB/Tremont indexes are based on 10 different investment styles:

1. Convertible arbitrage
2. Dedicated Short Bias
3. Emerging Markets
4. Equity Market Neutral
5. Event driven
6. Fixed Income Arbitrage
7. Global Macro
8. Long/Short Equity
9. Managed Futures
10. Multi-Strategy

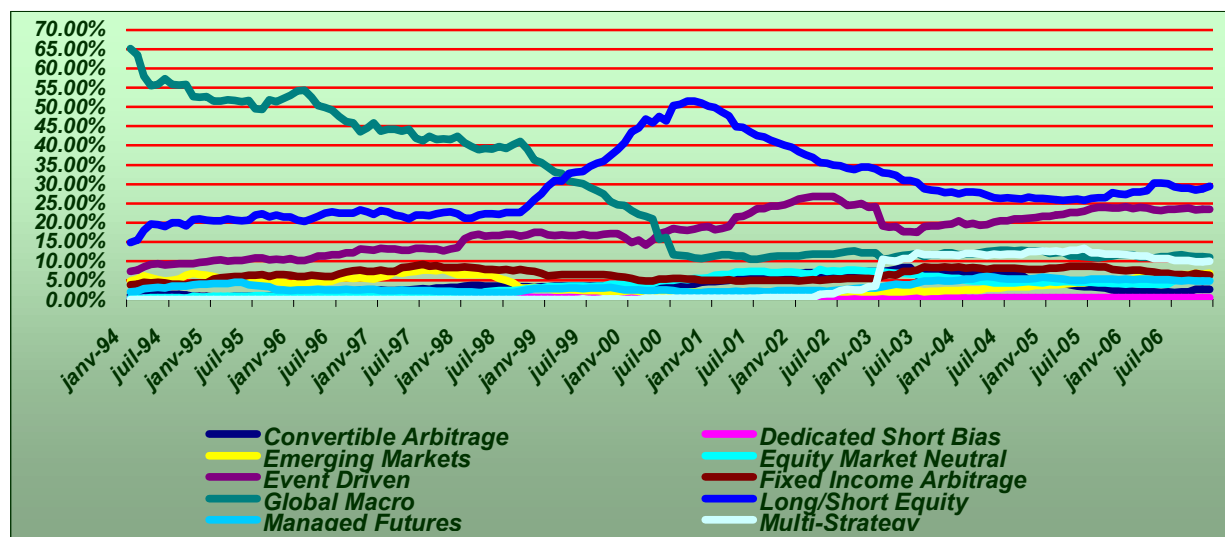
The first chart below reports the number of funds in each category. It is apparent that the representation of hedge fund style is concentrated among long short equity (29%) and event driven (23%). Dedicated short bias style is adopted by only 0.5% of hedge funds.



Source: CSFB/Tremont (december 2006)

The second chart below depicts the 1994 trend towards global macro. Indeed, 65% of hedge funds were global macro funds against 11% today.

Conversely, long/short and event driven strategies have risen to prominence. In 2006, 29% of hedge funds are long short funds and 23% event driven funds.



Source : CSFB/Tremont

2. MARKET INDEXES DATA

I use 7 market indexes spanning the period January 1994 – December 2006 from bloomberg database.

To portray the American Stock Market, I pick up the Dow Jones, the Russel 2000, the S&P 500, the Nasdaq and for the European one the Dow Jones euro stoxx 50.

To describe the American bond market indexes, I choose the Lehman Bond Composite US Index and to represent the European bond market the JP Morgan EMU Bond Index.

3. HEDGE FUND STRATEGIES DESCRIPTION

Neither a legal definition of hedge fund strategies nor an official classification do exist. According to Lhabitant (2006), there are 24 hedge fund indexes providers and these 24 data providers have their own classification, their own definition. For instance, HFR database computes 33 indexes whereas VAN Hedge Fund Advisors database calculates 15 indexes.

We use the CSFB/Tremont hedge fund indexes. The description of hedge fund strategies are directly taken from TASS documentaion.

- ***Convertible arbitrage***

This strategy is identified by hedge investing in the convertible securities of a company. A typical investment is long in the convertible bond and short in the common stock of the same company. Positions are designed to generate profits from the fixed income security as well as the short sale of stock, while protecting the principal from unexpected market gyrations.

- ***Dedicated short bias***

The purpose of the strategy is to maintain a net short as opposed to a pure short exposure. Short biased managers take short positions in mostly equities and derivatives. The short bias of a manager's portfolio must be constantly greater than zero to be classified in this category

- ***Emerging market***

This strategy involves equity or fixed income investing in emerging markets around the world. Because many emerging markets do not allow short selling, nor offer viable futures or other derivative products with which to hedge, emerging market investing often employs a long-only strategy.

- ***Equity market neutral***

This investment strategy is designed to exploit equity market inefficiencies and usually involves being simultaneously long and short matched equity portfolios of the same size within a country. Market neutral portfolios are designed to be either beta or currency neutral, or both. Well-designed portfolios typically control for industry, sector, market capitalization, and other exposures. Leverage is often applied to enhance returns.

- ***Event driven***

This strategy is defined as ‘special situations’ investing designed to capture price movements generated by a significant pending corporate event such as a merger, corporate restructuring, liquidation, bankruptcy or reorganization. There are three popular sub-categories in event-driven strategies: risk (merger) arbitrage, distressed/high yield securities, and Regulation D.

- ***Fixed Income arbitrage***

The fixed income arbitrageur aims to profit from price anomalies between related interest rate securities. Most managers trade globally with a goal of generating steady returns with low volatility. This category includes interest rate swap arbitrage, U.S. and non-U.S. government

bond arbitrage, forward yield curve arbitrage, and mortgage-backed securities arbitrage. The mortgage-backed market is primarily U.S.-based, over-the-counter and particularly complex.

- ***Global Macro***

Global macro managers carry long and short positions in any of the world's major capital or derivative markets. Their positions mirror their views on overall market direction as influenced by major economic trends and/or events. The portfolios of these funds can include stocks, bonds, currencies, and commodities in the form of cash or derivatives instruments. Most funds invest globally in both developed and emerging markets.

- ***Long/Short equity***

This directional strategy involves equity-oriented investing on both the long and short sides of the market. The objective is not to be market neutral. Managers have the ability to shift from value to growth, from small to medium to large capitalization stocks, and from a net long position to a net short position. Managers may use futures and options to hedge. The focus may be regional, such as long/short U.S. or European equity, or sector specific, such as long and short technology or healthcare stocks. Long/short equity funds tend to build and hold portfolios that are substantially more concentrated than those of traditional stock funds.

- ***Managed Futures***

This strategy invests in listed financial and commodity futures markets and currency markets around the world. The managers are usually referred to as Commodity Trading Advisors, or CTAs. Trading disciplines are generally systematic or discretionary. Systematic traders tend to use price and market specific information (often technical) to make trading decisions, while discretionary managers use a judgmental approach.

- ***Multi strategy***

The funds in this category are characterized by their ability to dynamically allocate capital among strategies falling within several traditional hedge fund disciplines. The use of many strategies, and the ability to reallocate capital between them in response to market opportunities, means that such funds are not easily assigned to any traditional category. The Multi-Strategy category also includes funds employing unique strategies that do not fall under any of the other descriptions.

4. SUMMARY STATISTICS

According to the mean-variance approach, returns should follow a normal distribution. Thus, the mean and the volatility computed in annualized form, are together a complete summary of the stochastic properties of returns. Therefore the two moments of the normal distribution and the Sharpe ratio that combines them exhibit everything that must be known about the strategies.

Table 1 below contains summary statistics for the monthly returns of the CSFB/Tremont indexes from January 1994 to December 2006.

	Mean*	Standard deviation**	Sharpe ratio***
HF Strategies			
Convertible Arbitrage	9,04%	4,62%	1,09
Dedicated Short Bias	-2,39%	16,97%	-0,38
Emerging Markets	9,25%	16,00%	0,33
Equity Market Neutral	10,01%	2,88%	2,09
Event Driven	11,77%	5,54%	1,40
Fixed Income Arbitrage	6,46%	3,66%	0,67
Global Macro	13,54%	10,75%	0,89
Long/Short Equity	12,09%	10,05%	0,81
Managed Futures	6,50%	11,84%	0,21
Multi-Strategy	9,57%	4,29%	1,30
CSFB global index	10,93%	7,66%	0,91
Stock exchange indexes			
Dow Jones	9,18%	14,60%	0,35
Russel 2000	8,69%	18,56%	0,25
Nasdaq	8,87%	26,10%	0,19
S&P 500	8,66%	14,27%	0,33
DJ EUROSTOXX 50	10,77%	18,93%	0,36
Bond market indexes			
Lehman Bond composite US	4,25%	3,60%	0,35
JP Morgan EMU Bond Index	4,45%	1,70%	0,26
Portfolio diversification			
25% shares + 75% bonds	5,57%	6,61%	0,30
50% shares + 50% bonds	6,79%	10,57%	0,30
75% shares + 25% bonds	8,01%	11,09%	0,26

*Annualized mean

**Annualized standard deviation

***The risk free rate proxy is US Generic Government 3 Months Yield (Bloomberg database)

Returns

Globally it can be noticed that CSFB global index offers higher returns than stocks and bonds. In the same way, hedge fund indexes offer higher mean than those from a simple portfolio diversification of market indexes.

Aggregate hedge fund index has an average mean return of 10.93%, which is slightly higher than Stocks. However hedge funds are much more attractive in term of returns than bonds. Indeed, the latter have an average mean of 4%.

Amongst investment styles, global macro exhibits the highest average mean return with 13.54% followed by long/short equity (12.09%) and event driven (11.77%). Dedicated short bias is the only strategy that presents negative returns with an average mean of -2.39%.

Volatility

Table 1 shows that standard deviations of stock market indexes are much higher than those of hedge funds. Similar conclusion is reached when standard deviations of hedge funds is compared to the volatility of portfolio diversification.

Nasdaq has an average standard deviation of 26.10%, followed by DJ Euro Soxx 50 index (18.93%) and the Russel 2000 (18.56%). Whereas CSFB global index exhibits a weak average standard deviation of 7.66%.

Only dedicated short bias (16.97%) and emerging markets (16.00%) are more volatile than Dow Jones (14.60%) and S&P 500 (14.27%).

The more attractive strategies in term of volatility are equity market neutral (2.88%), fixed income arbitrage (3.66%) and multi-strategy (4.29%).

Sharpe ratio

The Sharpe ratio is a measure of risk-adjusted performance. It is defined as a portfolio returns above the risk free rate adjusted for risk. Risk is estimated by the annualized standard deviation. The higher the ratio the better the performance.

Sharpe ratio formula is : $S_p = (E(R_p) - R_F) / \sigma(R_p)$

$E(R_p)$ = portfolio returns expected

R_F = risk free rate

$\sigma(R_p)$ = portfolio returns standard deviation

The proxy of the risk free rate is the US Generic Government 3 Months Yield.

Table 1 shows that CSFB global index has a Sharpe ratio much higher than those of stocks and bonds. Hedge fund indexes offer a seemingly better performance than those from portfolio diversification.

Indeed, CSFB index exhibits a 0.91 sharpe ratio whereas DJ Euro Stoxx 50 0.36, Dow Jones 0.35 and Lehman Bond composite US 0.35.

Equity market neutral has the highest sharpe ratio with 2.09. Sharpe ratios of event driven and multi-strategy are also attractive with 1.40 and 1.30. Despite the portfolio diversification, hedge fund strategies are more profitable.

These results show why hedge funds are very attractive. As a matter of fact their average mean is higher than those from stocks and bonds, their average standard deviation is lower than stock market indexes, and their Sharpe ratio is better than those from stocks and bonds. Equity market neutral and managed futures are the two more attractive strategies because they offer high returns, low volatilities and subsequently good Sharpe ratios.

On the other hand, global macro is apparently the best strategy in term of average mean return (13.54%). It is quite surprising because the number of funds in global macro is only 11%. But the flattering returns is an illusion due to the survivorship bias.

6. PERFORMANCE DISTRIBUTION OF ALTERNATIVE STRATEGIES

By considering only mean and variance, hedge funds dethrone traditional assets. But normal distribution of hedge funds returns has been assessed.

Do they really follow the normal distribution? If not, higher moments of the normal distribution function must enter the picture. Skewness and kurtosis must be computed. Consequently, volatility becomes an incomplete measure of hedge fund risks.

The skewness of a normal distribution function is equal to 0. It means that the distribution is symmetric. A negative skewness indicates that losses are more likely and a positive skewness that gains are more likely than in a Gaussian. Investors would like funds with high skewness. Normal distribution presents a kurtosis equal to 3. It is a measure of the probability of extreme returns since it indicates the thickness of distribution tails. A kurtosis higher than 3 means that extreme returns (either losses or gains) are more likely than they are with the normal distribution. The tails distribution are fat. Investors are looking for the lowest kurtosis.

In appendix, a glance to the histogram of hedge fund returns provides an intuition about the deviations from normality. It is not easy to see the potential asymmetry but it clearly appears that kurtosis are in excess of a normal distribution. Indeed, most of the strategies have significant distribution extremes. On the opposite side, equity market neutral and managed futures seem to follow the normal distribution.

Appendix B focuses on the hedge fund indexes quantile-quantile plots. When scatter plots are along the bisector, the hedge fund indexes follow the normal distribution. Only equity market neutral and managed futures follow the normal distribution.

Previously, it was demonstrated that hedge fund indexes were less risky than Stocks and Bonds. Let's see if the conclusion is similar when we take into account skewness and kurtosis.

	Skewness	Probability	V1	Kurtosis	Probability	V2
HF Strategies						
Convertible Arbitrage	-1.37	0.000	7.01	6.39	0.000	8.64
Dedicated Short Bias	0.84	0.000	4.30	5.15	0.000	5.48
Emerging Markets	-0.70	0.000	3.57	7.9	0.000	12.49
Equity Market Neutral	0.33	0.092	1.70	3.43	0.286	1.10
Event Driven	-3.45	0.000	17.61	28.06	0.000	63.89
Fixed Income						
Arbitrage	-3.11	0.000	15.86	20.07	0.000	43.52
Global Macro	0.04	0.860	0.18	6.13	0.000	7.98
Long/Short Equity	0.21	0.292	1.07	7.03	0.000	10.27
Managed Futures	0.03	0.879	0.15	3.4	0.314	1.02
Multi-Strategy	-1.21	0.000	6.17	6.4	0.000	8.67

Skewness

The two hypothesis of the skewness test are:

H0 : returns distribution is symmetric

H1 : returns distribution is asymmetric

Skewness is computed as :

$$S = [N^{-1} \sum_{i=1, T} (Y_i - \bar{Y})^3]^2 / [N^{-1} \sum_{i=1, T} (Y_i - \bar{Y})^2]^3 \text{ follow } N(0, \sqrt{(6/n)})$$

I calculate skewness test : $v1 = S-0 / \sqrt{(6/n)}$ follow $N(0, 1)$

S = skewness coefficient value

n = number of observations

Two decision rules can be considered. Firstly, if v_1 is higher than 1.96 (theoretical value read in normal law table) at the significant value of 5%, we accept H_1 . Returns distribution is asymmetric. Secondly, if skewness probability is lower than 5%, we accept H_1 . I conclude that skewness coefficient is significantly different from 0.

The results show that only equity market neutral, global macro, long/short equity and managed futures are symmetric at the significant value of 5%. On the other hand, it can be stressed that **event driven and fixed income arbitrage present the highest negative skewness values with -3.45 and -3.11 which denote a high probability of negative returns.**

Kurtosis

The two hypothesis of the kurtosis test are:

H_0 : returns distribution is normal

H_1 : returns distribution is leptokurtic

Kurtosis is computed as :

$$K = \frac{N^{-1} \sum_{i=1, T} (Y_i - \bar{Y}_i)^4}{[N^{-1} \sum_{i=1, T} (Y_i - \bar{Y}_i)^2]^2} \text{ follow } N(3, \sqrt{(24/n)})$$

I calculate kurtosis test : $v_2 = \frac{K-3}{\sqrt{(24/n)}}$ follow $N(0, 1)$

K = kurtosis coefficient value

n = number of observations

Two decision rules can be exposed. First, if v_2 is higher than 1.96 (theoretical value read in normal law table) at the significant value of 5%, H_1 is accepted. Second, if kurtosis probability is lower than 5%, H_1 is accepted. Consequently, the returns distribution is leptokurtic.

The results show that only equity market neutral and managed futures statistics are higher than 1.96 at the significant value of 5%. Kurtosis probabilities of equity market neutral and managed futures are lower than 5%. Their returns distribution are normal.

On the other hand, **event driven and fixed income arbitrage present the highest kurtosis values with 28.06 and 20.07 which denote a high probability of extreme losses.**

According to these results, only equity market neutral and managed futures returns follow the normal distribution. To support these conclusions, I consider the Shapiro Wilk and Jarque Bera normality tests.

	Shapiro Wilk test			Jarque Bera test		
	Statistic	Probability	Normality	Statistic	Probability	Normality
HF strategies						
Convertible Arbitrage	0.902	1.03E-08	no	123.9	0.00000000	no
Dedicated Short Bias	0.9567	8.80E-05	no	48.42	0.00000000	no
Emerging Markets	0.9356	1.65E-06	no	168.83	0.00000000	no
Equity Market Neutral	0.9854	0.1009	yes	4.08	0.13009256	yes
Event Driven	0.7783	4.33E-14	no	4393.38	0.00000000	no
Fixed Income Arbitrage	0.7707	2.42E-14	no	2146.11	0.00000000	no
Global Macro	0.9279	4.60E-07	no	63.8	0.00000000	no
Long/Short Equity	0.9448	8.50E-06	no	106.64	0.00000000	no
Managed Futures	0.9922	0.5589	yes	1.08	0.58199417	yes
Multi-Strategy	0.9288	6.62E-07	no	111.12	0.00000000	no

Shapiro-Wilk

The two hypothesis of the shapiro-wilk test are:

H0 : returns distribution is normal

H1 : returns distribution is not normal

I calculate the shapiro-wilk statistic :

$$W = \frac{b^2}{SCE} \text{ follow } W_{1-\alpha}$$

$$b = \sum a_i d_i$$

a_i = coefficients given in a table according to n and i values

$$d_1 = x_n - x_1$$

$$d_2 = x_{n-1} - x_2$$

$$d_3 = x_{n-2} - x_3$$

$$\dots$$

$$SCE = \sum (X_i - \bar{X})^2$$

n = number of observations

If W is higher than W^* (theoretical value read in shapiro-wilk table) at the significant value of 5% (0.947), H0 is accepted. Returns distribution is normal.

The results show that only equity market neutral and managed futures statistics are higher than 0.947 at the significant value of 5%.

Jarcque-Bera

This test summarizes skewness and kurtosis tests.

The two hypothesis of the jarcque-bera test are:

H0 : returns distribution is normal

H1 : returns distribution is not normal

We calculate jarcque-bera statistic : $s = (n/6)*S^2 + (n/24)*(K-3)^2$ suit $\chi^2_{1-\alpha}(2)$

S = skewness coefficient value

K = kurtosis coefficient value

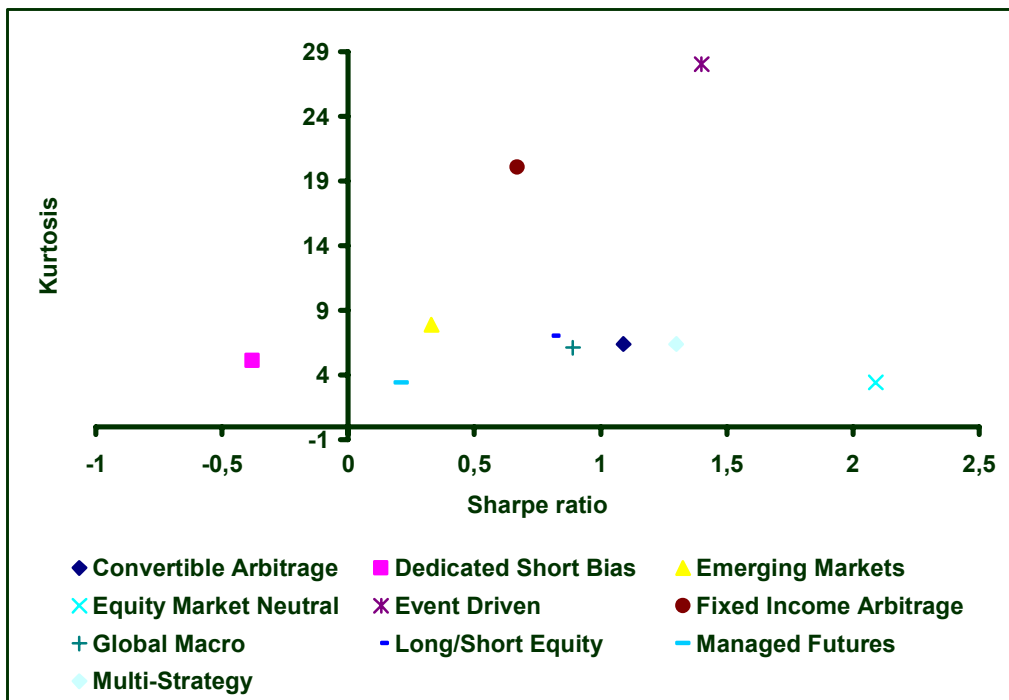
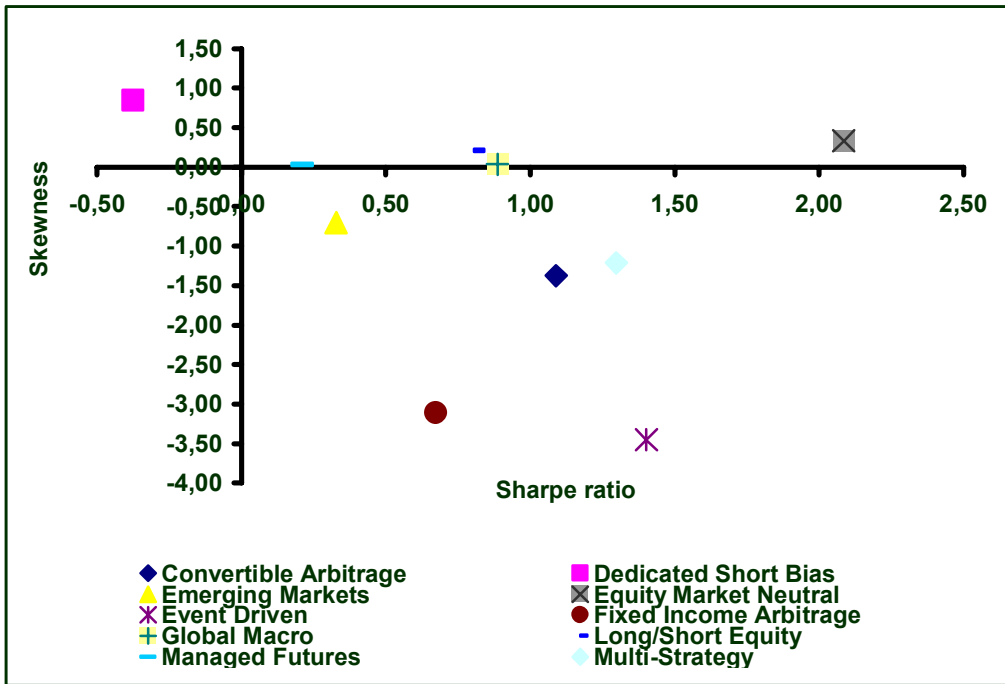
n = number of observations

If s is higher than theoretical value read in chi-deux table with 2 degrees of freedom at the significant value of 5% (5.99), H1 is accepted. Returns distribution is normal.

The results show that only equity market neutral and managed futures statistics are lower than 5.99 at the significant value of 5%.

These results support the conclusions of the shapiro-wilk test, skewness and kurtosis tests and hedge funds histograms and quantile-quantile plots.

On the other hand one can assesses the price of a good Sharpe ratio in term of skewness and kurtosis. Indeed, if one pays attention to the 2 following charts, one will see that event driven and fixed income arbitrage have a good Sharpe ratio (1.40 and 0.67) but skewness coefficients are highly negative (-3.45 and -3.11) and kurtosis coefficients are highly in excess (28.06 and 20.07). Consequently, for most of the strategies, a good Sharpe ratio is associated to asymmetric and extreme losses risks. Equity market neutral is the only strategy which does not exhibit this pattern..



The evidence shows that gauged by mean-variance approach, hedge fund strategies look very attractive. Indeed, their average means are higher than those from stocks and bonds. Their average standard deviations are lower than those from stock market indexes. And their Sharpe ratios are good.

But because skewness and kurtosis are substantial in the hedge fund returns distribution the performance distribution for hedge fund strategies is far from normally distributed.

Consequently, **volatility is absolutely not relevant to measure hedge fund risks**. Thus, Sharpe ratio overestimates performance.

7. ALTERNATIVE MEASURES : DOWNSIDE RISK AND SORTINO RATIO

A suitable response to volatility is downside risk. While volatility considers negative and positive returns, downside risk concentrates on those below an established threshold. Anything below the threshold rate is unacceptable. This indicator takes into account asymmetric risk.

It is computed as : $DR = 1/ T \sum_{t=0, T} (R_{Pt} - MAR)^2$

$R_{Pt} < MAR$ (minimal accepted return)

By replacing volatility by standard deviation in the Sharpe ratio formula, we obtain the Sortino ratio. It is defined as a portfolio return above threshold performance adjusted for the risk measured by downside risk.

The table below gives the downside risks and Sortino ratios for hedge fund indexes and stock and bond indexes for different MAR values.

	MAR	0%	0.50%	1%	1.50%	2%	2.50%	3%	3.50%	4%	4.50%	5%
HF Strategies												
CSFB global index	DR *	5.45%	5.30%	5.26%	5.29%	5.43%	5.55%	5.77%	6.13%	6.23%	6.23%	6.33%
	Sortino ratio	2.01	1.97	1.89	1.78	1.64	1.52	1.38	1.21	1.11	1.03	0.94
CA	DR *	4.35%	4.35%	4.34%	4.23%	4.28%	4.37%	4.44%	4.57%	4.62%	4.62%	4.62%
	Sortino ratio	2.08	1.96	1.85	1.78	1.65	1.50	1.36	1.21	1.09	1.09	1.09
DSB	DR *	8.62%	8.93%	9.31%	9.79%	9.99%	10.37%	10.92%	11.24%	11.58%	12.12%	12.23%
	Sortino ratio	- 0.23	- 0.28	- 0.32	- 0.36	- 0.40	- 0.43	- 0.46	- 0.49	- 0.52	- 0.54	-0.57
EM	DR *	12.74%	12.75%	12.82%	12.90%	12.96%	13.00%	13.01%	13.04%	13.17%	13.27%	13.41%
	Sortino ratio	0.71	0.67	0.62	0.58	0.54	0.50	0.46	0.42	0.38	0.34	0.30
EMN	DR *	1.27%	1.46%	1.76%	2.09%	2.34%	2.61%	2.67%	2.88%	2.88%	2.88%	2.88%
	Sortino ratio	7.89	6.49	5.12	4.08	3.42	2.87	2.62	2.25	2.25	2.25	2.25
ED	DR *	7.90%	6.50%	5.65%	5.28%	5.20%	5.29%	5.38%	5.47%	5.54%	5.54%	5.54%
	Sortino ratio	1.52	1.77	1.95	1.99	1.92	1.80	1.67	1.55	1.44	1.44	1.44
FIA	DR *	4.74%	4.26%	3.70%	3.58%	3.62%	3.66%	3.66%	3.66%	3.66%	3.66%	3.66%
	Sortino ratio	1.27	1.29	1.35	1.26	1.11	0.96	0.96	0.96	0.96	0.96	0.96
GM	DR *	8.20%	8.10%	7.94%	7.72%	7.71%	7.78%	7.90%	8.10%	8.16%	8.30%	8.42%
	Sortino ratio	1.71	1.67	1.64	1.62	1.56	1.48	1.39	1.30	1.23	1.14	1.07
LSE	DR *	6.71%	6.69%	6.69%	6.76%	6.89%	7.19%	7.27%	7.53%	7.69%	7.85%	8.07%
	Sortino ratio	1.79	1.72	1.64	1.55	1.45	1.32	1.24	1.13	1.04	0.96	0.87
MF	DR *	7.10%	7.24%	7.51%	7.75%	7.88%	8.05%	8.50%	8.86%	9.08%	9.52%	9.75%
	Sortino ratio	0.84	0.76	0.67	0.58	0.51	0.43	0.35	0.28	0.22	0.16	0.10
MS	DR *	4.32%	3.83%	3.63%	3.65%	3.88%	4.05%	4.19%	4.23%	4.29%	4.29%	4.29%
	Sortino ratio	2.32	2.48	2.48	2.33	2.06	1.85	1.67	1.54	1.40	1.40	1.40
Stock market indexes												
S&P 500	DR *	10.07%	10.32%	10.66%	10.88%	11.07%	11.21%	11.31%	11.55%	11.92%	12.11%	12.17%
	Sortino ratio	0.89	0.82	0.75	0.69	0.63	0.58	0.53	0.48	0.42	0.37	0.33
Dow Jones	DR *	10.44%	10.56%	10.76%	10.94%	11.17%	11.24%	11.47%	11.66%	12.04%	12.19%	12.32%
	Sortino ratio	0.86	0.80	0.74	0.69	0.63	0.58	0.52	0.47	0.42	0.37	0.32
Nasdaq	DR *	18.91%	18.85%	18.85%	18.90%	19.01%	19.20%	19.34%	19.60%	19.72%	19.87%	19.99%
	Sortino ratio	0.48	0.45	0.42	0.40	0.37	0.34	0.31	0.28	0.25	0.23	0.20
Russel 2000	DR *	12.67%	12.89%	13.11%	13.28%	13.70%	13.85%	13.98%	14.17%	14.46%	14.81%	15.35%
	Sortino ratio	0.71	0.66	0.61	0.56	0.51	0.47	0.43	0.39	0.35	0.30	0.26
DJ EUROSTOXX 50	DR *	14.01%	14.10%	14.20%	14.47%	14.57%	14.80%	14.95%	15.09%	15.38%	15.49%	15.65%
	Sortino ratio	0.93	0.89	0.85	0.79	0.76	0.71	0.67	0.63	0.59	0.55	0.51
Bond market indexes												
Lehman Bond composite US	DR *	2.57%	2.73%	2.96%	3.12%	3.36%	3.54%	3.60%	3.60%	3.60%	3.60%	3.60%
	Sortino ratio	1.56	1.28	1.01	0.80	0.60	0.42	0.28	0.28	0.28	0.28	0.28
JP Morgan EMU Bond Index	DR *	0.62%	0.93%	1.37%	1.53%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%
	Sortino ratio	6.46	3.76	2.18	1.64	1.18	1.18	1.18	1.18	1.18	1.18	1.18

	MAR	5.50%	6%	6.50%	7%	7.50%	8%	8.50%	9%	9.50%	10%
HF Strategies	DR *	6.56%	6.71%	7.01%	7.38%	7.38%	7.38%	7.38%	7.66%	7.66%	7.66%
CSFB global index	Sortino ratio	0.83	0.74	0.63	0.53	0.47	0.40	0.33	0.25	0.25	0.25
	DR *	4.62%	4.62%	4.62%	4.62%	4.62%	4.62%	4.62%	4.62%	4.62%	4.62%
CA	Sortino ratio	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09
	DR *	12.56%	12.79%	13.31%	13.59%	13.74%	13.91%	14.59%	14.59%	14.59%	15.06%
DSB	Sortino ratio	-0.60	-0.63	-0.64	-0.66	-0.69	-0.72	-0.72	-0.75	-0.79	-0.80
	DR *	13.62%	13.72%	13.92%	14.00%	14.19%	14.40%	14.40%	14.40%	14.73%	14.73%
EM	Sortino ratio	0.26	0.22	0.18	0.14	0.11	0.07	0.03	0.00	-0.03	-0.59
	DR *	2.88%	2.88%	2.88%	2.88%	2.88%	2.88%	2.88%	2.88%	2.88%	2.88%
EMN	Sortino ratio	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
	DR *	5.54%	5.54%	5.54%	5.54%	5.54%	5.54%	5.54%	5.54%	5.54%	5.54%
ED	Sortino ratio	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
	DR *	3.66%	3.66%	3.66%	3.66%	3.66%	3.66%	3.66%	3.66%	3.66%	3.66%
FIA	Sortino ratio	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
	DR *	8.64%	8.84%	8.84%	8.84%	8.84%	8.84%	9.27%	9.27%	9.53%	9.53%
GM	Sortino ratio	0.98	0.91	0.85	0.79	0.74	0.68	0.59	0.54	0.47	0.42
	DR *	8.29%	8.49%	8.60%	8.73%	8.87%	8.87%	9.09%	9.09%	9.09%	9.09%
LSE	Sortino ratio	0.78	0.71	0.64	0.57	0.51	0.45	0.39	0.33	0.28	0.22
	DR *	9.93%	10.31%	10.63%	10.99%	10.99%	11.15%	11.15%	11.35%	11.59%	11.84%
MF	Sortino ratio	0.05	0.00	-0.05	-0.09	-0.14	-0.18	-0.22	-0.26	-0.30	-0.34
	DR *	4.29%	4.29%	4.29%	4.29%	4.29%	4.29%	4.29%	4.29%	4.29%	4.29%
MS	Sortino ratio	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Stock market indexes											
	DR *	12.49%	12.95%	13.22%	13.22%	13.41%	13.74%	13.96%	14.09%	14.09%	14.27%
S&P 500	Sortino ratio	0.28	0.23	0.19	0.15	0.11	0.07	0.04	0.00	-0.04	-0.07
	DR *	12.50%	12.77%	13.00%	13.26%	13.36%	13.48%	13.74%	14.01%	14.01%	14.19%
Dow Jones	Sortino ratio	0.28	0.23	0.19	0.15	0.11	0.07	0.04	0.00	-0.04	-0.07
	DR *	20.10%	20.23%	20.51%	20.82%	21.00%	21.27%	21.55%	21.77%	22.00%	22.00%
Nasdaq	Sortino ratio	0.17	0.15	0.12	0.10	0.07	0.05	0.02	0.00	-0.02	-0.05
	DR *	15.35%	15.67%	16.00%	16.00%	16.29%	16.68%	16.90%	17.45%	17.57%	17.57%
Russel 2000	Sortino ratio	0.23	0.19	0.16	0.12	0.09	0.06	0.03	0.00	-0.03	-0.06
	DR *	15.85%	16.08%	16.18%	16.33%	16.57%	16.74%	17.04%	17.14%	17.14%	17.29%
DJ EUROSTOXX 50	Sortino ratio	0.47	0.44	0.40	0.37	0.33	0.30	0.26	0.23	0.20	0.17
Bond market indexes											
Lehman Bond composite US	DR *	3.60%	3.60%	3.60%	3.60%	3.60%	3.60%	3.60%	3.60%	3.60%	3.60%
	Sortino ratio	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
JP Morgan EMU Bond Index	DR*	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%
	Sortino ratio	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18

* Annualized downside risk

Stock market indexes are more volatile than hedge fund indexes. Emerging markets, event driven, dedicated short bias and long short equity have high downside risk for all MAR level. On the opposite side, equity market neutral has the lowest downside risk.

One can say that globally, Sortino ratios of hedge fund indexes are much higher than those from stock and bond markets. Equity market neutral strategy has the best Sortino ratio, but its

performance decreases as MAR level increases. The ratio goes from 7.9 for MAR equals zero to 2.25 for a MAR level of 4%. Only event driven, fixed income arbitrage and multi-strategy sortino ratios increase until a MAR level of 1.5% (event driven) and 1% (fixed income arbitrage and multi-strategy).

On the other hand, we note that stock market indexes performance is negative for an admittedly high level of 9.5%.

The ranking of hedge fund strategies by MAR level in appendix C shows that equity market neutral has the best Sortino ratio for all MAR levels. Multi-strategy is in second position until a MAR level of 2.5%. Stock market indexes have bad Sortino ratios. Dedicated short bias has the worst Sortino ratio for all levels of MAR.

8. CONCLUSION

The empirical analysis demonstrates that hedge funds dethrone stocks and bonds. Their returns and their volatility are very attractive. Under mean-variance approach, it is better to invest in hedge funds. But, when one goes further by taking into account skewness and kurtosis, ones can notice the presence of asymmetric and extreme losses risks in hedge fund returns. Event driven and fixed income arbitrage are the riskiest strategies because their skewness are highly negative and their kurstois highly in excess. Consequently we cannot use volatility anymore. This indicator does not give any information about those risks and investors need to know the most. More relevant indicators must be used. Similarly the Sharpe ratio is not a reliable risk-adjusted performance measure for hedge funds. It overestimates their performance.

The next step will be to test new relevant indicators that take into account the higher moments such as CVAR, Cornish-fisher ratio or Omega ratio.

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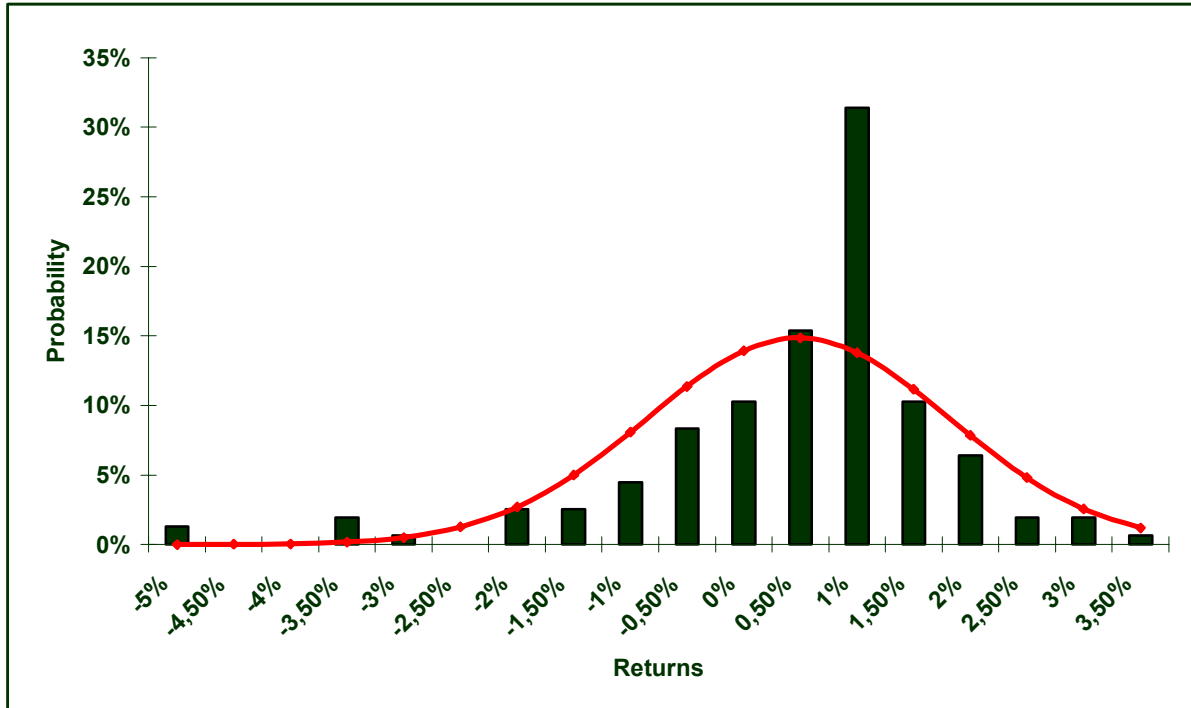
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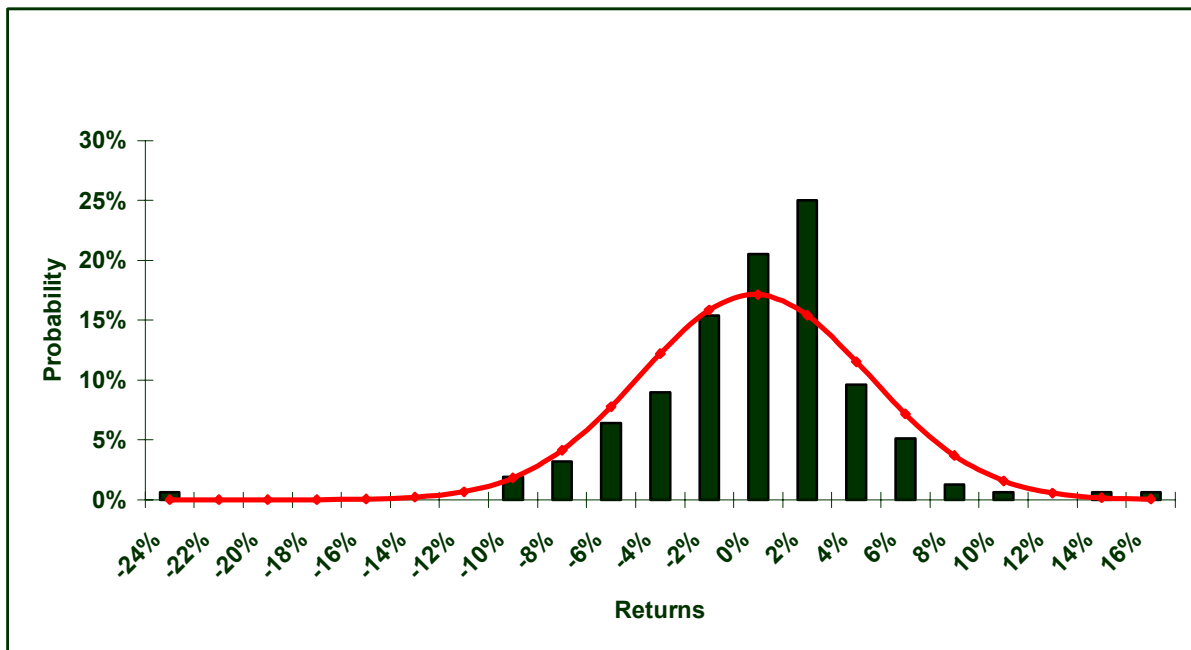
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Appendix A : Monthly returns hedge fund indexes histograms from January 1994 to december 2006

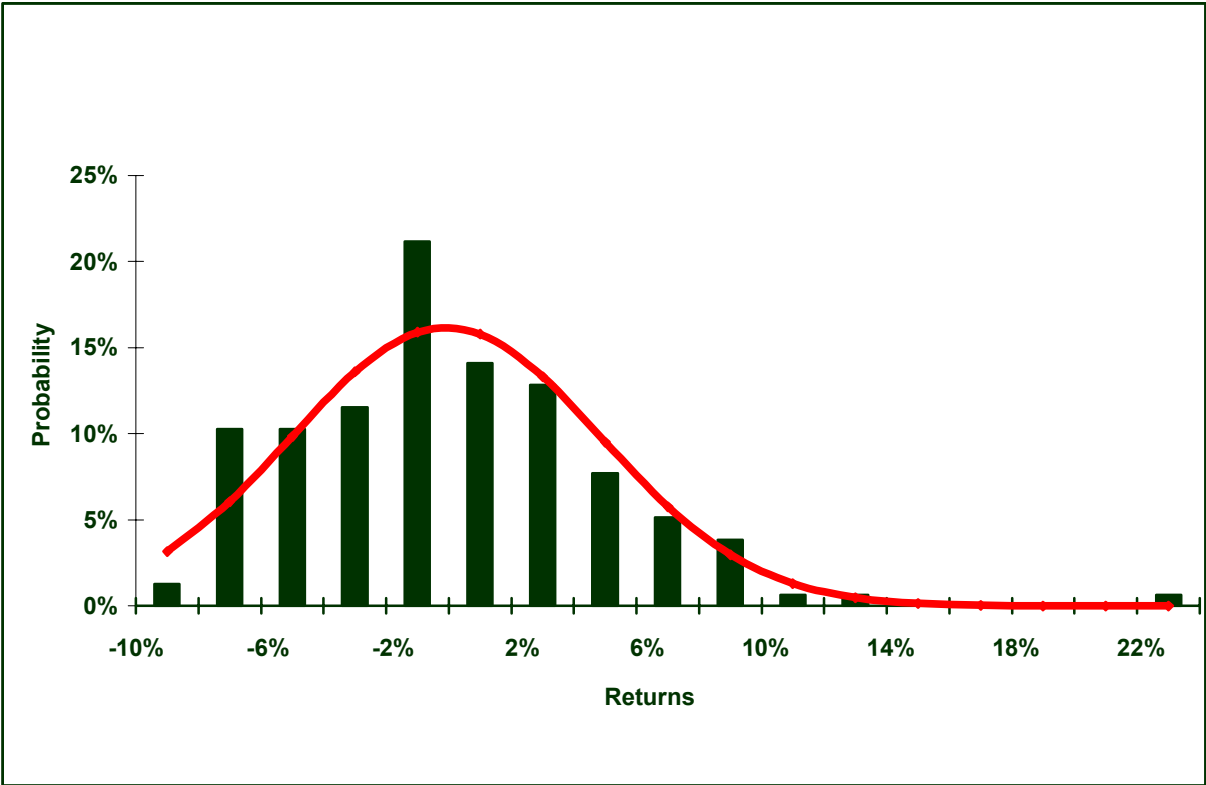
Convertible Arbitrage



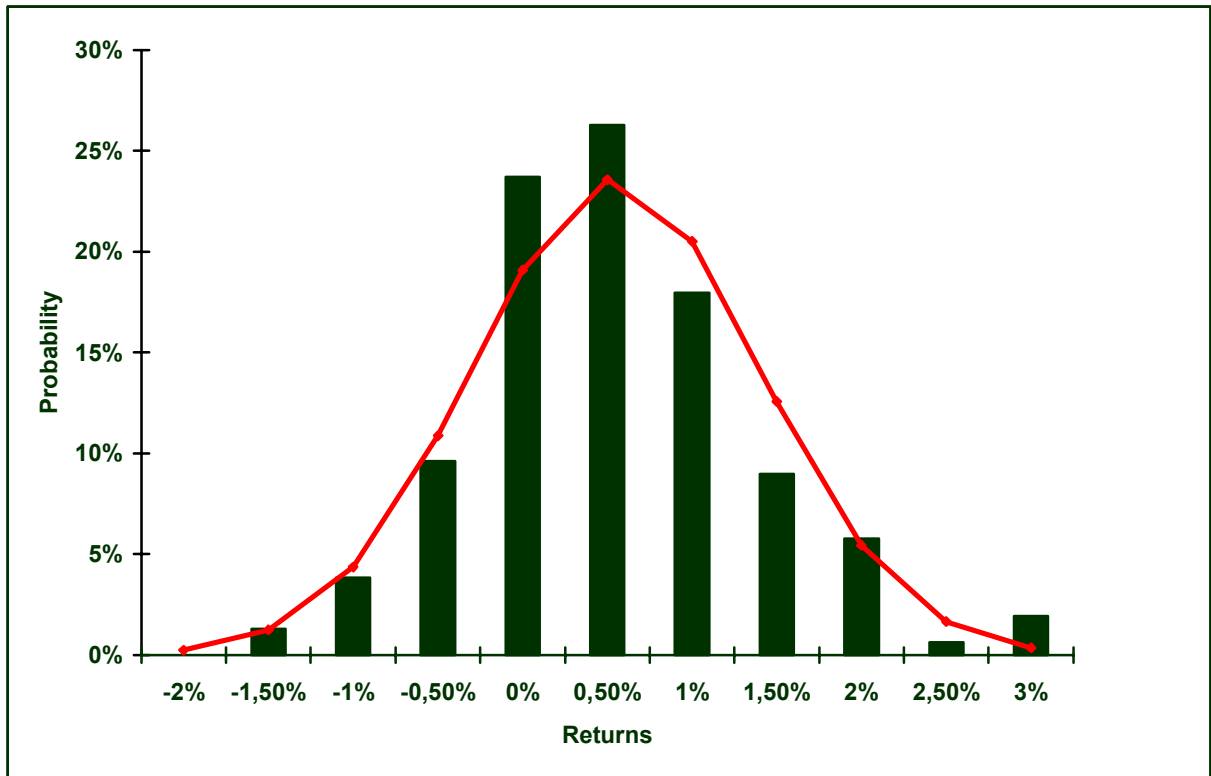
Dedicated Short Bias



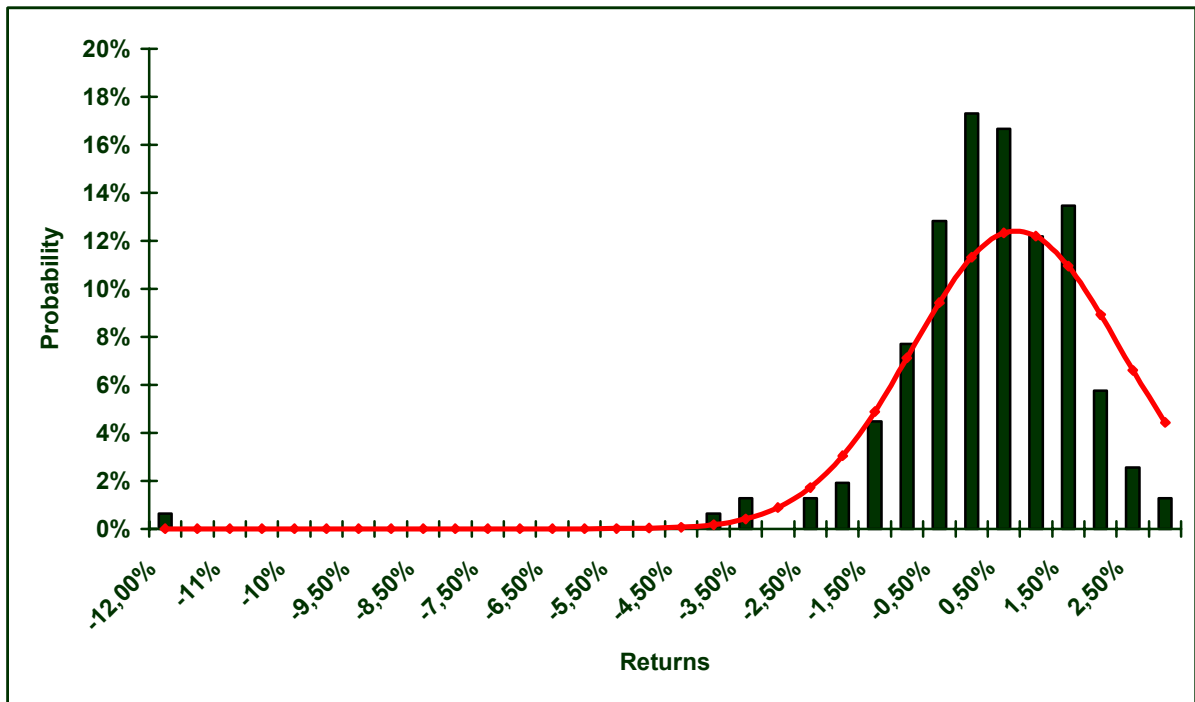
Emerging Markets



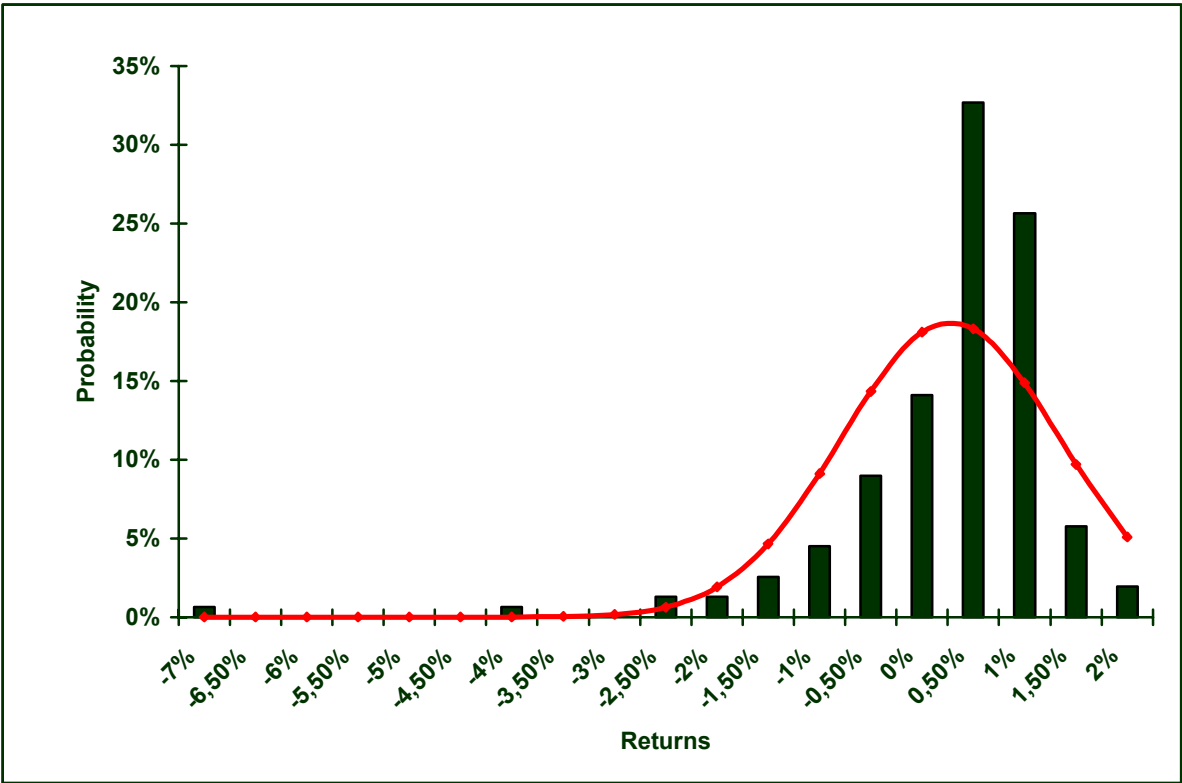
Equity Market Neutral



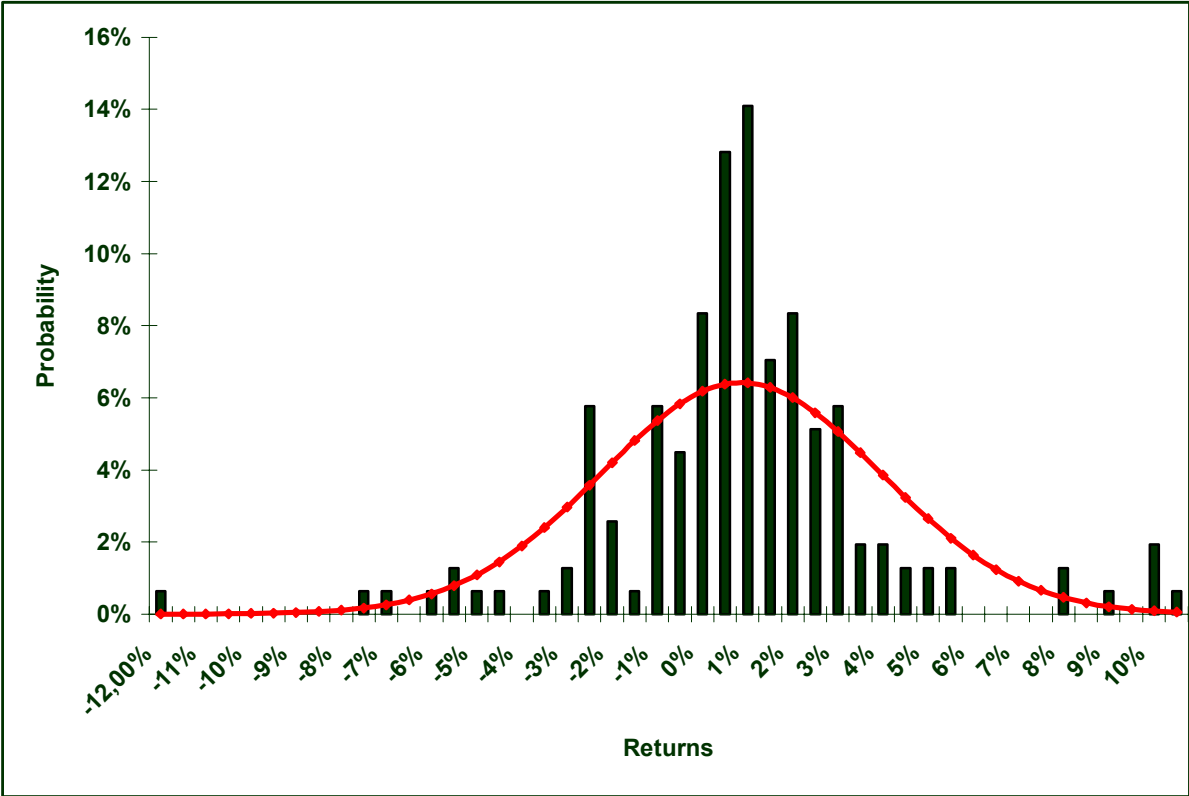
Event Driven



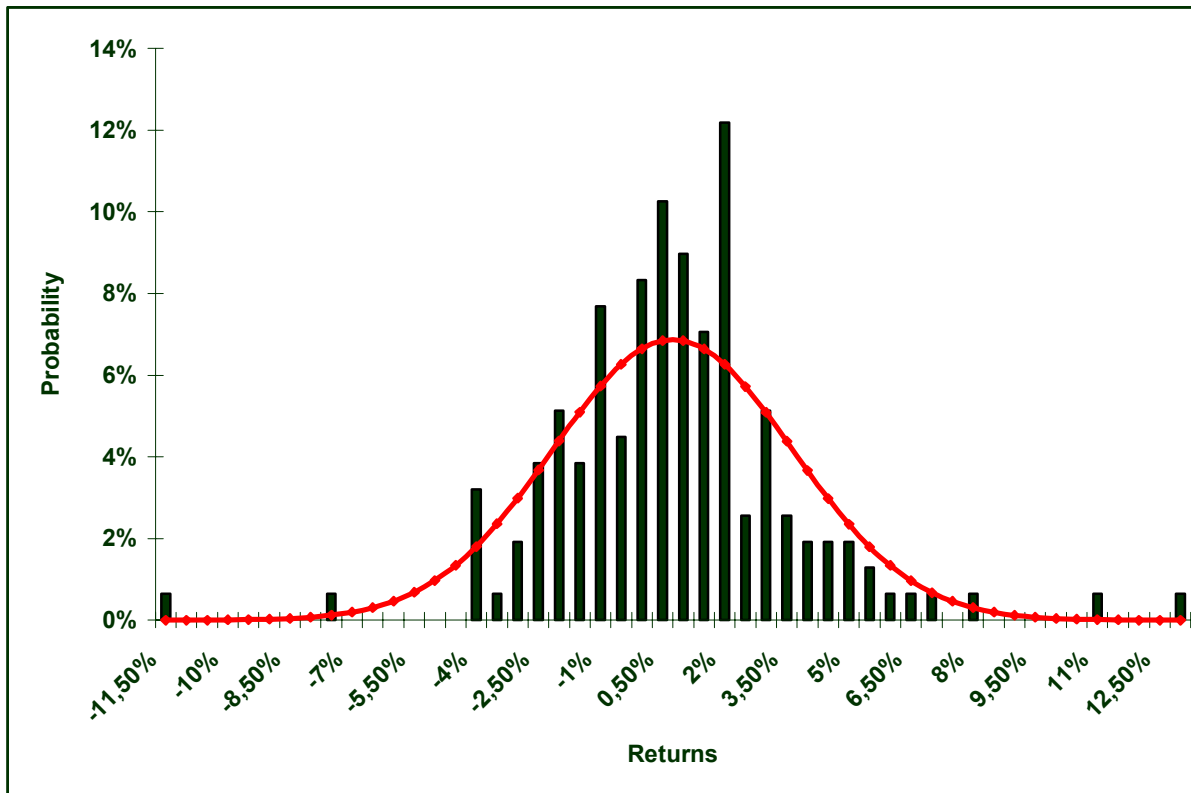
Fixed Income Arbitrage



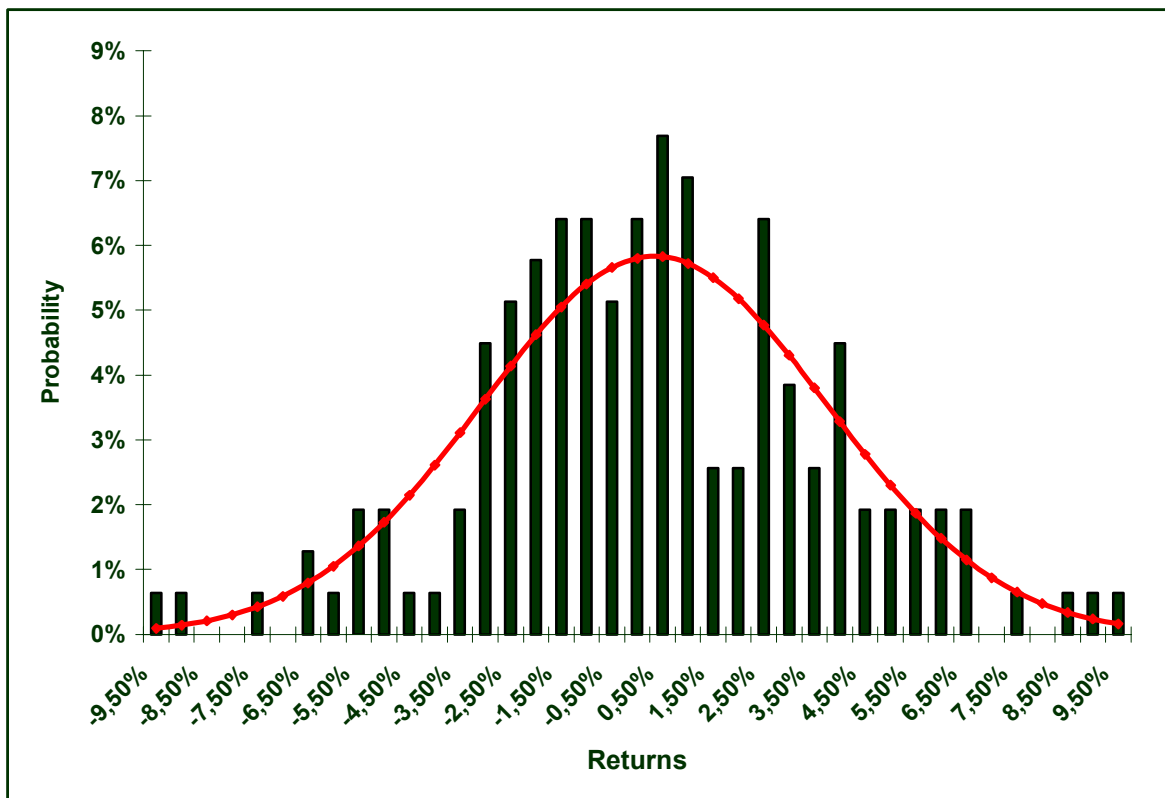
Global Macro



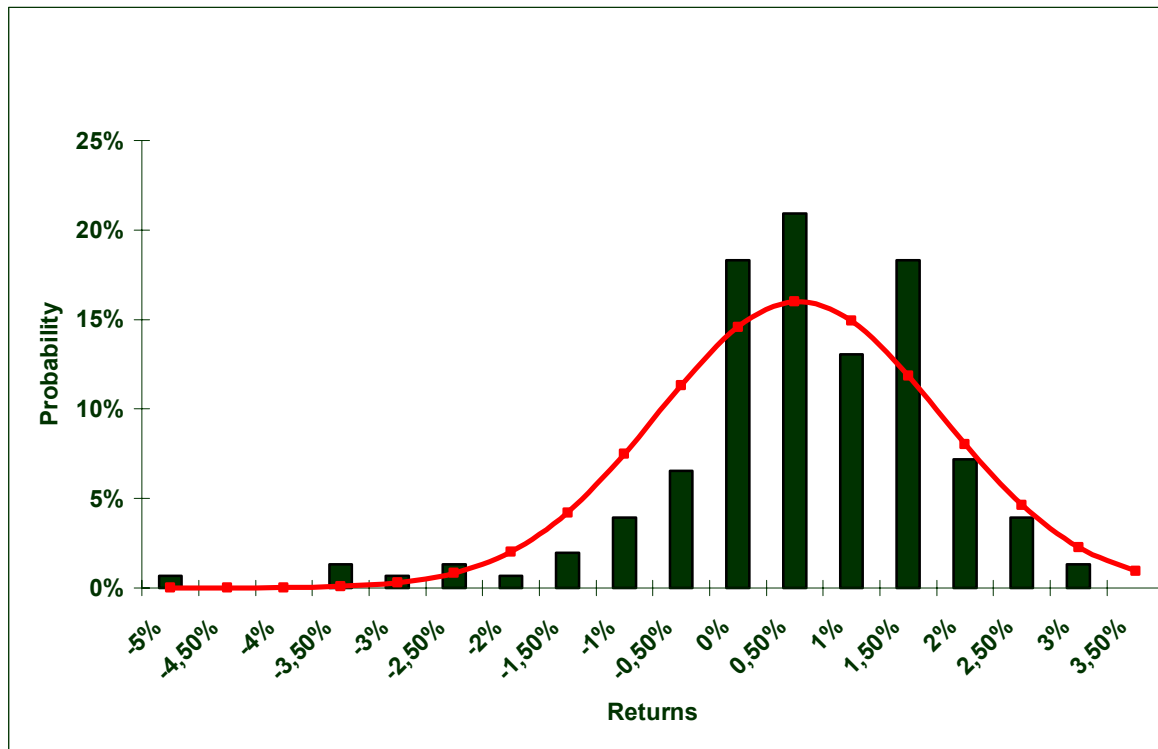
Long Short Equity



Managed futures

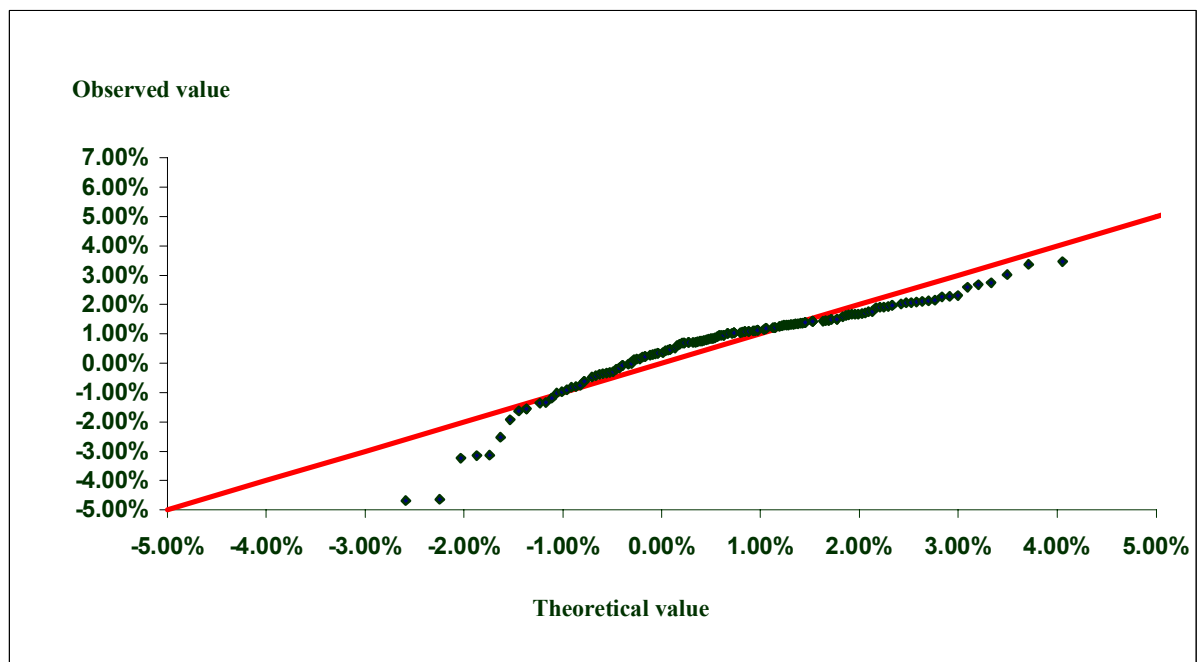


Multi-strategy

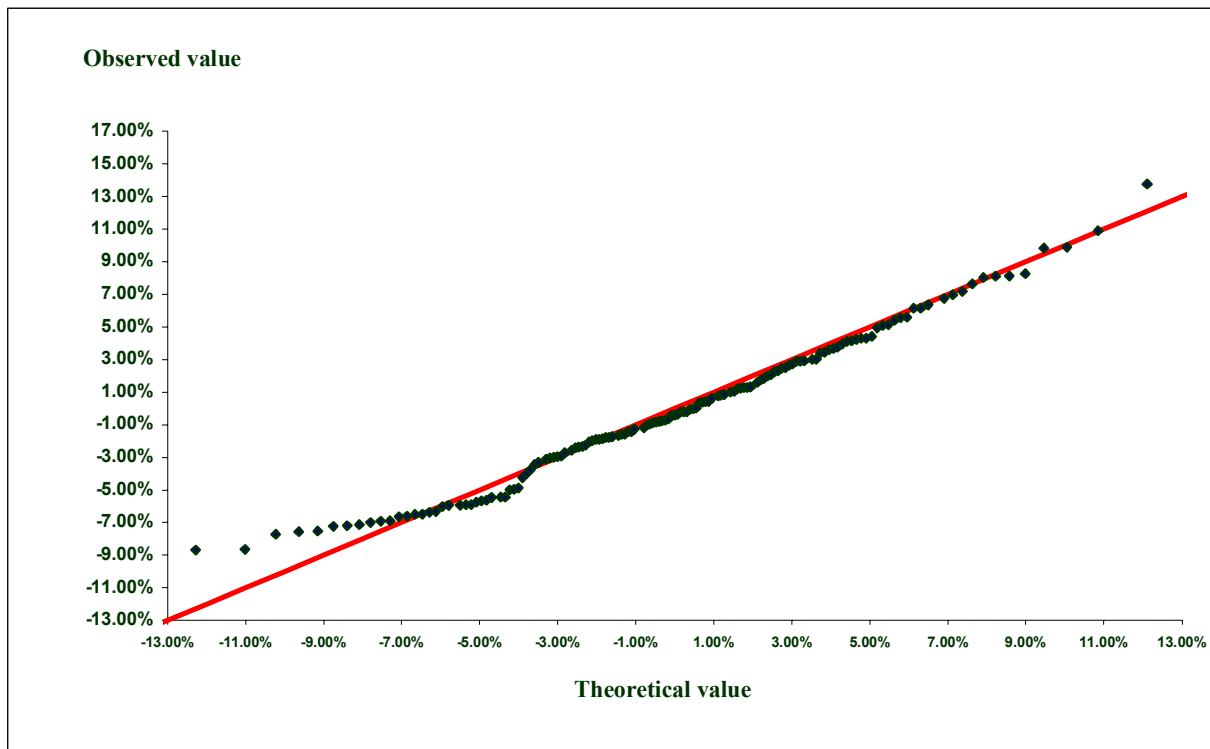


Appendix B : Monthly returns hedge fund indexes quantile-quantile plots from January 1994 to december 2006

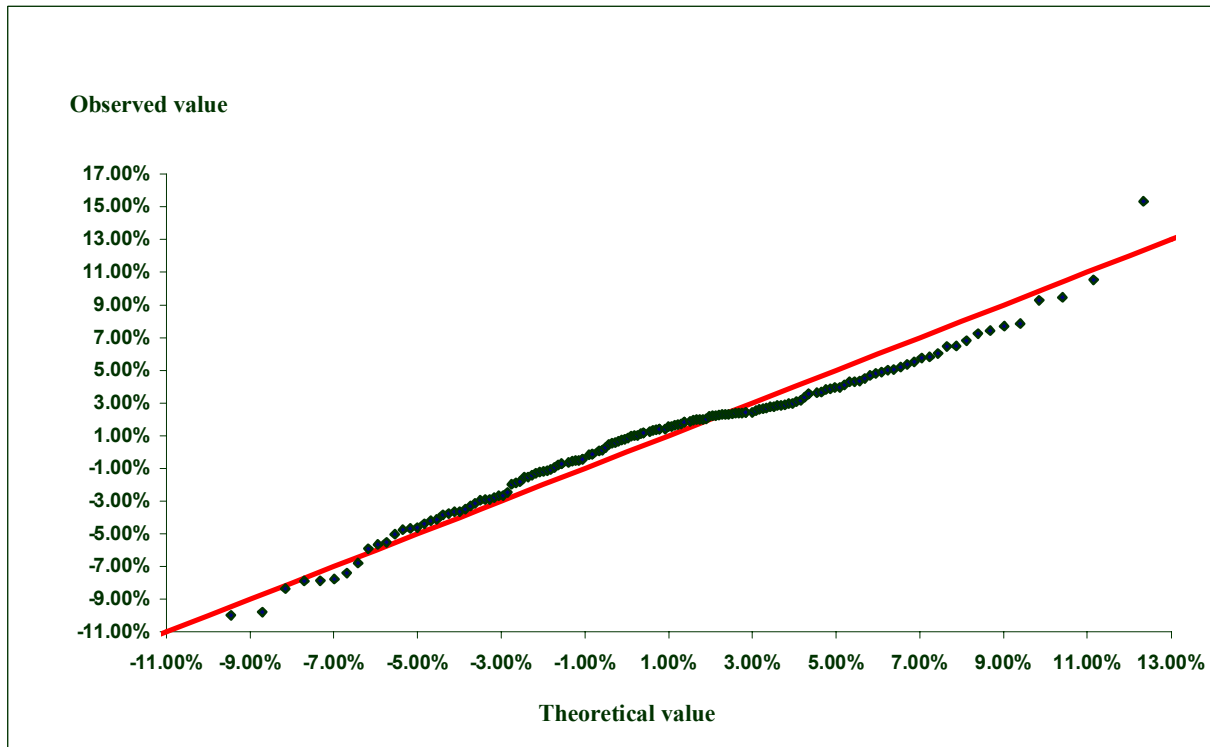
Convertible Arbitrage



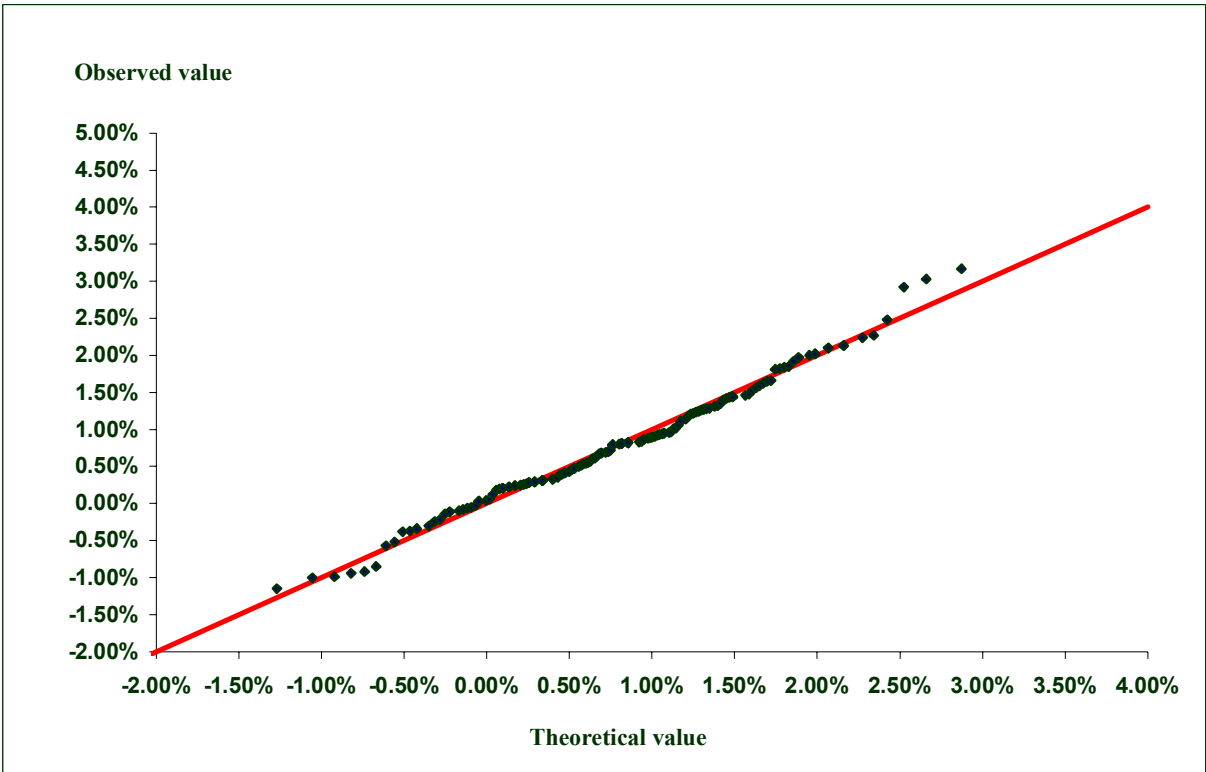
Dedicated Short Bias



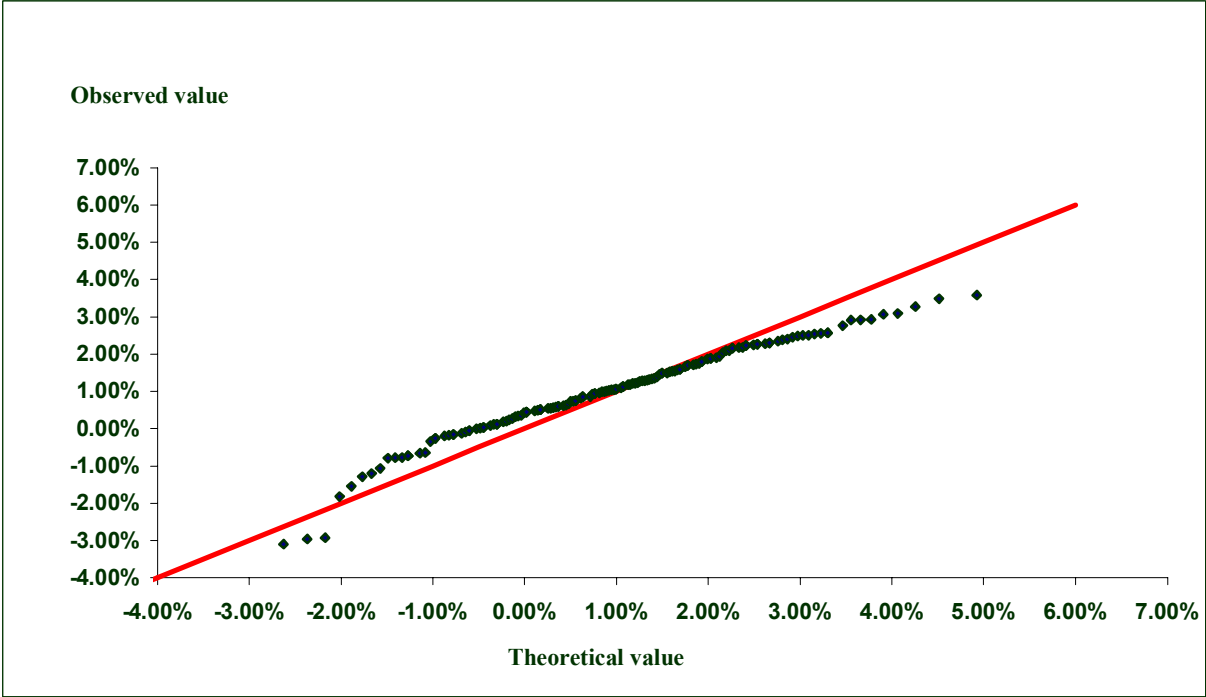
Emerging Markets



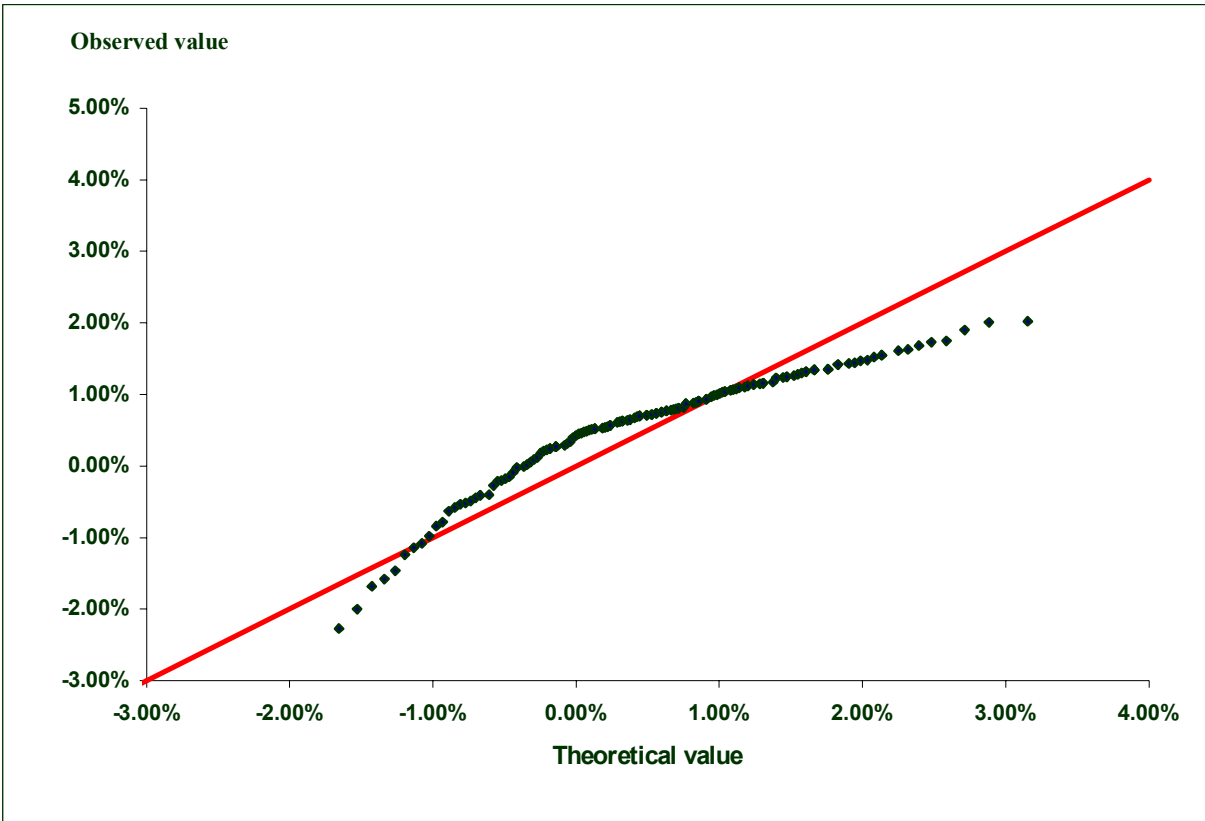
Equity Market Neutral



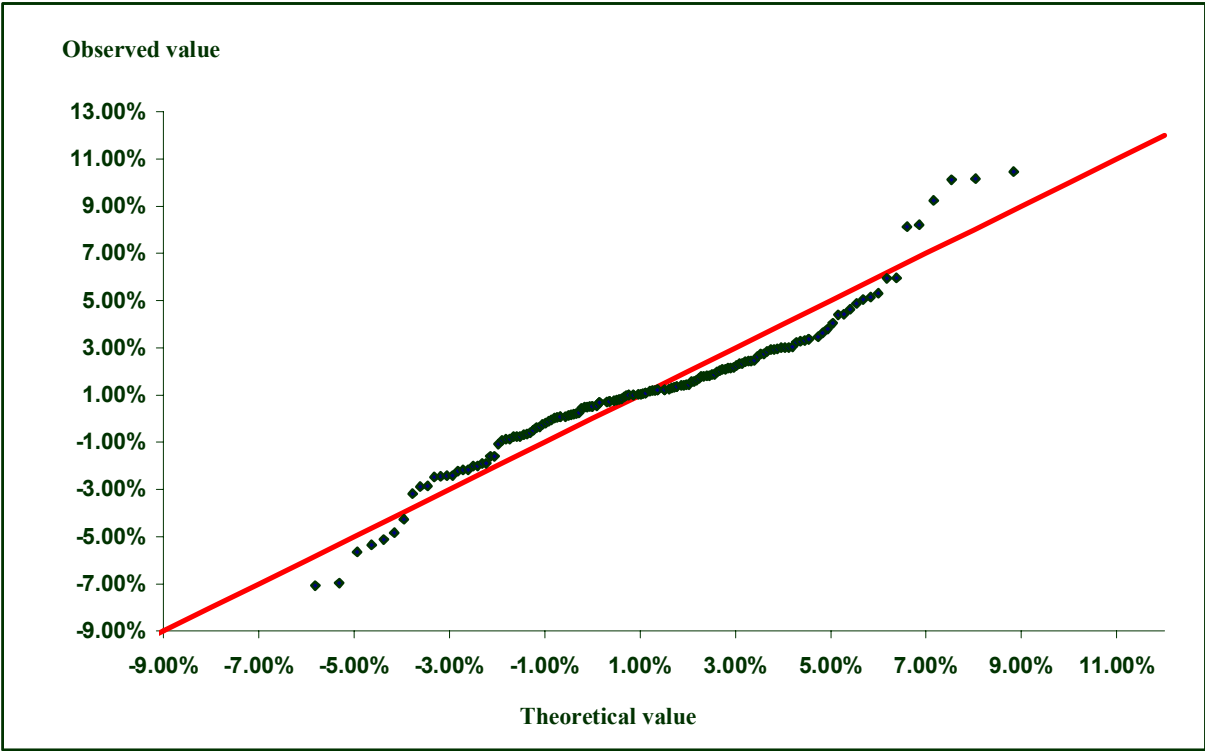
Event Driven



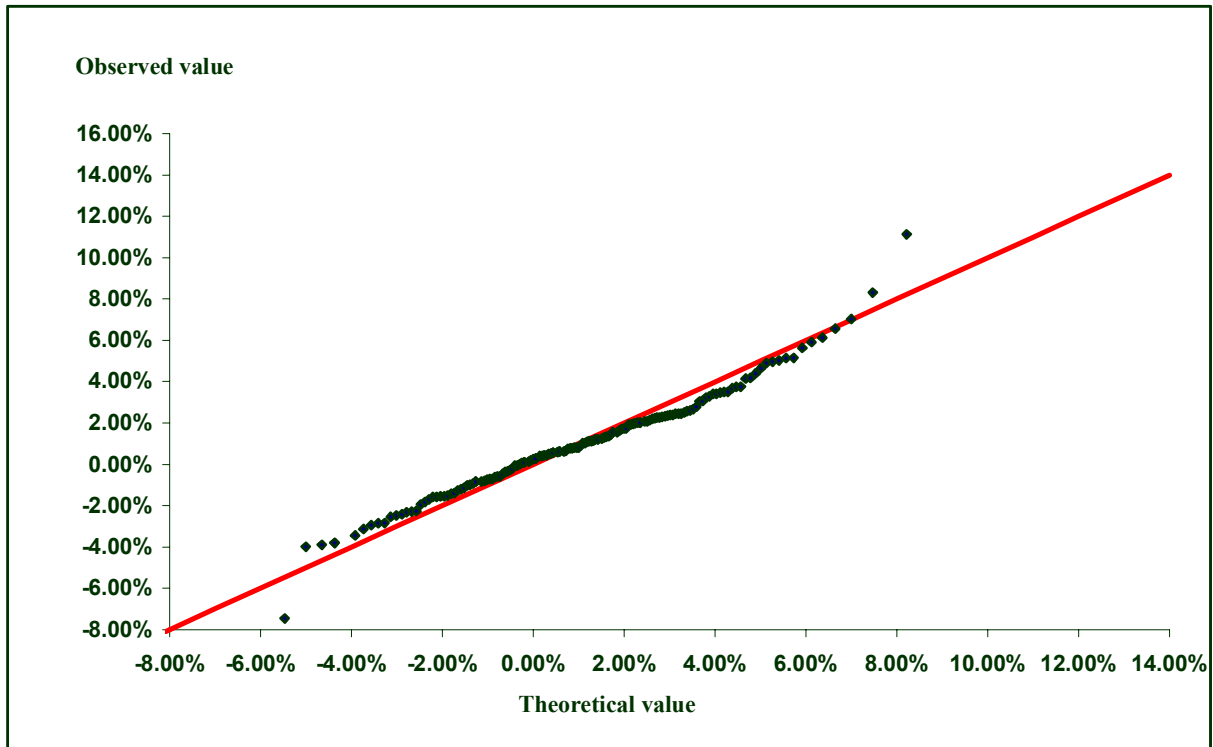
Fixed Income Arbitrage



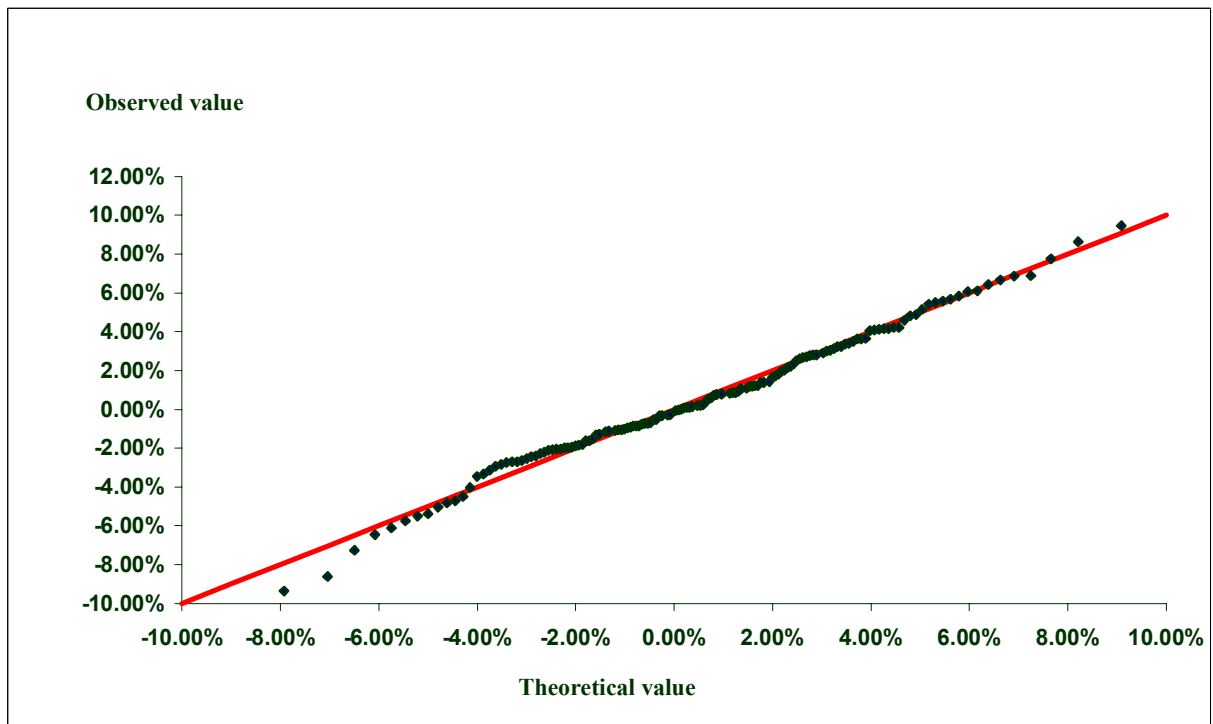
Global Macro



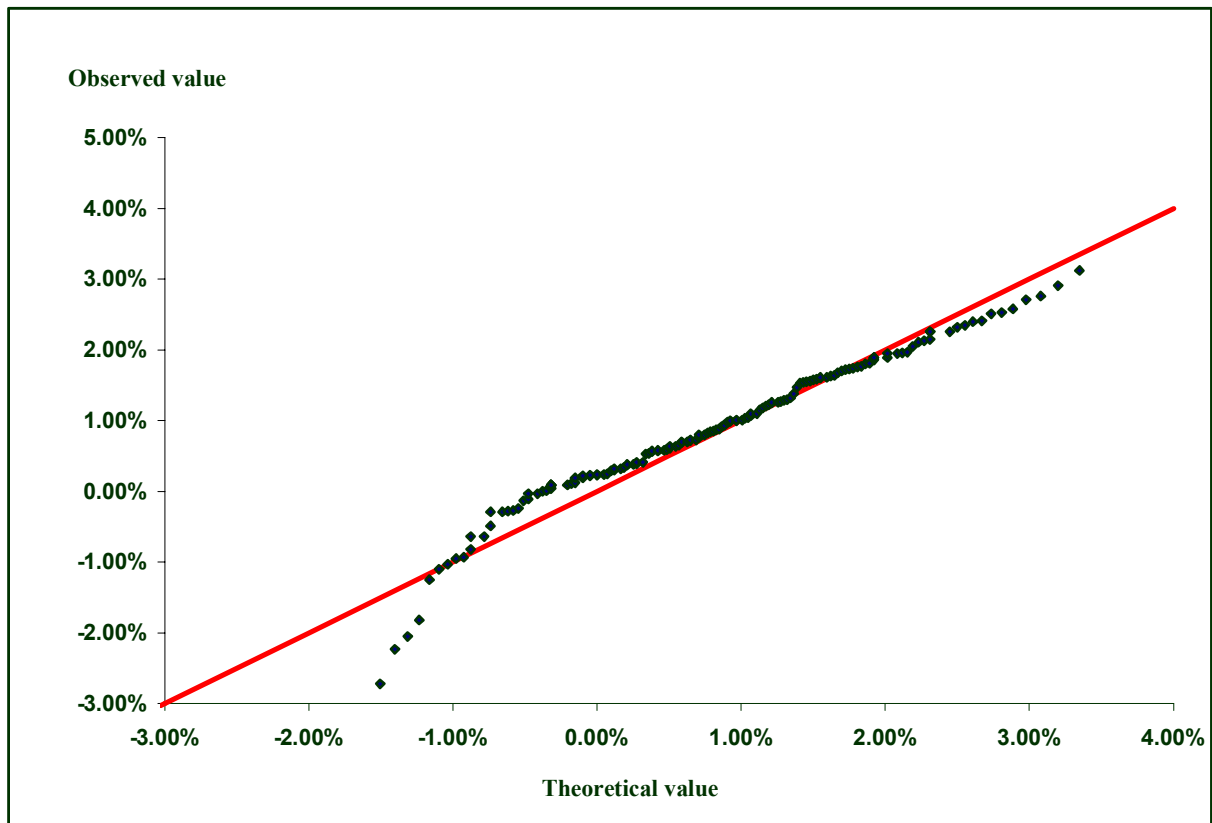
Long Short Equity



Managed futures



Multi-Strategy



Appendix C : Ranking of the monthly CSFB/Tremont hedge fund indexes by sortino ratio and MAR level (from 0% to 10%)

	MAR	0%	0.50%	1%	1.50%	2%	2.50%	3%	3.50%	4%	4.50%	5%
1	Rank											
		EMN (7.894)	EMN (6.494)	EMN (5.121)	EMN (4.076)	EMN (3.420)	EMN(2.874)	EMN (2.620)	EMN(2.255)	EMN(2.255)	EMN (2.255)	EMN (2.255)
2		JPM EMU Bond Index (6.457)	JPM EMU Bond Index (3.763)	MS (2.480)	MS (2.330)	MS(2.061)	MS (1.854)	ED (1.672)	ED (1.553)	ED(1.443)	ED (1.443)	ED (1.443)

6	5	4	3
LSE (1.789)	Indice global CSFB (2.007)	CA (2.081)	MS (2.316)
ED (1.769)	CA (1.962)	Indice global CSFB (1.967)	MS (2.481)
CA (1.854)	Indice global CSFB (1.889)	ED (1.947)	JPM EMU Bond Index (2.182)
JPM EMU Bond Index (1.639)	Indice global CSFB (1.783)	CA (1.784)	ED (1.987)
GM (1.557)	Indice global CSFB (1.644)	CA (1.646)	ED (1.923)
GM (1.477)	CA (1.497)	Indice global CSFB (1.520)	ED (1.797)
CA (1.361)	Indice global CSFB (1.376)	Global Macro (1.393)	MS (1.671)
CA (1.212)	Indice global CSFB (1.214)	GM (1.297)	MS (1.537)
Indice global CSFB (1.113)	JP Morgan EMU Bond Index (1.177)	GM (1.226)	MS (1.399)
CA (1.090)	GM (1.145)	JPM EMU Bond Index (1.177)	MS (1.399)
GM(0.984)	CA (1.090)	JPM EMU Bond Index (1.177)	MS (1.399)

10	9	8	7
FIA (1.266)	ED (1.520)	Lehman Bond composite US (1.557)	GM (1.708)
Lehman Bond composite US (1.283)	FIA (1.290)	GM (1.667)	LSE (1.718)
Lehman Bond composite US (1.015)	FIA (1.353)	GM(1.637)	LSE (1.644)
Lehman Bond composite US (0.802)	FIA (1.256)	LSE (1.553)	GM (1.618)
DJ EUROSTOXX 50 (0.755)	FIA (1.105)	JPM EMU Bond Index (1.177)	LSE (1.451)
DJ EUROSTOXX 50 (0.710)	FIA (0.957)	JPM EMU Bond Index (1.177)	LSE (1.322)
DJ EUROSTOXX 50 (0.669)	FIA (0.957)	JPM EMU Bond Index (1.177)	LSE (1.238)
DJ EUROSTOXX 50 (0.630)	FIA (0.957)	LSE (1.128)	JPM EMU Bond Index(1.177)
DJ EUROSTOXX 50 (0.585)	FIA (0.957)	LSE (1.041)	CA (1.090)
DJ EUROSTOXX 50 (0.549)	LSE (0.956)	FIA (0.957)	Indice global CSFB (1.033)
DJ EUROSTOXX 50 (0.473)	LSE (0.784)	Indice global CSFB (0.828)	FIA (0.957)

15	14	13	12	11
Russel 2000 (0.710)	MF(0.845)	Dow Jones (0.862)	S&P 500 (0.894)	DJ EUROSTOXX 50 (0.928)
EM (0.667)	MF(0.759)	Dow Jones (0.805)	S&P 500 (0.824)	DJ EUROSTOXX 50 (0.887)
EM (0.624)	MF (0.666)	Russel 2000 (0.744)	Dow Jones (0.751)	DJ EUROSTOXX 50 (0.845)
MF (0.581)	EM (0.581)	Dow Jones (0.686)	S&P 500 (0.689)	DJ EUROSTOXX 50 (0.795)
Russel 2000 (0.511)	EM (0.540)	Lehman Bond composite US (0.596)	Dow Jones (0.627)	S&P 500 (0.632)
MF (0.435)	Russel 2000 (0.469)	EM (0.500)	Dow Jones (0.578)	S&P 500 (0.580)
MF(0.353)	Russel 2000 (0.429)	EM (0.461)	Dow Jones (0.523)	S&P 500 (0.530)
MF(0.282)	Russel 2000 (0.388)	EM (0.422)	Dow Jones (0.472)	S&P 500 (0.476)
Lehman Bond composite US (0.278)	Russel 2000 (0.346)	EM (0.380)	Dow Jones (0.415)	S&P 500 (0.420)
Lehman Bond composite US (0.278)	Russel 2000 (0.304)	EM (0.339)	Dow Jones (0.369)	S&P 500 (0.372)
Russel 2000 (0.228)	EM (0.257)	Lehman Bond composite US (0.278)	Dow Jones (0.280)	S&P 500 (0.280)

Rank	MAR
	5.50%
	6%
	6.50%
	7%
	7.50%
	8%
	8.50%
	9%
	9.50%
	10%

18	17	16
DSB (0.232)	Nasdaq (0.476)	EM (0.706)
DSB (-0.280)	Nasdaq (0.451)	Russel 2000 (0.659)
DSB (-0.322)	Nasdaq (0.424)	S&P 500 (0.610)
DSB (-0.357)	Nasdaq (0.397)	Russel 2000 (0.565)
DSB (-0.400)	Nasdaq (0.368)	MF(0.508)
DSB (-0.434)	Nasdaq (0.339)	Lehman Bond composite US (0.424)
DSB (-0.458)	Lehman Bond composite US (0.278)	Nasdaq (0.310)
DSB (-0.489)	Lehman Bond composite US (0.278)	Nasdaq (0.281)
DSB (-0.518)	MF(0.220)	Nasdaq (0.254)
DSB (-0.536)	MF(0.158)	Nasdaq (0.226)
DSB (-0.597)	MF (0.050)	Nasdaq (0.174)

8	7	6	5	4	3	2	1
Indice global CSFB (0.828)	FIA (0.957)	GM(0.984)	CA (1.090)	JPM EMU Bond Index (1.177)	MS (1.399)	ED (1.443)	EMN (2.255)
Indice global CSFB (0.736)	GM(0.905)	FIA (0.957)	CA (1.090)	JPM EMU Bond Index (1.177)	MS (1.399)	ED (1.443)	EMN (2.255)
LSE (0.640)	GM(0.849)	FIA (0.957)	CA (1.090)	JPM EMU Bond Index (1.177)	MS (1.399)	ED (1.443)	EMN (2.255)
LSE (0.573)	GM(0.792)	FIA (0.957)	CA (1.090)	JPM EMU Bond Index (1.177)	MS (1.399)	ED (1.443)	EMN (2.255)
LSE (0.507)	GM(0.735)	FIA (0.957)	CA (1.090)	JPM EMU Bond Index (1.177)	MS(1.399)	ED (1.443)	EMN (2.255)
LSE (0.451)	GM(0.679)	FIA(0.957)	CA (1.090)	JPM EMU Bond Index (1.177)	MS (1.399)	ED (1.443)	EMN (2.255)
LSE (0.385)	GM (0.594)	FIA (0.957)	CA (1.090)	JPM EMU Bond Index (1.177)	MS (1.399)	ED (1.443)	EMN (2.255)
LSE (0.330)	GM (0.540)	FIA (0.957)	CA (1.090)	JPM EMU Bond Index (1.177)	MS (1.399)	ED (1.443)	EMN (2.255)
Lehman Bond composite US (0.278)	GM (0.472)	FIA (0.957)	CA (1.090)	JPM EMU Bond Index (1.177)	MS (1.399)	ED (1.443)	EMN (2.255)
Lehman Bond composite US (0.278)	GM (0.420)	FIA (0.957)	CA (1.090)	JPM EMU Bond Index(1.177)	MS(1.399)	ED (1.443)	EMN (2.255)

12	11	10	9
Dow Jones (0.280)	S&P 500 (0.280)	DJ EUROSTOXX 50 (0.473)	LSE (0.784)
Dow Jones (0.235)	Lehman Bond composite US (0.278)	DJ EUROSTOXX 50 (0.435)	LSE (0.707)
Dow Jones (0.192)	Lehman Bond composite US (0.278)	DJ EUROSTOXX 50 (0.402)	Indice global CSFB (0.632)
S&P 500 (0.151)	Lehman Bond composite US (0.278)	DJ EUROSTOXX 50 (0.367)	Indice global CSFB (0.533)
Dow Jones (0.112)	Lehman Bond composite US (0.278)	DJ EUROSTOXX 50 (0.332)	Indice global CSFB (0.465)
Dow Jones (0.074)	Lehman Bond composite US (0.278)	DJ EUROSTOXX 50 (0.299)	Indice global CSFB (0.398)
Dow Jones (0.036)	DJ EUROSTOXX 50 (0.264)	Lehman Bond composite US (0.278)	Indice global CSFB (0.330)
EM (0.000)	DJ EUROSTOXX 50 (0.233)	Indice global CSFB (0.253)	Lehman Bond composite US (0.278)
Nasdaq (-0.023)	DJ EUROSTOXX 50 (0.204)	Indice global CSFB (0.253)	LSE (0.275)
Nasdaq (-0.045)	DJ EUROSTOXX 50 (0.174)	LSE (0.220)	Indice global CSFB (0.253)

18	17	16	15	14	13
DSB (-0.597)	MF (0.050)	Nasdaq (0.174)	Russel 2000 (0.228)	EM (0.257)	Lehman Bond composite US (0.278)
DSB (-0.626)	MF (0.000)	Nasdaq (0.148)	Russel 2000 (0.191)	EM (0.219)	S&P 500 (0.232)
DSB(-0.639)	MF(-0.047)	Nasdaq (0.122)	Russel 2000 (0.156)	EM (0.180)	S&P 500 (0.189)
DSB (-0.662)	MF (-0.091)	Nasdaq (0.096)	Russel 2000 (0.125)	EM (0.143)	Dow Jones (0.151)
DSB (-0.691)	MF (-0.136)	Nasdaq (0.071)	Russel 2000 (0.092)	EM (0.106)	S&P 500 (0.112)
DSB (-0.719)	MF(-0.179)	Nasdaq (0.047)	Russel 2000 (0.060)	EM (0.069)	S&P 500 (0.073)
DSB (-0.720)	MF (-0.224)	Nasdaq (0.023)	Russel 2000 (0.030)	EM (0.035)	S&P 500 (0.036)
DSB(-0.754)	MF (-0.264)	Russel 2000 (0.000)	Nasdaq (0.000)	Dow Jones (0.000)	S&P 500 (0.000)
DSB(-0.788)	MF(-0.302)	Dow Jones (-0.036)	S&P 500 (-0.035)	EM (-0.034)	Russel 2000 (-0.028)
DSB (-0.797)	EM (-0.589)	MF(-0.338)	Dow Jones (-0.070)	S&P 500 (-0.070)	Russel 2000 (-0.057)

