Maximum Loss and Maximum Drawdown in Financial Markets

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Abstract

The main concern of this paper is the study of alternative risk measures: namely maximum loss and maximum drawdown. Both statistics have received little attention from academics despite their extensive use by proprietary traders and derivative fund managers.

Firstly, this paper recalls from previously published research the expected maximum loss under the normal random walk with drift assumption. In that case, we see that exact analytical formulae can be established. The expected maximum loss can be derived as a function of the mean and standard deviation of the asset. For the maximum drawdown, exact formulae seems more difficult to establish. Therefore Monte-Carlo simulations have to be used.

Secondly, this article observes maximum loss and maximum drawdown in varied financial markets including passive and actively managed funds. Statistics are compared with their expectations under the normal random walk with drift assuming mean return and volatility to be known ex-ante. The predictive accuracy of varied forecasts of maximum drawdown is investigated.

Finally, we question the issue of using maximum loss and maximum drawdown to separate funds managers exhibiting similar Sharpe ratios. The benefits and dangers of using such complementary statistics are highlighted.

The vast majority of investors measure the risk of their investments using either variance or standard deviation. This follows modern portfolio theory, in which risk is defined as the variability of returns. While standard deviation is a measure of uncertainty, uncertainty is not necessarily risk. Standard deviation does not differentiate between deviations above the average return and deviations below the average return. If standard deviation is used as measure of risk, positive performance relative to the average return is penalised just as much as negative performance relative to the mean. Consequently, a downside approach to risk should be preferred. Alternative risk measures such as the semi-variance have therefore been proposed. Basically, post modern portfolio theory points out that only volatility below the investor' target return is counted as risk. Another drawback of volatility is that it does not distinguish between intermittent losses and consecutive losses. Reviews of the literature on risk measures can be found in Clarkson (1996).

For institutions, risk capital is generically defined as the maximum possible loss for a given position or portfolio within a known confidence interval. Wilson (1996) sees three advantages to risk capital: risk comparability, determinant of capital adequacy, performance measurement. First, risk capital can be consistently applied across a wide variety of diverse risky positions and portfolios, allowing the relative importance of each to be directly compared and aggregated. Second, it has the intuitive interpretation as the amount of economic or equity capital which must be held to support that particular level of risky business activity. The final important reason for calculating risk capital is to help management evaluate the performance of business units and strategies on a risk adjusted basis. The biggest drawback of measures based on capital at risk is that they are one-period statistic. Consequently at the end of the period, losses are reset to zero and not aggregated over time. Small cumulative losses will therefore be ignored and considered less risky than a single but large daily loss preceded and/or followed by gains.

In many situations, a decision-maker must choose an alternative out of a choice of set, and the chosen element determines the outcome in several periods. These situations are called multi-period problems. Actually, single-period problems are the exception rather than the rule, since nearly every choice we make affects not only the present but also the future. Therefore, the relevance and importance of multi-period problems cannot be overstated. In particular, this paper argues that mutli-period loss is more appropriate than single-period loss. A loss of equity from a peak to valley in a series of consecutive periods is often called drawdown. For a trader, a large drawdown is an extreme test of his trading methodology and risk management. The trader's emotions subject the fund's performance to extra risks that test the trader's willpower to remain true to his trading methodology, whether it be technical, discretionary, or a combination of the two. It is also a very serious test for the risk management of the trader, because if risk management has been set up properly, a severe drawdown should occur only occasionally if at all. Drawdown statistics are widely used by tracking agencies to assess the risk of losses attached to money managers. Indeed funds managers and dealers, are rarely penalised for exhibiting excess volatility whereas abnormal string of losses could lead to the dismissal of money managers. Some investors have a definite drawdown level at which the investment will be withdrawn.

Maximum cumulative loss (ML) is lower than Value at Risk (VAR) and therefore more conservative. For a detailed relationship between VAR and ML, the reader is refereed to Studer and Luthi (1995, 1996).

The goal of this paper is to define what are abnormal losses either too low or too high. Such an information is useful since it will allow to distinguish the fund managers who control losses from those who do not. This article attempts to establish maximum losses conditionally to their mean return and volatility. Indeed, the question should be what additional information might be included in loss statistics which are not already included in a mean-variance approach ?

More precisely, this paper includes five sections. Firstly, we define loss statistics. Secondly, we establish expected maximum loss and maximum drawdown assuming that investment returns follow a normal distribution. Thirdly, we use previous results to assess the significance of losses triggered by various investments. The fourth section deals with the predictability of maximum drawdowns. Finally, the last section summarises our findings and conclude.

1) **Loss Statistics**

The "*Maximum Loss"* is over a defined period the loss realised when all the returns have been taken into account from the start of the investment. Let us note X_t the daily unrealised returns over the investment period of N days. Then the maximum loss is mathematically defined as:

$$ML = \mathrm{Min}(0, X_1, X_1 + X_2, \cdots, X_1 + X_2 + \cdots X_N)$$

An alternative definition is

$$ML^* = \mathrm{Min}(X_1, X_1 + X_2, \cdots, X_1 + X_2 + \cdots X_N) = \underset{t=1,\ldots N}{\mathrm{Min}}\left(\sum_{i=1}^{t} X_i\right).$$

Opposite to ML, ML* can be strictly positive.

The "*Maximum Drawdown"* is over a defined period the biggest decline of the investment after reaching a peak. This need not be a continuous decline but can even be a series of positive and negative returns where the negative returns are larger than the positive ones. This is mathematically defined as:

$$MD = \mathrm{Min}(X_1, X_1 + X_2, \cdots, X_1 + X_2 + \cdots X_N, \quad X_2, \cdots, X_2 + X_3 + \cdots X_N \quad \ldots, \quad , X_N)$$

$$MD = \underset{i=1,\ldots,t;\, t=1,\ldots N}{\mathrm{Min}}\left(\sum_{j=i}^{t} X_j\right)$$

By construction, the maximum drawdown is higher in absolute values than the maximum loss. Indeed, this is the most pessimistic scenario.

2) **A theoretical study**

The purpose of this section is to relate varied risk criteria. More specifically, we will try to establish the expected maximum loss and maximum drawdown as a function of the mean rate of return and volatility.

Maximum Loss

The following paragraph recalls theoretical results on maximum loss. A review of the literature and proofs to the propositions stated here can be found in Acar and Prieul (1997).

If we assume that the mean rate of return is equal to zero $\mu = 0$, it is possible to analytically derive a formula to establish the maximum loss as a function of the volatility σ and the number of days N in the period. This is given by:

$$E(ML) = -\sigma \frac{1}{\sqrt{2\pi}} \sum_{i=1}^{N} i^{-1/2} \qquad (1)$$

$$E(ML^*) = -\sigma \frac{1}{\sqrt{2\pi}} \sum_{i=1}^{N-1} i^{-1/2} \qquad E(ML^{*2}) = \sigma^2 [\frac{1}{2}(N+1) + \frac{1}{2\pi} \sum_{i-1}^{N-2} \sum_{j=1}^{i} \{ j(i-j+1)\}^{0.5}] \quad (2)$$

The maximum loss is a negative function of the volatility. In the case of zero drift, this is even a linear function of the volatility. This means that the ratio of maximum loss divided by volatility is a constant. Therefore minimising the volatility will minimise the maximum loss in absolute terms.

A more realistic assumption is to suppose that the rate of return of the asset follows a normal law with mean μ and standard deviation σ, $N(\mu,\sigma^2)$. In that case, the expected maximum loss can be calculated. This is equal to:

$$E(ML) = \sum_{i=1}^{N} \mu \Phi(-\sqrt{i}\frac{\mu}{\sigma}) - \frac{\sigma}{\sqrt{i}} \frac{1}{\sqrt{2\pi}} \exp[-0.5\, i\, (\frac{\mu}{\sigma})^2] \qquad (3)$$

where Φ is the standard normal cumulative.

As can be seen from Figure 1, the maximum loss is a negative function of volatility and a positive function of the mean return.

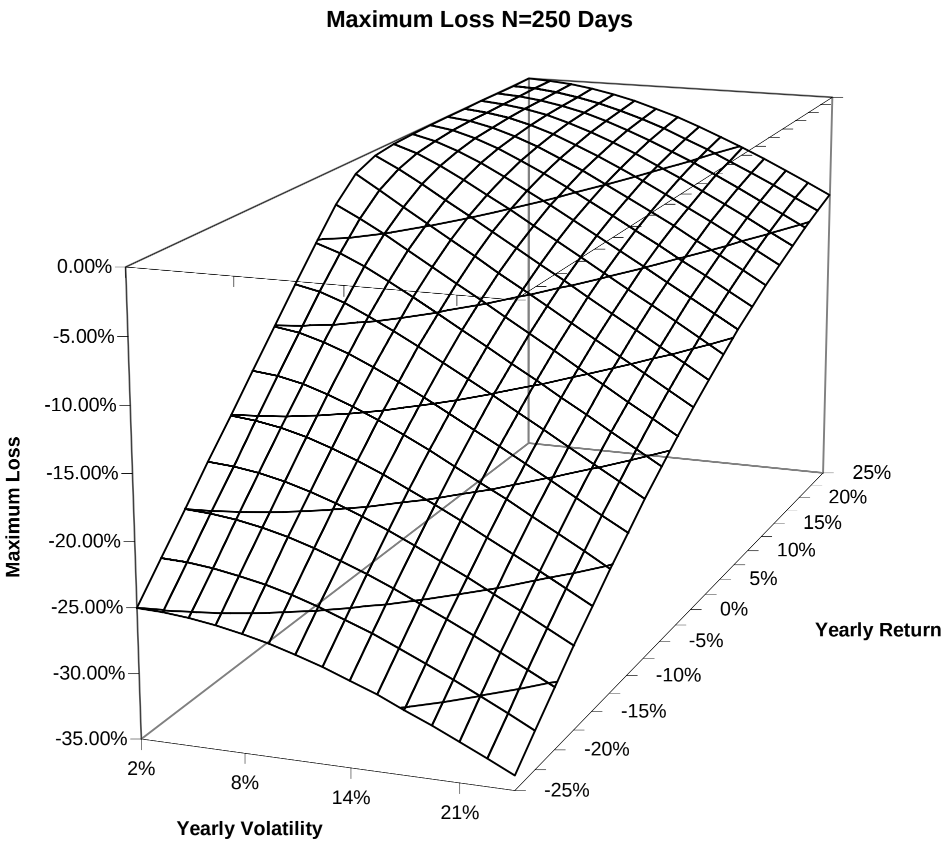

Fig 1: Maximum Loss as a function of Mean and Volatility

We should note that due to its definition, the maximum loss divided by volatility is an only function of the ratio mean divided by volatility.

$$ML / \sigma = \underset{t=1,\ldots N}{\mathrm{Min}}\left(\sum_{j=1}^{t} X_j\right) / \sigma = F(\mu / \sigma)$$

Figure 2 highlights the relationship between maximum loss per unit of volatility and return divided by volatility. As expected, the lower the return/volatility ratio, the higher the magnitude of losses. The interesting point from figure 2 is that it analyses losses per unit of risk. That is indeed what matters in financial markets. Are losses abnormally high given the volatility of the investment ? Alternative risk measures should be investigated relatively to the primary risk measure, volatility. Indeed, the question should less be shall we prefer alternative statistics to volatility as a risk measure, but instead what additional information might be included in these statistics which are not already included in the volatility measure. Too many investors make the mistake of focusing solely on absolute losses when they evaluate money managers. It is critical to also incorporate some measure of relativity as part of the evaluation process.

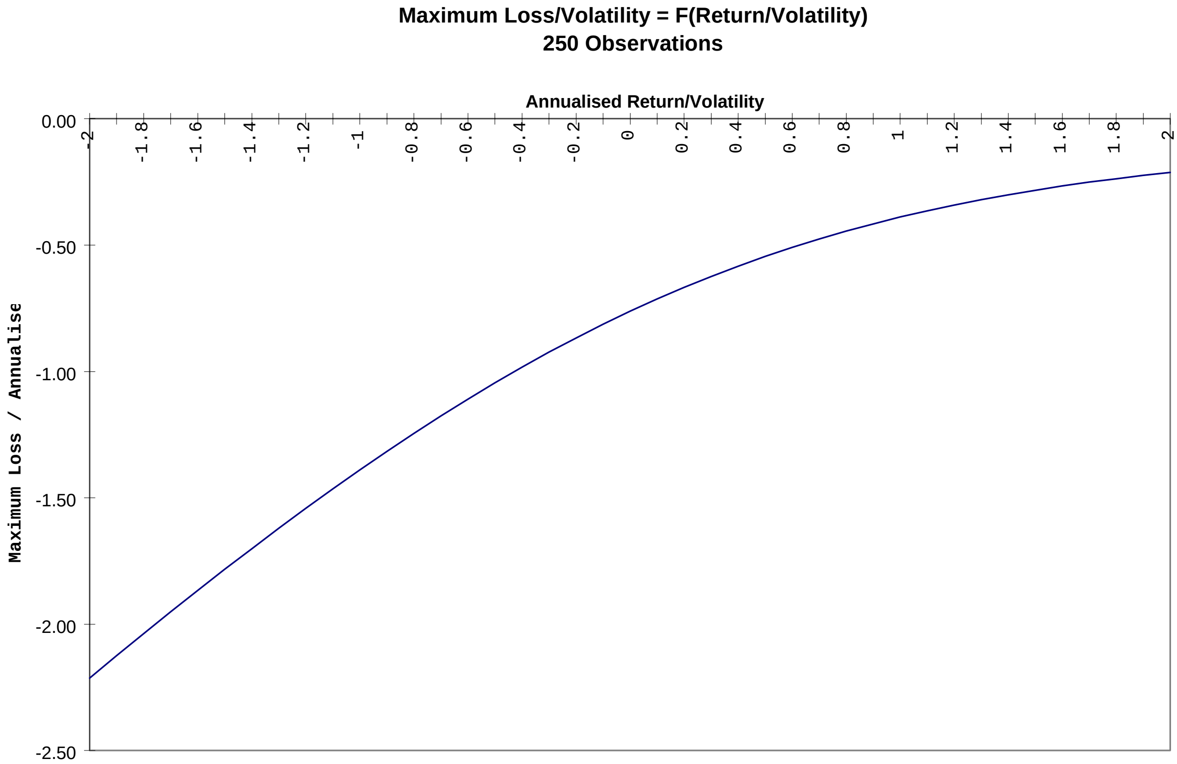

Fig 2: Maximum Loss/ Annualised Volatility as a function of Annualised Mean/ Volatility

In addition, it must be stressed that the expected maximum loss increases in absolute value as the number of observations increases (figure 3). The maximum loss per unit of risk is larger for longer time periods. However the slope of the curve depends on the return divided by volatility ratio. Standardized losses increase very little with the number of observations for investment exhibiting superior return divided by risk ratio (u/s=2) whereas they increase almost linearly for investment displaying negative return divided by risk ratio (u/s=-2).

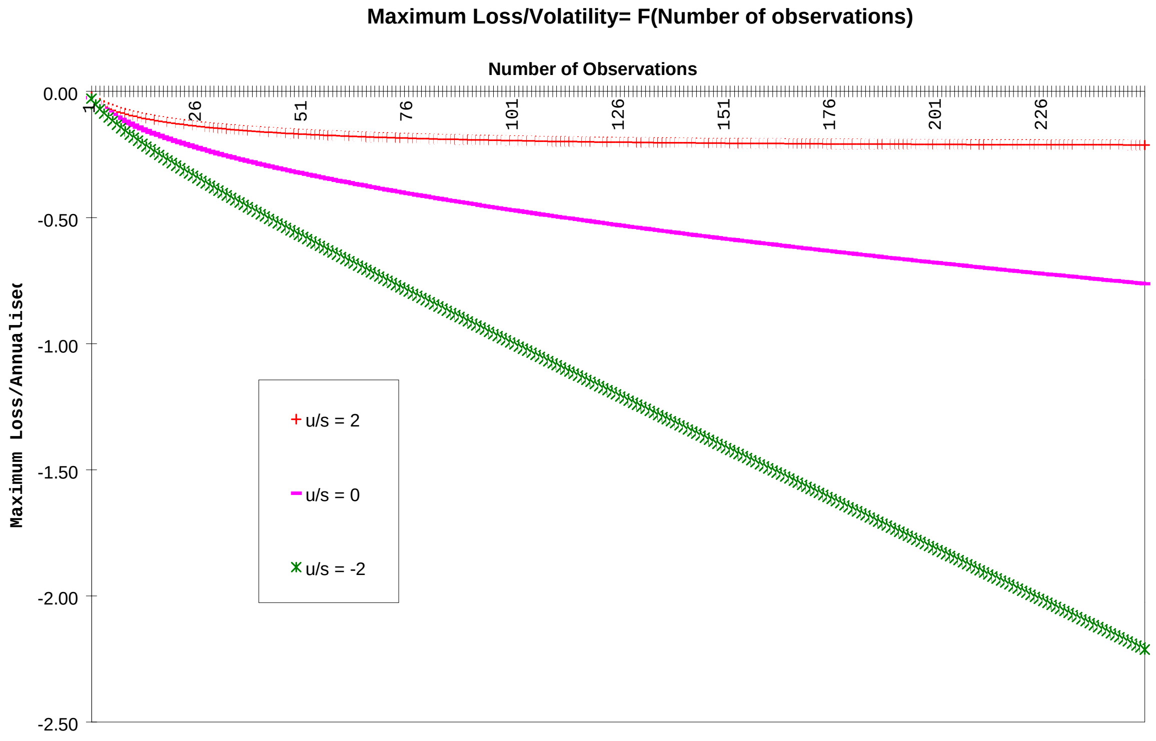

Fig 3: Maximum Loss/ Annualised Volatility as a function of Number of Observations

Maximum Drawdown

Unfortunately, there is no analytical formulae to establish the maximum drawdown properties under the random walk assumption. We should note first that due to its definition, the maximum drawdown divided by volatility is an only function of the ratio mean divided by volatility.

$$MD / \sigma = \underset{i=1,\ldots,t;t=1,\ldots N}{\mathrm{Min}} \left(\sum_{j=i}^{t} X_j\right) / \sigma = F(\mu / \sigma)$$

Such a ratio is useful in that this is a complementary statistic to the return divided by volatility ratio.

To get some insight on the relationships between maximum drawdown per unit of volatility and mean return divided by volatility, we have proceeded to Monte-Carlo simulations. We have simulated cash flows over a period of 36 monthly returns and measured maximum drawdown for varied levels of annualised return divided by volatility varying from minus two to two by step of 0.1. The process has been repeated six thousand times.

Figure 4 illustrates the average maximum drawdown as well as the quantiles 1%, 5%, 10%, 50%, 90%, 95% and 99%. For instance, an investment exhibiting an annualised return/volatility equal to -2 should experience on average a maximum drawdown equal to six times the annualised volatility. Other observations are that:

- maximum drawdown is a positive function of the return/volatility ratio
- confidence interval widens as the return/volatility ratio decreases

This means that as the return/volatility increases not only the magnitude of drawdown decreases but the confidence interval as well. In others words losses are both smaller and more predictable.

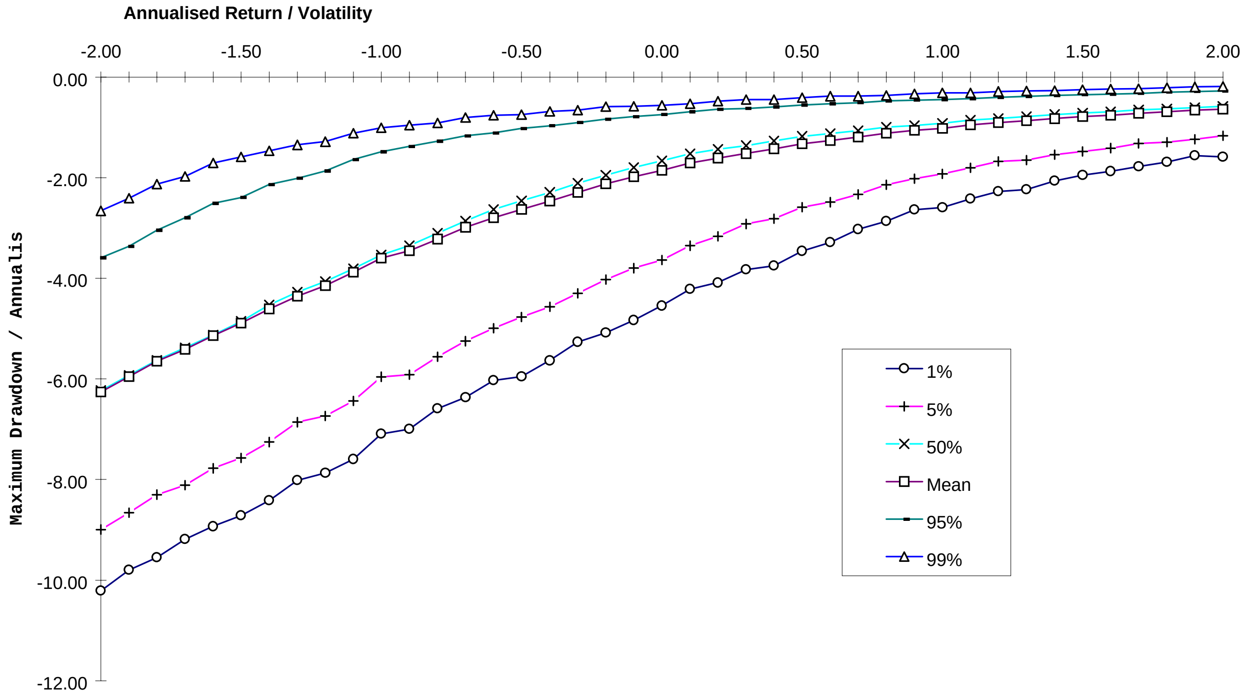

Fig 4: Maximum Drawdown/Volatility as a function of Return/Volatility
36 monthly returns simulated 6,000 times (Annualised Volatility)

3) **An empirical application to fund management**

The maximum loss statistic presents the primary disadvantage of depending on the entry point which can be viewed as arbitrary. Indeed, a time period starting just before a crash will exhibit a huge maximum loss whereas there may not be any maximum loss whatsoever for a period starting during a growth period. For that reason, studies beginning just before or after October 1987 in the stock market or just before or after September 1992 in the currency market will bring completely different conclusions. This is why maximum loss is scarcely used by tracking agencies which prefer to rely on maximum drawdown. We would recommend the use of maximum loss on overlapping periods or maximum drawdown on non-overlapping data. This paper concentrates on the latter approach.

Our universe of funds include passive indices and actively managed funds. Passive funds encompass stocks, bonds, commodities and emerging markets. Actively managed funds are derivatives funds reported in the Tass database. There are fourty-seven funds in total. The data sample has been split into three distinct periods including 36 months each: January 1987 to December 1989, January 1990 to December 1992 and January 1993 to December 1995. Three years is the minimum time required to assess funds performance. A detailed list of the funds including basic statistics such as return, volatility and maximum drawdown can be found in Appendix, tables 2 to 4.

Figures 5 and 6 summarise the distribution of standardized skewness and kurtosis for the fourty-seven funds and three time periods. One should note that the range of variation for standardised skewness and kurtosis is extremely large from -7.4 to 10 and -1.5 to 13.5 respectively. Overall, fund performance are positively skewed and leptokurtic.

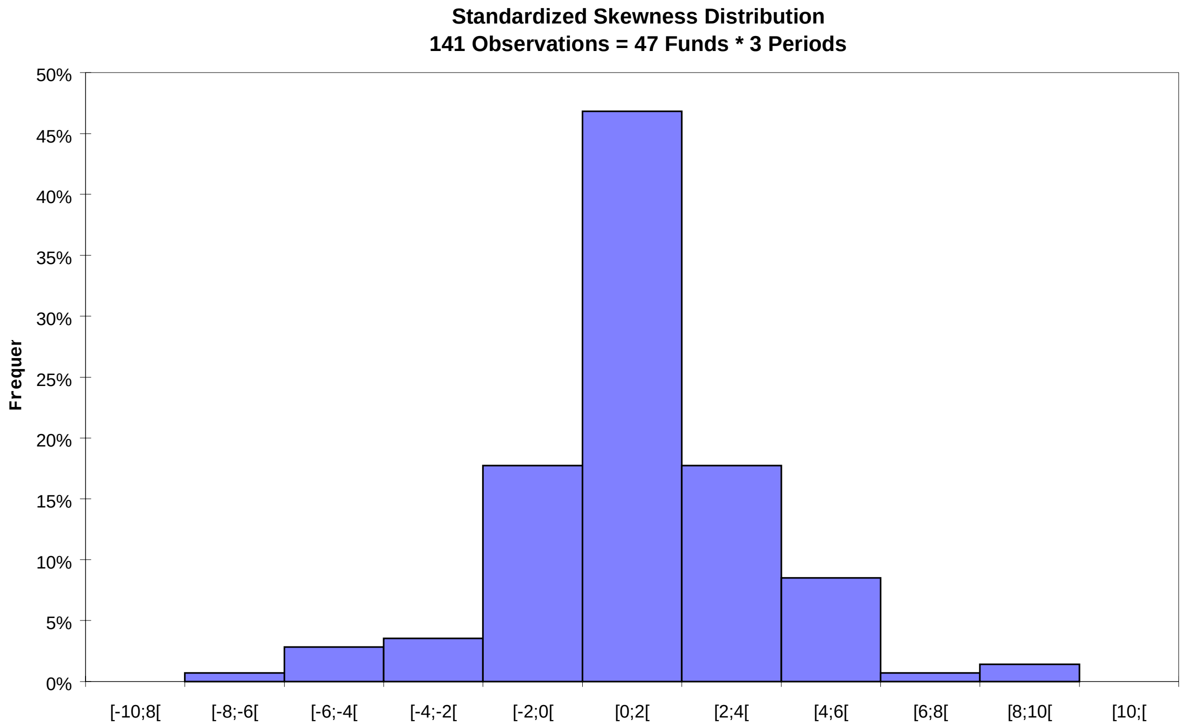

Fig 5: Skewness Distribution

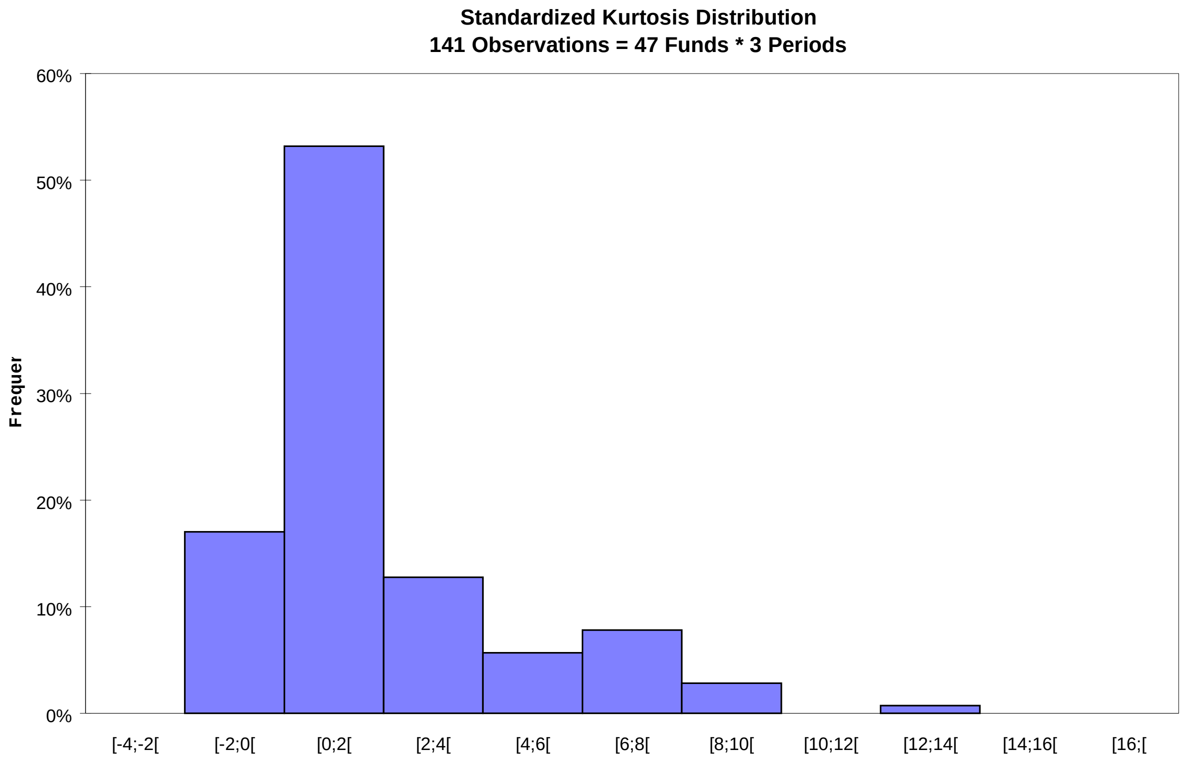

Fig 6: Kurtosis Distribution

Positive skewness means that the upper tail of the curve is longer than the lower tail. Positive kurtosis indicates that the curve is steep at the centre and has fat tails. However it is not straightforward to figure out the implications of skewness and kurtosis in terms of cumulative maximum loss. Assuming a normal distribution whereas the observed distribution is leptokurtic, will underestimate single period maximum loss. However it is unclear how it will affect a multi-period loss. Indeed positive kurtosis implies as well that the curve is steeper at the centre than a normal distribution. Very small variations will happen more often than expected. Therefore string of losses may include abnormally large and small losses making the cumulative sum no more than expected. A similar remark applies to skewness. This is why we will still use the results of the previous section to assess the significance of drawdown. This is a crude test which will need to be refined but it has the advantage of specifying a confidence interval.

The first step is to measure for varied funds maximum drawdown/volatility as a function of mean return/volatility. For each of the three periods (j=1 to 3), we get thirty-six monthly returns (i=1 to 36): $X_{i,j}$. To be consistent with the first section, a logarithmic Net Asset Value has been established as:

$$NAV_{i,j} = \exp(X_{i,j})\ NAV_{i-1,j} \text{ with } NAV_{0,j} = 1000.$$

Consequently, the maximum loss is simply the logarithmic variation from 1000 to the lowest NAV in the period. Similarly, the maximum drawdown is the logarithmic variation from the NAV at its peak to its trough. Expected maximum drawdown and confidence interval have been calculated ex-post using historical mean and standard deviation. First return divided by volatility have been calculated for each fund and rounded to one decimal. The corresponding expected drawdown distribution comes from the results of section two.

A striking result is that most of the funds do not display abnormal losses either too high or too low (figures 7 to 9). Only three funds out of forty-seven exhibit exceptionally low drawdowns at the critical threshold of 5%, yet for only one period January 1987 to December 1989. Only two funds trigger significantly high drawdowns at the critical threshold of 95%, yet for only one period January 1993 to December 1995.

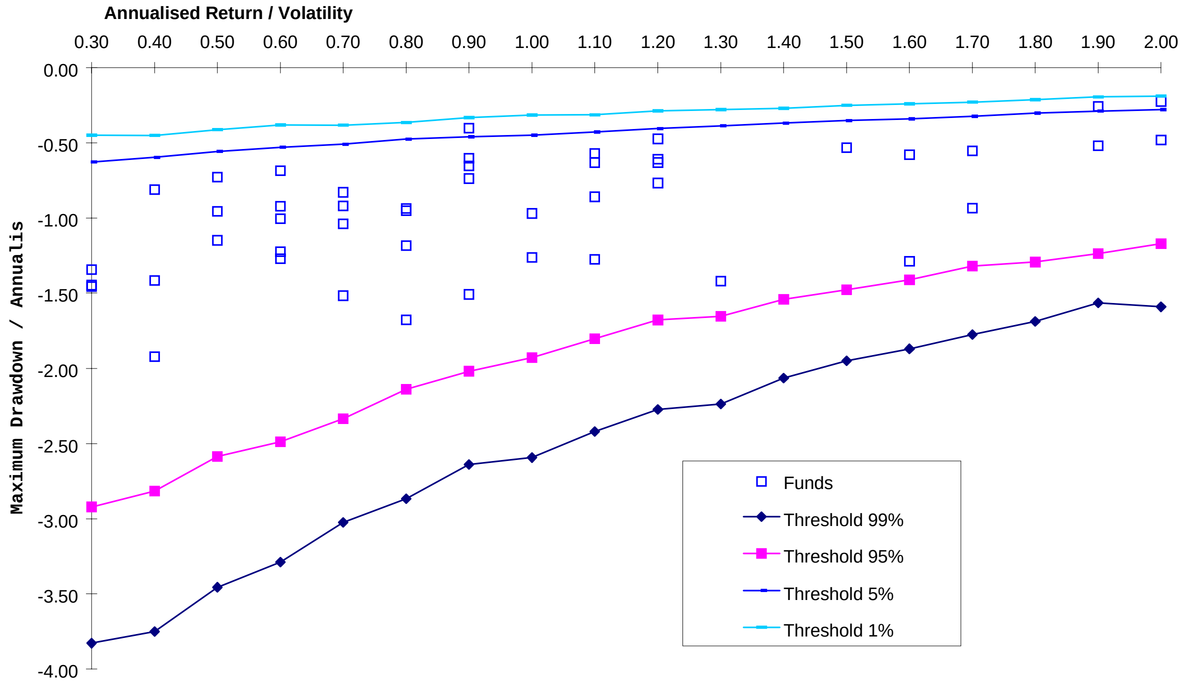

Fig 7: Maximum Drawdown/ Annualised Volatility as a function of Annualised Return/Volatility January 1987 - December 1989

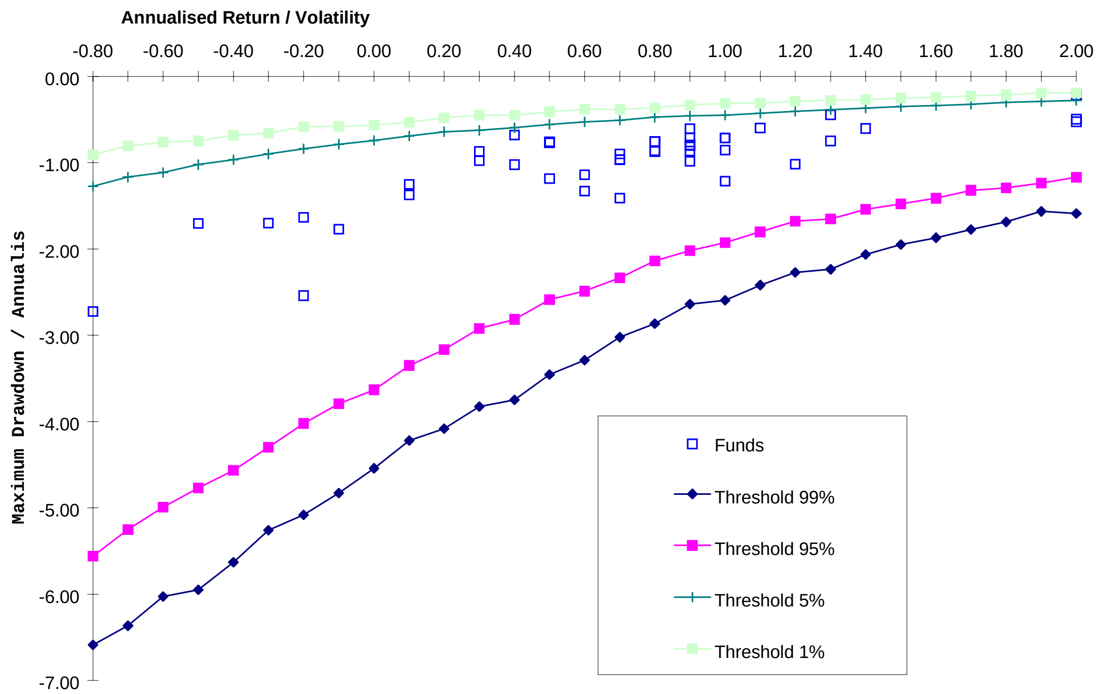

Fig 8: Maximum Drawdown/ Annualised Volatility as a function of Annualised Return/Volatility January 1990 - December 1992

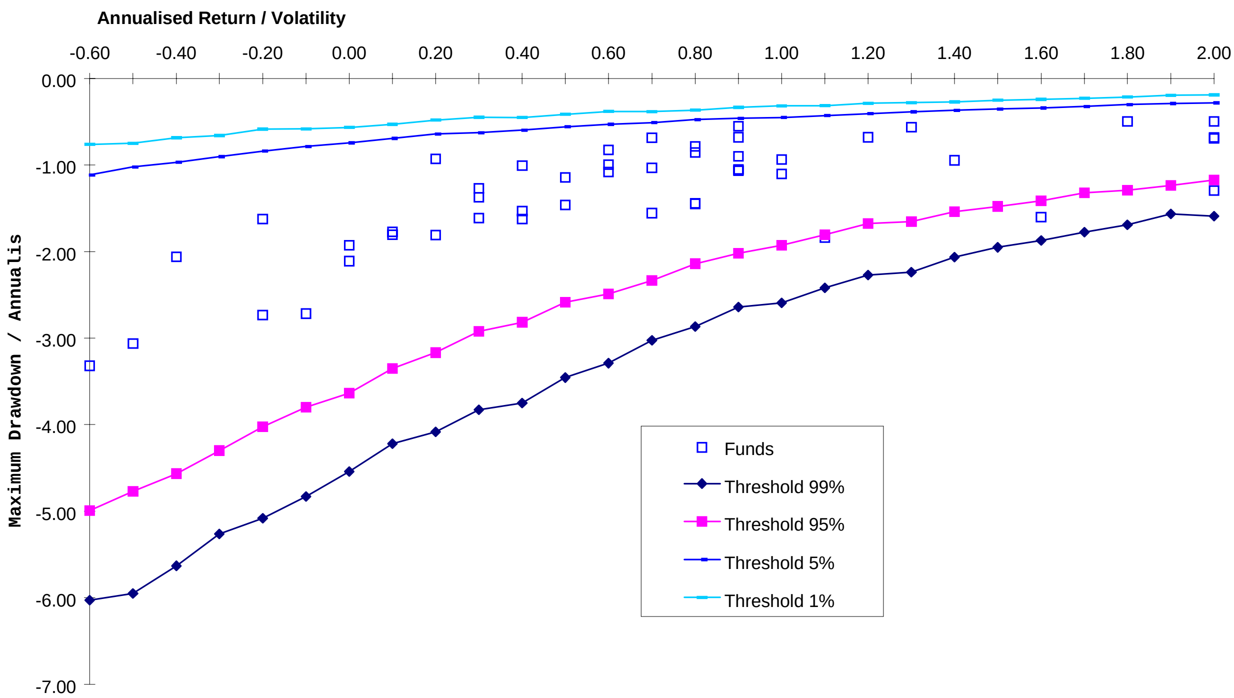

Fig 9: Maximum Drawdown/ Annualised Volatility as a function of Annualised Return/Volatility January 1993 - December 1995

4) **Predicting Maximum Drawdowns**

A striking question is: "Are maximum drawdowns predictable ?". To assess this issue, we have considered three forecasts of maximum drawdown. The three forecasts we have used are:

(1) Past maximum drawdown

(2) Expected maximum drawdown assuming zero return and previous volatility

(3) Expected maximum drawdown assuming previous return and volatility.

Forecasting accuracy has been calculated as:

$$\text{Error} = \frac{(\text{Observed Drawdown} \quad - \quad \text{Forecast})}{\text{Observed Drawdown}}$$

The first two 36 months periods have been used to build the forecasts of the next two periods. As can be seen from table 1, the best one-ahead predictor of maximum drawdown is the previous maximum drawdown followed by the expected drawdown using previous mean and volatility. Far behind lies the predictor based on the expected drawdown assuming zero mean return. Overall, forecasting errors are huge, ranging from 27% to 223% of the observed drawdown. The main reason lies in the nature itself of maximum drawdown. This is an extrema statistic which therefore generates an extremely large confidence interval. The smallest confidence interval are for funds managers exhibiting high Sharpe ratio. However past performance is a poor indicator of future performance. This is a well known fact for mutual funds (Carhart, 1997), which has been recently demonstrated for futures funds (Schwager, 1996). Therefore the fund managers achieving the best Sharpe ratio in one period are not more likely to display the highest Sharpe ratio in the consecutive period. Similarly to Sharpe ratio, maximum drawdown are volatile statistics which may explain why forecasts may be of little use to predict one-ahead drawdown. Nevertheless, if one predictor has to be used, it may well be the previously observed drawdown. It must be noted that all predictors tend to overestimate the absolute value of drawdowns. This may be a desirable feature since from a risk manager view point overestimating the risk of loss is the primary concern.

An additional point to note is the decreasing magnitude of losses. There may be two reasons for this. First, volatility has decreased in financial markets, especially in the currency market. Secondly, derivative fund managers have reduced the leverage they use. The race to manage institution money has started. Hedge funds used to deal almost exclusively for wealthy private individuals whose appetite for risk is considerable. The shift towards institution which are per nature risk-adverse has generated a new set of funds exhibiting much lower leverage.

Table 1: Forecast Error

	Previous Drawdown	Expectation (zero return)	Expectation
Error (01/90-12/92)	-0.42	-2.23	-0.65
Error (01/93-12/95)	-0.27	-1.60	-0.49

5) **Conclusion**

Measuring risk through extreme losses is a very appealing idea. This is indeed how financial companies perceive risks. This explains the popularity of loss statistics such as the maximum drawdown and maximum loss. The relevance and importance of multi-period problems cannot be overstated.

To gain a better understanding of these measures, we have established their distributional properties under the brownian random walk with drift assumption. Firstly, analytical formulae exist only for the maximum loss measure. The magnitude of losses increases with volatility and the length of the investment period. This decreases with the mean return. Secondly, it does not seem possible to derive exact results for the expected maximum drawdown. Properties have therefore been analysed using Monte Carlo simulations. Not only drawdowns per unit of risk increase as the return divided by standard deviation of the investment decreases but the confidence interval widens as well. The consequence is that investment displaying poor return/risk ratio will exhibit big and highly variable drawdowns per unit of volatility.

An empirical application to fund managers performance show that very few investments exhibit abnormally high or low drawdowns. Consequently, it is doubtful that drawdowns statistics can be used to significantly distinguish fund managers. This is confirmed by the fact that predicting one-period ahead drawdown is an almost impossible task. Errors average at the very best 27% of the true value observed in the market.

Clearly further research is needed. On the one hand, risk as measured by cumulative losses is what face investors. On the other hand, measures based on cumulative losses such as maximum loss or maximum drawdown exhibit large confidence interval. This is the inherent feature of extreme statistics which make them so challenging to predict. Either drawdown forecasts should be improved or alternative loss measures should be proposed which are easier to predict.

Finally, alternative models allowing for kurtosis and skewness should be investigated. Whereas, monthly data tend to follow a normal distribution, this is no longer the case for daily time series and even less the case for intra-day data. Ideally, the worse case scenario should be measured from an intraday equity high to an intraday equity low. The true drawdown (on a real time basis) in equity is always larger than monthly drawdowns, so it is somewhat of a misrepresentation to represent the largest monthly drawdown as the largest drawdown. In consequence, extreme statistics should be established using high frequency data and studied via continuous models of financial prices. A prerequisite is the availability of high frequency fund manager performance. In the early eighties, derivative fund managers used to report their performance on a quarterly basis. Today (1997), the frequency has been increased for compliance reasons to monthly. Still very few quoted funds publish weekly or daily figures. Publishing monthly figures is the industry standard and to not report drawdowns by the industry's standards is to handicap oneself.

It is hoped that this paper has raised some issues related to using maximum loss and maximum drawdown to separate funds managers. The benefits and dangers of using such statistics have been highlighted. In summary, cumulative losses are not recommended as a sole risk measure or the risk component in a return/risk ratio because they may be very unrepresentative of overall performance. As a related consideration, the use of maximum loss and maximum drawdown introduces a negative bias for managers with longer track records. Traders with longer track records have had more time to go through a severe drawdown. However, both criteria, maximum loss and maximum drawdown might provide important information and should be consulted in conjunction with volatility measures.

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Appendix

Table 2: Funds Performance, January 1987 to December 1989

	Volatility	Return	Return/Volatility	Maximum Loss	Maximum Drawdown	Loss/Volatility	Drawdown/Volatility
BARRA/MLM Index	6.60%	13.51%	2.05	1.09%	-3.43%	0.17	-0.52
DAX (In Deutsche Marks)	23.82%	10.33%	0.43	-37.44%	-45.77%	-1.57	-1.92
FTSE 100 Index (Sterling)	23.57%	15.21%	0.65	-0.08%	-35.75%	0.00	-1.52
Goldman Sachs Commodity DRI	12.48%	27.16%	2.18	-0.28%	-6.00%	-0.02	-0.48
Hang Seng - Hong Kong $	35.53%	10.80%	0.30	-2.21%	-47.74%	-0.06	-1.34
IFC Emerging Markets Index	27.98%	35.73%	1.28	0.15%	-39.73%	0.01	-1.42
MSCI $ World Index	17.11%	17.02%	1.00	11.57%	-21.62%	0.68	-1.26
S&P 500	19.51%	14.64%	0.75	-0.64%	-32.71%	-0.03	-1.68
NIKKEI 225 Cash Index - US $	19.25%	29.49%	1.53	9.69%	-10.25%	0.50	-0.53
Salomon Bros W Gvt 1 Yr - US$	3.90%	6.48%	1.66	-0.68%	-3.65%	-0.17	-0.94
TASS Currency Index	39.67%	25.38%	0.64	-6.76%	-48.60%	-0.17	-1.23
TASS Index of CTAs	17.70%	21.10%	1.19	9.81%	-13.58%	0.55	-0.77
Nikkei	18.64%	19.76%	1.06	9.28%	-23.77%	0.50	-1.28
American Futures Fund LP	43.78%	24.67%	0.56	12.00%	-44.00%	0.27	-1.01
Campbell Global Diversified Portfolio Composite	24.97%	26.17%	1.05	10.96%	-15.76%	0.44	-0.63
Dean Witter Cornerstone Fund II	30.86%	16.76%	0.54	8.05%	-35.45%	0.26	-1.15
Dean Witter Cornerstone Fund III	35.40%	16.87%	0.48	5.48%	-33.84%	0.15	-0.96
GAMut Investments Inc	24.07%	40.00%	1.66	14.01%	-13.34%	0.58	-0.55
GSAM Composite Inc.	12.31%	19.39%	1.58	9.92%	-15.85%	0.81	-1.29
Haussmann Holdings N.V.	17.29%	15.48%	0.90	5.82%	-26.06%	0.34	-1.51
High Sierra Futures Fund	17.78%	38.63%	2.17	12.40%	-4.00%	0.70	-0.22
Mark III LP	41.44%	17.93%	0.43	-1.37%	-33.63%	-0.03	-0.81
MINT Guaranteed Ltd (Nov 2002)	19.14%	23.30%	1.22	11.29%	-12.09%	0.59	-0.63
MINT Guaranteed Ltd Special Issue	18.76%	21.25%	1.13	9.66%	-10.69%	0.51	-0.57
MINT Ltd (Ordinary)	18.18%	21.13%	1.16	8.61%	-11.06%	0.47	-0.61
MRC Currency Partners LP	41.91%	41.94%	1.00	21.99%	-40.65%	0.52	-0.97
Nestor Partners	24.21%	14.69%	0.61	15.11%	-30.75%	0.62	-1.27
Quantum Fund N.V.	28.23%	21.26%	0.75	12.19%	-33.44%	0.43	-1.18
Sunrise Futures Fund	43.90%	29.20%	0.67	-15.60%	-36.40%	-0.36	-0.83
Sunrise Select Davco Fund LP	48.24%	28.03%	0.58	-13.30%	-44.50%	-0.28	-0.92
Sunrise Sierra International Currency Fund	51.36%	39.10%	0.76	-31.10%	-48.10%	-0.61	-0.94
Systemtrend Ltd	19.23%	6.38%	0.33	11.15%	-28.02%	0.58	-1.46
Tactical Commodity Fund	66.54%	39.27%	0.59	-5.68%	-45.67%	-0.09	-0.69
Tactical Futures Fund II	65.90%	35.40%	0.54	-6.97%	-47.92%	-0.11	-0.73
Tamiso - Lexford Partners	28.04%	30.03%	1.07	14.16%	-24.09%	0.51	-0.86
TGS LP	18.21%	35.21%	1.93	14.81%	-4.70%	0.81	-0.26
ZZ! Alpha Futures Associates LP	40.67%	33.40%	0.82	-2.07%	-38.75%	-0.05	-0.95
ZZ! Futures Expansion Fund LP	23.37%	8.19%	0.35	3.51%	-33.05%	0.15	-1.41
ZZ! Kenmar Performance Partners BVI Ltd	31.27%	38.45%	1.23	22.46%	-14.80%	0.72	-0.47
ZZ! MINT Limited - Income	18.97%	16.26%	0.86	8.61%	-11.43%	0.45	-0.60
ZZ! Waldner Pool Limited Partnership	52.48%	49.07%	0.93	10.00%	-38.70%	0.19	-0.74
Compucom Finance Single Account - FX	24.27%	8.20%	0.34	4.64%	-35.11%	0.19	-1.45
Friedberg Currency Only Trading Program	77.95%	53.49%	0.69	14.26%	-80.95%	0.18	-1.04
Mississippi Managed Accounts (Inc Not)	45.23%	39.16%	0.87	-3.70%	-29.59%	-0.08	-0.65
Niederhoffer Div Comm/Securities Program	23.79%	37.03%	1.56	5.29%	-13.77%	0.22	-0.58
Rabar Fully Diversified Program (Table B)	75.19%	64.13%	0.85	-2.70%	-30.30%	-0.04	-0.40
Sunrise Currency Program	43.86%	31.53%	0.72	-21.70%	-40.30%	-0.49	-0.92

Table 3: Funds Performance, January 1990 to December 1992

	Volatility	Return	Return/Volatility	Maximum Loss	Maximum Drawdown	Loss/Volatility	Drawdown/Volatility
BARRA/MLM Index	5.66%	5.26%	0.93	1.34%	-4.04%	0.24	-0.71
DAX (In Deutsche Marks)	19.95%	-2.87%	-0.14	-25.46%	-35.33%	-1.28	-1.77
FTSE 100 Index (Sterling)	17.65%	6.88%	0.39	-18.08%	-18.08%	-1.02	-1.02
Goldman Sachs Commodity DRI	20.19%	9.71%	0.48	-3.37%	-23.97%	-0.17	-1.19
Hang Seng - Hong Kong $	20.41%	24.36%	1.19	-3.00%	-20.79%	-0.15	-1.02
IFC Emerging Markets Index	22.54%	-5.42%	-0.24	-45.42%	-57.29%	-2.01	-2.54
MSCI $ World Index	16.69%	-3.04%	-0.18	-27.27%	-27.27%	-1.63	-1.63
S&P 500	14.57%	8.02%	0.55	-13.72%	-16.63%	-0.94	-1.14
NIKKEI 225 Cash Index - US $	35.47%	-16.87%	-0.48	-60.52%	-60.52%	-1.71	-1.71
Salomon Bros W Gvt 1 Yr - US$	3.53%	10.14%	2.87	-2.73%	-2.73%	-0.77	-0.77
TASS Currency Index	22.97%	21.01%	0.91	2.12%	-13.93%	0.09	-0.61
TASS Index of CTAs	15.72%	13.38%	0.85	3.54%	-13.61%	0.22	-0.87
Nikkei	27.27%	-22.28%	-0.82	-74.37%	-74.37%	-2.73	-2.73
American Futures Fund LP	24.48%	16.67%	0.68	6.00%	-22.00%	0.25	-0.90
Campbell Global Diversified Portfolio Composite	21.97%	19.68%	0.90	5.63%	-17.56%	0.26	-0.80
Dean Witter Cornerstone Fund II	22.75%	18.60%	0.82	3.04%	-24.36%	0.13	-1.07
Dean Witter Cornerstone Fund III	32.37%	10.43%	0.32	2.08%	-31.66%	0.06	-0.98
GAMut Investments Inc	18.63%	26.00%	1.40	-5.08%	-11.25%	-0.27	-0.60
GSAM Composite Inc.	8.19%	5.86%	0.72	-7.91%	-7.91%	-0.97	-0.97
Haussmann Holdings N.V.	8.24%	19.52%	2.37	-4.10%	-4.10%	-0.50	-0.50
High Sierra Futures Fund	8.92%	17.60%	1.97	1.80%	-4.70%	0.20	-0.53
Mark III LP	26.03%	24.78%	0.95	-1.55%	-22.25%	-0.06	-0.85
MINT Guaranteed Ltd (Nov 2002)	23.86%	8.70%	0.36	1.55%	-16.28%	0.06	-0.68
MINT Guaranteed Ltd Special Issue	24.87%	11.85%	0.48	5.46%	-18.89%	0.22	-0.76
MINT Ltd (Ordinary)	23.33%	6.47%	0.28	-1.89%	-20.36%	-0.08	-0.87
MRC Currency Partners LP	18.33%	24.36%	1.33	2.37%	-13.71%	0.13	-0.75
Nestor Partners	19.07%	21.41%	1.12	3.36%	-11.41%	0.18	-0.60
Quantum Fund N.V.	16.99%	42.24%	2.49	-2.32%	-3.73%	-0.14	-0.22
Sunrise Futures Fund	33.12%	25.73%	0.78	6.80%	-28.50%	0.21	-0.86
Sunrise Select Davco Fund LP	36.31%	30.70%	0.85	7.10%	-29.20%	0.20	-0.80
Sunrise Sierra International Currency Fund	43.46%	44.30%	1.02	3.80%	-31.00%	0.09	-0.71
Systemtrend Ltd	18.71%	9.70%	0.52	3.00%	-28.01%	0.16	-1.50
Tactical Commodity Fund	34.23%	33.46%	0.98	6.04%	-41.65%	0.18	-1.22
Tactical Futures Fund II	33.71%	30.27%	0.90	6.08%	-42.51%	0.18	-1.26
Tamiso - Lexford Partners	24.32%	21.43%	0.88	13.97%	-22.60%	0.57	-0.93
TGS LP	11.45%	14.89%	1.30	5.96%	-5.12%	0.52	-0.45
ZZ! Alpha Futures Associates LP	28.14%	3.03%	0.11	-9.74%	-38.66%	-0.35	-1.37
ZZ! Futures Expansion Fund LP	21.08%	16.93%	0.80	4.29%	-18.40%	0.20	-0.87
ZZ! Kenmar Performance Partners BVI Ltd	26.43%	15.64%	0.59	2.45%	-35.16%	0.09	-1.33
ZZ! MINT Limited - Income	22.70%	1.86%	0.08	-10.01%	-28.47%	-0.44	-1.25
ZZ! Waldner Pool Limited Partnership	40.36%	32.70%	0.81	-3.00%	-30.50%	-0.07	-0.76
Compucom Finance Single Account - FX	30.58%	22.46%	0.73	-12.94%	-21.98%	-0.42	-0.72
Friedberg Currency Only Trading Program	80.82%	56.46%	0.70	28.39%	-113.94%	0.35	-1.41
Mississippi Managed Accounts (Inc Not)	21.51%	-5.67%	-0.26	-19.77%	-36.61%	-0.92	-1.70
Niederhoffer Div Comm/Securities Program	29.39%	14.50%	0.49	-10.02%	-22.61%	-0.34	-0.77
Rabar Fully Diversified Program (Table B)	30.31%	27.73%	0.91	1.90%	-29.90%	0.06	-0.99
Sunrise Currency Program	39.11%	33.33%	0.85	2.70%	-31.20%	0.07	-0.80

Table 4: Funds Performance, January 93 to December 1995

	Volatility	Return	Return/Volatility	Maximum Loss	Maximum Drawdown	Loss/Volatility	Drawdown/Volatility
BARRA/MLM Index	4.64%	10.28%	2.21	-0.54%	-3.21%	-0.12	-0.69
DAX (In Deutsche Marks)	16.23%	13.93%	0.86	1.73%	-14.59%	0.11	-0.90
FTSE 100 Index (Sterling)	11.98%	9.38%	0.78	-1.38%	-17.37%	-0.12	-1.45
Goldman Sachs Commodity DRI	11.27%	4.12%	0.37	-12.80%	-17.26%	-1.14	-1.53
Hang Seng - Hong Kong $	30.59%	24.55%	0.80	4.34%	-44.14%	0.14	-1.44
IFC Emerging Markets Index	18.68%	12.50%	0.67	-0.31%	-29.05%	-0.02	-1.56
MSCI $ World Index	10.50%	13.61%	1.30	0.14%	-5.92%	0.01	-0.56
S&P 500	8.33%	11.93%	1.43	0.70%	-7.87%	0.08	-0.94
NIKKEI 225 Cash Index - US $	25.03%	14.77%	0.59	0.65%	-27.01%	0.03	-1.08
Salomon Bros W Gvt 1 Yr - US$	3.69%	8.79%	2.38	1.81%	-4.78%	0.49	-1.29
TASS Currency Index	11.03%	0.42%	0.04	-15.32%	-21.28%	-1.39	-1.93
TASS Index of CTAs	8.88%	6.92%	0.78	-0.84%	-7.60%	-0.09	-0.86
Nikkei	21.33%	9.58%	0.45	-1.48%	-31.15%	-0.07	-1.46
American Futures Fund LP	26.10%	8.30%	0.32	-25.82%	-35.82%	-0.99	-1.37
Campbell Global Diversified Portfolio Composite	17.38%	7.54%	0.43	-7.81%	-28.25%	-0.45	-1.63
Dean Witter Cornerstone Fund II	15.49%	8.37%	0.54	-3.97%	-17.73%	-0.26	-1.14
Dean Witter Cornerstone Fund III	19.10%	4.71%	0.25	-19.34%	-30.82%	-1.01	-1.61
GAMut Investments Inc	13.16%	15.60%	1.19	1.75%	-8.93%	0.13	-0.68
GSAM Composite Inc.	8.32%	9.18%	1.10	1.40%	-15.29%	0.17	-1.84
Haussmann Holdings N.V.	8.40%	13.24%	1.58	1.33%	-13.46%	0.16	-1.60
High Sierra Futures Fund	8.46%	18.73%	2.21	0.70%	-4.20%	0.08	-0.50
Mark III LP	14.32%	1.13%	0.08	-16.81%	-25.35%	-1.17	-1.77
MINT Guaranteed Ltd (Nov 2002)	10.78%	-2.06%	-0.19	-12.72%	-29.43%	-1.18	-2.73
MINT Guaranteed Ltd Special Issue	10.25%	-0.69%	-0.07	-5.26%	-27.86%	-0.51	-2.72
MINT Ltd (Ordinary)	13.77%	-6.27%	-0.46	-25.12%	-42.19%	-1.82	-3.06
MRC Currency Partners LP	21.55%	3.43%	0.16	-18.44%	-19.99%	-0.86	-0.93
Nestor Partners	15.95%	14.90%	0.93	-2.88%	-8.83%	-0.18	-0.55
Quantum Fund N.V.	16.77%	30.26%	1.80	2.20%	-8.32%	0.13	-0.50
Sunrise Futures Fund	25.77%	19.65%	0.76	-4.60%	-26.60%	-0.18	-1.03
Sunrise Select Davco Fund LP	25.87%	7.77%	0.30	-8.30%	-32.80%	-0.32	-1.27
Sunrise Sierra International Currency Fund	33.10%	7.03%	0.21	-30.20%	-59.90%	-0.91	-1.81
Systemtrend Ltd	19.22%	2.65%	0.14	-8.47%	-34.72%	-0.44	-1.81
Tactical Commodity Fund	38.99%	38.24%	0.98	1.05%	-36.52%	0.03	-0.94
Tactical Futures Fund II	38.11%	33.63%	0.88	0.61%	-40.00%	0.02	-1.05
Tamiso - Lexford Partners	17.94%	11.04%	0.62	-14.06%	-14.84%	-0.78	-0.83
TGS LP	14.80%	12.02%	0.81	-1.39%	-11.62%	-0.09	-0.78
ZZ! Alpha Futures Associates LP	32.22%	-12.31%	-0.38	-37.32%	-66.37%	-1.16	-2.06
ZZ! Futures Expansion Fund LP	16.65%	10.88%	0.65	-5.02%	-11.41%	-0.30	-0.69
ZZ! Kenmar Performance Partners BVI Ltd	27.05%	15.87%	0.59	-0.69%	-26.95%	-0.03	-1.00
ZZ! MINT Limited - Income	13.21%	-8.38%	-0.63	-31.44%	-43.83%	-2.38	-3.32
ZZ! Waldner Pool Limited Partnership	33.76%	-5.51%	-0.16	-22.83%	-54.83%	-0.68	-1.62
Compucom Finance Single Account - FX	24.06%	8.72%	0.36	-5.87%	-24.20%	-0.24	-1.01
Friedberg Currency Only Trading Program	38.07%	35.58%	0.93	-13.91%	-25.56%	-0.37	-0.67
Mississippi Managed Accounts (Inc Not)	40.93%	35.41%	0.86	-10.82%	-43.57%	-0.26	-1.06
Niederhoffer Div Comm/Securities Program	12.25%	25.10%	2.05	-3.95%	-8.35%	-0.32	-0.68
Rabar Fully Diversified Program (Table B)	30.82%	31.87%	1.03	-0.10%	-34.00%	0.00	-1.10
Sunrise Currency Program	32.00%	0.97%	0.03	-44.00%	-67.50%	-1.37	-2.11