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# **Performance Measurement in the Investment Industry: Does the Measure Matter?**

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# PERFORMANCE MEASUREMENT IN THE INVESTMENT INDUSTRY: DOES THE MEASURE MATTER?

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## ABSTRACT

It is frequently noted that investment funds with a nonnormal return distribution cannot be adequately evaluated using the classic Sharpe ratio. However, recent research compared the Sharpe ratio with other performance measures and found virtually identical rank ordering using hedge fund data. We extend this research by analyzing a large data set of 38,954 funds investing in seven different asset classes. We find that the research result is true not only for hedge funds, but also for mutual funds investing in stocks, bonds, and real estate, funds of hedge funds, commodity trading advisors, and commodity pool operators. This finding has serious implications for performance measurement in the investment industry: the choice of performance measure is not critical to fund evaluation and the Sharpe ratio is generally adequate for analyzing hedge funds and mutual funds.

## 1. INTRODUCTION

The most widely known risk-adjusted performance measure is the Sharpe ratio. It measures the relationship between the risk premium and the standard deviation of the returns generated by a fund (see Sharpe [1966]). Hedge funds and other alternative investments are especially prone to generating returns that have a nonnormal distribution. For this reason, it is frequently noted that these funds cannot be adequately evaluated using the Sharpe ratio (see, e.g., Brooks and Kat [2002]; Mahdavi [2004]; Sharma [2004]; Sharpe [2007]). This problem has motivated the development of numerous new performance measures, including Omega, the Sortino ratio, the Calmar ratio, and the modified Sharpe ratio, all of which are currently being debated in hedge fund literature (for an overview, see, e.g., Lhabitant [2004]).

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In a recent study, Eling and Schuhmacher [2007] compare these new performance measures with the Sharpe ratio using data on 2,763 hedge funds. Despite hedge fund returns' significant deviation from a normal distribution, the Sharpe ratio and the other measures result in virtually identical rank ordering across the hedge funds. However, Eling and Schuhmacher [2007] analyze only hedge funds and thus it is not yet known whether this result is also true for funds investing in other asset classes.

The aim of this paper is to answer this question. Combining two large data sets, we analyze 38,954 investment funds and find that Eling and Schuhmacher's [2007] result is robust in regard to a large number of different asset classes, including stocks, bonds, real estate, hedge funds, funds of hedge funds, commodity trading advisors (CTAs), and commodity pool operators (CPOs). This finding has serious implications for performance measurement in the investment industry: from a practical point of view, the Sharpe ratio is adequate for analyzing hedge funds and mutual funds. Our finding is in accord with other research finding that, despite some undesirable features, the Sharpe ratio is adequate for analyzing performance in the investment industry (see Fung and Hsieh [1999]; Dowd [1999, 2000]).

## **2. PERFORMANCE MEASURES**

In risk-adjusted performance measurement, the fund return is set into relation with a suitable risk measure. In investment fund analysis, the Sharpe ratio is often chosen as a performance measure and a comparison is made with the Sharpe ratios of other funds or market indices (see Ackermann, McEnally, and Ravenscraft [1999]; Schneeweis, Kazemi, and Martin [2002]).

However, in the context of hedge funds, use of the Sharpe ratio has been strongly criticized because hedge fund returns do not exhibit a normal distribution (see Kao [2002]; Amin and Kat [2003]; Gregoriou and Gueyie [2003]). For example, use of derivative instruments results in an asymmetric return distribution, as well as fat tails, leading to the danger that use of standard risk and performance measures will underestimate risk and overestimate performance (see Kat [2003]; McFall Lamm [2003]; Geman and Kharoubi [2003]). To avoid this problem,

newer performance measures that illustrate the risk of loss are recommended (see Pedersen and Rudholm-Alfvén [2003]; Lhabitant [2004]).

The newer performance measures differ from the Sharpe ratio in that standard deviation is replaced by an alternative risk measure. The alternative risk measures we consider in this paper are the lower partial moments (LPM) of orders 1, 2, and 3, three variants based on the drawdown, and three value-at-risk approaches. The risk measures, the performance measures, and references that contain more information on all these measures are given in Exhibit 1 (for a brief overview of all measures, see Eling and Schuhmacher [2007]).

The standard deviation involves both positive and negative deviations of the returns from the expected value, which is not the general understanding of risk. In contrast, LPMs consider only negative deviations of returns from a minimal acceptable return, the situation that most investors would like to avoid. Thus, LPMs might seem a more appropriate measure of risk. Using the lower partial moments of orders 1, 2, or 3, one can define the Omega, Sortino ratio, and Kappa 3 performance measures. Excess return is used as a return measure for these three measures, not in relation to the risk-free interest rate but, rather, in relation to the given minimal acceptable return  $\tau$ . Of course, it is also possible to use other measures for return, for example, the higher partial moments of order 1, as is the case with the upside potential ratio. With this measure, the first-order higher partial moment is combined with the second-order LPM.

The drawdown of a fund measures the loss incurred over a given investment period. The Calmar ratio, Sterling ratio, and Burke ratio use the maximum drawdown, an average of a certain number of drawdowns, or a type of standard deviation of a number of the largest drawdowns as risk measures.

The value at risk is the possible loss of an investment, which is not exceeded with a given probability of  $1 - \alpha$  in a certain period. To take into account the distribution of returns below the value at risk, the literature frequently considers expected loss under the condition that the value at risk is exceeded. This leads to the conditional value at risk. To include skewness and kurtosis in computing value at risk, the Cornish-Fisher expansion can be used, which leads to the modi-

fied value at risk. The performance measures excess return on value at risk, conditional Sharpe ratio, and modified Sharpe ratio measure risk by standard value at risk, conditional value at risk, or modified value at risk, respectively.

### **3. DATA, DESCRIPTIVE STATISTICS, AND DATA BIASES**

In our empirical investigation we use two large data sets. Return data for 17,817 stock funds, 12,279 bond funds, and 751 real estate funds were obtained from the Datastream database.<sup>1</sup> Return data for 4,048 hedge funds, 1,949 funds of hedge funds, 1,076 CTAs, and 1,034 CPOs were taken from the Center for International Securities and Derivatives Markets (CISDM) database.<sup>2</sup> For all funds we obtained monthly net-of-fee returns for the period from January 1996 to December 2005.

The return distributions of all funds are set out in Exhibit 2. The exhibit shows the mean, the median, the standard deviation, the minimum, and the maximum of the first four moments of the return distribution (mean value, standard deviation, skewness, and excess kurtosis). For example, consider the sample of the 17,817 stock funds: the standard deviation in Row 5 of Exhibit 2 means that across the 17,817 funds, the standard deviation has a mean of 4.70% (second column in Row 5) with a standard deviation of 2.43% (fourth column in Row 5).<sup>3</sup> The exhibit also shows the results of the Jarque-Bera test, which gives the portion of funds for which the assumption of normally distributed returns must be rejected at the 1% (5%) significance level, and the average correlation among the funds in each sample.

According to capital market theory, there is a functional relationship between risk and return of an investment—higher risk taking is rewarded with a higher return. Taking the mean value as a measure of return and the standard deviation as a measure of risk, we find that this relationship is generally true with the analyzed funds. For example, the asset class with the lowest risk (bonds) also provides the lowest return. In comparing risk and return for the different asset classes, it appears that hedge funds and funds of hedge funds are the most attractive. Hedge funds provide the highest return but do not have the highest risk, and funds of hedge funds have a noticeably low standard deviation for the level of return gen-

erated, which might be due to their higher degree of diversification compared to single funds.

However, while some investors might be more concerned with central tendencies of the return distribution (mean value, standard deviation), others may care more about the extreme values. For these investors, it is interesting to consider skewness, kurtosis, and the results of the Jarque-Bera test. Of particular note is the fact that not only is there a high rejection rate for the Jarque-Bera test for hedge funds, but also for other asset classes. At a 1% significance level, the rejection rate varies from 19.84% for stock funds to 45.54% for real estate funds. These strong deviations from normally distributed returns would appear to imply that use of the Sharpe ratio is not only inappropriate for measuring hedge fund performance, but also when it is used for measuring the performance of other asset classes. Note that there is a strong common factor with the stock funds, which results in a relatively high correlation among the funds of 0.57. In contrast, the sample of hedge funds is very diverse and does not exhibit a strong common factor (the average correlation is 0.16).

Like other databases, the Datastream and CISDM databases suffer from survivorship bias. Exhibit 3 shows attrition rate and survivorship bias for the analyzed funds. Survivorship bias is calculated as the difference in fund returns between all funds and the surviving funds.

The survivorship bias is 0.08 percentage points per month for hedge funds, which is comparable to other values found in literature (see, e.g., Ackermann, McE-nally, and Ravenscraft [1999]; Liang [2000]). The fact that, compared to hedge funds, the attrition rate and the survivorship bias are lower for traditional investments such as stocks and bonds and higher for commodity funds is well documented in literature (see Liang [2000]). In our sample, survivorship bias amounts to only 0.01 percentage points for stock funds and 0.0034 percentage points for bond funds, whereas these values are 0.10 and 0.09 for CTAs and CPOs, respectively.<sup>4</sup>

#### 4. PERFORMANCE MEASUREMENT

The findings reported in this section were generated by first using the above-discussed performance measures to determine the fund performance in each asset class. Next, for each performance measure, the funds were ranked on the basis of the measured values. Finally, the rank correlations between the performance measures were calculated.<sup>5</sup> For the LPM-based performance measures, we assume that the minimal acceptable return is equal to the risk-free monthly interest rate ( $\tau = r_f = 0.35\%$ ; which is the interest rate on 10-year U.S. Treasury bonds as of December 30, 2005 (4.28% per annum)). For the Sterling and Burke ratios, the five largest drawdowns are considered ( $N = 5$ ). The value-at-risk-based performance measures were calculated using a significance level of  $\alpha = 0.05$ . Exhibit 4 shows the rank correlations of the Sharpe ratio in relation to the other performance measures.

All performance measures display a very high rank correlation with respect to the Sharpe ratio. We first compare the rank correlations for hedge funds (Column 5 in Exhibit 4). For hedge funds, the rank correlation coefficient for the Sharpe ratio varies between 0.94 (Sterling ratio) and 1.00 (excess return on value at risk). On average, the rank correlation of the Sharpe ratio in relation to the other performance measures is 0.97. There is also a very high correlation between the Sharpe ratio, Omega, the Sortino ratio, Kappa 3, and the conditional Sharpe ratio (rank correlation greater than 0.98 in each case). These findings regarding hedge funds clearly confirm the results of Eling and Schuhmacher [2007].

We also find very high rank correlations for all the other asset classes. The highest rank correlations are found for stock funds. On average, the rank correlation of the Sharpe ratio in relation to the other performance measures is 0.99. Real estate has the lowest rank correlations; for this asset class, the rank correlation of the Sharpe ratio in relation to the other performance measures on average is 0.96. There appears to be a negative relationship between the rejection rate for the Jarque-Bera test and the rank correlation: the asset class with the highest rejection rate (real estate) has the lowest rank correlation and the asset class with the lowest rejection rate (stocks) has the highest rank correlation. However, even in the case that the returns of more than half of all funds deviate significantly from

normally distributed returns (which is the case with real estate), we find only very slight changes in rankings and rank correlation (we also find high rank correlations when comparing the new performance measures to each other; this comparison can be found in the Appendix).

Two test statistics can be used to check the significance of the rank correlations (see Eling and Schuhmacher [2007]). The first is a standardized version of the Hotelling-Pabst statistic. In this test, the hypothesis of independence of the two related rankings is checked for all correlation coefficients. However, even at the significance level of  $\alpha = 0.01$ , there is no case in which the hypothesis of independence can be confirmed in our study. Therefore, the hypothesis of independence of the measurement series must be rejected for all correlation coefficients presented in Exhibit 4. In addition to testing whether the rankings are independent (in other words, the rank correlation is zero), we also checked the hypothesis that the rank correlation is smaller than a certain given rank correlation  $x$ . We did this using the Fisher transformation and found, for a significance level of  $\alpha = 0.01$ , that the hypothesis that the rank correlation is smaller than  $x$  is rejected for all  $x$  smaller than 0.896 (see Rees [1987], p. 383, for the test statistic).

In conclusion, on the basis of our data, none of the new performance measures results in significant changes in the ranking of investment funds from that found using the Sharpe ratio. Thus, it does not matter which of the numerous measures is used to assess the performance of the different funds. Because the newer performance measures result in rankings that are practically the same, and thus give a similar assessment of the funds, use of the Sharpe ratio (regardless of possibly undesirable features) is justified, at least from a practical perspective.

## **5. ROBUSTNESS**

In this section we report the results of various robustness tests. These tests are important because the findings presented in the last section are valid only for the subject being examined, the time period considered, and several other given parameters (e.g., the minimal acceptable return). We found that the main result is robust with respect to:



- variations of the investigation period (we broke down the period from 1996 to 2005 into five periods of two years each),
- variations of the exogenously fixed parameters (for the LPM-based measures, the minimal acceptable return was varied between 0 and 1%, for the drawdown-based measures, the number of drawdowns was varied between 1 and 10, and for the value-at-risk-based measures, the significance level was varied between 1 and 20%),
- an elimination of outliers (we eliminated between 1 and 10 of the highest and lowest returns from the time series), and
- a separate consideration of surviving funds and dissolved funds (to account for a potential survivorship bias in our results).

For all these tests, we find high rank correlations comparable to those presented in the previous section. Exhibit 5 sets out the robustness results for stocks. Results for the other asset classes can be found in the Appendix. As an additional robustness test, we split the samples of stock funds, bond funds, and hedge funds into different strategy groups. E.g., the total sample of 4,048 hedge funds contains very diverse funds and it thus seemed appropriate to split this sample into different strategy groups, such as convertible arbitrage, distressed securities, and other. Results are presented in Exhibit 6. Again, we find very high rank correlations among the performance measures.

## **6. HOW CAN THE HIGH RANK CORRELATIONS BE EXPLAINED?**

In this section we try to explain the high rank correlations. From a practical point of view, it could be argued that the high rank correlations are simply due to using similar performance measures, that is, the numerator is excess return for ten of the eleven measures and the denominator contains a more or less comparable risk measure. We also find high rank correlations when comparing the different risk measures and the different return measures to each other, which results in high rank correlations when we compare the performance measures.<sup>6</sup>

Eling and Schuhmacher [2007] suggest that one possible explanation for the high rank correlations is that fund returns are elliptically distributed. The distributions that permit mean-variance analysis can be elliptical, not just the multivariate

normal distributions (see Ingersoll [1987]). Lhabitant [2004], as well as Eling and Schuhmacher [2007], find evidence for elliptically distributed hedge funds returns. Both studies observe a good statistical fit using the lognormal, the logistic, the Weibull, or the generalized beta distribution, which all belong to the group of elliptical distributions. We determine the underlying distribution for each fund on the basis of historical returns using the distribution fitting software BestFit. The results are presented in Exhibit 7. The parametric distribution that best fits the empirical distribution is in most cases a logistic, a Weibull, or a normal distribution. We thus confirm the above findings that fund returns are elliptically distributed.

To further explore the link between the fund's return distribution and rank correlation, we analyze a series of synthetic returns produced by a Monte Carlo simulation. In Exhibit 8 we present rank correlations for 1,000 simulated funds with 120 monthly returns under five different distributional assumptions (normal, lognormal, logistic, Weibull, and generalized beta distribution; we used the simulation software @RISK). All the simulated funds have been calibrated to produce equal means and standard deviations, but under the different distributional assumptions they result in different values for skewness and kurtosis. Nevertheless, the simulated time series also exhibit very high rank correlations. The only exception is the drawdown-based performance measures, which might be due to the fact that we did not correlate the simulated returns, so there is no strong common factor in these time series. It thus seems that the rank correlations for the drawdown-based measures are higher the higher the correlation between the funds. Reconsidering the results in Exhibit 4 confirms this finding: stock funds have the highest rank correlations with the drawdown-based measures, while hedge funds exhibit relatively low rank correlations. However, the results for funds of hedge funds do not confirm this evidence.<sup>7</sup>

We thus conclude that the reasons for the high rank correlations are that the performance measures are relatively similar (i.e., the risk and return measures are comparable) and that the fund returns are relatively similar (i.e., the returns are elliptically distributed and correlated).<sup>8/9</sup>

## 7. WHY IS THE SHARPE RATIO THE RIGHT MEASURE FOR INVESTORS?

In this section we discuss why the Sharpe ratio is the right measure for investors when analyzing both hedge funds and mutual funds. From a practitioner's point of view, the Sharpe ratio might be considered superior to other performance measures for the following reasons:

- It is widely used in the investment industry and is the best-known performance measure (see Modigliani and Modigliani [1997]). Most asset allocation analyses use the mean-variance approach in analyzing the trade-off between risk and return (see Leland [1999]; Sharpe [2007]). The Sharpe ratio is also reported by most financial information providers, such as Morningstar and Yahoo Finance.
- It provides a convenient summary of two important aspects (risk and return) of any investment strategy (see Sharpe [1994]) and is probably the best understood performance measures (see Lo [2002]). It is simple to calculate compared to other more complex performance metrics such as, e.g., the drawdown-based measures, and it is easily communicated to other professionals and even nonprofessionals. Furthermore, the data requirements are fewer, e.g., compared to measures where higher moments must be calculated.
- A wide range of statistical tests are available for the Sharpe ratio (see, e.g., Jobson and Korkie [1981]; Memmel [2003]), which is not the case for the other performance measures. Additionally, the Sharpe ratio has been the subject of much research and thus its strengths and weaknesses are well known in academia and practice, also not the case for the other performance measures.
- As shown above, when analyzing either hedge funds or mutual funds the choice of performance measure does not critical influence the relative evaluation of the funds.

From a theoretical point of view, the Sharpe ratio is consistent with expected utility maximization under the assumption of elliptically distributed returns (see Ingersoll [1987]). Even without the assumption of elliptically distributed returns, mean-variance analysis of mutual funds and hedge funds approximately pre-

serves the ranking of preferences in standard utility functions (see Levy and Markowitz [1979] and Hlawitschka [1994] for mutual funds and Fung and Hsieh [1999] for hedge funds). Furthermore, if an investor maximizes the expected utility of portfolio return and considers utility a quadratic function of portfolio return, only mean-variance-efficient portfolios need to be considered (see Sharpe [2007]). The Sharpe ratio thus builds upon a sound theoretical framework, which cannot be said of many of the other performance measures examined in this paper (e.g., the drawdown-based performance measures). The Sharpe ratio is closely connected to the separation theorem derived by Tobin [1958] and the efficient frontier derived by Markowitz [1952], which are the theoretical foundation of many other important applications in financial theory and practice, such as the capital asset pricing model (see Sharpe [1964]; Lintner [1965]; Mossin [1966]) or the Fama and French [1993] three-factor model. Finally, as shown by Dowd [1999, 2000], the Sharpe ratio can be the right measure both when a fund represents the entire risky investment and when it represents only a portion of the investor's risky investment (thus making it necessary to take correlations into account).

In conclusion, the Sharpe ratio is adequate for analyzing both hedge funds and mutual funds from a practical as well as from a theoretical point of view.

## **8. CONCLUDING REMARKS**

The main result from our empirical investigation is that the choice of performance measure does not affect the ranking of hedge funds and mutual funds. We find a slight negative relationship between the rejection rate for the Jarque-Bera test and the rank correlation: the asset class with the highest rejection rate (real estate) has the lowest rank correlation and the asset class with the lowest rejection rate (stocks) has the highest rank correlation. However, even for fund returns that usually display a strong deviation from a normal distribution, we find only very small changes in rankings and rank correlation.

It is generally difficult to draw precise statistical inferences on fund performance due to the low signal-to-noise ratio (see Kritzman [1986]), i.e., in our context, the small value of return relative to the level of risk found for many funds. Therefore,

a sample that is both large and covers an extensive period of time is needed to verify statistically whether the results are genuine or spurious (see Blake and Timmermann [2003] for a related discussion). However, our results are based on a large data sample (38,954 funds investing in seven different asset classes), covering a lengthy period (1996 to 2005, which is long as possible, especially for the sample of hedge funds) of monthly, weekly, and daily data (see note 9), as well as on numerous robustness tests, which should allow sound conclusions to be drawn.

From a practical point of view, the choice of performance measure is not critical to the relative evaluation of hedge funds and mutual funds. The Sharpe ratio is the best known and best understood performance measure and might thus be considered superior to other performance measures from a practitioner's point of view. From a theoretical point of view, the Sharpe ratio could also be considered superior to the other performance measures, as it is consistent with expected utility maximization. We conclude that the Sharpe ratio is adequate for analyzing the returns of hedge funds as well as those of mutual funds.

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## Notes

- 1 The Datastream investment funds database contains no strategy descriptions and does not categorize funds into different strategy groups. The only information available is the fund name (with ISIN and SEDOL numbers), the country of issue, and the underlying currency. We thus classified funds according to their names, i.e., all the selected funds have the words “stock,” “bond,” “real estate,” or a similar expression in their names. The underlying assumption is that a fund having the words “stock,” “bond,” or “real estate” in its title also invests in stocks, bonds, or real estate. To reduce misclassification, we cross-checked all funds by examining their return distributions. For example, for all bond funds with a standard deviation of monthly returns three times higher than the average (i.e., three times 1.91%; see Exhibit 2, second column in Row 11), we checked on the Internet whether this fund really does have a focus on bonds or if it is misclassified. Altogether we did 538 of these tests for the funds in the Datastream database, corrected misclassified funds, and eliminated all ambiguous cases. This plausibility check should reduce the danger of misclassification to a minimum. As shown in later robustness tests (see Exhibit 6), the selected funds include a wide variety of countries and investment styles (e.g., value and growth, small cap and large cap). Other academic studies that use the Datastream database include, e.g., Gemmill and Thomas [2002] and Otten and Bams [2002].
- 2 The CISDM database has been the subject of many academic studies (see, e.g., Capocci and Hübner [2004]; Ding and Shawky [2007]). The full database contains information on 8,542 funds. However, we eliminated 435 funds, including those that appeared twice in the database, had less than four monthly returns, or reported returns only on a quarterly basis.
- 3 Note that the standard deviation of 2.43% is relatively small given the minimums and maximums (Columns 5 and 6 in Row 5), as outliers in the data result in very skewed distribution of the standard deviation across all funds.
- 4 We also calculated estimators for the backfilling bias by stepwise deleting the first 12, 24, 36, 48, and 60 months of returns (see Brown et al. [1999]; Fung and Hsieh [2000]; Capocci and Hübner [2004]). Results are presented in Appendix 1. The monthly return of the portfolio that invests in all funds is

0.97% for hedge funds and 0.67% for funds of funds. Eliminating the first 12 (24, 36, 48, 60) months of returns for each fund reduces the return about 0.25% (0.41%, 0.30%, 0.43%, 0.34%) for hedge funds and by 0.02% (0.05%, 0.02%, 0.11%, 0.10%) for funds of funds. These values are comparable to other values in the literature; e.g., Fung and Hsieh [2000] find that backfilling bias is noticeably lower with funds of funds than with hedge funds. We find comparable results for CTAs and CPOs, while for stock, bond, and real estate funds the extent of the backfilling bias is low and its direction unclear. Other types of bias, such as the self-selection bias, should be negligible. For example, there is no selection bias for mutual funds because these must publicly disclose their performance. For alternative investment vehicles (hedge funds, funds of hedge funds, CTAs, CPOs) that do not make such a disclosure, the magnitude of the self-selection bias is limited and its direction unclear. See Fung and Hsieh [2000], p. 299.

- 5 We calculate Spearman's [1904] rank correlation coefficient ( $r_s$ ), which is a nonparametric measure of correlation. Unlike the Pearson product-moment correlation coefficient, this one requires neither the assumption that the relationship between the variables is linear nor that the variables be measured on interval scales; it can be used for variables measured at ordinal level. The performance measurement results are converted to ranks and the differences  $d_i$  between the ranks of each fund  $i$  on two measures are calculated as  $r_s = 1 - \left( 6 \cdot \sum_{i=1}^N d_i^2 \right) / (N^3 - N)$ , where  $N$  denotes the total number of funds considered. Rank correlation matters in our context as the performance of funds is regularly ranked in order to benchmark the success of a fund compared to other funds and to serve as the basis for investment decisions.
- 6 High rank correlations comparing risk measures were also reported in a different context by Pfingsten, Wagner, and Wolferink [2004].
- 7 Another idea would be to remove the common factor and then to test whether performance as determined by various measures is undifferentiable. We did this by calculating fund returns in excess of the beta ( $\beta_i$ ) adjusted mean return of all funds ( $r_{mt}$ ) for each asset class and month (the excess return of fund  $i$  in time period  $t$  is calculated as  $er_{it} = r_{it} - \beta_i \cdot r_{mt}$ ) using various definitions for beta (beta = 1, constant beta, rolling 24-month beta). Again, we found high rank

correlations between the performance measures. The results of these tests are available upon request.

- 8 We also did some other numerical tests that show that the result of high rank correlation between different measures is robust even for very diverse funds. These tests are available upon request.
- 9 Another supposition might be that the high rank correlations are due to the monthly measurement interval, since low-frequency data usually show relatively little skewness and excess kurtosis (see Bollen and Busse [2001]; Malkiel and Saha [2005]; Kosowski et al. [2006]). However, we calculated the performance measures for a randomly selected sample of 1,000 stock funds using weekly and daily data and again found high rank correlations. These tests are presented in Appendix 4. Using weekly (daily) data, the average rank correlation is 0.98 (0.93).



**Exhibit 1: Performance Measures**

| Risk Measure                  |                    | Performance Measure   | Reference                                   |
|-------------------------------|--------------------|---|---|
| Standard deviation            |                    | Sharpe Ratio <sub>i</sub> = $(r_i^a - r_f) / \sigma_i$  | Sharpe [1966]                               |
| Lower partial moment of order | 1                  | Omega <sub>i</sub> = $(r_i^a - \tau) / \text{LPM}_{1i}(\tau) + 1$                               | Shadwick and Keating [2002]                 |
|                               | 2                  | Sortino Ratio <sub>i</sub> = $(r_i^a - \tau) / \sqrt[2]{\text{LPM}_{2i}(\tau)}$                 | Sortino and van der Meer [1991]             |
|                               | 2                  | Upside Potential Ratio <sub>i</sub> = $\text{HPM}_{1i}(\tau) / \sqrt[2]{\text{LPM}_{2i}(\tau)}$ | Sortino, van der Meer, and Plantinga [1999] |
|                               | 3                  | Kappa 3 <sub>i</sub> = $(r_i^a - \tau) / \sqrt[3]{\text{LPM}_{3i}(\tau)}$                       | Kaplan and Knowles [2004]                   |
| Drawdown                      | Maximum            | Calmar Ratio <sub>i</sub> = $(r_i^a - r_f) / -D_{1i}$   | Young [1991]                                |
|                               | Average            | Sterling Ratio <sub>i</sub> = $(r_i^a - r_f) / \left( \frac{1}{K} \sum_{k=1}^K -D_{ik} \right)$ | Kestner [1996]                              |
|                               | Standard deviation | Burke Ratio <sub>i</sub> = $(r_i^a - r_f) / \sqrt[2]{\sum_{k=1}^K D_{ik}^2}$                    | Burke [1994]                                |
| Value at risk                 | Standard           | Excess Return on Value at Risk <sub>i</sub> = $(r_i^a - r_f) / \text{VaR}_i$                    | Dowd [2000]                                 |
|                               | Conditional        | Conditional Sharpe Ratio <sub>i</sub> = $(r_i^a - r_f) / \text{CVaR}_i$                         | Agarwal and Naik [2004]                     |
|                               | Modified           | Modified Sharpe Ratio <sub>i</sub> = $(r_i^a - r_f) / \text{MVaR}_i$                            | Gregoriou and Gueyie [2003]                 |

Notes:  $r_i^a$ : mean return  $(= 1/T \sum_{t=1}^T r_{it})$ , with:  $r_{it}$  as discrete return of fund i in month t (t = 1, ..., T) and T as number of months)

$r_f$ : (constant) risk-free interest rate

$\sigma_i$ : standard deviation  $(= \sqrt{\frac{1}{T-1} \sum_{t=1}^T (r_{it} - r_i^a)^2})$

$\text{LPM}_{in}$ : lower partial moment (LPM) of order n  $(= \frac{1}{T} \sum_{t=1}^T \max[\tau - r_{it}, 0]^n)$ , with  $\tau$  as minimal acceptable return)

$\text{HPM}_{in}$ : higher partial moment (HPM) of order n  $(= \frac{1}{T} \sum_{t=1}^T \max[r_{it} - \tau, 0]^n)$

$D_{ik}$ : drawdown of fund i

K: number of drawdowns (k = 1: maximum drawdown, k = 2: second-largest drawdown, k = 3: third-largest drawdown, ...)

$\text{VaR}_i$ : value at risk  $(= -(r_i^a + z_\alpha \cdot \sigma_i))$ , with  $z_\alpha$ :  $\alpha$ -quantile of the standard normal distribution)

$\text{CVaR}_i$ : conditional value at risk  $(= E[-r_{it} | r_{it} \leq -\text{VaR}_i])$

$\text{MVaR}_i$ : modified value at risk  $(= -(r_i^a + \sigma_i \cdot (z_\alpha + (z_\alpha^2 - 1) \cdot S_i / 6 + (z_\alpha^3 - 3 \cdot z_\alpha) \cdot E_i / 24 - (2 \cdot z_\alpha^3 - 5 \cdot z_\alpha) \cdot S_i^2 / 36)))$ , with  $S_i$  as skewness  $(= (1/T \sum_{t=1}^T (r_{it} - r_i^a)^3) / \sigma_i^3)$ , and  $E_i$  as excess kurtosis  $(= (1/T \sum_{t=1}^T (r_{it} - r_i^a)^4) / \sigma_i^4 - 3)$

**Exhibit 2: Return Distribution**

| Cross-Sectional Analysis (Across Funds)  |       |        |                    |         |         |
|--|-------|--------|--------------------|---------|---------|
| Fund   | Mean  | Median | Standard Deviation | Minimum | Maximum |
| Stocks (17,817 funds, Source: Datastream)  |       |        |                    |         |         |
| JB-rejection: 19.84% (26.73%) at 1% (5%) significance level; average correlation among funds: 0.57 |       |        |                    |         |         |
| Mean value (%)   | 0.53  | 0.49   | 1.19               | -9.52   | 9.79    |
| Standard deviation (%)   | 4.70  | 4.50   | 2.43               | 0.06    | 29.31   |
| Skewness   | -0.29 | -0.32  | 0.76               | -9.50   | 9.38    |
| Excess kurtosis  | 0.76  | 0.11   | 4.35               | -7.19   | 100.83  |
| Bonds (12,279 funds, Source: Datastream)   |       |        |                    |         |         |
| JB-rejection: 25.60% (31.89%) at 1% (5%) significance level; average correlation among funds: 0.28 |       |        |                    |         |         |
| Mean value (%)   | 0.37  | 0.34   | 0.58               | -3.94   | 6.23    |
| Standard deviation (%)   | 1.91  | 1.36   | 1.69               | 0.01    | 17.17   |
| Skewness   | -0.38 | -0.32  | 1.04               | -10.67  | 10.00   |
| Excess kurtosis  | 1.53  | 0.20   | 7.11               | -7.99   | 119.65  |
| Real Estate (751 funds, Source: Datastream)  |       |        |                    |         |         |
| JB-rejection: 45.54% (53.66%) at 1% (5%) significance level; average correlation among funds: 0.30 |       |        |                    |         |         |
| Mean value (%)   | 0.90  | 0.86   | 0.84               | -3.54   | 4.60    |
| Standard deviation (%)   | 3.49  | 3.65   | 2.44               | 0.01    | 22.77   |
| Skewness   | -0.45 | -0.53  | 1.20               | -6.77   | 6.80    |
| Excess kurtosis  | 2.44  | 1.06   | 6.45               | -5.99   | 61.93   |
| Hedge Funds (4,048 funds, Source: CISDM)   |       |        |                    |         |         |
| JB-rejection: 37.67% (43.60%) at 1% (5%) significance level; average correlation among funds: 0.16 |       |        |                    |         |         |
| Mean value (%)   | 0.97  | 0.86   | 1.48               | -18.96  | 19.58   |
| Standard deviation (%)   | 4.37  | 3.01   | 4.32               | 0.03    | 49.50   |
| Skewness   | 0.01  | 0.00   | 1.15               | -9.21   | 6.23    |
| Excess kurtosis  | 2.45  | 0.91   | 6.13               | -4.71   | 95.00   |
| Funds of Hedge Funds (1,949 funds, Source: CISDM)  |       |        |                    |         |         |
| JB-rejection: 29.66% (34.89%) at 1% (5%) significance level; average correlation among funds: 0.55 |       |        |                    |         |         |
| Mean value (%)   | 0.67  | 0.64   | 0.59               | -7.95   | 11.89   |
| Standard deviation (%)   | 1.94  | 1.43   | 1.71               | 0.06    | 21.75   |
| Skewness   | -0.26 | -0.27  | 0.96               | -8.00   | 6.60    |
| Excess kurtosis  | 1.81  | 0.39   | 5.23               | -3.99   | 79.08   |
| CTAs (1,076 funds, Source: CISDM)  |       |        |                    |         |         |
| JB-rejection: 31.42% (37.95%) at 1% (5%) significance level; average correlation among funds: 0.13 |       |        |                    |         |         |
| Mean value (%)   | 0.80  | 0.70   | 1.40               | -7.96   | 11.16   |
| Standard deviation (%)   | 5.89  | 4.78   | 4.46               | 0.01    | 35.16   |
| Skewness   | 0.28  | 0.26   | 0.87               | -3.96   | 5.87    |
| Excess kurtosis  | 1.49  | 0.59   | 3.65               | -7.14   | 40.75   |
| CPOs (1,034 funds, Source: CISDM)  |       |        |                    |         |         |
| JB-rejection: 26.86% (32.45%) at 1% (5%) significance level; average correlation among funds: 0.23 |       |        |                    |         |         |
| Mean value (%)   | 0.48  | 0.52   | 1.40               | -13.87  | 14.68   |
| Standard deviation (%)   | 5.16  | 4.48   | 3.72               | 0.07    | 35.45   |
| Skewness   | 0.16  | 0.19   | 0.87               | -4.92   | 4.61    |
| Excess kurtosis  | 1.40  | 0.45   | 4.06               | -6.90   | 33.59   |

Time-series analysis

**Exhibit 3: Attrition Rate and Survivorship Bias**

| Year    | Attrition Rate (%) |       |             |             |              |       |       | Survivorship Bias (%) |       |             |             |              |      |      |
|---------|--------------------|-------|-------------|-------------|--------------|-------|-------|-----------------------|-------|-------------|-------------|--------------|------|------|
|         | Stocks             | Bonds | Real Estate | Hedge Funds | Funds of HFs | CTAs  | CPOs  | Stocks                | Bonds | Real Estate | Hedge Funds | Funds of HFs | CTAs | CPOs |
| 1996    | 2.14               | 2.10  | 6.33        | 5.06        | 2.92         | 2.64  | 14.10 | 0.00                  | 0.00  | 0.02        | 0.07        | 0.02         | 0.02 | 0.10 |
| 1997    | 2.72               | 3.97  | 1.05        | 10.79       | 5.01         | 15.62 | 20.22 | 0.00                  | -0.01 | 0.00        | 0.05        | 0.02         | 0.10 | 0.07 |
| 1998    | 4.17               | 5.43  | 0.00        | 13.81       | 8.01         | 22.26 | 18.82 | 0.00                  | 0.00  | 0.00        | 0.17        | 0.03         | 0.25 | 0.16 |
| 1999    | 5.34               | 7.46  | 6.11        | 14.42       | 6.75         | 17.94 | 22.47 | 0.02                  | 0.00  | 0.01        | 0.13        | 0.02         | 0.07 | 0.07 |
| 2000    | 3.52               | 5.22  | 6.03        | 11.00       | 7.49         | 19.42 | 15.58 | 0.00                  | 0.01  | -0.01       | 0.06        | 0.02         | 0.23 | 0.18 |
| 2001    | 6.17               | 9.09  | 5.60        | 12.54       | 8.46         | 13.82 | 14.62 | 0.02                  | 0.01  | 0.00        | 0.10        | 0.03         | 0.07 | 0.07 |
| 2002    | 9.15               | 9.25  | 5.17        | 12.61       | 4.24         | 10.48 | 17.01 | 0.01                  | 0.00  | 0.00        | 0.09        | 0.01         | 0.08 | 0.13 |
| 2003    | 9.17               | 8.29  | 6.78        | 12.21       | 4.85         | 11.81 | 19.63 | 0.03                  | 0.00  | 0.02        | 0.05        | 0.01         | 0.08 | 0.02 |
| 2004    | 7.35               | 7.45  | 3.48        | 13.23       | 7.90         | 13.43 | 12.54 | 0.02                  | 0.01  | 0.01        | 0.05        | 0.01         | 0.07 | 0.02 |
| 2005    | 7.90               | 8.95  | 6.30        | 14.80       | 7.88         | 18.74 | 18.96 | 0.03                  | 0.01  | 0.01        | 0.05        | 0.01         | 0.06 | 0.07 |
| Average | 5.76               | 6.72  | 4.68        | 12.05       | 6.35         | 14.62 | 17.40 | 0.01                  | 0.00  | 0.00        | 0.08        | 0.02         | 0.10 | 0.09 |

**Exhibit 4: Rank Correlation Based on Different Performance Measures**

| Performance Measure                                 | Stocks | Bonds | Real Estate | Hedge Funds | Funds of Hedge Funds | CTAs | CPOs |
|---|--------|-------|-------------|-------------|----------------------|------|------|
| Rank correlation of the Sharpe ratio in relation to |        |       |             |             |                      |      |      |
| Omega   | 1.00   | 0.99  | 0.98        | 0.99        | 0.99                 | 1.00 | 1.00 |
| Sortino ratio                                       | 1.00   | 1.00  | 0.98        | 0.99        | 0.99                 | 1.00 | 1.00 |
| Kappa 3   | 1.00   | 1.00  | 0.98        | 0.98        | 0.98                 | 0.99 | 1.00 |
| Upside potential ratio                              | 0.98   | 0.97  | 0.95        | 0.96        | 0.95                 | 0.95 | 0.96 |
| Calmar ratio  | 0.99   | 0.95  | 0.96        | 0.95        | 0.93                 | 0.98 | 0.98 |
| Sterling ratio                                      | 0.98   | 0.95  | 0.94        | 0.94        | 0.91                 | 0.96 | 0.97 |
| Burke ratio   | 0.99   | 0.95  | 0.95        | 0.95        | 0.93                 | 0.98 | 0.98 |
| Excess return on value at risk                      | 0.97   | 0.95  | 0.96        | 1.00        | 0.99                 | 0.97 | 0.99 |
| Conditional Sharpe ratio                            | 0.98   | 0.97  | 0.96        | 0.98        | 0.97                 | 0.98 | 0.99 |
| Modified Sharpe ratio                               | 1.00   | 0.99  | 0.97        | 0.97        | 0.97                 | 0.99 | 0.99 |
| Average   | 0.99   | 0.97  | 0.96        | 0.97        | 0.96                 | 0.98 | 0.99 |

**Exhibit 5: Results of Robustness Tests (Stocks)**

| Performance measure      | Basic Results | Robustness Test                                  |              |              |              |              | b) Parameters  |  |  | c) Outliers  | d) Bias  |   |
|--------------------------|---------------|--|--------------|--------------|--------------|--------------|--|--|--|--|--|---|
|                          |               | a) Investigation Period                          |              |              |              |              |  |  |  |  |  |   |
|                          |               | 1996 to 1997                                     | 1998 to 1999 | 2000 to 2001 | 2002 to 2003 | 2004 to 2005 | Variation of minimal acceptable return between 0 and 1%* | Variation of number of drawdowns between 1 and 10* | Variation of significance level between 0.01 and 0.20* | Elimination of 1 up to 10 of highest and lowest returns* | Separate consideration of surviving funds (N = 13,039) | Separate consideration of dissolved funds (N = 4,778) |
|                          |               | Rank correlation in relation to the Sharpe ratio |              |              |              |              |  |  |  |  |  |   |
| Omega                    | 1.00          | 1.00   | 0.99         | 0.99         | 1.00         | 1.00         | 1.00   | /  | /  | 1.00   | 1.00   | 1.00  |
| Sortino ratio            | 1.00          | 0.99   | 0.99         | 0.99         | 1.00         | 0.99         | 1.00   | /  | /  | 1.00   | 1.00   | 1.00  |
| Kappa 3                  | 1.00          | 0.99   | 0.98         | 0.99         | 1.00         | 0.99         | 1.00   | /  | /  | 1.00   | 1.00   | 1.00  |
| Upside potential ratio   | 0.98          | 0.97   | 0.97         | 0.94         | 0.97         | 0.97         | 0.95   | /  | /  | 0.99   | 0.97   | 0.96  |
| Calmar ratio             | 0.99          | 0.97   | 0.97         | 0.85         | 0.98         | 0.95         | /  | 0.99   | /  | 0.99   | 0.98   | 0.97  |
| Sterling ratio           | 0.98          | 0.95   | 0.96         | 0.85         | 0.99         | 0.95         | /  | 0.98   | /  | 0.99   | 0.98   | 0.97  |
| Burke ratio              | 0.99          | 0.96   | 0.97         | 0.88         | 0.99         | 0.97         | /  | 0.99   | /  | 0.99   | 0.98   | 0.97  |
| Excess return on VaR     | 0.97          | 0.99   | 1.00         | 1.00         | 0.99         | 0.99         | /  | /  | 1.00   | 0.98   | 0.97   | 1.00  |
| Conditional Sharpe ratio | 0.98          | 0.99   | 0.97         | 0.97         | 0.99         | 0.96         | /  | /  | 0.98   | 0.97   | 0.98   | 0.99  |
| Modified Sharpe ratio    | 1.00          | 0.99   | 0.99         | 0.99         | 1.00         | 0.99         | /  | /  | 0.99   | 0.99   | 0.99   | 0.99  |
| Average                  | 0.99          | 0.98   | 0.98         | 0.95         | 0.99         | 0.98         | /  | /  | /  | 0.99   | 0.99   | 0.98  |

\*The rank correlations presented in the table are average values above different robustness tests.

**Exhibit 6: Rank Correlation for Different Strategy Groups**

|                                   |                               | Rank correlation of the Sharpe ratio in relation to |       |               |         |                        |              |                |             |                                |                          |                       |         |
|-----------------------------------|-------------------------------|---|-------|---------------|---------|------------------------|--------------|----------------|-------------|--------------------------------|--------------------------|-----------------------|---------|
|                                   |                               | Number of funds                                     | Omega | Sortino ratio | Kappa 3 | Upside potential ratio | Calmar ratio | Sterling ratio | Burke ratio | Excess return on value at risk | Conditional Sharpe ratio | Modified Sharpe ratio | Average |
| <b>Hedge Funds (4,048 funds)</b>  |                               |   |       |               |         |                        |              |                |             |                                |                          |                       |         |
|                                   | Convertible Arbitrage         | 195   | 1.00  | 0.99          | 0.99    | 0.97                   | 0.93         | 0.92           | 0.93        | 0.99                           | 0.99                     | 0.98                  | 0.97    |
|                                   | Distressed Securities         | 141   | 0.99  | 0.98          | 0.97    | 0.95                   | 0.91         | 0.91           | 0.92        | 1.00                           | 0.98                     | 0.96                  | 0.96    |
|                                   | Emerging Markets              | 378   | 0.99  | 0.99          | 0.99    | 0.95                   | 0.97         | 0.96           | 0.97        | 1.00                           | 0.98                     | 0.98                  | 0.98    |
|                                   | Equity Long Only              | 84  | 0.99  | 0.99          | 0.98    | 0.96                   | 0.97         | 0.95           | 0.96        | 0.99                           | 0.98                     | 0.98                  | 0.98    |
|                                   | Equity Long/Short             | 1553  | 0.99  | 0.99          | 0.98    | 0.96                   | 0.95         | 0.93           | 0.95        | 1.00                           | 0.98                     | 0.97                  | 0.97    |
|                                   | Equity Market Neutral         | 231   | 1.00  | 1.00          | 0.99    | 0.97                   | 0.97         | 0.97           | 0.97        | 1.00                           | 0.99                     | 0.99                  | 0.98    |
|                                   | Event Driven Multi Strategy   | 155   | 0.99  | 0.98          | 0.97    | 0.94                   | 0.88         | 0.88           | 0.89        | 1.00                           | 0.95                     | 0.95                  | 0.94    |
|                                   | Fixed Income                  | 107   | 1.00  | 0.99          | 0.99    | 0.98                   | 0.96         | 0.96           | 0.96        | 0.99                           | 0.99                     | 0.98                  | 0.98    |
|                                   | Fixed Income - MBS            | 72  | 0.97  | 0.98          | 0.97    | 0.93                   | 0.93         | 0.95           | 0.94        | 0.98                           | 0.97                     | 0.96                  | 0.96    |
|                                   | Fixed Income Arbitrage        | 158   | 0.99  | 0.99          | 0.99    | 0.95                   | 0.96         | 0.96           | 0.96        | 0.99                           | 0.98                     | 0.98                  | 0.97    |
|                                   | Global Macro                  | 207   | 0.99  | 0.99          | 0.99    | 0.96                   | 0.97         | 0.96           | 0.97        | 1.00                           | 0.99                     | 0.98                  | 0.98    |
|                                   | Merger Arbitrage              | 120   | 0.99  | 0.99          | 0.98    | 0.96                   | 0.94         | 0.93           | 0.94        | 0.99                           | 0.94                     | 0.97                  | 0.96    |
|                                   | Multi Strategy                | 72  | 0.97  | 0.95          | 0.94    | 0.92                   | 0.84         | 0.84           | 0.84        | 1.00                           | 0.96                     | 0.89                  | 0.91    |
|                                   | No Strategy                   | 59  | 1.00  | 0.99          | 0.99    | 0.97                   | 0.97         | 0.96           | 0.97        | 0.99                           | 0.97                     | 0.99                  | 0.98    |
|                                   | Other*                        | 60  | 0.99  | 0.98          | 0.98    | 0.98                   | 0.92         | 0.92           | 0.92        | 0.93                           | 0.94                     | 0.93                  | 0.95    |
|                                   | Relative Value Multi Strategy | 72  | 0.98  | 0.95          | 0.93    | 0.92                   | 0.90         | 0.92           | 0.91        | 0.97                           | 0.95                     | 0.93                  | 0.94    |
|                                   | Sector                        | 342   | 0.99  | 0.98          | 0.98    | 0.94                   | 0.95         | 0.92           | 0.95        | 1.00                           | 0.98                     | 0.95                  | 0.96    |
|                                   | Short Bias                    | 42  | 1.00  | 1.00          | 1.00    | 0.96                   | 0.99         | 0.98           | 0.99        | 1.00                           | 0.99                     | 1.00                  | 0.99    |
|                                   | All                           | 4048  | 0.99  | 0.99          | 0.98    | 0.96                   | 0.95         | 0.94           | 0.95        | 1.00                           | 0.98                     | 0.97                  | 0.97    |
| <b>Stock Funds (17,817 funds)</b> |                               |   |       |               |         |                        |              |                |             |                                |                          |                       |         |
|                                   | Value                         | 1944  | 1.00  | 1.00          | 1.00    | 0.97                   | 0.98         | 0.98           | 0.99        | 0.95                           | 0.98                     | 1.00                  | 0.98    |
| Fund Investment Style             | Growth                        | 3310  | 1.00  | 1.00          | 1.00    | 0.97                   | 0.99         | 0.99           | 0.99        | 0.98                           | 0.98                     | 1.00                  | 0.99    |
|                                   | Other                         | 12563   | 1.00  | 1.00          | 1.00    | 0.97                   | 0.98         | 0.98           | 0.98        | 0.97                           | 0.98                     | 1.00                  | 0.98    |
| Market Capitalization             | Large                         | 1414  | 1.00  | 1.00          | 1.00    | 0.97                   | 0.98         | 0.99           | 0.99        | 0.90                           | 0.90                     | 1.00                  | 0.97    |
|                                   | Small                         | 2026  | 1.00  | 1.00          | 1.00    | 0.97                   | 0.98         | 0.98           | 0.98        | 0.96                           | 0.99                     | 1.00                  | 0.99    |
|                                   | Other                         | 14377   | 1.00  | 1.00          | 1.00    | 0.97                   | 0.98         | 0.98           | 0.98        | 0.98                           | 0.99                     | 1.00                  | 0.99    |
|                                   | US-\$                         | 7242  | 1.00  | 1.00          | 1.00    | 0.97                   | 0.99         | 0.98           | 0.99        | 1.00                           | 1.00                     | 1.00                  | 0.99    |
| Currency                          | Europe                        | 5156  | 1.00  | 1.00          | 1.00    | 0.98                   | 0.99         | 0.99           | 0.99        | 0.92                           | 0.97                     | 1.00                  | 0.98    |
|                                   | Other                         | 5419  | 1.00  | 1.00          | 1.00    | 0.97                   | 0.99         | 0.98           | 0.99        | 0.98                           | 0.97                     | 0.99                  | 0.99    |
|                                   | All                           | 17817   | 1.00  | 1.00          | 1.00    | 0.98                   | 0.99         | 0.98           | 0.99        | 0.97                           | 0.98                     | 1.00                  | 0.99    |
| <b>Bond Funds (12,279 funds)</b>  |                               |   |       |               |         |                        |              |                |             |                                |                          |                       |         |
|                                   | Government                    | 534   | 0.98  | 1.00          | 1.00    | 0.95                   | 0.86         | 0.87           | 0.87        | 0.99                           | 0.98                     | 0.98                  | 0.95    |
| Fund Investment Style             | Corporate                     | 459   | 1.00  | 1.00          | 1.00    | 0.98                   | 0.96         | 0.96           | 0.97        | 0.99                           | 0.99                     | 0.99                  | 0.98    |
|                                   | Mixed                         | 11286   | 0.99  | 1.00          | 1.00    | 0.97                   | 0.95         | 0.96           | 0.96        | 0.96                           | 0.97                     | 0.99                  | 0.97    |
|                                   | US-\$                         | 4079  | 0.99  | 1.00          | 0.99    | 0.95                   | 0.89         | 0.90           | 0.90        | 0.99                           | 0.98                     | 0.99                  | 0.96    |
| Currency                          | Euro                          | 4656  | 0.99  | 1.00          | 1.00    | 0.96                   | 0.96         | 0.97           | 0.97        | 0.90                           | 0.96                     | 0.99                  | 0.97    |
|                                   | Other                         | 3544  | 1.00  | 1.00          | 1.00    | 0.97                   | 0.97         | 0.97           | 0.98        | 0.96                           | 0.96                     | 0.99                  | 0.98    |
|                                   | All                           | 12279   | 0.99  | 1.00          | 1.00    | 0.97                   | 0.95         | 0.95           | 0.95        | 0.95                           | 0.97                     | 0.99                  | 0.97    |

\*: The CISDM database contains information on 22 different strategy groups, but due to an insufficient number of funds, we combined the hedge fund strategies Capital Structure Arbitrage, Market Timing, Option Arbitrage, Other Relative Value, and Regulation D into one new hedge fund strategy—Other.

**Exhibit 7: Best Fit Analysis**

|                      | Logistic | Weibull | Normal | Generalized beta | Loglogistic | Lognormal | Other  |
|----------------------|----------|---------|--------|------------------|-------------|-----------|--------|
| Stock Funds          | 30.18%   | 26.96%  | 12.27% | 8.05%            | 3.22%       | 0.80%     | 18.51% |
| Bond Funds           | 37.12%   | 18.06%  | 13.38% | 13.71%           | 3.01%       | 1.34%     | 13.38% |
| Real Estate Funds    | 40.40%   | 14.52%  | 11.85% | 14.36%           | 9.68%       | 0.83%     | 8.35%  |
| Hedge Funds          | 36.75%   | 8.43%   | 11.45% | 7.63%            | 15.66%      | 1.20%     | 18.88% |
| Funds of Hedge Funds | 37.40%   | 11.19%  | 10.35% | 7.68%            | 12.52%      | 1.34%     | 19.53% |
| CTAs                 | 30.87%   | 5.70%   | 10.40% | 4.70%            | 23.32%      | 1.51%     | 23.49% |
| CPOs                 | 30.25%   | 7.56%   | 11.76% | 5.38%            | 20.17%      | 2.18%     | 22.69% |

**Exhibit 8: Simulation Analysis**

| Distribution                        | Normal  | Lognormal*  | Logistic                         | Weibull*  | Generalized beta   |
|-------------------------------------|---|---|----------------------------------|---|--|
| @RISK function                      | RiskNormal<br>(0.0053; 0.047)                 | RiskLognorm<br>(0.1;0.047;Risk<br>Shift(-0.0947)) | RiskLogistic<br>(0.0053;0.02559) | RiskWeibull<br>8.1842;0.34282;<br>RiskShift(-<br>0.31787) | RiskBetaGeneral<br>(9.2401; 3.4794; -<br>0.2782; 0.1121) |
| Mean value (%)                      | 0.53%   | 0.53%   | 0.53%                            | 0.53%   | 0.53%  |
| Standard deviation (%)              | 4.70%   | 4.70%   | 4.70%                            | 4.70%   | 4.70%  |
| Skewness                            | 0.00  | 1.43  | 0.02                             | -0.54   | -0.51  |
| Excess kurtosis                     | -0.04   | 3.69  | 1.12                             | 0.34  | -0.05  |
| JB-rejection at 1% (5%) sign. level | 0.80% (1.50%)                                 | 100% (100%)                                       | 25.50%<br>(34.80%)               | 17.40% (40.10%)   | 6.30% (21.20%)   |
| Performance measures                | Rank correlation compared to the Sharpe ratio |   |                                  |   |  |
| Omega                               | 1.00  | 1.00  | 1.00                             | 1.00  | 1.00   |
| Sortino ratio                       | 1.00  | 1.00  | 1.00                             | 1.00  | 1.00   |
| Kappa 3                             | 1.00  | 1.00  | 1.00                             | 1.00  | 1.00   |
| Upside potential ratio              | 0.96  | 1.00  | 0.95                             | 0.97  | 0.98   |
| Calmar ratio                        | 0.39  | 0.59  | 0.59                             | 0.42  | 0.40   |
| Sterling ratio                      | 0.42  | 0.66  | 0.63                             | 0.46  | 0.38   |
| Burke ratio                         | 0.53  | 0.75  | 0.73                             | 0.56  | 0.54   |
| Excess return on VaR                | 1.00  | 1.00  | 1.00                             | 1.00  | 1.00   |
| Conditional Sharpe ratio            | 0.98  | 0.93  | 0.99                             | 0.99  | 0.99   |
| Modified Sharpe ratio               | 1.00  | 0.99  | 1.00                             | 1.00  | 1.00   |

\*: To generate negative returns, we needed to shift the lognormal and Weibull distributions.

## Appendix

### Exhibit A1: Backfilling Bias

| Year   | Mean monthly return | Difference | Total number of funds |
|--|---------------------|------------|-----------------------|
| <b>Stocks (17,817 funds, Source: Datastream)</b>         |                     |            |                       |
| All months   | 0.53%               |            | 17817                 |
| Without first 12 months                                  | 0.56%               | -0.03%     | 15739                 |
| Without first 24 months                                  | 0.65%               | -0.12%     | 12998                 |
| Without first 36 months                                  | 0.63%               | -0.10%     | 10505                 |
| Without first 48 months                                  | 0.57%               | -0.04%     | 8371                  |
| Without first 60 months                                  | 0.63%               | -0.10%     | 6200                  |
| <b>Bonds (12,279 funds, Source: Datastream)</b>          |                     |            |                       |
| All months   | 0.37%               |            | 12,279                |
| Without first 12 months                                  | 0.37%               | 0.00%      | 10,502                |
| Without first 24 months                                  | 0.39%               | -0.01%     | 8,713                 |
| Without first 36 months                                  | 0.38%               | 0.00%      | 7,116                 |
| Without first 48 months                                  | 0.33%               | 0.04%      | 5,636                 |
| Without first 60 months                                  | 0.32%               | 0.05%      | 4,252                 |
| <b>Real Estate (751 funds, Source: Datastream)</b>       |                     |            |                       |
| All months   | 0.89%               |            | 751                   |
| Without first 12 months                                  | 0.84%               | 0.05%      | 607                   |
| Without first 24 months                                  | 0.75%               | 0.13%      | 502                   |
| Without first 36 months                                  | 0.76%               | 0.13%      | 402                   |
| Without first 48 months                                  | 0.70%               | 0.19%      | 306                   |
| Without first 60 months                                  | 0.95%               | -0.06%     | 236                   |
| <b>Hedge Funds (4,048 funds, Source: CISDM)</b>          |                     |            |                       |
| All months   | 0.97%               |            | 4,048                 |
| Without first 12 months                                  | 0.72%               | 0.25%      | 3,550                 |
| Without first 24 months                                  | 0.55%               | 0.41%      | 2,863                 |
| Without first 36 months                                  | 0.67%               | 0.30%      | 2,263                 |
| Without first 48 months                                  | 0.53%               | 0.43%      | 1,687                 |
| Without first 60 months                                  | 0.63%               | 0.34%      | 1,298                 |
| <b>Funds of Hedge Funds (1,949 funds, Source: CISDM)</b> |                     |            |                       |
| All months   | 0.67%               |            | 1,949                 |
| Without first 12 months                                  | 0.66%               | 0.02%      | 1,734                 |
| Without first 24 months                                  | 0.63%               | 0.05%      | 1,323                 |
| Without first 36 months                                  | 0.65%               | 0.02%      | 1,018                 |
| Without first 48 months                                  | 0.57%               | 0.11%      | 773                   |
| Without first 60 months                                  | 0.57%               | 0.10%      | 574                   |
| <b>CTAs (1,076 funds, Source: CISDM)</b>                 |                     |            |                       |
| All months   | 0.80%               |            | 1,076                 |
| Without first 12 months                                  | 0.48%               | 0.32%      | 968                   |
| Without first 24 months                                  | 0.31%               | 0.49%      | 759                   |
| Without first 36 months                                  | 0.32%               | 0.48%      | 593                   |
| Without first 48 months                                  | 0.36%               | 0.44%      | 459                   |
| Without first 60 months                                  | 0.40%               | 0.40%      | 351                   |
| <b>CPOs (1,034 funds, Source: CISDM)</b>                 |                     |            |                       |
| All months   | 0.48%               |            | 1,034                 |
| Without first 12 months                                  | 0.33%               | 0.15%      | 902                   |
| Without first 24 months                                  | 0.26%               | 0.21%      | 726                   |
| Without first 36 months                                  | 0.32%               | 0.15%      | 551                   |
| Without first 48 months                                  | 0.38%               | 0.10%      | 414                   |
| Without first 60 months                                  | 0.39%               | 0.08%      | 338                   |

**Exhibit A2: Rank Correlation Based on Different Performance Measures**

| Performance measure            | Sharpe Ratio | Omega | Sortino Ratio | Kappa 3 | Upside Potential Ratio | Calmar Ratio | Sterling Ratio | Burke Ratio | Excess Return on Value at Risk | Conditional Sharpe Ratio | Modified Sharpe Ratio |
|--------------------------------|--------------|-------|---------------|---------|------------------------|--------------|----------------|-------------|--------------------------------|--------------------------|-----------------------|
| <b>Stocks (17,817 funds)</b>   |              |       |               |         |                        |              |                |             |                                |                          |                       |
| Sharpe ratio                   |              | 1.00  | 1.00          | 1.00    | 0.98                   | 0.99         | 0.98           | 0.99        | 0.97                           | 0.98                     | 1.00                  |
| Omega                          | 1.00         |       | 1.00          | 1.00    | 0.98                   | 0.99         | 0.99           | 0.99        | 0.97                           | 0.98                     | 1.00                  |
| Sortino ratio                  | 1.00         | 1.00  |               | 1.00    | 0.98                   | 0.99         | 0.99           | 0.99        | 0.97                           | 0.98                     | 1.00                  |
| Kappa 3                        | 1.00         | 1.00  | 1.00          |         | 0.98                   | 0.99         | 0.99           | 0.99        | 0.97                           | 0.98                     | 1.00                  |
| Upside potential ratio         | 0.98         | 0.98  | 0.98          | 0.98    |                        | 0.97         | 0.97           | 0.97        | 0.94                           | 0.96                     | 0.97                  |
| Calmar ratio                   | 0.99         | 0.99  | 0.99          | 0.99    | 0.97                   |              | 1.00           | 1.00        | 0.99                           | 0.99                     | 0.99                  |
| Sterling ratio                 | 0.98         | 0.99  | 0.99          | 0.99    | 0.97                   | 1.00         |                | 1.00        | 0.98                           | 0.99                     | 0.99                  |
| Burke ratio                    | 0.99         | 0.99  | 0.99          | 0.99    | 0.97                   | 1.00         | 1.00           |             | 0.99                           | 0.99                     | 0.99                  |
| Excess return on value at risk | 0.97         | 0.97  | 0.97          | 0.97    | 0.94                   | 0.99         | 0.98           | 0.99        |                                | 0.99                     | 0.97                  |
| Conditional Sharpe ratio       | 0.98         | 0.98  | 0.98          | 0.98    | 0.96                   | 0.99         | 0.99           | 0.99        | 0.99                           |                          | 0.98                  |
| Modified Sharpe ratio          | 1.00         | 1.00  | 1.00          | 1.00    | 0.97                   | 0.99         | 0.99           | 0.99        | 0.97                           | 0.98                     |                       |
| Average                        | 0.99         | 0.99  | 0.99          | 0.99    | 0.97                   | 0.99         | 0.99           | 0.99        | 0.97                           | 0.98                     | 0.99                  |
| <b>Bonds (12,279 funds)</b>    |              |       |               |         |                        |              |                |             |                                |                          |                       |
| Sharpe ratio                   |              | 0.99  | 1.00          | 1.00    | 0.97                   | 0.95         | 0.95           | 0.95        | 0.95                           | 0.97                     | 0.99                  |
| Omega                          | 0.99         |       | 0.99          | 0.99    | 0.98                   | 0.94         | 0.95           | 0.95        | 0.94                           | 0.96                     | 0.99                  |
| Sortino ratio                  | 1.00         | 0.99  |               | 1.00    | 0.96                   | 0.95         | 0.96           | 0.96        | 0.95                           | 0.97                     | 0.99                  |
| Kappa 3                        | 1.00         | 0.99  | 1.00          |         | 0.95                   | 0.95         | 0.96           | 0.96        | 0.94                           | 0.98                     | 0.99                  |
| Upside potential ratio         | 0.97         | 0.98  | 0.96          | 0.95    |                        | 0.91         | 0.92           | 0.92        | 0.92                           | 0.92                     | 0.95                  |
| Calmar ratio                   | 0.95         | 0.94  | 0.95          | 0.95    | 0.91                   |              | 0.98           | 1.00        | 0.95                           | 0.95                     | 0.95                  |
| Sterling ratio                 | 0.95         | 0.95  | 0.96          | 0.96    | 0.92                   | 0.98         |                | 0.99        | 0.95                           | 0.96                     | 0.96                  |
| Burke ratio                    | 0.95         | 0.95  | 0.96          | 0.96    | 0.92                   | 1.00         | 0.99           |             | 0.95                           | 0.96                     | 0.96                  |
| Excess return on value at risk | 0.95         | 0.94  | 0.95          | 0.94    | 0.92                   | 0.95         | 0.95           | 0.95        |                                | 0.98                     | 0.94                  |
| Conditional Sharpe ratio       | 0.97         | 0.96  | 0.97          | 0.98    | 0.92                   | 0.95         | 0.96           | 0.96        | 0.98                           |                          | 0.97                  |
| Modified Sharpe ratio          | 0.99         | 0.99  | 0.99          | 0.99    | 0.95                   | 0.95         | 0.96           | 0.96        | 0.94                           | 0.97                     |                       |
| Average                        | 0.97         | 0.97  | 0.97          | 0.97    | 0.94                   | 0.95         | 0.96           | 0.96        | 0.95                           | 0.96                     | 0.97                  |
| <b>Real Estate (751 funds)</b> |              |       |               |         |                        |              |                |             |                                |                          |                       |
| Sharpe ratio                   |              | 0.98  | 0.98          | 0.98    | 0.95                   | 0.96         | 0.94           | 0.95        | 0.96                           | 0.96                     | 0.97                  |
| Omega                          | 0.98         |       | 0.99          | 0.98    | 0.95                   | 0.96         | 0.94           | 0.95        | 0.94                           | 0.94                     | 0.98                  |
| Sortino ratio                  | 0.98         | 0.99  |               | 1.00    | 0.97                   | 0.97         | 0.95           | 0.96        | 0.94                           | 0.96                     | 0.98                  |
| Kappa 3                        | 0.98         | 0.98  | 1.00          |         | 0.98                   | 0.97         | 0.95           | 0.97        | 0.94                           | 0.96                     | 0.98                  |
| Upside potential ratio         | 0.95         | 0.95  | 0.97          | 0.98    |                        | 0.94         | 0.92           | 0.94        | 0.91                           | 0.95                     | 0.95                  |
| Calmar ratio                   | 0.96         | 0.96  | 0.97          | 0.97    | 0.94                   |              | 0.99           | 1.00        | 0.96                           | 0.96                     | 0.95                  |
| Sterling ratio                 | 0.94         | 0.94  | 0.95          | 0.95    | 0.92                   | 0.99         |                | 1.00        | 0.94                           | 0.95                     | 0.94                  |
| Burke ratio                    | 0.95         | 0.95  | 0.96          | 0.97    | 0.94                   | 1.00         | 1.00           |             | 0.95                           | 0.96                     | 0.95                  |
| Excess return on value at risk | 0.96         | 0.94  | 0.94          | 0.94    | 0.91                   | 0.96         | 0.94           | 0.95        |                                | 0.98                     | 0.94                  |
| Conditional Sharpe ratio       | 0.96         | 0.94  | 0.96          | 0.96    | 0.95                   | 0.96         | 0.95           | 0.96        | 0.98                           |                          | 0.94                  |
| Modified Sharpe ratio          | 0.97         | 0.98  | 0.98          | 0.98    | 0.95                   | 0.95         | 0.94           | 0.95        | 0.94                           | 0.94                     |                       |
| Average                        | 0.96         | 0.96  | 0.97          | 0.97    | 0.95                   | 0.96         | 0.95           | 0.96        | 0.95                           | 0.96                     | 0.96                  |



**Exhibit A2: Rank Correlation Based on Different Performance Measures (continued)**

| Performance measure                       | Sharpe Ratio | Omega | Sortino Ratio | Kappa 3 | Upside Potential Ratio | Calmar Ratio | Sterling Ratio | Burke Ratio | Excess Return on Value at Risk | Conditional Sharpe Ratio | Modified Sharpe Ratio |
|---|--------------|-------|---------------|---------|------------------------|--------------|----------------|-------------|--------------------------------|--------------------------|-----------------------|
| <b>Hedge Funds (4,048 funds)</b>          |              |       |               |         |                        |              |                |             |                                |                          |                       |
| Sharpe ratio                              |              | 0.99  | 0.99          | 0.98    | 0.96                   | 0.95         | 0.94           | 0.95        | 1.00                           | 0.98                     | 0.97                  |
| Omega                                     | 0.99         |       | 0.99          | 0.98    | 0.95                   | 0.94         | 0.93           | 0.95        | 0.99                           | 0.97                     | 0.98                  |
| Sortino ratio                             | 0.99         | 0.99  |               | 1.00    | 0.98                   | 0.96         | 0.94           | 0.96        | 0.98                           | 0.98                     | 0.99                  |
| Kappa 3                                   | 0.98         | 0.98  | 1.00          |         | 0.99                   | 0.97         | 0.95           | 0.97        | 0.98                           | 0.99                     | 0.98                  |
| Upside potential ratio                    | 0.96         | 0.95  | 0.98          | 0.99    |                        | 0.95         | 0.93           | 0.95        | 0.95                           | 0.97                     | 0.96                  |
| Calmar ratio                              | 0.95         | 0.94  | 0.96          | 0.97    | 0.95                   |              | 0.98           | 1.00        | 0.95                           | 0.97                     | 0.94                  |
| Sterling ratio                            | 0.94         | 0.93  | 0.94          | 0.95    | 0.93                   | 0.98         |                | 0.99        | 0.94                           | 0.95                     | 0.93                  |
| Burke ratio                               | 0.95         | 0.95  | 0.96          | 0.97    | 0.95                   | 1.00         | 0.99           |             | 0.96                           | 0.97                     | 0.94                  |
| Excess return on value at risk            | 1.00         | 0.99  | 0.98          | 0.98    | 0.95                   | 0.95         | 0.94           | 0.96        |                                | 0.98                     | 0.97                  |
| Conditional Sharpe ratio                  | 0.98         | 0.97  | 0.98          | 0.99    | 0.97                   | 0.97         | 0.95           | 0.97        | 0.98                           |                          | 0.97                  |
| Modified Sharpe ratio                     | 0.97         | 0.98  | 0.99          | 0.98    | 0.96                   | 0.94         | 0.93           | 0.94        | 0.97                           | 0.97                     |                       |
| Average                                   | 0.97         | 0.97  | 0.98          | 0.98    | 0.96                   | 0.96         | 0.95           | 0.96        | 0.97                           | 0.97                     | 0.96                  |
| <b>Funds of Hedge Funds (1,949 funds)</b> |              |       |               |         |                        |              |                |             |                                |                          |                       |
| Sharpe ratio                              |              | 0.99  | 0.99          | 0.98    | 0.95                   | 0.93         | 0.91           | 0.93        | 0.99                           | 0.97                     | 0.97                  |
| Omega                                     | 0.99         |       | 0.99          | 0.98    | 0.95                   | 0.91         | 0.90           | 0.91        | 0.98                           | 0.95                     | 0.98                  |
| Sortino ratio                             | 0.99         | 0.99  |               | 1.00    | 0.98                   | 0.93         | 0.91           | 0.94        | 0.97                           | 0.97                     | 0.99                  |
| Kappa 3                                   | 0.98         | 0.98  | 1.00          |         | 0.99                   | 0.95         | 0.93           | 0.95        | 0.97                           | 0.98                     | 0.98                  |
| Upside potential ratio                    | 0.95         | 0.95  | 0.98          | 0.99    |                        | 0.94         | 0.91           | 0.93        | 0.94                           | 0.96                     | 0.96                  |
| Calmar ratio                              | 0.93         | 0.91  | 0.93          | 0.95    | 0.94                   |              | 0.98           | 0.99        | 0.93                           | 0.96                     | 0.92                  |
| Sterling ratio                            | 0.91         | 0.90  | 0.91          | 0.93    | 0.91                   | 0.98         |                | 0.99        | 0.92                           | 0.95                     | 0.89                  |
| Burke ratio                               | 0.93         | 0.91  | 0.94          | 0.95    | 0.93                   | 0.99         | 0.99           |             | 0.93                           | 0.97                     | 0.92                  |
| Excess return on value at risk            | 0.99         | 0.98  | 0.97          | 0.97    | 0.94                   | 0.93         | 0.92           | 0.93        |                                | 0.97                     | 0.97                  |
| Conditional Sharpe ratio                  | 0.97         | 0.95  | 0.97          | 0.98    | 0.96                   | 0.96         | 0.95           | 0.97        | 0.97                           |                          | 0.95                  |
| Modified Sharpe ratio                     | 0.97         | 0.98  | 0.99          | 0.98    | 0.96                   | 0.92         | 0.89           | 0.92        | 0.97                           | 0.95                     |                       |
| Average                                   | 0.96         | 0.95  | 0.96          | 0.97    | 0.95                   | 0.95         | 0.93           | 0.95        | 0.95                           | 0.96                     | 0.95                  |
| <b>CTAs (1,076 funds)</b>                 |              |       |               |         |                        |              |                |             |                                |                          |                       |
| Sharpe ratio                              |              | 1.00  | 1.00          | 0.99    | 0.95                   | 0.98         | 0.96           | 0.98        | 0.97                           | 0.98                     | 0.99                  |
| Omega                                     | 1.00         |       | 1.00          | 0.99    | 0.95                   | 0.98         | 0.96           | 0.98        | 0.96                           | 0.98                     | 0.99                  |
| Sortino ratio                             | 1.00         | 1.00  |               | 1.00    | 0.97                   | 0.98         | 0.96           | 0.98        | 0.96                           | 0.98                     | 0.99                  |
| Kappa 3                                   | 0.99         | 0.99  | 1.00          |         | 0.97                   | 0.98         | 0.96           | 0.98        | 0.96                           | 0.99                     | 0.99                  |
| Upside potential ratio                    | 0.95         | 0.95  | 0.97          | 0.97    |                        | 0.95         | 0.92           | 0.94        | 0.92                           | 0.95                     | 0.96                  |
| Calmar ratio                              | 0.98         | 0.98  | 0.98          | 0.98    | 0.95                   |              | 0.98           | 1.00        | 0.98                           | 0.98                     | 0.97                  |
| Sterling ratio                            | 0.96         | 0.96  | 0.96          | 0.96    | 0.92                   | 0.98         |                | 0.99        | 0.96                           | 0.96                     | 0.95                  |
| Burke ratio                               | 0.98         | 0.98  | 0.98          | 0.98    | 0.94                   | 1.00         | 0.99           |             | 0.98                           | 0.98                     | 0.97                  |
| Excess return on value at risk            | 0.97         | 0.96  | 0.96          | 0.96    | 0.92                   | 0.98         | 0.96           | 0.98        |                                | 0.99                     | 0.95                  |
| Conditional Sharpe ratio                  | 0.98         | 0.98  | 0.98          | 0.99    | 0.95                   | 0.98         | 0.96           | 0.98        | 0.99                           |                          | 0.98                  |
| Modified Sharpe ratio                     | 0.99         | 0.99  | 0.99          | 0.99    | 0.96                   | 0.97         | 0.95           | 0.97        | 0.95                           | 0.98                     |                       |
| Average                                   | 0.98         | 0.98  | 0.98          | 0.98    | 0.95                   | 0.98         | 0.96           | 0.98        | 0.96                           | 0.98                     | 0.97                  |
| <b>CPOs (1,034 funds)</b>                 |              |       |               |         |                        |              |                |             |                                |                          |                       |
| Sharpe ratio                              |              | 1.00  | 1.00          | 1.00    | 0.96                   | 0.98         | 0.97           | 0.98        | 0.99                           | 0.99                     | 0.99                  |
| Omega                                     | 1.00         |       | 1.00          | 0.99    | 0.96                   | 0.98         | 0.97           | 0.98        | 0.99                           | 0.99                     | 0.99                  |
| Sortino ratio                             | 1.00         | 1.00  |               | 1.00    | 0.97                   | 0.99         | 0.97           | 0.98        | 0.99                           | 1.00                     | 0.99                  |
| Kappa 3                                   | 1.00         | 0.99  | 1.00          |         | 0.97                   | 0.99         | 0.97           | 0.98        | 0.99                           | 1.00                     | 0.99                  |
| Upside potential ratio                    | 0.96         | 0.96  | 0.97          | 0.97    |                        | 0.95         | 0.94           | 0.95        | 0.95                           | 0.96                     | 0.96                  |
| Calmar ratio                              | 0.98         | 0.98  | 0.99          | 0.99    | 0.95                   |              | 0.99           | 1.00        | 0.98                           | 0.99                     | 0.98                  |
| Sterling ratio                            | 0.97         | 0.97  | 0.97          | 0.97    | 0.94                   | 0.99         |                | 1.00        | 0.97                           | 0.97                     | 0.96                  |
| Burke ratio                               | 0.98         | 0.98  | 0.98          | 0.98    | 0.95                   | 1.00         | 1.00           |             | 0.98                           | 0.98                     | 0.97                  |
| Excess return on value at risk            | 0.99         | 0.99  | 0.99          | 0.99    | 0.95                   | 0.98         | 0.97           | 0.98        |                                | 0.99                     | 0.99                  |
| Conditional Sharpe ratio                  | 0.99         | 0.99  | 1.00          | 1.00    | 0.96                   | 0.99         | 0.97           | 0.98        | 0.99                           |                          | 0.99                  |
| Modified Sharpe ratio                     | 0.99         | 0.99  | 0.99          | 0.99    | 0.96                   | 0.98         | 0.96           | 0.97        | 0.99                           | 0.99                     |                       |
| Average                                   | 0.99         | 0.98  | 0.99          | 0.99    | 0.96                   | 0.98         | 0.97           | 0.98        | 0.98                           | 0.99                     | 0.98                  |

**Exhibit A3: Results of Robustness Tests**

| Performance measure       | Basic Results | Robustness Test a) Investigation Period          |              |              |              |              | b) Parameters  |  |  | c) Outliers  | d) Bias   |   |
|---------------------------|---------------|--|--------------|--------------|--------------|--------------|--|--|--|--|---|---|
|                           |               | 1996 to 1997                                     | 1998 to 1999 | 2000 to 2001 | 2002 to 2003 | 2004 to 2005 | Variation of minimal acceptable return between 0 and 1%* | Variation of number of drawdowns between 1 and 10* | Variation of significance level between 1 and 20%* | Elimination of 1 up to 10 of highest and lowest returns* | Separate consideration of surviving funds (number of funds) | Separate consideration of dissolved funds (number of funds) |
| Bonds (12,279 funds)      |               | Rank correlation in relation to the Sharpe ratio |              |              |              |              | (8,639 surviving) (3,640 dissolved)                      |  |  |  |   |   |
| Omega                     | 0.99          | 0.99   | 0.99         | 0.99         | 0.99         | 1.00         | 1.00   | /  | /  | 1.00   | 1.00  | 0.99  |
| Sortino ratio             | 1.00          | 1.00   | 0.99         | 1.00         | 1.00         | 0.99         | 1.00   | /  | /  | 1.00   | 1.00  | 1.00  |
| Kappa 3                   | 1.00          | 0.99   | 0.99         | 0.99         | 1.00         | 0.99         | 1.00   | /  | /  | 1.00   | 1.00  | 0.99  |
| Upside potential ratio    | 0.97          | 0.96   | 0.95         | 0.95         | 0.97         | 0.96         | 0.94   | /  | /  | 0.99   | 0.97  | 0.95  |
| Calmar ratio              | 0.95          | 0.96   | 0.97         | 0.89         | 0.99         | 0.96         | /  | 0.95   | /  | 0.96   | 0.95  | 0.93  |
| Sterling ratio            | 0.95          | 0.96   | 0.96         | 0.89         | 0.99         | 0.95         | /  | 0.95   | /  | 0.98   | 0.96  | 0.94  |
| Burke ratio               | 0.95          | 0.96   | 0.97         | 0.85         | 0.99         | 0.97         | /  | 0.95   | /  | 0.97   | 0.96  | 0.94  |
| Excess return on VaR      | 0.95          | 0.99   | 0.99         | 1.00         | 0.98         | 0.99         | /  | /  | 0.95   | 0.95   | 0.94  | 0.99  |
| Conditional Sharpe ratio  | 0.97          | 0.98   | 0.99         | 0.96         | 0.99         | 0.97         | /  | /  | 0.96   | 0.95   | 0.97  | 0.98  |
| Modified Sharpe ratio     | 0.99          | 0.99   | 0.99         | 1.00         | 1.00         | 0.99         | /  | /  | 0.99   | 0.96   | 0.99  | 0.99  |
| Average                   | 0.97          | 0.98   | 0.98         | 0.95         | 0.99         | 0.98         | /  | /  | /  | 0.98   | 0.97  | 0.97  |
| Real Estate (751 funds)   |               | Rank correlation in relation to the Sharpe ratio |              |              |              |              | (614 surviving) (137 dissolved)                          |  |  |  |   |   |
| Omega                     | 0.98          | 0.99   | 0.99         | 0.99         | 0.99         | 0.99         | 0.98   | /  | /  | 1.00   | 0.98  | 0.98  |
| Sortino ratio             | 0.98          | 0.97   | 0.98         | 0.98         | 0.98         | 0.98         | 0.98   | /  | /  | 1.00   | 0.98  | 0.99  |
| Kappa 3                   | 0.98          | 0.97   | 0.97         | 0.97         | 0.97         | 0.97         | 0.97   | /  | /  | 0.99   | 0.98  | 0.98  |
| Upside potential ratio    | 0.95          | 0.93   | 0.94         | 0.93         | 0.92         | 0.93         | 0.88   | /  | /  | 0.99   | 0.95  | 0.93  |
| Calmar ratio              | 0.96          | 0.93   | 0.93         | 0.93         | 0.93         | 0.93         | /  | 0.96   | /  | 0.94   | 0.96  | 0.97  |
| Sterling ratio            | 0.94          | 0.88   | 0.90         | 0.85         | 0.90         | 0.91         | /  | 0.94   | /  | 0.95   | 0.94  | 0.97  |
| Burke ratio               | 0.95          | 0.91   | 0.92         | 0.88         | 0.91         | 0.91         | /  | 0.95   | /  | 0.95   | 0.95  | 0.97  |
| Excess return on VaR      | 0.96          | 1.00   | 1.00         | 0.99         | 0.99         | 1.00         | /  | /  | 0.95   | 0.92   | 0.96  | 0.87  |
| Conditional Sharpe ratio  | 0.96          | 0.97   | 0.98         | 0.95         | 0.96         | 0.97         | /  | /  | 0.94   | 0.91   | 0.96  | 0.93  |
| Modified Sharpe ratio     | 0.97          | 0.98   | 0.98         | 0.97         | 0.98         | 0.98         | /  | /  | 0.97   | 0.91   | 0.97  | 0.98  |
| Average                   | 0.96          | 0.95   | 0.96         | 0.94         | 0.95         | 0.96         | /  | /  | /  | 0.96   | 0.96  | 0.96  |
| Hedge Funds (4,048 funds) |               | Rank correlation in relation to the Sharpe ratio |              |              |              |              | (2099 surviving, 1949 dissolved)                         |  |  |  |   |   |
| Omega                     | 0.99          | 0.97   | 0.98         | 0.99         | 0.99         | 0.99         | 0.98   | /  | /  | 1.00   | 0.99  | 0.99  |
| Sortino ratio             | 0.99          | 0.98   | 0.99         | 0.99         | 1            | 1            | 0.99   | /  | /  | 0.99   | 0.98  | 0.99  |
| Kappa 3                   | 0.98          | 0.99   | 0.98         | 0.98         | 0.97         | 0.98         | 0.98   | /  | /  | 0.99   | 0.98  | 0.99  |
| Upside potential ratio    | 0.96          | 0.96   | 0.96         | 0.94         | 0.95         | 0.96         | 0.94   | /  | /  | 0.99   | 0.95  | 0.95  |
| Calmar ratio              | 0.95          | 0.95   | 0.96         | 0.92         | 0.94         | 0.95         | /  | 0.95   | /  | 0.95   | 0.92  | 0.97  |
| Sterling ratio            | 0.94          | 0.93   | 0.93         | 0.9          | 0.94         | 0.94         | /  | 0.94   | /  | 0.95   | 0.90  | 0.97  |
| Burke ratio               | 0.95          | 0.95   | 0.95         | 0.95         | 0.95         | 0.95         | /  | 0.95   | /  | 0.95   | 0.92  | 0.97  |
| Excess return on VaR      | 1.00          | 1.00   | 0.99         | 0.99         | 0.99         | 0.99         | /  | /  | 0.99   | 0.98   | 0.99  | 1.00  |
| Conditional Sharpe ratio  | 0.98          | 0.98   | 0.96         | 0.95         | 0.95         | 0.94         | /  | /  | 0.98   | 0.95   | 0.97  | 0.99  |
| Modified Sharpe ratio     | 0.97          | 0.97   | 0.96         | 0.97         | 0.97         | 0.97         | /  | /  | 0.97   | 0.96   | 0.96  | 0.98  |
| Average                   | 0.97          | 0.97   | 0.97         | 0.96         | 0.97         | 0.97         | /  | /  | /  | 0.97   | 0.96  | 0.98  |

\*The rank correlations presented in the table are average values above different robustness tests.

**Exhibit A3: Results of Robustness Tests (continued)**

| Performance measure       | Basic Results  | Robustness Test a) Investigation Period |              |              |              |              | b) Parameters  |  |  | c) Outliers  | d) Bias   |   |
|---------------------------|--|---|--------------|--------------|--------------|--------------|--|--|--|--|---|---|
|                           |  | 1996 to 1997                            | 1998 to 1999 | 2000 to 2001 | 2002 to 2003 | 2004 to 2005 | Variation of minimal acceptable return between 0 and 1%* | Variation of number of drawdowns between 1 and 10* | Variation of significance level between 1 and 20%* | Elimination of 1 up to 10 of highest and lowest returns* | Separate consideration of surviving funds (number of funds) | Separate consideration of dissolved funds (number of funds) |
| Funds of HF (1,949 funds) | Rank correlation in relation to the Sharpe ratio (1481 surviving, 468 dissolved) |   |              |              |              |              |  |  |  |  |   |   |
| Omega                     | 0.99   | 1.00                                    | 1.00         | 0.99         | 0.99         | 0.96         | 0.99   | /  | /  | 1.00   | 0.99  | 0.99  |
| Sortino ratio             | 0.99   | 0.98                                    | 0.99         | 0.98         | 0.96         | 0.97         | 0.98   | /  | /  | 0.99   | 0.99  | 0.99  |
| Kappa 3                   | 0.98   | 0.98                                    | 0.98         | 0.95         | 0.98         | 0.96         | 0.97   | /  | /  | 0.99   | 0.98  | 0.98  |
| Upside potential ratio    | 0.96   | 0.96                                    | 0.96         | 0.96         | 0.96         | 0.94         | 0.93   | /  | /  | 0.98   | 0.96  | 0.94  |
| Calmar ratio              | 0.93   | 0.93                                    | 0.93         | 0.90         | 0.93         | 0.93         | /  | 0.93   | /  | 0.91   | 0.92  | 0.95  |
| Sterling ratio            | 0.91   | 0.91                                    | 0.91         | 0.88         | 0.91         | 0.91         | /  | 0.92   | /  | 0.95   | 0.90  | 0.95  |
| Burke ratio               | 0.93   | 0.94                                    | 0.95         | 0.91         | 0.93         | 0.93         | /  | 0.93   | /  | 0.93   | 0.92  | 0.95  |
| Excess return on VaR      | 0.99   | 0.99                                    | 0.99         | 0.96         | 0.99         | 0.99         | /  | /  | 0.97   | 0.93   | 0.99  | 0.98  |
| Conditional Sharpe ratio  | 0.97   | 0.99                                    | 0.99         | 0.97         | 1.00         | 1.00         | /  | /  | 0.96   | 0.90   | 0.96  | 0.98  |
| Modified Sharpe ratio     | 0.97   | 0.98                                    | 0.99         | 0.94         | 0.96         | 0.95         | /  | /  | 0.94   | 0.89   | 0.97  | 0.98  |
| Average                   | 0.96   | 0.97                                    | 0.97         | 0.94         | 0.96         | 0.95         | /  | /  | /  | 0.95   | 0.96  | 0.97  |
| CTAs (1,076 funds)        | Rank correlation in relation to the Sharpe ratio (405 surviving, 671 dissolved)  |   |              |              |              |              |  |  |  |  |   |   |
| Omega                     | 1.00   | 1.00                                    | 0.99         | 0.97         | 0.99         | 0.99         | 1.00   | /  | /  | 1.00   | 1.00  | 1.00  |
| Sortino ratio             | 1.00   | 1.00                                    | 0.98         | 0.96         | 1.00         | 1.00         | 1.00   | /  | /  | 1.00   | 0.99  | 1.00  |
| Kappa 3                   | 0.99   | 0.99                                    | 0.99         | 0.99         | 0.99         | 0.99         | 0.98   | /  | /  | 1.00   | 0.99  | 0.99  |
| Upside potential ratio    | 0.95   | 0.95                                    | 0.95         | 0.95         | 0.95         | 0.95         | 0.94   | /  | /  | 0.99   | 0.94  | 0.95  |
| Calmar ratio              | 0.98   | 0.97                                    | 0.98         | 0.96         | 0.98         | 1.00         | /  | 0.98   | /  | 0.97   | 0.97  | 0.98  |
| Sterling ratio            | 0.96   | 0.95                                    | 0.96         | 0.96         | 0.96         | 0.96         | /  | 0.96   | /  | 0.99   | 0.94  | 0.97  |
| Burke ratio               | 0.98   | 0.98                                    | 0.98         | 0.96         | 0.98         | 0.98         | /  | 0.98   | /  | 0.98   | 0.96  | 0.98  |
| Excess return on VaR      | 0.97   | 0.99                                    | 0.97         | 0.97         | 0.97         | 1.00         | /  | /  | 0.97   | 0.96   | 1.00  | 0.95  |
| Conditional Sharpe ratio  | 0.98   | 0.98                                    | 0.98         | 0.93         | 0.98         | 0.98         | /  | /  | 0.98   | 0.94   | 0.99  | 0.98  |
| Modified Sharpe ratio     | 0.99   | 0.99                                    | 1.00         | 0.99         | 1.00         | 1.00         | /  | /  | 0.98   | 0.96   | 0.98  | 0.99  |
| Average                   | 0.98   | 0.98                                    | 0.98         | 0.96         | 0.98         | 0.99         | /  | /  | /  | 0.98   | 0.98  | 0.98  |
| CPOs (1,034 funds)        | Rank correlation in relation to the Sharpe ratio (273 surviving, 761 dissolved)  |   |              |              |              |              |  |  |  |  |   |   |
| Omega                     | 1.00   | 1.00                                    | 1.00         | 0.97         | 0.98         | 0.98         | 1.00   | /  | /  | 1.00   | 1.00  | 1.00  |
| Sortino ratio             | 1.00   | 0.99                                    | 0.99         | 0.99         | 0.99         | 0.99         | 1.00   | /  | /  | 1.00   | 1.00  | 1.00  |
| Kappa 3                   | 1.00   | 0.99                                    | 0.99         | 0.99         | 0.99         | 0.98         | 0.99   | /  | /  | 1.00   | 0.99  | 1.00  |
| Upside potential ratio    | 0.96   | 0.96                                    | 0.95         | 0.93         | 0.96         | 0.96         | 0.92   | /  | /  | 0.99   | 0.95  | 0.96  |
| Calmar ratio              | 0.98   | 0.98                                    | 0.98         | 0.94         | 0.98         | 0.98         | /  | 0.98   | /  | 0.98   | 0.98  | 0.98  |
| Sterling ratio            | 0.97   | 0.97                                    | 0.97         | 0.97         | 0.97         | 0.97         | /  | 0.97   | /  | 0.99   | 0.97  | 0.98  |
| Burke ratio               | 0.98   | 0.98                                    | 0.98         | 0.98         | 0.99         | 0.98         | /  | 0.98   | /  | 0.99   | 0.98  | 0.98  |
| Excess return on VaR      | 0.99   | 0.99                                    | 0.99         | 0.99         | 0.99         | 0.98         | /  | /  | 0.99   | 0.98   | 1.00  | 0.99  |
| Conditional Sharpe ratio  | 0.99   | 0.99                                    | 0.99         | 0.99         | 0.99         | 0.99         | /  | /  | 0.99   | 0.97   | 0.99  | 1.00  |
| Modified Sharpe ratio     | 0.99   | 0.99                                    | 0.95         | 0.95         | 0.94         | 0.97         | /  | /  | 0.99   | 0.97   | 0.98  | 0.99  |
| Average                   | 0.99   | 0.98                                    | 0.98         | 0.97         | 0.98         | 0.98         | /  | /  | /  | 0.99   | 0.98  | 0.99  |

\*The rank correlations presented in the table are average values above different robustness tests.

**Exhibit A4: Rank Correlation for the Analysis of Weekly and Daily Data**

| Frequency                                  | Monthly returns                               | Weekly returns | Daily returns |
|--|---|----------------|---------------|
| Number of analyzed funds                   | 17,817  | 1,000          | 1,000         |
| Mean value (%)                             | 0.53  | 0.21           | 0.07          |
| Standard deviation (%)                     | 4.70  | 1.16           | 0.50          |
| Skewness                                   | -0.29   | -0.43          | -0.08         |
| Excess kurtosis                            | 0.76  | 2.70           | 9.46          |
| JB-rejection at 1% (5%) significance level | 19.84 (26.73)                                 | 31.23 (37.54)  | 66.76 (74.50) |
| Performance measures                       | Rank correlation compared to the Sharpe Ratio |                |               |
| Omega                                      | 1.00  | 0.99           | 0.92          |
| Sortino ratio                              | 1.00  | 1.00           | 0.98          |
| Kappa 3                                    | 1.00  | 0.99           | 0.97          |
| Upside potential ratio                     | 0.98  | 0.94           | 0.86          |
| Calmar ratio                               | 0.99  | 0.97           | 0.87          |
| Sterling ratio                             | 0.98  | 0.97           | 0.91          |
| Burke ratio                                | 0.99  | 0.98           | 0.91          |
| Excess return on VaR                       | 0.97  | 0.98           | 1.00          |
| Conditional Sharpe ratio                   | 0.98  | 0.99           | 0.97          |
| Modified Sharpe ratio                      | 1.00  | 0.99           | 0.89          |
| Average                                    | 0.99  | 0.98           | 0.93          |

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