FORECASTING HEDGE FUNDS VOLATILITY: A RISK MANAGEMENT APPROACH

Paulo Monteiro[a]

This Version: March 2004

[a] MSc in Finance. Portfolio Manager, Banco Alves Ribeiro S.A., Av. Eng. Duarte Pacheco Torre 1 – 11º, 1070-101 Lisboa, Portugal. Email: pmonteiro@bancoalvesribeiro.pt

I would like to thank Prof. Miguel A. Ferreira (ISCTE – Business School) and Prof. Vikas Agarwal (Georgia State University) for many helpful comments and suggestions. I am responsible for all errors.

FORECASTING HEDGE FUNDS VOLATILITY: A RISK MANAGEMENT APPROACH

Abstract

We evaluate the performance of volatility and Value-at-Risk models for hedge fund indexes over the period from January 1994 to December 2003. The exponentially weighted sample variance (EWMA) and E-GARCH models have the best volatility forecast performance for hedge funds in terms of statistical loss functions. In contrast for traditional assets, the best volatility model is the simple sample variance. There is evidence that hedge fund volatility is less persistent that stocks and bonds volatility. We find that the critical decision in selecting a Value-at-Risk model for hedge funds is the distributional assumption. However, in contrast with traditional assets for which the normal distribution presents the best performance, the t-student and, especially the Cornish-Fisher expansion, distributional assumptions present the best performance.

Keywords: Hedge funds; Volatility; Value at risk

JEL Classification: C5; G10

1. Introduction

An important question to portfolio managers, investors and financial regulators, is the risk profile of hedge funds and how should it be measured, given the recent interest on the hedge fund industry.[1] Unlike the traditional asset classes, with well-defined and stable statistical properties, in the hedge funds industry, due to the various strategies implemented and styles, there is not an overall accepted model to assess the risk of these investment vehicles. Beside this, the trading strategies implemented by these funds are considered proprietary and, therefore, not disclosed to the investors, making the risk assessment even more challenging.[2]

Despite the growing popularity of hedge funds, there is still relatively little research about hedge funds when compared with the traditional asset classes. The existing literature may be divided into two major areas. First, hedge funds returns distribution and performance evaluation, in particular the diversification benefits of hedge fund in portfolios of stocks and bonds. Second, hedge funds risk, capital adequacy and risk management.

The majority of the research on hedge funds is about performance evaluation and attribution. This is natural, taking into consideration the importance to investors of the links between investment styles and traditional asset classes, in the portfolio construction and optimization.

In the effort to model hedge funds returns, the Sharpe (1992) asset-class model is often the starting point. Fung and Hsieh (1998) propose an extension to this model to allow

---

[1] According to Van Hedge Fund Advisors International, Inc. estimates, at the end of 2002 there were 7500 funds, with US$650 billion under management, comparing with 6200 funds and $US480 billion at the end of 1999. For a definition of hedge funds, see Tremont Partners, Inc and Tass Investment Research Ltd (1999).

[2] See Meyers and Heim (2001), for a survey of the US hedge fund regulation. For a review of the law applicable to hedge funds in different selected countries, see also Cullen and Parry (2000).

a uniform treatment of mutual funds as well as hedge funds strategies. They extend the traditional style analysis to alternative managers employing dynamic trading strategies and conclude that these strategies can improve the performance of a traditional stock-bond portfolio without substantially increasing its risk, despite the possibility and exposure to extreme or tail events.

Amin and Kat (2001) analyze the performance of hedge funds and their results show that they do not offer a superior risk-return profile as a stand-alone investment. However, hedge funds score much better when seen as part of an investment portfolio. The best results are achieved when only 10% to 20% of the portfolio value is invested in hedge funds. Agarwal and Naik (2000c) obtain similar results in a mean-variance framework. They show that a combination of alternative investments with passive indexing provides a significantly better risk-return trade-off than passively investing in the different asset classes. McCarthy and Spurgin (1998a) and Schneeweis and Spurgin (1998) also demonstrate that hedge funds offer risk-adjusted returns greater than traditional stock and bond investments.

The recent decline of the international stock markets, have raised the attention on hedge funds and the claimed capability of its managers on generating positive returns uncorrelated with the traditional benchmarks. McCarthy and Spurgin (1998b) test this claim and find that all three indexes studied have similar risk-adjusted returns and positive correlation with equity indexes. Edwards and Caglayan (2001) estimate six-factor Jensen alphas for individual hedge funds employing eight different investment styles. Their results show that only 25% of hedge funds earn positive excess returns, and the frequency and magnitude of funds' excess returns differ significantly with the investment style. They also conclude that hedge fund positive excess return (relative to the market return) is partially attributable to the skill of hedge fund managers. Agarwal and Naik (2000b) examine the performance of hedge funds following different strategies using a generalized asset-class factor model consisting of excess returns on buy-and-hold strategies and passive option-based strategies. This model is able to explain a significant proportion of variation in hedge fund returns over time and its results suggested that only 35% of the hedge funds have added significant value in excess of a monthly survivorship bias of 0.3%.

Many of the strategies employed by hedge funds managers present non-linear return distribution, which may lead to distortions in performance measures. Brooks and Kat (2001) find that hedge fund indexes exhibit highly unusual skewness and kurtosis properties, as well first-order serial correlation. As a consequence traditional performance measures such as the Sharpe ratio and Jensen's alpha are not suitable for evaluation of hedge fund performance. Fung and Hsieh (1997) have shown that although the hedge funds returns are not normally distributed, the mean-variance analysis approximately preserves the ranking of preferences using standard utility functions. Another characteristic of hedge funds returns is persistence, as shown by Agarwal and Naik (2000a). They examine the before and after-fee performance persistence exhibited by hedge funds using the traditional two-period framework and compared the findings with those observed using a multi-period framework. Results suggests that there is a considerable amount of persistence at a quarterly horizon, which decreases as one moves to yearly returns, indicating that persistence among hedge fund managers is primarily of short-term nature. They also find that persistence seems to be unrelated to the type of strategy followed by the fund. Amin and Kat (2002), conclude that, due the lower skewness and higher kurtosis of the portfolios including alternative strategies, hedge funds might be more suitable for institutional than for private investors.

The relationship between hedge fund performance and the fee structures has also received some attention. Brown, Goetzmann and Park (1999) investigate whether hedge fund return variance depends on whether the manager is doing well or poorly. They conclude that managers whose performance is relatively poor increase the volatility of their funds, whereas managers whose performance is favorable decrease volatility. In their opinion, this is consistent with adverse incentives created by the existence of performance-based fee arrangements. Liang (1999) argues that hedge funds special fee structures apparently align managers incentives with fund performance. Funds with incentive fees significantly outperform those without incentive fees. He also finds that the average hedge fund returns are positively related to fund assets and lockup periods.

A different question also important to investors and regulators is the market risk profile of hedge funds and what is the best way to forecast its volatility. Few studies address this issue. Jorion (2000) studies the debacle of the well-known hedge fund Long-Term Capital Management (LTCM) using a Value-at-Risk (VaR) framework, and conclude that fund managers severely underestimated its risk. Lhabitant (2001) studies the investment styles of hedge funds and funds of funds using factor models to estimate the VaR of the funds. However, hedge fund return information is not directly used to estimate VaR. Gupta and Liang (2001) study the capital adequacy of the hedge fund industry using a VaR approach. They conclude that the LTCM debacle was an extreme case, not representative of the industry. Despite the importance of their work to assessing hedge funds market risk and capital adequacy, Gupta and Liang (2001) do not study what is the best model to measure the market risk of hedge funds. In fact, they only consider two VaR alternative distributional assumptions (extreme value theory and normal distribution) and, mostly important, one simple model of historical volatility (sample standard deviation).

This paper contributes to a better understanding of the market risks faced by hedge funds investors. We characterize hedge funds market risk across different styles and address the following questions. How are hedge fund returns distributed? Which is the best model to forecast the volatility of hedge fund returns? What is the best distributional assumption to calculate hedge funds VaR? Finally, what are the risk characteristics of hedge funds and are they significantly different from those of the traditional stock and bond benchmarks?

We study hedge funds return volatility using the Credit Suisse First Boston Tremont (CSFB/Tremont) indexes, and evaluate the out-of-sample performance of four alternative volatility models: sample variance (SMA), exponentially-weighted sample variance (EWMA), GARCH, and E-GARCH. We consider both statistical and economic loss functions measures to evaluate volatility models forecasting power, but we focus on a particular economic loss function: VaR. VaR is estimated for each model under alternative distributional assumptions: normal, t-student, Cornish-Fisher expansion, and historical.

We examine alternative VaR models for ten different hedge fund styles. In order to evaluate the performance of the VaR models, we test whether models have the correct unconditional and conditional coverage. We find that the best volatility models in terms of statistical loss functions are the exponentially weighted moving average (EWMA) and the E-GARCH, which is consistent with the evidence in the traditional assets. The evaluation of the hedge funds market risk in a VaR framework shows that the performance of the models mainly depends on the VaR distributional assumption. This finding is consistent with previous evidence in the foreign exchange market in Lopez and Walter (2000). However, the best results are obtained using the t-student distribution and the Cornish-Fisher expansion, especially for the lower quantiles, as the returns of these funds differ significantly from those of stocks and bonds. In contrast, Lopez and Walter (2000) and Ferreira and Lopez (2003) find that within a VaR framework the normal and historical distribution have the best performances for a portfolio of foreign exchange rates and interest rates, respectively.

The remainder of the paper is organized as follows. Section 2 describes the data and gives descriptive statistics of the hedge fund and traditional benchmarks indexes. Section 3 describes the volatility models. Section 4 presents the results of the out-of-sample performance of the volatility models using alternative statistical loss functions. Section 5 describes the VaR models and presents the results of the VaR models performance evaluation. Section 6 concludes.

2. Data and Descriptive Statistics

Hedge fund returns are given by the Credit Suisse First Boston Tremont Hedge Fund Indexes (CSFB/Tremont). The construction of these indexes is based on the TASS database, which tracks over 2600 funds. The universe consists only of funds with a minimum of 10 million US dollars under management and a current audited financial statement. Funds are separated into primary sub-categories based on their investment style. The index in all cases represents at least 85% of the assets under management in the universe. CSFB/Tremont analyses the percentage of assets invested in each sub-category and selects funds for the index based on those percentages, matching the shape of the index to the shape of the universe. The index is re-balanced monthly. Funds are re-selected on a quarterly basis as necessary. Funds are not removed from the index until they are liquidated or fail to meet the financial reporting requirements. Returns are calculated in US dollars and are net of fees. We briefly describe the CSFB/Tremont Hedge Fund indexes investment styles in Appendix A.

The data covers the period from January 1994 to December 2003 (120 monthly observations). Our sample includes three periods of low hedge fund returns – 1994, 1998 and 2001 – and incorporates a variety of market conditions that include the Asian and the Russian crisis, the technology bubble bursting in the late 1990s and, more recently, the global economic slowdown. Table 1 presents summary statistics for the returns of each index. For comparison, we also present summary statistics of returns of stocks and bond benchmarks, MSCI World Equity, JP Morgan Govt. Bond, S&P500, DJ EuroStoxx600, Nasdaq Composite and Russell 2000. Figure 1 compares the aggregate hedge fund index return with the returns of a stock (MSCI World) and bond benchmark (JP Morgan Govt. Bond).

Most of the strategies followed by hedge funds present higher returns and lower standard deviations than the stocks benchmarks, with the exception of the Dedicated Short Bias strategy. The Dedicated Short Bias is the only purely equity-oriented strategy and presents a average return lower than the stocks benchmarks, a situation explained by the bull market in the second half of the 1990s, but a slightly higher standard deviation.

The Equity Market Neutral, Event Driven and Long/Short Equity strategies present higher average returns and lower volatility when compared with the traditional benchmarks. With respect to the fixed income strategies, the risk-return pattern is more familiar. Higher returns are associated with higher standard deviations, when compared to the JP Morgan Government Bond index. However, hedge funds indexes present lower skewness and higher kurtosis than the bond benchmarks. In particular, the strategies Convertible Arbitrage, Emerging Markets, Event Driven and Fixed Income Arbitrage exhibit not only high negative skewness but also large excess kurtosis. The Global Macro and Long/Short Equity strategies have the highest monthly returns, but also present high kurtosis. The exceptions to this pattern are the Equity Market Neutral and Managed Futures strategies, which returns distributions are fairly normal, i.e., the returns are not either skewed nor leptokurtic. To check on how normal is the distribution of returns of the hedge fund indexes, we use the Jarque-Bera test and conclude that the majority of hedge fund strategies returns are not normally distributed. This is also true for the equities benchmarks monthly returns.

Table 1 also examines the basic time series properties of the hedge funds indexes and traditional benchmarks returns. We present the autocorrelation coefficients for lags up to the order six and the result for the Ljung-Box test. Not surprisingly, for the stock market indexes there is very little evidence of statistically significant autocorrelation. In contrast, five out of the ten hedge fund indexes exhibit highly significant positive autocorrelation: the Convertible Arbitrage, Emerging Markets, Equity Market Neutral, Event Driven and Fixed Income Arbitrage. All these strategies have a first order serial correlation of at least 29%, which are statistically significant at the 1% level. The observed positive autocorrelation is inconsistent with the notion of efficient markets. However, like Brooks and Kat (2001) mention, this may be due to the lack of up-to-date valuations of positions in illiquid and complex over-the-counter securities. This situation may easily create lags in the evolution of their net asset value.

Table 2 examines the correlations between the hedge fund index returns and stocks and bonds indexes returns. The correlation with the bond market is relatively low and statistically insignificant, with the exception of the Global Macro and Managed Futures strategies. In contrast, despite the claim frequently made by hedge fund managers, most of the hedge fund indexes present high correlation with the equity benchmark, especially with the Russell 2000 and the Nasdaq Composite. As observed by Brooks and Kat (2001), the correlation with these two benchmarks is particularly high for the Long/Short Equity strategy, indicating that fund managers may have been heavily invested in small technology stocks. Even the Equity Market Neutral strategy presents a relative high correlation with the equity indexes, 0.28 and 0.39 with the Russell 2000 and S&P 500, respectively. Of all the equity related strategies, the Convertible Arbitrage is the one with lower correlation with the equity market, between 0.13 and 0.22. The observed correlation with equity indexes allows us to conclude that, in spite of the alternative strategies followed by the funds, a big part of their systematic risk is still equity market risk. The exception is the Managed Futures strategy because of the diversity of markets in which invest, which presents a higher correlation with the bond index and a lower correlation with equity index.

Table 3 reports the correlation among the hedge fund indexes returns. The results are surprising since there are extremely high correlations between some strategies, as for example, between Event Driven and the Convertible Arbitrage and Long/Short Equity. The strategy with the lowest correlation with the remaining is the Managed Futures, indicating again that this strategy carries different systematic risk factors.

3. Volatility Models

We consider four alternative models to forecast the conditional variance of hedge funds and traditional indexes returns. The sample variance, the exponentially weighted sample variance, the GARCH model of Bollerslev (1986), and the E-GARCH model of Nelson (1991). We estimate the model parameters using a rolling window of fixed length. Each month, the forecasts are updated by adding information from the preceding month and dropping the oldest observation. The sample variances use two alternative rolling windows: 36 observations (initial period is from January 1996 to December 1996) and 60 observations (initial period is from January 1994 to December 1998). The GARCH and E-GARCH models consider a rolling window of 60 observations. The out-of-sample period is January 1999 to December 2003.

3.1. Simple Moving Averages (SMA)

The simplest method to estimate the volatility of an asset return is the sample variance using a fixed window (moving average estimator). The one-step ahead volatility forecast, at time *t*, is given by

$$\hat{h}_t^2(1) = \frac{1}{R}\sum_{t=1}^{R} r_t^{\,2} \tag{1}$$

where $\hat{h}_t^2(1)$ is the one-step ahead conditional variance forecast formulated at month *t*, and r_t is the hedge fund or benchmark returns. We set the sample mean to zero according with previous evidence that shows that these forecasts have higher accuracy; see, for example, Figlewski (1994). These forecasts are denoted SMA(36) and SMA(60) for the cases of a window with 36 and 60 historical observations, respectively.

3.2. Exponentially-Weighted Moving Averages (EWMA)

It is well-known that conditional volatility is not constant across time and it is highly persistent. A popular estimator that takes into account this fact is the exponentially weighted sample variance. This is the estimator used in the industry standard approach - Riskmetrics. The one-step ahead forecast is given by:

$$\hat{h}_t^2(1) = \lambda \hat{h}_{t-1}^2(1) + (1-\lambda) r_t^2 \qquad (2)$$

We assume a fixed decay factor, $\lambda = 0.97$, for our monthly forecasts as it is common practice in previous studies and proposed in Riskmetrics. The alternative of estimating the decay factor does not, in general, produce better out-of-sample forecasting accuracy. These forecasts are denoted EWMA(36) and EWMA(60) for the cases of a window with 36 and 60 historical observations, respectively.

3.3. GARCH

We also use the GARCH model of Bollerslev (1986) to formulate volatility forecasts. The one-step ahead forecast is given by:

$$\hat{h}_t^2(1) = \alpha_0 + \alpha_1 \varepsilon_t^2 + \alpha_2 \hat{h}_t^2 \qquad (3)$$

An AR(1) specification is considered for the conditional mean equation,

$$r_t = \alpha_t + \beta r_{t-1} + \varepsilon_t \qquad (4)$$

where $\varepsilon_t \sim N(0, h_t)$ is the residual. This volatility estimator is denoted as GARCH(60).[3]

3.4. E-GARCH

The last volatility model is the E-GARCH of Nelson (1991), where positive and negative values unexpected returns can have a different impact on the subsequent period volatility. As shown in many empirical studies stock market volatility has an asymmetric behavior, i.e., negative shocks tend to increase volatility more than positive shocks; see, for example, Glosten, Jagannathan and Runkle (1993). The one-step ahead forecast is given by:

$$\ln \hat{h}_t^2(1) = \alpha_0 + \beta_1 \ln \hat{h}_t^2 + \beta_2 \frac{|\varepsilon_t|}{\hat{h}_t} + \beta_3 \frac{\varepsilon_t}{\hat{h}_t} \qquad (5)$$

The conditional mean equation specification is an AR(1) as in the GARCH model. This model is denoted as E-GARCH(60).

4. Out-Sample Forecasting Power

In this section we present the hedge fund volatility model forecasts and study the out-of-sample forecasting performance using statistical loss functions. Figure 2 shows the out-of-sample historical volatility, measured by the EWMA(60) model, for the CSFB/Tremont

---

[3] The EWMA method corresponds to a particular case of the GARCH model, where the variance process is assumed as nonstationary and designated by IGARCH, with a $\alpha_0 = 0$ and $\alpha_1 + \alpha_2 = 1$.

Hedge Fund, the MSCI World Equity and the JPM Gov Bond indexes. Interestingly, despite the turbulence on the equities markets, especially on 2002, hedge funds volatility shows a declining pattern, which may be signaling a tight risk control and the capability of producing positive returns on every market conditions.

4.1. Statistical Loss Functions

We use four statistical loss functions to evaluate the out-of-sample forecast performance of the models presented above. Let h_{t+1}^2 be the realized variance of r_{t+1} and $\widehat{h}_{m,t}^2(1)$ be the one-step ahead forecast of the variance of r_{t+1} formulated at time *t*, according to model *m*. The horizon forecast is one month, which is consistent with the liquidity of most hedge funds. The first two loss functions are the root mean square prediction error (RMSPE) and the mean absolute prediction error (MAPE):

$$RMSPE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(h_{t+1}^2 - \widehat{h}_{m,t}^2(1)\right)^2} \tag{6}$$

$$MAPE = \frac{1}{T}\sum_{t=1}^{T}\left|h_{t+1}^2 - \widehat{h}_{m,t}^2(1)\right| \tag{7}$$

where *T* is the number of out-of-sample observations.

However, as noted by Bollerslev, Engle and Nelson (1994), these loss functions penalize volatility forecasts errors in a symmetrical way, which can be incorrect in the presence of heteroskedasticity. So, we also use a loss function that considers an asymmetric penalty function, such as the logarithmic loss function (LL), used in Pagan and Schwert (1990):

$$LL = \frac{1}{T}\sum_{t=1}^{T}\left[\ln\left(h_{t+1}^{2}\right) - \ln\left(\widehat{h}_{m,t}^{2}(1)\right)\right]^{2} \tag{8}$$

The final statistical loss function employed to evaluate the variance forecasts, is based on the Gaussian quasi-maximum likelihood function commonly used to estimate GARCH models, as suggested by Bollerslev, Engle and Nelson (1994):

$$GMLE = \frac{1}{T}\sum_{t=1}^{T}\left[\ln\left(\widehat{h}_{m,t}^{2}(1)\right) + \frac{h_{t+1}^{2}}{\widehat{h}_{m,t}^{2}(1)}\right] \tag{9}$$

Under a given loss function, the forecasts generating the lowest value can be said to be the most accurate. We use the statistical test suggested by Diebold and Mariano (1995) to conclude about the statistical significance of the differences in forecasting errors across loss functions. To any given loss function, we calculate the time series differences between the loss function errors of a set of forecasts and the forecasts produced by the model that minimized the loss function over the sample period (benchmark model). The null hypothesis is that both models give equally accurate forecasts. If the null hypothesis is rejected, the benchmark model is more accurate. The asymptotic Diebold-Mariano statistic is given by:

$$DM = \frac{\bar{d}}{\sqrt{\frac{\hat{\sigma}_d^2}{T}}} \cap N(0,1) \quad (10)$$

where $\bar{d}$ is the sample mean of the differences series and $\hat{\sigma}_d^2$ is a estimate of its variance.

4.2. Empirical Results

Table 4 reports the values of the statistical loss functions to each of the calculated variance forecasts. The goal is to verify whether the forecast models usually used for stocks and bonds produce equally satisfying results when applied to the hedge funds monthly returns.

Panel A of Table 4 presents the results under the RMSPE loss function. The EWMA(60) model is the one that presents the best forecast performance for hedge funds in seven out of ten strategies. The only exceptions are the aggregate hedge fund index, the Global Macro and the Long/Short strategies, but in any case we cannot reject the null hypothesis that the EWMA(60) presents similar forecasting accuracy to the model with the best performance (minimum RMSPE). The superiority of the EWMA volatility forecasts under the RMSPE loss functions is more clear for the Event Driven strategy for which all the other volatility models the null hypothesis of similar forecasting accuracy is rejected. In contrast, for the traditional stocks and bonds benchmarks, the model that presents the minimizing forecasts in three cases out of six is the SMA(60). However, we cannot reject the null hypothesis that the EWMA(60) presents similar forecasting accuracy. Nevertheless, the SMA model presents a much better performance for the stocks and bonds benchmarks than for the hedge funds indexes (the SMA is rejected in six cases out of ten against the minimizing forecast for hedge fund indexes). This is evidence that hedge funds volatility is less persistent than stocks and bond volatility and, consequently, reverts faster to its long-term mean.

Panel B of Table 4 presents similar results using the MAPE loss function. The best variance forecasts are given by the E-GARCH(60) and EWMA(60) models, with five minimum MAPE's out of ten for hedge funds. These models are also the best models for most stocks and bonds benchmarks.

Panels C and D present the performance of our volatility models using the LL and GMLE statistical loss functions, respectively. Under the LL loss function, the best performing model is the E-GARCH(60). The variance forecasts produced by the GARCH(60) and EWMA(60) models also present a good performance with only three rejections against the alternative of the minimizing forecasts. For the traditional stock and bond indexes the EWMA(60) model is also the best performing model. Panel D presents the results for the GMLE loss function. The best performing model for hedge fund volatility is once again the EWMA(60), with the exception of the Emerging Markets, Equity Market Neutral, Global Macro and Long/Short strategies. The SMA(60) presents the best performance for the traditional stock and bond indexes.

In summary, for the hedge fund indexes, the EWMA and E-GARCH models produce the best variance forecasts. In contrast, for the traditional stock and bond index, the SMA model of volatility present better (or similar) performance to models that use different weights across observations to formulate the volatility forecasts. This is evidence that hedge funds volatility is less persistent than traditional asset volatility.

5. Value-at-Risk Framework

5.1. Definitions

VaR is calculated in currency units and is designed to cover most, but not all, of the losses that a portfolio might face due adverse movements in market variables.[4] For its simplicity, VaR estimates are commonly used by banks and regulators as measures of exposure to financial markets fluctuations.

We start by defining the Value-at-Risk (VaR) approach to quantify market risk. Let r_t be the portfolio return at time *t*. For a given horizon *T* and confidence level, 1-α, the VaR is a threshold such that losses greater than VaR occur with a probability α. Let the probability density of r_t be given by f_t, and the associated distribution function by F_t. Using the inverse distribution function, we can write the α significance level VaR as a percentile,

$$VaR_t(\alpha) = F_t^{-1}(\alpha) \tag{11}$$

We use the three most commonly used confidence levels, the 90%, 95% and 99% confidence levels. The target horizon is one month, which is equal to the hedge fund return series frequency. The models used to compute the VaR estimates are described below.

[4] See Duffie and Pan (1997) for an extensive review of the VaR methodology.

5.2. VaR Models

We calculate VaR using four alternative distributional forms to assess the hedge funds indexes market risk. The first distributional form is the standard normal distribution, the one most commonly used in practice (e.g. Riskmetrics).

The second distributional form is the t-student distribution. The t-distribution requires an additional parameter to be estimated, the degrees of freedom, which controls the tail thickness of the distribution. The degrees of freedom (v) are estimated using the in-sample standardised residuals from the GARCH model specification, for each of the hedge fund and market indexes. Table 5 reports the estimated degrees of freedom, which range from 8, for the Convertible Arbitrage strategy, and 381 for the Russell 2000 Index. When the estimated v is greater than 30, we use the standard normal distribution.

Under the normal and t-student distributional forms, the VaR estimates are equal to the product of the forecast portfolio standard deviations by the appropriate percentile:

$$VaR_{mt}(\alpha) = F_m^{-1}(\alpha)\sqrt{\hat{h}_{mt}^2(1)} \qquad (12)$$

where $VaR_{mt}(\alpha)$ denotes the α quantile VaR estimate from model *m* generated at time *t* for period *t+1*, and F_m is the distribution function.

The third distributional assumption for VaR estimation is the Historical Simulation. This technique, one of the most common for VaR estimation, is based on the concept of rolling windows and use the actual percentiles of the observation period as value-at-risk measures, thus, not requiring any distributional assumptions.[5] Each historical observation forms a possible scenario and the resulting portfolio distribution is more realistic since it is based on the empirical distribution of risk factors. Important to notice is that, although not making explicit assumptions on the distribution of the returns, it is assumed that the distribution of portfolio returns is constant within the estimation window. Hendricks (1996) also points out that historical simulation requires many historical observations, which in the case of hedge funds may be difficult, as a way to minimize event risk (the possibility of analysing a whole different time and situation). Since that for a horizon of a month the hedge fund and market indexes returns can be quite significant, our empirical VaR is estimated out-sample relative to the expected return,

$$VaR_{mt}(\alpha) = -\left(R_{\alpha}^{*} - \mu\right) \tag{13}$$

where, R_{α}^{*} is the cut-off rate of return and μ is the mean index return from historical distribution, using either a 36 or 60-month rolling window.

The majority of hedge fund strategies returns exhibit non-zero skewness and significant excess kurtosis, as shown in Section 2. Since standard VaR methodology is not appropriate, and using the t-student or empirical distributional assumption can be computationally and time intensive, we also use a normal analytical approximation known as the Cornish-Fisher Expansion to find the percentiles of the hedge fund and market indexes returns distributions. These percentiles are then used to calculate the VaR estimates.

[5] See Engle and Manganelli (2001), for a brief review on the implementation and limitations of this method.

This approach to calculate VaR of non-normal asset returns was first described by Zangari (1996). The rationale is that any distribution can be viewed as a function of any other one. That is, it is possible to obtain explicit polynomial expansions for standardized percentiles of a general distribution in terms of its standardized moments and the corresponding percentiles of the standard normal distribution. To summarize this model, let r be the hedge fund return with mean $E[r]$. In the standard normal VaR model, its α% confidence interval is given by

$$C_v = \{z_{1-\alpha}\sigma_P + E[r], z_\alpha \sigma_P + E[r]\} \tag{14}$$

where $z_{1-\alpha}$ and z_α are the (1-α) and α percentiles of the standardized normal distribution.

As mentioned above, in order to reduce the noise in estimating the sample mean, $E[r]$ is often set to zero. If, as is the case with hedge fund returns, r is no longer normal, and becomes $r^{'}$, the approximate confidence interval for $E[r^{'}]$ should be written as

$$\begin{aligned} C_{v^{'}} &= \{(z_{1-\alpha} + s_{1-\alpha})\sigma + E[r^{'}], (z_\alpha + s_\alpha)\sigma + E[r^{'}]\} \\ &= \{(\tilde{z}_{1-\alpha})\sigma + E[r^{'}], (\tilde{z}_\alpha)\sigma + E[r^{'}]\} \end{aligned} \tag{15}$$

where $\tilde{z}_{1-\alpha}$ and $\tilde{z}_\alpha$ denote the (1-α) and α percentiles of $R_P^{'}$ distribution. The main purpose of the correction term s_α is to correct for higher-order departures from normality. In practice, the Cornish-Fisher expansion allows us to compute the adjusted critical values

$\tilde{z}_{1-\alpha}$ and $\tilde{z}_{\alpha}$ as a function of the normal critical values $z_{1-\alpha}$ and z_{α} directly.[6] The first four terms of the Cornish-Fisher expansion for the α-percentile of $\frac{r^{'} - E\left[r^{'}\right]}{\sigma}$ are

$$\tilde{z}_{\alpha} = z_{\alpha} + \frac{1}{6}\left(z_{\alpha}^{2} - 1\right)S + \frac{1}{24}\left(z_{\alpha}^{3} - 3z_{\alpha}\right)(K-3) - \frac{1}{36}\left(2z_{\alpha}^{3} - 5z_{\alpha}\right)S^{2} \qquad (16)$$

where S and K are the skewness and kurtosis of $R_{P}^{'}$, and z_{α} is the α-percentile of the standard normal distribution. The in-the-sample percentiles for the Cornish-Fisher approximation are presented in Table 6, for comparison with those of the normal distribution. In the empirical work the percentiles for the Cornish-Fisher approximation are estimated out-of-sample and the VaR estimates are computed as presented in (12). The volatility model used is the SMA, due to its lower parameter risk.

[6] Mina and Ulmer (1999) compare the Cornish-Fisher expansion with three other methods to compute the VaR of non-normally distributed assets – Johnson transformations, Fourier method and Partial Monte-Carlo. In their empirical work, the Cornish-Fisher method gives very good results in three of four portfolios, being very fast and tractable. However, they warn that in extremely sharp distributions it may give unacceptable results and, therefore should be used with caution. The same conclusion is made by Jaschke (2001).

5.3. VaR Evaluation Tests

The out-of-sample forecast evaluation is the conducted from January 1999 to December 2003 using 60 historical observations $(P = 60)$. The total sample period is $T = R + P = 120$ observations.

We define an indicator variable for the case when return falls beyond the VaR forecast estimated from model *m*, $d_{mt} = 1$ if $r_{t+1} < VaR_{mt}(\alpha)$, $d_{mt} = 0$ otherwise, for t = R,…,T.

In order to evaluate the performance of the VaR models, we use both unconditional coverage test proposed of Kupiec (1995) and the conditional coverage test of Christoffersen (1998). First, we test whether the probability of the unconditional coverage failure, $p = \Pr[r_{t+1} < VaR_{mt}(\alpha)]$, is equal to α. Thus, we test $H_0 : p = \alpha$ against $H_1 : p \neq \alpha$. Given that the indicator d_{mt} has a binomial distribution, the likelihood is $L(p) = (1-p)^{n_0} p^{n_1}$. Under the null hypothesis $L(p) = L(\alpha) = (1-\alpha)^{n_0} \alpha^{n_1}$ and the likelihood ratio test statistic is given by:

$$LR_{uc} = -2\ln\left[\frac{L(\alpha)}{L(\hat{p})}\right] \qquad (17)$$

where $\hat{p} = \frac{n_1}{n_0 + n_1}$ is the maximum likelihood estimator of p and n_0 and n_1 are the number of 0s and 1s in the indicator sequence. The LR_{uc} test statistic is distributed $\chi^2(1)$.

If the VaR model is correct, then the exceptions should not follow any kind of pattern. So, the second test is to check whether the process $\{d_{mt}\}$ is serially independent. If we the denote the transition probability of the first order Markov chain as $\pi_{ij} = \Pr(d_{mt} = j | d_{mt-1} = i)$, then the likelihood ratio of independence can be tested using the LR_{ind} statistic, defined as

$$LR_{ind} = -2\ln\left[\frac{L(\hat{p})}{L(\hat{\pi}_{01}, \hat{\pi}_{11})}\right] \tag{18}$$

where $L(\hat{\pi}_{01}, \hat{\pi}_{11}) = (1-\hat{\pi}_{01})^{n_{00}}\, \hat{\pi}_{01}^{n_{01}}\, (1-\hat{\pi}_{11})^{n_{10}}\, \hat{\pi}_{11}^{n_{11}}$, n_{ij} is the number of observations with value *i* followed by *j*, $\hat{\pi}_{01} = \dfrac{n_{01}}{n_{00}+n_{01}}$, and $\hat{\pi}_{11} = \dfrac{n_{11}}{n_{10}+n_{11}}$. The LR_{ind} statistic is distributed $\chi^2(1)$. The conditional coverage test is given by:

$$LR_{cc} = LR_{uc} + LR_{ind} \cap \chi^2(2) \tag{19}$$

which it is distributed $\chi^2(2)$.

5.4. Empirical Results

Table 7 reports the percentage exceptions observed for each of the VaR models for the 90%, 95% and 99% confidence levels over the out-of-sample period. Since these results are the key components of the LR_{uc} and LR_{cc} tests, we focus the analysis on Tables 8 and 9.

As shown in Panel A of Table 8, under the normal distributional assumption, the best results are obtained at the lower quantiles (1% and 5%) in that only three VaR forecasts fail the LR_{uc} test at the 5% significance level. In both cases, the failures occur only on the market indexes (MSCI World Equity and DJ EuroStoxx 600). The null hypothesis is not rejected for any hedge fund index, being difficult to distinguish among the different VaR models. However, for the 10% quantile, it is easier to distinguish between the VaR models. For hedge funds indexes, the best performing model is the E-GARCH(60) with only one rejection of the null hypothesis (Emerging Markets strategy). The model with the worst unconditional coverage is the EWMA(60), which is rejected in six cases. In fact, the exceptions rates are very low and VaR is overestimated under the EWMA(60) model, as can be seen in Panel A of Table 7. For the Dedicated Short Bias, Equity Market Neutral and Managed Futures strategies all the models perform similarly well, with no rejections of the null hypothesis. For the traditional market indexes, the standard normal distributional assumption performs quiet well at all quantiles, providing support for the common industry practice of using it in generating VaR estimates for the traditional assets.

Panel B of Table 8 presents the results for the unconditional coverage under the t-student distributional assumption. The results are similar than the ones under the normal distributional assumption for lower quantiles, but they are better for the 10% quantile. The performance of the EWMA(60) model is improved in the t-student distribution relative to the normal distribution at the 10% quantile, in particular for the Emerging Markets and Global Macro strategies. This indicates that the tail thickness of these strategies returns distributions is better captured under the t-student distributional assumption. The same happens to Event Driven strategy under the GARCH(60) model. And the same explanation can be also applied to the Convertible Arbitrage strategy, which unconditional coverage is rejected for the E-GARCH(60), since the exception rate decreases under the t-student distributional assumption relatively to the normal distributional assumption.

Panel C of Table 8 shows the results for the VaR models based on the Cornish-Fisher Expansion. Similarly to the normal and t-student distributional assumptions, the hypothesis of correct unconditional coverage is not rejected at the lower quantiles for any of the hedge funds indexes. Regarding the market indexes, the performance is increased for the MSCI World and DJ EuroStoxx 600 indexes. At the 10% quantile, the best results are achieved using 36 historical observations, with only three rejections of the null hypothesis.

Finally, Panel D of Table 8 shows the results of the LR_{uc} tests for the historical simulation approach. As a result of the higher exceptions rates (see Panel D of Table 7) for the hedge funds indexes, the historical simulation presents fewer rejections of the null hypothesis of correct unconditional coverage. The main difference relatively to the alternative distributional assumptions is for the equity market benchmarks at the 1% quantile.

Table 9 presents the p-values for the test of correct conditional coverage. Panel A shows the results of the conditional coverage test under the standard normal distributional assumption. Two main conclusions can be drawn. The null hypothesis is not rejected for any of the models specifications for the market indexes at the lower quantiles. Although the unconditional coverage of the E-GARCH(60) specification is rejected for the MSCI World and DJ EuroStoxx 600 indexes, these models generate VaR exceptions that are not serially dependent for equity benchmarks, which is consistent with the results presented on Table 1. In contrast, the serially independence of the Event Driven VaR exceptions is clearly rejected at the 10% quantile, which is also consistent with the highly significant positive autocorrelation of its returns. For the GARCH(60) and E-GARCH(60) specifications, the serial independence of the Long/Short and Fixed Income Arbitrage is also rejected at the 1% quantile. This means that, although not statistically significant, the exceptions produced by these specifications are autocorrelated, which is also consistent with the results present previously in Section 2. Similarly to the LR_{uc} tests, for the 5% quantile it is difficult to distinguish between models specifications, due to low number of exceptions.

Panel B of Table 9 presents the same set of results for the t-student distributional assumption. There is some improvement relative to the normal distribution VaR estimates. The null hypothesis of correct conditional coverage is no longer rejected for the Long/Short strategy at the 1% quantile, which can be explained by the fatter tails of this distributional assumption (t-student with 16 degrees of freedom). The same happens with the Event Driven strategy at the 10% quantile, which now presents correct conditional coverage under the SMA(60) and GARCH(60) models specifications.

Panel C reports the results for the Cornish-Fisher Expansion LR_{cc} tests. As for the two previous distributional assumptions, despite the no rejection of the unconditional coverage, the exceptions for the Event Driven VaR estimates exhibit serial dependence, thus rejecting the conditional coverage for both specifications at the 10% quantile. For the lower quantiles, the null hypothesis is not rejected for any hedge fund and market index.

Finally, Panel D presents the LR_{cc} results for the historical simulation VaR models. Accordingly to the unconditional coverage results, at the 10% quantile, the conditional coverage is rejected for the overall index and Global Macro index, for both specifications, and for the Emerging Markets strategy, using 36 past observations. Contrary to the other distributional forms, the historical simulation VaR estimates for the Event Driven do not exhibit significant serial autocorrelation, thus being more suitable to this strategy risk assessment. However, this method is less appropriate for the Long/Short strategies, which serial independence and conditional coverage are rejected. At the 1% quantile, the historical simulation is the only method to register one rejection of the null hypothesis of conditional coverage, namely for the Fixed Income Arbitrage strategy under the 36 past observations specification.

Overall, our results support that the dominant factor in determining the coverage accuracy of VaR estimates at lower quantiles is the distributional assumption. This is consistent with the results of Lopez and Walter (2000) and Ferreira and Lopez (2003) for portfolios of foreign exchange rates and interest rates.

The historical simulation is the model with the best performance at the 10% quantile. Among the other three distributional forms, the t-student distributional assumption is the best performing one, improving the results for the SMA(60), EWMA(60) and GARCH(60) specifications, relatively to the standard normal distribution. The Cornish-Fisher expansion performs equally well at the 10% quantile, and it is the best performing model at the lower quantiles. In contrast with the standard normal, t-student and historical simulation distributional assumptions, the hypothesis of correct conditional coverage of the VaR estimates produced by the Cornish-Fisher expansion is not rejected for all hedge fund indexes at the lower quantiles.

We find evidence that the Cornish-Fisher Expansion is a worthy and accurate alternative to easily incorporate the third and fourth distribution moment of the hedge fund returns in VaR estimates. For equities and bond benchmarks the standard normal and t-student distributional produces similar VaR estimates, providing support for the use of the standard normal distribution by the practitioners. However, the Cornish-Fisher expansion distributional assumption is also the best performing at the 1% quantile.

5.5. Robustness

Most hedge funds have monthly liquidity and report net-asset-value (nav) only with monthly frequency, contrary to what is common in traditional financial assets, like stocks and bonds, which have daily quotes. Considering that in market risk assessment literature, daily observations are usually considered, we compare the VaR estimates for the Russell 2000 index using daily and monthly observations. In addition, we compute VaR estimates for the HFRI Fund Weighted Composite Index (HFRI Fund Index), an alternative hedge fund index.[7] This index has a longer history, which allows us to extend the analysis back to January 1990.

Panel A of Table 10 reports descriptive statistics of returns and mean VaR estimates calculated in-sample using Historical Simulation with 60 observations for the HFRI Fund Index using two alternative sample periods. The time series of returns and VaR estimates are very similar for the HFRI Fund Index using the sample period 1994-2003 and the extended sample period 1990-2003. This means that the results are not biased by the relatively small sample period considered.

Panel B assesses the impact of using daily returns instead of monthly returns in our results. We consider the Russel 2000 index returns at the daily and monthly frequency in the sample period 1994-2003. The results show that the time series of returns and VaR estimates present similar properties. Thus, it is unlikely that the use of daily hedge fund returns would change dramatically our main findings.

[7] The HFRI Fund Weighted Composite Index is provided by Hedge Fund Research, Inc. The company is a hedge fund research and consulting firm that has collected data on around 4000 different hedge funds. Around 1500 funds are used to calculate 37 indexes that reflect the monthly net of fee returns on equally weighted portfolios of funds.

Table 11 presents the out-of-sample VaR evaluation test results considering the extended period 1990-2003 and the historical simulation distributional assumption. This allows us to consider an extended out-of-sample period (1995-2003). The null hypothesis of correct conditional coverage is not rejected for the HFRI Fund Index, similarly to the CSFB/Tremont aggregate index. With respect to the Russell 2000 index, the null hypothesis of correct conditional coverage is only rejected at the 1% quantile. Thus, we can conclude that, for the hedge funds indexes, our analysis is not unbiased by the use of CSFB/Tremont indexes, despite the shorter sample period.

6. Conclusion

We examine the statistical properties of ten monthly hedge fund and six market indexes returns. Our sample shows that hedge funds have performed remarkably well with no single year of significantly negative returns. In fact, hedge funds average returns have closely paralleled equities, but with lower volatility. We find significant non-normality in hedge fund returns, especially in terms of excess kurtosis.

The exponentially weighted sample variance (EWMA) and E-GARCH models have the best volatility forecast performance for hedge funds in terms of statistical loss functions. In contrast for traditional assets, the best volatility model is the sample variance (SMA). There is evidence that hedge fund volatility is less persistent that stocks and bonds volatility.

A VaR framework is used to evaluate the performance of our volatility models. Consistent with evidence on traditional assets, we find that the critical decision in selecting a VaR model for hedge funds is the distributional assumption. However, in contrast with traditional assets for which the normal distribution presents the best performance, we find that the t-student and, especially the Cornish-Fisher expansion, distributional assumptions have the best performance.

Although more research is needed, especially testing more models and using directly the funds returns instead of indexes returns, our findings can be particular useful and interesting to practitioners like portfolio managers, risk managers and financial regulators.

Appendix

Convertible Arbitrage: this strategy is identified by a hedge investment in convertible securities. A typical investment is to be long the convertible bond and short the common stock of the same company.

Dedicated Short Bias: the strategy is to maintain a net short as opposed to pure short exposure. Short biased managers take short positions mostly in equities and derivatives. The short bias must be constantly greater than zero to be classified in this category.

Emerging Markets: this strategy involves equity and fixed income investing in emerging markets around the world. Because many emerging markets do not allow short selling, nor offer liquid derivative products with which to hedge, the managers often employ a long-only strategy.

Equity Market Neutral: this strategy is designed to exploit equity market inefficiencies and usually involves being simultaneously long and short matched equity portfolios of the same size within a country. Market neutral portfolios are designed to be either beta or currency neutral, or both. Leverage is often applied to enhance returns.

Event-driven: this strategy is equity-oriented and designed to capture price movements generated by an anticipated corporate event. There are four popular sub-categories in event-driven strategies: risk arbitrage, distressed securities, Regulation D and high yield investing.

Fixed Income Arbitrage: this strategy aims to profit from price anomalies between related interest rate securities. Includes interest rate swap arbitrage, US vs. non-US government bond arbitrage, forward yield curve arbitrage and mortgage-backed securities arbitrage.

Global Macro: these managers carry long and short positions in any of the world's major capital or derivative markets. These positions reflect their views on overall market direction as influenced by major economic trends and events. The portfolios of these funds can include stocks, bonds, currencies and commodities in the form of cash or derivatives instruments.

Long/Short Equity: this directional strategy involves equity-oriented investing on both the long and short sides of the market. The objective is not to be market neutral. Managers have the ability to shift from value to growth, from small to large capitalisation stocks, and from a net long position to a net short position. Long/short equity funds tend to build and hold portfolios that are substantially more concentrated than those of traditional stock funds.

Managed Futures: this strategy invests in listed financial an commodity futures markets and currency markets around the world. The managers are usually referred to as Commodity Trading Advisors, or CTAs. Trading disciplines are generally systematic or discretionary. Systematic traders tend to use price and market specific information (technical analysis) to make trading decisions, while discretionary managers use more fundamental approach.

References

Agarwal, V. and Narayan Y. Naik (2000a), Multi-Period Performance Persistence Analysis of Hedge Funds, *Journal of Financial and Quantitative Analysis*, Vol. 35, N.º 2.

Agarwal, V. and Narayan Y. Naik (2000b), Performance Evaluation of Hedge Funds with Option-based and Buy-and-Hold Strategies, Working Paper, London Business School.

Agarwal, V. and Narayan Y. Naik (2000c), On Taking the 'Alternative' Route: The Risks, Rewards, and Performance Persistence of Hedge Funds, *Journal of Alternative Investment*, Vol. 2, N.º 4, 6-23.

Amin, Gaurav S. and Harry Kat (2001), Hedge Fund Performance 1990-2000: Do Money Machines Really Add Value?, Working Paper, ISMA Centre, University of Reading.

Amin, Gaurav S. and Harry Kat (2002), Whou Should Buy Hedge Funds? The Effects of Including Hedge Funds in Portfolios of Stock and Bonds, Working Paper, ISMA Centre, University of Reading.

Bollerslev, T. (1986), Generalized Autoregressive Conditional Heteroskedasticity, *Journal of Econometrics*, 31, 307-327.

Bollerslev, T., Robert F. Engle, and D.B. Nelson (1994), ARCH Models, in Handbook of Econometrics, Robert F. Engle and D. McFadden (ed.), Vol. 4, Amsterdam: North-Holland.

Brooks, C. and H. Kat (2001), The Statistical Properties of Hedge Fund Index Returns and Their Implications for Investors, Working Paper, ISMA Centre, University of Reading.

Brown, Stephen J., William Goetzmann, and Roger Ibbotson (1999), Offshore Hedge Funds: Survival and Performance 1989-1995, *Journal of Business*, 72, 91-117.

Christoffersen, P. F. (1998), Evaluating Interval Forecasts, *International Economic Review*, 39, 841-864.

Cornish, E.A., and R.A. Fisher (1937), Moments and Cumulants in the specification of distributions, *Review of the International Statistical Institute*, 5, 307-320.

Cullen, Iain, and Hellen Parry (2000), Hedge Funds: Law and Regulation, ed: Sweet and Maxwell

Diebold, F.X. and R.S. Marino (1995), Comparing Predictive Accuracy, *Journal of Business and Economic Statistics*, 13, 253-263.

Duffie, D. and Pan, J. (1997), An Overview of Value at Risk, *The Journal of Derivatives*, Spring, 7-49.

Edwards, Franklin R. and Mustafa Onur Caglayan (2001), Hedge Fund Performance and Manager Skill, Working Paper.

Ferreira, Miguel, and Jose A. Lopez (2003), Evaluating Interest Rate Covariance Models within a Value-at-Risk Framework, Working Paper, Federal Reserve Bank of San Francisco.

Figlewski, Stephen (1994), Forecasting Volatility Using Historical Data, Working Paper n.º 13, New York University.

Fung, William and David Hsieh (1997), Is Mean-Variance Analysis Applicable to Hedge Funds?, Working Paper, Fuqua School of Business, Duke University.

Fung, William and David Hsieh (1998), Performance Attribution and Style Analysis: From Mutual Funds to Hedge Funds, Working Paper, Fuqua School of Business, Duke University.

Glosten, L., R. Jagannathan and D. Runkle (1993), On the Relation Between the Expected

Value and the Volatility of the Nominal Excess Return on Stocks, *Journal of Finance* 48, 1779-1801.

Gupta, A., and Bing Liang (2001), Do Hedge Funds Have Enough Capital? A Value at Risk Approach, Working Paper, Department of Banking and Finance, Weatherhead School of Management, Case Western Reserve University.

Hendricks, Darryll (1996), Evaluation of Value-at-Risk Models Using Historical Data, Federal Reserve Bank of New York, Economic Policy Review, April, 39-69.

J.P. Morgan Bank (1995), RiskMetrics Technical Document, 3d ed., New York.

Jaschke, Stefan R. (2001), The Cornish-Fisher Expansion in the Context of Delta-Gamma Normal Approximations, Working Paper.

Jorion, Philippe (2000), Risk Management Lessons from Long Term Capital Management, *European Financial Management*, 6, 277-300.

Kupiec, P. (1995), Techniques for Verifying the Accuracy of Risk Measurement Models, *Journal of Derivatives*, 3, 73-84.

Lhabitant, Francois-Serge (2001), Assessing Market Risk for Hedge Funds and Hedge Funds Portfolios, Working Paper, Thunderbird.

Liang, Bing (1999), On the Performance of Hedge Funds, *Financial Analysts Journal*, 55, N.º 4, 72-85.

Lopez, Jose A., and Christian A. Walter (2000), Evaluating Covariance Matrix Forecasts in a Value-at-Risk Framework, Working Paper, Federal Reserve Bank of San Francisco.

McCarthy, David and Richard Spurgin (1998a), A Comparison of Return Patterns in Traditional and Alternative Investments, in Sohail Jaffer, ed.: Alternative Investment Strategies (Euromoney, 1998), 157-188.

McCarthy, David and Richard Spurgin (1998b), A Review of Hedge Fund Performance Benchmarks, *Journal of Alternative Investment*, Vol. 1, N.º 1, 18-28.

Meyers, Howard S., and Robert G. Heim, (2001), An Overview of U.S. Hedge Fund Regulation, Meyers & Heim LLP, AIMA Newsletter September 2001.

Mina J., and Andrew Ulmer (1999), Delta-Gamma Four Ways, RiskMetrics Group, Working Paper.

Nelson, Daniel B. (1991), Conditional Heteroskedasticity in Asset Returns: A New Approach, *Econometrica*, Vol. 59, 347-370.

Pagan, A.R., and Schwert, G.W. (1990), Alternative Models for Conditional Stock Volatility, *Journal of Econometrics*, Vol. 45, 267-290. Amsterdam: North-Holland.

Schneeweis, Thomas and Richard Spurgin (1998), Multi-Factor Analysis of Hedge Fund, Managed Futures and Mutual Funds Return and Risk Characteristics, *Journal of Alternative Investment*, Vol. 1, N.º 2, 1-24.

Sharpe, William (1992), Asset Allocation: Management Style and Performance Measurement, *Journal of Porfolio Management*, Vol.18, N.º 2, 7-19.

Tremont Partners, Inc. and TASS Investment Research Ltd (1999), The Case for Hedge Funds.

Zangari, P. (1996), A VaR methodology for portfolios that include options, RiskMetrics Monitor, 1st quarter 1996, 4-12.

Table 1
Summary Statistics of Hedge Fund and Market Indexes Returns

The Jarque-Bera normality test is asymptoticaly distributed $\chi^2(2)$. The cells in bold font indicate the rejection of the null hypothesis at the 5% significance level. The Ljung-Box test for autocorrelation of order up to 6 is asymptotically distributed $\chi^2(6)$. *, ** and *** denote significance at the 10%, 5% and 1% levels respectively.

	Mean	Median	Std. Deviation	Maximum	Minimum	Skewness	Kurtosis	Jarque-Bera p-value	ACF(1)	ACF(2)	ACF(3)	ACF(4)	ACF(5)	ACF(6)	LB (6) p-value
Hedge Fund Indices															
Hedge Fund Index	0.009	0.008	0.024	0.082	-0.078	-0.053	4.684	**0.001**	0.117	0.033	-0.009	-0.077	0.052	-0.011	0.815
Convertible Arbitrage	0.008	0.011	0.014	0.035	-0.048	-1.622	7.102	**0.000**	0.550***	0.404***	0.129***	0.121***	0.069***	-0.011***	0.000
Ded Short Bias	-0.003	-0.004	0.051	0.205	-0.091	0.688	4.162	**0.000**	0.101	-0.034	-0.018	-0.081	-0.103	-0.013	0.729
Emerging Markets	0.006	0.012	0.052	0.152	-0.262	-1.011	8.094	**0.000**	0.297***	0.021***	0.000**	-0.049**	-0.078**	-0.117**	0.033
Equity Mkt Ntrl	0.008	0.008	0.009	0.032	-0.012	0.181	3.158	0.676	0.294***	0.196***	0.096***	0.027***	0.059***	-0.007***	0.009
Event Driven	0.009	0.010	0.018	0.036	-0.125	-3.757	28.276	**0.000**	0.339***	0.145***	0.038***	0.012***	-0.023***	-0.022***	0.009
Fixed Inc Arb	0.005	0.008	0.012	0.020	-0.072	-3.347	20.090	**0.000**	0.403***	0.084***	0.017***	0.071***	-0.009***	-0.075***	0.001
Global Macro	0.011	0.012	0.035	0.101	-0.123	-0.241	5.055	**0.000**	0.062	0.037	0.079	-0.092	0.230*	-0.096	0.109
Long/Short	0.010	0.008	0.031	0.122	-0.121	-0.030	6.308	**0.000**	0.161*	0.041	-0.050	-0.090	-0.175	0.159*	0.065
Managed Futures	0.006	0.002	0.035	0.095	-0.098	-0.106	3.572	0.394	0.027	-0.120	-0.008	-0.005	-0.006	-0.108	0.758
Market Indices															
MSCI World	0.004	0.009	0.043	0.077	-0.150	-0.797	3.714	**0.000**	0.040	0.001	0.055	-0.042	0.055	0.068	0.938
JPM Gov Bond Index	0.005	0.005	0.009	0.034	-0.020	-0.239	3.299	0.451	0.223**	0.075**	0.176**	0.102**	-0.078**	-0.014**	0.046
S&P500	0.007	0.012	0.046	0.092	-0.158	-0.721	3.559	**0.003**	-0.008	-0.028	0.078	-0.065	0.091	0.085	0.758
DJ Stoxx 600	0.004	0.011	0.050	0.104	-0.152	-0.681	3.392	**0.007**	0.105	0.072	0.058	-0.002	0.004	0.101	0.712
Nasdaq Composite	0.008	0.016	0.084	0.199	-0.260	-0.679	3.887	**0.001**	0.071	-0.021	0.023	-0.001	-0.021	0.176	0.574
Russell 2000	0.006	0.015	0.058	0.152	-0.217	-0.721	4.458	**0.000**	0.093	-0.060	-0.144	-0.098	-0.083	0.148	0.175

Table 2
Correlation between Hedge Fund and Market Indexes Returns

	MSCI World	JPM Gov Bond Index	S&P500	DJ Stoxx 600	Nasdaq Composite	Russell 2000
Hedge Fund Index	0.542	0.183	0.480	0.526	0.532	0.572
Convertible Arbitrage	0.169	0.126	0.133	0.215	0.148	0.220
Ded Short Bias	-0.752	0.126	-0.762	-0.622	-0.829	-0.820
Emerging Markets	0.577	-0.141	0.490	0.543	0.498	0.559
Equity Mkt Ntrl	0.363	0.135	0.393	0.320	0.286	0.278
Event Driven	0.619	-0.065	0.562	0.586	0.519	0.652
Fixed Inc Arb	0.101	0.187	0.031	0.156	0.049	0.088
Global Macro	0.277	0.303	0.227	0.302	0.181	0.230
Long/Short	0.616	0.040	0.593	0.550	0.757	0.780
Managed Futures	-0.237	0.364	-0.234	-0.249	-0.253	-0.233

Table 3
Correlation Between Hedge Fund Indexes

	Hedge Fund Index	Convertible Arbitrage	Ded Short Bias	Emerging Markets	Equity Mkt Ntrl	Event Driven	Fixed Inc Arb	Global Macro	Long/ Short	Managed Futures
Hedge Fund Index	1.000	0.406	-0.470	0.648	0.329	0.658	0.456	0.859	0.781	0.088
Convertible Arbitrage		1.000	-0.220	0.337	0.311	0.590	0.552	0.298	0.262	-0.217
Ded Short Bias			1.000	-0.570	-0.354	-0.615	-0.070	-0.117	-0.727	0.239
Emerging Markets				1.000	0.226	0.700	0.300	0.406	0.595	-0.141
Equity Mkt Ntrl					1.000	0.374	0.087	0.203	0.350	0.131
Event Driven						1.000	0.384	0.368	0.660	-0.234
Fixed Inc Arb							1.000	0.467	0.208	-0.077
Global Macro								1.000	0.421	0.245
Long/Short									1.000	-0.076
Managed Futures										1.000

Table 4
Evaluation Results Under the Statistical Loss Functions

The evaluation of the variance forecasts power is based on 36 and 60 out-of-sample observations. The minimum value in each row is in bold font. The shaded cells indicate that the null hypothesis of equal loss function values between the forecast and the minimizing forecast is rejected using the Diebold-Mariano statistic.

Panel A. Out-of-Sample Root Mean Squared Prediction Error (RMSPE)

	SMA(36)	SMA(60)	EWMA(36)	EWMA(60)	GARCH(60)	EGARCH(60)
Hedge Funds Indices						
Hedge Fund Index	0.0011	0.0011	0.0011	0.0011	0.0011	**0.0011**
Convertible Arbitrage	0.0003	0.0003	0.0003	**0.0003**	0.0009	0.0003
Ded Short Bias	0.0031	0.0031	0.0030	**0.0030**	0.0031	0.0032
Emerging Markets	0.0034	0.0034	0.0032	**0.0031**	0.0035	0.0033
Equity Mkt Ntrl	0.0001	0.0001	0.0001	**0.0001**	0.0001	0.0001
Event Driven	0.0005	0.0004	0.0004	**0.0003**	0.0004	0.0005
Fixed Inc Arb	0.0002	0.0002	0.0001	**0.0001**	0.0003	0.0002
Global Macro	0.0014	0.0015	0.0013	0.0013	**0.0012**	0.0012
Long/Short	0.0026	0.0027	**0.0026**	0.0026	0.0027	0.0028
Managed Futures	0.0018	0.0018	0.0018	**0.0018**	0.0019	0.0018
Market Indices						
MSCI World	0.0027	**0.0026**	0.0027	0.0027	0.0028	0.0027
JPM Gov Bond Index	0.0001	0.0001	**0.0001**	0.0001	0.0001	0.0001
S&P500	0.0029	**0.0029**	0.0029	0.0029	0.0030	0.0029
DJ Stoxx 600	0.0042	**0.0041**	0.0042	0.0042	0.0043	0.0043
Nasdaq Composite	0.0146	0.0148	**0.0143**	0.0145	0.0151	0.0145
Russell 2000	0.0055	0.0055	0.0055	0.0055	**0.0055**	0.0070

Panel B. Out-of-Sample Mean Absolute Prediction Error (MAPE)

	SMA(36)	SMA(60)	EWMA(36)	EWMA(60)	GARCH(60)	EGARCH(60)
Hedge Funds Indices						
Hedge Fund Index	0.0007	0.0008	0.0007	0.0007	0.0006	**0.0005**
Convertible Arbitrage	0.0002	0.0002	0.0002	0.0002	0.0004	**0.0002**
Ded Short Bias	0.0025	0.0024	0.0024	**0.0023**	0.0024	0.0025
Emerging Markets	0.0025	0.0027	0.0024	**0.0023**	0.0027	0.0024
Equity Mkt Ntrl	0.0001	0.0001	0.0001	0.0001	0.0001	**0.0001**
Event Driven	0.0004	0.0004	0.0003	**0.0003**	0.0004	0.0004
Fixed Inc Arb	0.0002	0.0001	0.0001	**0.0001**	0.0001	0.0001
Global Macro	0.0010	0.0013	0.0011	0.0010	0.0008	**0.0006**
Long/Short	0.0017	0.0017	0.0015	**0.0015**	0.0015	0.0015
Managed Futures	0.0013	0.0013	0.0013	0.0013	0.0013	**0.0012**
Market Indices						
MSCI World	0.0020	0.0019	0.0019	0.0019	0.0020	**0.0018**
JPM Gov Bond Index	0.0001	0.0001	0.0001	0.0001	0.0001	**0.0001**
S&P500	0.0024	0.0022	0.0023	0.0022	0.0024	**0.0022**
DJ Stoxx 600	0.0029	0.0027	0.0027	**0.0026**	0.0029	0.0027
Nasdaq Composite	0.0102	0.0098	**0.0092**	0.0092	0.0105	0.0096
Russell 2000	0.0038	0.0036	0.0035	**0.0035**	0.0036	0.0045

Table 4 (cont.)

Panel C. Out-of-Sample Logarithmic Loss (LL)

	SMA(36)	SMA(60)	EWMA(36)	EWMA(60)	GARCH(60)	EGARCH(60)
Hedge Funds Indices						
Hedge Fund Index	10.9982	11.7640	11.0276	10.8943	9.4063	**8.1690**
Convertible Arbitrage	4.0758	4.0869	3.8790	3.7561	**3.6218**	4.1527
Ded Short Bias	6.2803	6.0867	5.9332	**5.7086**	5.9115	5.8259
Emerging Markets	**5.5928**	6.3872	5.8810	5.5990	6.8667	5.8317
Equity Mkt Ntrl	6.5035	7.1257	6.6353	6.5977	**4.0402**	4.3560
Event Driven	8.8319	9.0626	8.4238	**7.8285**	9.4765	7.8833
Fixed Inc Arb	4.8358	4.7589	4.3573	3.8614	**2.8925**	3.7877
Global Macro	6.2702	7.5445	6.9693	6.8254	6.1931	**4.3487**
Long/Short	9.5089	9.9247	8.8773	8.6319	7.5782	**6.1315**
Managed Futures	8.4772	8.4529	8.3621	8.2881	9.3558	**8.2672**
Market Indices						
MSCI World	7.1486	6.8916	6.8272	**6.6876**	6.8423	6.7569
JPM Gov Bond Index	6.9524	7.1337	7.0310	7.0493	6.5005	**5.6096**
S&P500	4.5389	4.2845	4.1776	**4.0414**	4.3908	4.2159
DJ Stoxx 600	6.2609	5.8782	5.8488	**5.6644**	5.7924	5.7198
Nasdaq Composite	6.9429	6.5039	6.3062	**6.2381**	6.8173	6.5759
Russell 2000	4.6629	4.3462	4.3212	4.1625	**4.0234**	4.8163

Panel D. Out-of-Sample GMLE

	SMA(36)	SMA(60)	EWMA(36)	EWMA(60)	GARCH(60)	EGARCH(60)
Hedge Funds Indices						
Hedge Fund Index	-6.7089	-6.6286	-6.7180	**-6.7283**	-4.4657	-6.5517
Convertible Arbitrage	-7.2448	-7.2304	-7.2560	**-7.2562**	-5.9959	-4.8600
Ded Short Bias	-4.9513	-4.9458	-4.9666	**-4.9724**	-4.9252	-4.8969
Emerging Markets	**-5.4021**	-5.2591	-5.3481	-5.3877	-3.0223	-5.2684
Equity Mkt Ntrl	**-8.1370**	-8.0592	-8.1188	-8.1229	-7.8711	-8.0628
Event Driven	-7.0403	-7.0767	-7.1651	**-7.2346**	-6.4564	-6.5920
Fixed Inc Arb	-7.9261	-8.0178	-8.0806	**-8.1660**	-7.7769	-7.1997
Global Macro	**-6.2989**	-6.1153	-6.2081	-6.2304	1.2602	-4.7339
Long/Short	-5.8079	-5.6603	**-5.8370**	-5.8234	-5.4565	-5.2518
Managed Futures	-5.5976	-5.6255	-5.6442	**-5.6449**	15.8463	-1.4580
Market Indices						
MSCI World	-5.1083	**-5.1542**	-5.1252	-5.1172	-5.0523	-4.7076
JPM Gov Bond Index	-8.1953	-8.2205	**-8.2351**	-8.2339	-7.7776	-7.8592
S&P500	-4.9915	**-5.0210**	-5.0019	-4.9949	-4.9507	-4.9010
DJ Stoxx 600	-4.7978	**-4.8650**	-4.8234	-4.8174	-4.8253	-4.5759
Nasdaq Composite	-3.4456	-3.2989	-3.4073	-3.3488	**-3.4966**	-3.3521
Russell 2000	-4.4533	-4.4480	-4.4426	-4.4166	**-4.4984**	-3.9743

Table 5
Degrees of Freedom for the t-student Distribution

The degrees of freedom (v) for the t-student distributional assumption are estimated on in-the-sample standardised residuals for the GARCH model specification. For $v > 30$, the standard normal distribution was used.

Hedge Fund Indices	
Hedge Fund Index	16
Convertible Arbitrage	8
Ded Short Bias	31
Emerging Markets	12
Equity Mkt Ntrl	33
Event Driven	9
Fixed Inc Arb	12
Global Macro	15
Long/Short	16
Managed Futures	23
Market Indices	
MSCI World	101
JPM Gov Bond Index	63
S&P500	123
DJ Stoxx 600	44
Nasdaq Composite	24
Russell 2000	381

Table 6
Percentiles for Cornish-Fisher Expansion

The 1th/99th , 5th/95th and 10th/90th percentiles of the standardised normal distribution are -/+ 1.282, -/+ 1.645 and -/+ 2.326, respectively. The presented values are the percentiles for the Cornish-Fisher Expansion and are computed in-the-sample for comparison.

	1%	99%	5%	95%	10%	90%
Hedge Funds Indices						
Hedge Fund Index	-2.758	2.680	-1.626	1.596	-1.165	1.154
Convertible Arbitrage	-3.488	1.102	-1.974	1.051	-1.319	0.971
Ded Short Bias	-1.914	2.926	-1.417	1.808	-1.153	1.300
Emerging Markets	-3.876	2.388	-1.810	1.235	-1.083	0.866
Equity Mkt Ntrl	-2.218	2.484	-1.590	1.693	-1.253	1.292
Event Driven	-5.687	0.162	-1.938	-0.198	-0.713	-0.091
Fixed Inc Arb	-4.567	-0.355	-2.041	0.138	-1.085	0.368
Global Macro	-2.962	2.608	-1.671	1.534	-1.162	1.110
Long/Short	-3.122	3.077	-1.587	1.570	-1.045	1.039
Managed Futures	-2.534	2.378	-1.663	1.603	-1.252	1.229
Market Indices						
MSCI World	-2.840	1.668	-1.845	1.392	-1.354	1.183
JPM Gov Bond Index	-2.551	2.199	-1.706	1.570	-1.289	1.238
S&P500	-2.792	1.731	-1.829	1.419	-1.350	1.196
DJ Stoxx 600	-2.744	1.742	-1.822	1.435	-1.354	1.209
Nasdaq Composite	-2.859	1.861	-1.811	1.425	-1.318	1.173
Russell 2000	-3.002	1.942	-1.810	1.401	-1.285	1.130

Table 7
Out-of-Sample Exception Rates for the VaR Models

The out-the-sample exception rates are the number of losses greater than the VaR estimated for the period, as percentage of the total sample.

Panel A. VaR models based on the standard normal distributional assumption

	SMA(36)	SMA(60)	EWMA(36)	EWMA(60)	GARCH(60)	EGARCH(60)
			90%			
Hedge Fund Indices						
Hedge Fund Index	0.0167	0.0167	0.0167	0.0167	0.0500	0.0500
Convertible Arbitrage	0.0167	0.0167	0.0167	0.0167	0.0167	0.0333
Ded Short Bias	0.0333	0.1333	0.1333	0.1500	0.1333	0.1667
Emerging Markets	0.0000	0.0167	0.0000	0.0167	0.0167	0.0167
Equity Mkt Ntrl	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Event Driven	0.0333	0.0333	0.0333	0.0333	0.0167	0.0000
Fixed Inc Arb	0.0333	0.0167	0.0167	0.0167	0.0500	0.0500
Global Macro	0.0000	0.0000	0.0000	0.0167	0.0167	0.0667
Long/Short	0.0167	0.0167	0.0167	0.0167	0.0500	0.0333
Managed Futures	0.0833	0.0833	0.0833	0.0833	0.0833	0.1000
Market Indices						
MSCI World	0.1333	0.1333	0.1500	0.1500	0.1500	0.1500
JPM Gov Bond Index	0.0500	0.0167	0.0333	0.0333	0.1167	0.1167
S&P500	0.1167	0.1333	0.1500	0.1500	0.1333	0.1333
DJ Stoxx 600	0.1000	0.1167	0.1333	0.1333	0.1167	0.1333
Nasdaq Composite	0.1167	0.1333	0.1333	0.1333	0.0833	0.1000
Russell 2000	0.0667	0.0667	0.0667	0.0667	0.0833	0.0833
			95%			
Hedge Fund Indices						
Hedge Fund Index	0.0000	0.0000	0.0000	0.0000	0.0500	0.0500
Convertible Arbitrage	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167
Ded Short Bias	0.0000	0.0167	0.0167	0.0167	0.0667	0.1000
Emerging Markets	0.0000	0.0000	0.0000	0.0000	0.0000	0.0167
Equity Mkt Ntrl	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Event Driven	0.0333	0.0000	0.0167	0.0333	0.0000	0.0000
Fixed Inc Arb	0.0167	0.0000	0.0167	0.0167	0.0333	0.0333
Global Macro	0.0000	0.0000	0.0000	0.0000	0.0167	0.0333
Long/Short	0.0000	0.0167	0.0167	0.0167	0.0500	0.0333
Managed Futures	0.0333	0.0500	0.0333	0.0333	0.0667	0.0500
Market Indices						
MSCI World	0.0833	0.0833	0.0833	0.1000	0.0833	0.1167
JPM Gov Bond Index	0.0167	0.0167	0.0167	0.0167	0.0500	0.0500
S&P500	0.0667	0.0500	0.0833	0.0833	0.1000	0.0500
DJ Stoxx 600	0.0833	0.0833	0.1000	0.1000	0.1000	0.1000
Nasdaq Composite	0.0500	0.0833	0.0667	0.0667	0.0500	0.0500
Russell 2000	0.0333	0.0667	0.0500	0.0667	0.0667	0.0667
			99%			
Hedge Fund Indices						
Hedge Fund Index	0.0000	0.0000	0.0000	0.0000	0.0167	0.0333
Convertible Arbitrage	0.0000	0.0000	0.0000	0.0000	0.0167	0.0167
Ded Short Bias	0.0000	0.0000	0.0000	0.0000	0.0000	0.0167
Emerging Markets	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Equity Mkt Ntrl	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Event Driven	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000
Fixed Inc Arb	0.0167	0.0000	0.0000	0.0000	0.0167	0.0333
Global Macro	0.0000	0.0000	0.0000	0.0000	0.0167	0.0167
Long/Short	0.0000	0.0000	0.0000	0.0000	0.0333	0.0333
Managed Futures	0.0167	0.0167	0.0167	0.0167	0.0333	0.0167
Market Indices						
MSCI World	0.0167	0.0167	0.0167	0.0167	0.0167	0.0500
JPM Gov Bond Index	0.0000	0.0000	0.0000	0.0000	0.0167	0.0333
S&P500	0.0000	0.0000	0.0167	0.0167	0.0000	0.0333
DJ Stoxx 600	0.0167	0.0167	0.0333	0.0333	0.0167	0.0500
Nasdaq Composite	0.0167	0.0333	0.0333	0.0333	0.0167	0.0167
Russell 2000	0.0167	0.0333	0.0333	0.0333	0.0167	0.0167

Table 7 (cont.)

Panel B. VaR models based on the t-student distributional assumption

	SMA(36)	SMA(60)	EWMA(36)	EWMA(60)	GARCH(60)	EGARCH(60)
			90%			
Hedge Fund Indices						
Hedge Fund Index	0.0167	0.0167	0.0167	0.0167	0.0500	0.0500
Convertible Arbitrage	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167
Ded Short Bias	0.0333	0.1333	0.1333	0.1500	0.1333	0.1667
Emerging Markets	0.0000	0.0167	0.0000	0.0000	0.0167	0.0167
Equity Mkt Ntrl	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Event Driven	0.0333	0.0000	0.0333	0.0333	0.0000	0.0000
Fixed Inc Arb	0.0333	0.0167	0.0167	0.0167	0.0500	0.0500
Global Macro	0.0000	0.0000	0.0000	0.0000	0.0167	0.0500
Long/Short	0.0167	0.0167	0.0167	0.0167	0.0500	0.0333
Managed Futures	0.0833	0.0833	0.0833	0.0833	0.0833	0.1000
Market Indices						
MSCI World	0.1333	0.1333	0.1500	0.1500	0.1500	0.1500
JPM Gov Bond Index	0.0500	0.0167	0.0333	0.0333	0.1167	0.1167
S&P500	0.1167	0.1333	0.1500	0.1500	0.1333	0.1333
DJ Stoxx 600	0.1000	0.1167	0.1333	0.1333	0.1167	0.1333
Nasdaq Composite	0.1167	0.1333	0.1333	0.1333	0.0833	0.1000
Russell 2000	0.0667	0.0667	0.0667	0.0667	0.0833	0.0833
			95%			
Hedge Fund Indices						
Hedge Fund Index	0.0000	0.0000	0.0000	0.0000	0.0500	0.0500
Convertible Arbitrage	0.0167	0.0000	0.0167	0.0167	0.0167	0.0167
Ded Short Bias	0.0000	0.0167	0.0167	0.0167	0.0667	0.1000
Emerging Markets	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Equity Mkt Ntrl	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Event Driven	0.0333	0.0000	0.0000	0.0000	0.0000	0.0000
Fixed Inc Arb	0.0167	0.0000	0.0167	0.0167	0.0333	0.0333
Global Macro	0.0000	0.0000	0.0000	0.0000	0.0167	0.0333
Long/Short	0.0000	0.0167	0.0167	0.0167	0.0333	0.0333
Managed Futures	0.0167	0.0333	0.0333	0.0333	0.0500	0.0333
Market Indices						
MSCI World	0.0833	0.0833	0.0833	0.1000	0.0833	0.1167
JPM Gov Bond Index	0.0167	0.0167	0.0167	0.0167	0.0500	0.0500
S&P500	0.0667	0.0500	0.0833	0.0833	0.1000	0.0500
DJ Stoxx 600	0.0667	0.0667	0.0667	0.1000	0.1000	0.1000
Nasdaq Composite	0.0500	0.0833	0.0667	0.0667	0.0500	0.0500
Russell 2000	0.0333	0.0667	0.0500	0.0667	0.0667	0.0667
			99%			
Hedge Fund Indices						
Hedge Fund Index	0.0000	0.0000	0.0000	0.0000	0.0167	0.0167
Convertible Arbitrage	0.0000	0.0000	0.0000	0.0000	0.0167	0.0000
Ded Short Bias	0.0000	0.0000	0.0000	0.0000	0.0000	0.0167
Emerging Markets	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Equity Mkt Ntrl	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Event Driven	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fixed Inc Arb	0.0167	0.0000	0.0000	0.0000	0.0167	0.0333
Global Macro	0.0000	0.0000	0.0000	0.0000	0.0167	0.0167
Long/Short	0.0000	0.0000	0.0000	0.0000	0.0167	0.0167
Managed Futures	0.0167	0.0167	0.0167	0.0167	0.0333	0.0167
Market Indices						
MSCI World	0.0167	0.0167	0.0167	0.0167	0.0167	0.0500
JPM Gov Bond Index	0.0000	0.0000	0.0000	0.0000	0.0167	0.0333
S&P500	0.0000	0.0000	0.0167	0.0167	0.0000	0.0333
DJ Stoxx 600	0.0167	0.0167	0.0167	0.0167	0.0167	0.0500
Nasdaq Composite	0.0167	0.0333	0.0333	0.0333	0.0167	0.0167
Russell 2000	0.0167	0.0333	0.0333	0.0333	0.0167	0.0167

Table 7 (cont.)

Panel C. VaR models based on the Cornish-Fisher Expansion

	90%		95%		99%	
	36 obs.	60 obs.	36 obs.	60 obs.	36 obs.	60 obs.
Hedge Fund Indices						
Hedge Fund Index	0.0167	0.0167	0.0000	0.0000	0.0000	0.0000
Convertible Arbitrage	0.0167	0.0167	0.0167	0.0000	0.0167	0.0000
Ded Short Bias	0.1167	0.1500	0.0833	0.0833	0.0000	0.0167
Emerging Markets	0.0000	0.0333	0.0000	0.0000	0.0000	0.0000
Equity Mkt Ntrl	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Event Driven	0.0333	0.0333	0.0333	0.0000	0.0000	0.0000
Fixed Inc Arb	0.0333	0.0167	0.0167	0.0000	0.0000	0.0000
Global Macro	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Long/Short	0.0167	0.0167	0.0000	0.0167	0.0000	0.0000
Managed Futures	0.1000	0.0833	0.0333	0.0500	0.0333	0.0167
Market Indices						
MSCI World	0.1167	0.1167	0.0667	0.0667	0.0333	0.0000
JPM Gov Bond Index	0.0333	0.0333	0.0167	0.0167	0.0000	0.0000
S&P500	0.1000	0.1000	0.0500	0.0333	0.0167	0.0000
DJ Stoxx 600	0.1000	0.1167	0.0667	0.0500	0.0333	0.0167
Nasdaq Composite	0.1000	0.1333	0.0500	0.0667	0.0167	0.0167
Russell 2000	0.0667	0.0833	0.0333	0.0500	0.0333	0.0000

Table 7 (cont.)

Panel D. VaR models based on historical simulation

	90%		95%		99%	
	36 obs.	60 obs.	36 obs.	60 obs.	36 obs.	60 obs.
Hedge Fund Indices						
Hedge Fund Index	0.0167	0.0167	0.0167	0.0000	0.0000	0.0000
Convertible Arbitrage	0.0333	0.0333	0.0333	0.0167	0.0167	0.0000
Ded Short Bias	0.1333	0.1333	0.0833	0.1167	0.0333	0.0167
Emerging Markets	0.0167	0.0333	0.0000	0.0000	0.0000	0.0000
Equity Mkt Ntrl	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Event Driven	0.0500	0.0500	0.0333	0.0333	0.0167	0.0000
Fixed Inc Arb	0.0500	0.0500	0.0333	0.0167	0.0333	0.0000
Global Macro	0.0167	0.0167	0.0000	0.0000	0.0000	0.0000
Long/Short	0.0333	0.0333	0.0167	0.0167	0.0000	0.0000
Managed Futures	0.1000	0.1000	0.0667	0.0667	0.0333	0.0167
Market Indices						
MSCI World	0.1500	0.1667	0.1000	0.1000	0.0500	0.0167
JPM Gov Bond Index	0.0833	0.0833	0.0333	0.0333	0.0167	0.0167
S&P500	0.1667	0.1500	0.1000	0.0667	0.0333	0.0167
DJ Stoxx 600	0.1333	0.1333	0.0833	0.0667	0.0500	0.0167
Nasdaq Composite	0.1333	0.1333	0.0667	0.1167	0.0333	0.0500
Russell 2000	0.1000	0.1000	0.0500	0.0667	0.0333	0.0000

Table 8
Asymptotic p-values for the LR_{uc} Test Results

The LR_{uc} statistics are asymptotically distributed $\chi^2(1)$. The cells in bold font indicate the rejection of the null hypothesis at the 5% significance level.

Panel A. VaR models based on the standard normal distributional assumption

	SMA(36)	SMA(60)	EWMA(36)	EWMA(60)	GARCH(60)	EGARCH(60)
			90%			
Hedge Fund Indices						
Hedge Fund Index	**0.0097**	**0.0097**	**0.0097**	**0.0097**	0.1685	0.1685
Convertible Arbitrage	**0.0097**	**0.0097**	**0.0097**	**0.0097**	**0.0097**	0.0527
Ded Short Bias	0.0527	0.3854	0.3854	0.2084	0.3854	0.1020
Emerging Markets	1.0000	**0.0097**	1.0000	**0.0097**	**0.0097**	**0.0097**
Equity Mkt Ntrl	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Event Driven	0.0527	0.0527	0.0527	0.0527	**0.0097**	1.0000
Fixed Inc Arb	0.0527	**0.0097**	**0.0097**	**0.0097**	0.1685	0.1685
Global Macro	1.0000	1.0000	1.0000	**0.0097**	**0.0097**	0.3844
Long/Short	**0.0097**	**0.0097**	**0.0097**	**0.0097**	0.1685	0.0527
Managed Futures	0.6905	0.6905	0.6905	0.6905	0.6905	1.0000
Market Indices						
MSCI World	0.3854	0.3854	0.2084	0.2084	0.2084	0.2084
JPM Gov Bond Index	0.1685	**0.0097**	0.0527	0.0527	0.6436	0.6436
S&P500	0.6436	0.3854	0.2084	0.2084	0.3854	0.3854
DJ Stoxx 600	1.0000	0.6436	0.3854	0.3854	0.6436	0.3854
Nasdaq Composite	0.6436	0.3854	0.3854	0.3854	0.6905	1.0000
Russell 2000	0.3844	0.3844	0.3844	0.3844	0.6905	0.6905
			95%			
Hedge Fund Indices						
Hedge Fund Index	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Convertible Arbitrage	0.1793	0.1793	0.1793	0.1793	0.1793	0.1793
Ded Short Bias	1.0000	0.1793	0.1793	0.1793	0.5516	0.1078
Emerging Markets	1.0000	1.0000	1.0000	1.0000	1.0000	0.1793
Equity Mkt Ntrl	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Event Driven	0.5481	1.0000	0.1793	0.5481	1.0000	1.0000
Fixed Inc Arb	0.1793	1.0000	0.1793	0.1793	0.5481	0.5481
Global Macro	1.0000	1.0000	1.0000	1.0000	0.1793	0.5481
Long/Short	1.0000	0.1793	0.1793	0.1793	1.0000	0.5481
Managed Futures	0.5481	1.0000	0.5481	0.5481	0.5516	1.0000
Market Indices						
MSCI World	0.2634	0.2634	0.2634	0.1078	0.2634	**0.0382**
JPM Gov Bond Index	0.1793	0.1793	0.1793	0.1793	1.0000	1.0000
S&P500	0.5516	1.0000	0.2634	0.2634	0.1078	1.0000
DJ Stoxx 600	0.2634	0.2634	0.1078	0.1078	0.1078	0.1078
Nasdaq Composite	1.0000	0.2634	0.5516	0.5516	1.0000	1.0000
Russell 2000	0.5481	0.5516	1.0000	0.5516	0.5516	0.5516
			99%			
Hedge Fund Indices						
Hedge Fund Index	1.0000	1.0000	1.0000	1.0000	0.6258	0.1476
Convertible Arbitrage	1.0000	1.0000	1.0000	1.0000	0.6258	0.6258
Ded Short Bias	1.0000	1.0000	1.0000	1.0000	1.0000	0.6258
Emerging Markets	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Equity Mkt Ntrl	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Event Driven	0.6258	1.0000	1.0000	1.0000	1.0000	1.0000
Fixed Inc Arb	0.6258	1.0000	1.0000	1.0000	0.6258	0.1476
Global Macro	1.0000	1.0000	1.0000	1.0000	0.6258	0.6258
Long/Short	1.0000	1.0000	1.0000	1.0000	0.1476	0.1476
Managed Futures	0.6258	0.6258	0.6258	0.6258	0.1476	0.6258
Market Indices						
MSCI World	0.6258	0.6258	0.6258	0.6258	0.6258	**0.0248**
JPM Gov Bond Index	1.0000	1.0000	1.0000	1.0000	0.6258	0.1476
S&P500	1.0000	1.0000	0.6258	0.6258	1.0000	0.1476
DJ Stoxx 600	0.6258	0.6258	0.1476	0.1476	0.6258	**0.0248**
Nasdaq Composite	0.6258	0.1476	0.1476	0.1476	0.6258	0.6258
Russell 2000	0.6258	0.1476	0.1476	0.1476	0.6258	0.6258

Table 8 (cont.)

Panel B. VaR models based on the t-student distributional assumption

	SMA(36)	SMA(60)	EWMA(36)	EWMA(60)	GARCH(60)	EGARCH(60)
			90%			
Hedge Fund Indices						
Hedge Fund Index	**0.0097**	**0.0097**	**0.0097**	**0.0097**	0.1685	0.1685
Convertible Arbitrage	**0.0097**	**0.0097**	**0.0097**	**0.0097**	**0.0097**	**0.0097**
Ded Short Bias	0.0527	0.3854	0.3854	0.2084	0.3854	0.1020
Emerging Markets	1.0000	**0.0097**	1.0000	1.0000	**0.0097**	**0.0097**
Equity Mkt Ntrl	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Event Driven	0.0527	1.0000	0.0527	0.0527	1.0000	1.0000
Fixed Inc Arb	0.0527	**0.0097**	**0.0097**	**0.0097**	0.1685	0.1685
Global Macro	1.0000	1.0000	1.0000	1.0000	**0.0097**	0.1685
Long/Short	**0.0097**	**0.0097**	**0.0097**	**0.0097**	0.1685	0.0527
Managed Futures	0.6905	0.6905	0.6905	0.6905	0.6905	1.0000
Market Indices						
MSCI World	0.3854	0.3854	0.2084	0.2084	0.2084	0.2084
JPM Gov Bond Index	0.1685	**0.0097**	0.0527	0.0527	0.6436	0.6436
S&P500	0.6436	0.3854	0.2084	0.2084	0.3854	0.3854
DJ Stoxx 600	1.0000	0.6436	0.3854	0.3854	0.6436	0.3854
Nasdaq Composite	0.6436	0.3854	0.3854	0.3854	0.6905	1.0000
Russell 2000	0.3844	0.3844	0.3844	0.3844	0.6905	0.6905
			95%			
Hedge Fund Indices						
Hedge Fund Index	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Convertible Arbitrage	0.1793	1.0000	0.1793	0.1793	0.1793	0.1793
Ded Short Bias	1.0000	0.1793	0.1793	0.1793	0.5516	0.1078
Emerging Markets	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Equity Mkt Ntrl	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Event Driven	0.5481	1.0000	1.0000	1.0000	1.0000	1.0000
Fixed Inc Arb	0.1793	1.0000	0.1793	0.1793	0.5481	0.5481
Global Macro	1.0000	1.0000	1.0000	1.0000	0.1793	0.5481
Long/Short	1.0000	0.1793	0.1793	0.1793	0.5481	0.5481
Managed Futures	0.1793	0.5481	0.5481	0.5481	1.0000	0.5481
Market Indices						
MSCI World	0.2634	0.2634	0.2634	0.1078	0.2634	**0.0382**
JPM Gov Bond Index	0.1793	0.1793	0.1793	0.1793	1.0000	1.0000
S&P500	0.5516	1.0000	0.2634	0.2634	0.1078	1.0000
DJ Stoxx 600	0.5516	0.5516	0.5516	0.1078	0.1078	0.1078
Nasdaq Composite	1.0000	0.2634	0.5516	0.5516	1.0000	1.0000
Russell 2000	0.5481	0.5516	1.0000	0.5516	0.5516	0.5516
			99%			
Hedge Fund Indices						
Hedge Fund Index	1.0000	1.0000	1.0000	1.0000	0.6258	0.6258
Convertible Arbitrage	1.0000	1.0000	1.0000	1.0000	0.6258	1.0000
Ded Short Bias	1.0000	1.0000	1.0000	1.0000	1.0000	0.6258
Emerging Markets	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Equity Mkt Ntrl	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Event Driven	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Fixed Inc Arb	0.6258	1.0000	1.0000	1.0000	0.6258	0.1476
Global Macro	1.0000	1.0000	1.0000	1.0000	0.6258	0.6258
Long/Short	1.0000	1.0000	1.0000	1.0000	0.6258	0.6258
Managed Futures	0.6258	0.6258	0.6258	0.6258	0.1476	0.6258
Market Indices						
MSCI World	0.6258	0.6258	0.6258	0.6258	0.6258	**0.0248**
JPM Gov Bond Index	1.0000	1.0000	1.0000	1.0000	0.6258	0.1476
S&P500	1.0000	1.0000	0.6258	0.6258	1.0000	0.1476
DJ Stoxx 600	0.6258	0.6258	0.6258	0.6258	0.6258	**0.0248**
Nasdaq Composite	0.6258	0.1476	0.1476	0.1476	0.6258	0.6258
Russell 2000	0.6258	0.1476	0.1476	0.1476	0.6258	0.6258

Table 8 (cont.)

Panel C. VaR models based on the Cornish-Fisher Expansion

	90%		95%		99%	
	36 obs.	60 obs.	36 obs.	60 obs.	36 obs.	60 obs.
Hedge Fund Indices						
Hedge Fund Index	**0.0097**	**0.0097**	1.0000	1.0000	1.0000	1.0000
Convertible Arbitrage	**0.0097**	**0.0097**	0.1793	1.0000	0.6258	1.0000
Ded Short Bias	0.6436	0.2084	0.2634	0.2634	1.0000	0.6258
Emerging Markets	1.0000	0.0527	1.0000	1.0000	1.0000	1.0000
Equity Mkt Ntrl	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Event Driven	0.0527	0.0527	0.5481	1.0000	1.0000	1.0000
Fixed Inc Arb	0.0527	**0.0097**	0.1793	1.0000	1.0000	1.0000
Global Macro	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Long/Short	**0.0097**	**0.0097**	1.0000	0.1793	1.0000	1.0000
Managed Futures	1.0000	0.6905	0.5481	1.0000	0.1476	0.6258
Market Indices						
MSCI World	0.6436	0.6436	0.5516	0.5516	0.1476	1.0000
JPM Gov Bond Index	0.0527	0.0527	0.1793	0.1793	1.0000	1.0000
S&P500	1.0000	1.0000	1.0000	0.5481	0.6258	1.0000
DJ Stoxx 600	1.0000	0.6436	0.5516	1.0000	0.1476	0.6258
Nasdaq Composite	1.0000	0.3854	1.0000	0.5516	0.6258	0.6258
Russell 2000	0.3844	0.6905	0.5481	1.0000	0.1476	1.0000

Table 8 (cont.)

Panel D. VaR models based on historical simulation

	90%		95%		99%	
	36 obs.	60 obs.	36 obs.	60 obs.	36 obs.	60 obs.
Hedge Fund Indices						
Hedge Fund Index	**0.0097**	**0.0097**	0.1793	1.0000	1.0000	1.0000
Convertible Arbitrage	0.0527	0.0527	0.5481	0.1793	0.6258	1.0000
Ded Short Bias	0.3854	0.3854	0.2634	**0.0382**	0.1476	0.6258
Emerging Markets	**0.0097**	0.0527	1.0000	1.0000	1.0000	1.0000
Equity Mkt Ntrl	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Event Driven	0.1685	0.1685	0.5481	0.5481	0.6258	1.0000
Fixed Inc Arb	0.1685	0.1685	0.5481	0.1793	0.1476	1.0000
Global Macro	**0.0097**	**0.0097**	1.0000	1.0000	1.0000	1.0000
Long/Short	0.0527	0.0527	0.1793	0.1793	1.0000	1.0000
Managed Futures	1.0000	1.0000	0.5516	0.5516	0.1476	0.6258
Market Indices						
MSCI World	0.2084	0.1020	0.1078	0.1078	**0.0248**	0.6258
JPM Gov Bond Index	0.6905	0.6905	0.5481	0.5481	0.6258	0.6258
S&P500	0.1020	0.2084	0.1078	0.5516	0.1476	0.6258
DJ Stoxx 600	0.3854	0.3854	0.2634	0.5516	**0.0248**	0.6258
Nasdaq Composite	0.3854	0.3854	0.5516	**0.0382**	0.1476	**0.0248**
Russell 2000	1.0000	1.0000	1.0000	0.5516	0.1476	1.0000

Table 9
Asymptotic p-values for the LR_{cc} Test Results

The LR_{cc} statistics are asymptotically distributed $\chi^2(2)$. The cells in bold font indicate the rejection of the null hypothesis at the 5% significance level.

Panel A. VaR models based on the standard normal distributional assumption

	SMA(36)	SMA(60)	EWMA(36)	EWMA(60)	GARCH(60)	EGARCH(60)
			90%			
Hedge Fund Indices						
Hedge Fund Index	**0.0347**	**0.0347**	**0.0347**	**0.0347**	0.1033	0.1033
Convertible Arbitrage	**0.0347**	**0.0347**	**0.0347**	**0.0347**	**0.0347**	0.1428
Ded Short Bias	0.1428	0.6849	0.2304	0.4406	0.6830	0.1097
Emerging Markets	1.0000	**0.0347**	1.0000	**0.0347**	**0.0347**	**0.0347**
Equity Mkt Ntrl	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Event Driven	**0.0151**	**0.0151**	**0.0151**	**0.0151**	**0.0347**	1.0000
Fixed Inc Arb	**0.0151**	**0.0347**	**0.0347**	**0.0347**	0.1033	0.1033
Global Macro	1.0000	1.0000	1.0000	**0.0347**	**0.0347**	0.5120
Long/Short	**0.0347**	**0.0347**	**0.0347**	**0.0347**	0.1033	0.1428
Managed Futures	0.5811	0.5811	0.5811	0.5811	0.6435	0.5702
Market Indices						
MSCI World	0.4398	0.4398	0.3775	0.3775	0.3775	0.3775
JPM Gov Bond Index	0.3299	**0.0347**	0.1428	0.1428	0.8796	0.3492
S&P500	0.8796	0.1174	0.1474	0.1474	0.4398	0.4398
DJ Stoxx 600	0.8740	0.8796	0.4398	0.4398	0.8796	0.6830
Nasdaq Composite	0.3878	0.4398	0.4398	0.4398	0.5811	0.5063
Russell 2000	0.5120	0.5120	0.5120	0.5120	0.5811	0.5811
			95%			
Hedge Fund Indices						
Hedge Fund Index	1.0000	1.0000	1.0000	1.0000	0.2668	0.2668
Convertible Arbitrage	0.3990	0.3990	0.3990	0.3990	0.3990	0.3990
Ded Short Bias	1.0000	0.3990	0.3990	0.3990	0.6260	0.1564
Emerging Markets	1.0000	1.0000	1.0000	1.0000	1.0000	0.3990
Equity Mkt Ntrl	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Event Driven	0.0825	1.0000	0.3990	0.0825	1.0000	1.0000
Fixed Inc Arb	0.3990	1.0000	0.3990	0.3990	0.0825	0.0825
Global Macro	1.0000	1.0000	1.0000	1.0000	0.3990	0.7783
Long/Short	1.0000	0.3990	0.3990	0.3990	0.2668	0.7783
Managed Futures	0.7783	0.8515	0.7783	0.7783	0.6260	0.8992
Market Indices						
MSCI World	0.3727	0.3727	0.3727	0.2398	0.3727	0.1143
JPM Gov Bond Index	0.3990	0.3990	0.3990	0.3990	0.8515	0.8515
S&P500	0.6260	0.8515	0.3366	0.3366	0.1389	0.8515
DJ Stoxx 600	0.3727	0.3727	0.2398	0.2398	0.2398	0.2398
Nasdaq Composite	0.8515	0.3366	0.6260	0.6260	0.8515	0.8515
Russell 2000	0.7783	0.6260	0.8515	0.6260	0.6260	0.6260
			99%			
Hedge Fund Indices						
Hedge Fund Index	1.0000	1.0000	1.0000	1.0000	0.8727	0.3267
Convertible Arbitrage	1.0000	1.0000	1.0000	1.0000	0.8727	0.8727
Ded Short Bias	1.0000	1.0000	1.0000	1.0000	1.0000	0.8727
Emerging Markets	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Equity Mkt Ntrl	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Event Driven	0.8727	1.0000	1.0000	1.0000	1.0000	1.0000
Fixed Inc Arb	0.8727	1.0000	1.0000	1.0000	0.8727	**0.0347**
Global Macro	1.0000	1.0000	1.0000	1.0000	0.8727	0.8727
Long/Short	1.0000	1.0000	1.0000	1.0000	**0.0347**	0.3267
Managed Futures	0.8727	0.8727	0.8727	0.8727	0.3267	0.8727
Market Indices						
MSCI World	0.8727	0.8727	0.8727	0.8727	0.8727	0.0686
JPM Gov Bond Index	1.0000	1.0000	1.0000	1.0000	0.8727	0.3267
S&P500	1.0000	1.0000	0.8727	0.8727	1.0000	0.3267
DJ Stoxx 600	0.8727	0.8727	0.3267	0.3267	0.8727	0.0686
Nasdaq Composite	0.8727	0.3267	0.3267	0.3267	0.8727	0.8727
Russell 2000	0.8727	0.3267	0.3267	0.3267	0.8727	0.8727

Table 9 (cont.)

Panel B. VaR models based on the t-student distributional assumption

	SMA(36)	SMA(60)	EWMA(36)	EWMA(60)	GARCH(60)	EGARCH(60)
			90%			
Hedge Fund Indices						
Hedge Fund Index	**0.0347**	**0.0347**	**0.0347**	**0.0347**	0.1033	0.1033
Convertible Arbitrage	**0.0347**	**0.0347**	**0.0347**	**0.0347**	**0.0347**	**0.0347**
Ded Short Bias	0.1428	0.6849	0.2304	0.4406	0.6830	0.1097
Emerging Markets	1.0000	**0.0347**	1.0000	1.0000	**0.0347**	**0.0347**
Equity Mkt Ntrl	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Event Driven	**0.0151**	1.0000	**0.0151**	**0.0151**	1.0000	1.0000
Fixed Inc Arb	**0.0151**	**0.0347**	**0.0347**	**0.0347**	0.1033	0.1033
Global Macro	1.0000	1.0000	1.0000	1.0000	**0.0347**	0.3299
Long/Short	**0.0347**	**0.0347**	**0.0347**	**0.0347**	0.1033	0.1428
Managed Futures	0.5811	0.5811	0.5811	0.5811	0.6435	0.5702
Market Indices						
MSCI World	0.4398	0.4398	0.3775	0.3775	0.3775	0.3775
JPM Gov Bond Index	0.3299	**0.0347**	0.1428	0.1428	0.8796	0.3492
S&P500	0.8796	0.1174	0.1474	0.1474	0.4398	0.4398
DJ Stoxx 600	0.8740	0.8796	0.4398	0.4398	0.8796	0.6830
Nasdaq Composite	0.3878	0.4398	0.4398	0.4398	0.5811	0.5063
Russell 2000	0.5120	0.5120	0.5120	0.5120	0.5811	0.5811
			95%			
Hedge Fund Indices						
Hedge Fund Index	1.0000	1.0000	1.0000	1.0000	0.2668	0.2668
Convertible Arbitrage	0.3990	1.0000	0.3990	0.3990	0.3990	0.3990
Ded Short Bias	1.0000	0.3990	0.3990	0.3990	0.6260	0.1564
Emerging Markets	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Equity Mkt Ntrl	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Event Driven	0.0825	1.0000	1.0000	1.0000	1.0000	1.0000
Fixed Inc Arb	0.3990	1.0000	0.3990	0.3990	0.0825	0.0825
Global Macro	1.0000	1.0000	1.0000	1.0000	0.3990	0.7783
Long/Short	1.0000	0.3990	0.3990	0.3990	0.0825	0.7783
Managed Futures	0.3990	0.7783	0.7783	0.7783	0.8515	0.7783
Market Indices						
MSCI World	0.3727	0.3727	0.3727	0.2398	0.3727	0.1143
JPM Gov Bond Index	0.3990	0.3990	0.3990	0.3990	0.8515	0.8515
S&P500	0.6260	0.8515	0.3366	0.3366	0.1389	0.8515
DJ Stoxx 600	0.4020	0.4020	0.4020	0.2398	0.2398	0.2398
Nasdaq Composite	0.8515	0.3366	0.6260	0.6260	0.8515	0.8515
Russell 2000	0.7783	0.6260	0.8515	0.6260	0.6260	0.6260
			99%			
Hedge Fund Indices						
Hedge Fund Index	1.0000	1.0000	1.0000	1.0000	0.8727	0.8727
Convertible Arbitrage	1.0000	1.0000	1.0000	1.0000	0.8727	1.0000
Ded Short Bias	1.0000	1.0000	1.0000	1.0000	1.0000	0.8727
Emerging Markets	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Equity Mkt Ntrl	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Event Driven	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Fixed Inc Arb	0.8727	1.0000	1.0000	1.0000	0.8727	**0.0347**
Global Macro	1.0000	1.0000	1.0000	1.0000	0.8727	0.8727
Long/Short	1.0000	1.0000	1.0000	1.0000	0.8727	0.8727
Managed Futures	0.8727	0.8727	0.8727	0.8727	0.3267	0.8727
Market Indices						
MSCI World	0.8727	0.8727	0.8727	0.8727	0.8727	0.0686
JPM Gov Bond Index	1.0000	1.0000	1.0000	1.0000	0.8727	0.3267
S&P500	1.0000	1.0000	0.8727	0.8727	1.0000	0.3267
DJ Stoxx 600	0.8727	0.8727	0.8727	0.8727	0.8727	0.0686
Nasdaq Composite	0.8727	0.3267	0.3267	0.3267	0.8727	0.8727
Russell 2000	0.8727	0.3267	0.3267	0.3267	0.8727	0.8727

Table 9 (cont.)

Panel C. VaR models based on the Cornish-Fisher Expansion

	90%		95%		99%	
	36 obs.	60 obs.	36 obs.	60 obs.	36 obs.	60 obs.
Hedge Fund Indices						
Hedge Fund Index	**0.0347**	**0.0347**	1.0000	1.0000	1.0000	1.0000
Convertible Arbitrage	**0.0347**	**0.0347**	0.3990	1.0000	0.8727	1.0000
Ded Short Bias	0.8400	0.3350	0.3124	0.3124	1.0000	0.8727
Emerging Markets	1.0000	0.1428	1.0000	1.0000	1.0000	1.0000
Equity Mkt Ntrl	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Event Driven	**0.0151**	**0.0151**	0.0825	1.0000	1.0000	1.0000
Fixed Inc Arb	**0.0151**	**0.0347**	0.3990	1.0000	1.0000	1.0000
Global Macro	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Long/Short	**0.0347**	**0.0347**	1.0000	0.3990	1.0000	1.0000
Managed Futures	0.5063	0.5811	0.7783	0.8515	0.3267	0.8727
Market Indices						
MSCI World	0.3878	0.3878	0.4020	0.6260	0.3267	1.0000
JPM Gov Bond Index	0.1428	0.1428	0.3990	0.3990	1.0000	1.0000
S&P500	0.8740	0.8740	0.8515	0.7783	0.8727	1.0000
DJ Stoxx 600	0.8740	0.8796	0.4020	0.8515	0.3267	0.8727
Nasdaq Composite	0.8740	0.4398	0.8515	0.6260	0.8727	0.8727
Russell 2000	0.5120	0.5811	0.7783	0.8515	0.3267	1.0000

Table 9 (cont.)

Panel D. VaR models based on historical simulation

	90%		95%		99%	
	36 obs.	60 obs.	36 obs.	60 obs.	36 obs.	60 obs.
Hedge Fund Indices						
Hedge Fund Index	**0.0347**	**0.0347**	0.3990	1.0000	1.0000	1.0000
Convertible Arbitrage	0.1428	0.1428	0.7783	0.3990	0.8727	1.0000
Ded Short Bias	0.6849	0.6849	0.3706	0.0524	0.3267	0.8727
Emerging Markets	**0.0347**	0.1428	1.0000	1.0000	1.0000	1.0000
Equity Mkt Ntrl	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Event Driven	0.1033	0.1033	0.0825	0.0825	0.8727	1.0000
Fixed Inc Arb	0.1033	0.1033	0.0825	0.3990	**0.0347**	1.0000
Global Macro	**0.0347**	**0.0347**	1.0000	1.0000	1.0000	1.0000
Long/Short	**0.0151**	**0.0151**	0.3990	0.3990	1.0000	1.0000
Managed Futures	0.5063	0.5063	0.6260	0.6260	0.3267	0.8727
Market Indices						
MSCI World	0.3775	0.2527	0.2398	0.2398	0.0686	0.8727
JPM Gov Bond Index	0.5811	0.5811	0.7783	0.7783	0.8727	0.8727
S&P500	0.1377	0.1474	0.1389	0.6260	0.3267	0.8727
DJ Stoxx 600	0.4398	0.6830	0.3727	0.4020	0.0686	0.8727
Nasdaq Composite	0.4398	0.4398	0.6260	0.1143	0.3267	0.0686
Russell 2000	0.5063	0.5063	0.8515	0.6260	0.3267	1.0000

Table 10
VaR Estimates Comparison for HFRI Fund and Russell 2000 Indexes

Historical simulation in-sample VaR estimates using different time periods and samples. For the daily sample, the number of observations used is 2519. For the monthly samples the number of observations are 120 and 168, respectively.

Panel A. HFRI Fund Index

	Mean	Median	Stdev	Skewness	Kurtosis	Mean VaR		
						90%	95%	99%
Jan 94 - Dez 03 (monthly)	0.0098	0.0104	0.0216	-0.5170	5.9242	0.0259	0.0307	0.0432
Jan 90 - Dez 03 (monthly)	0.0118	0.0135	0.0204	-0.6568	5.8304	0.0273	0.0327	0.0461

Panel B. Russell 2000 Index

	Mean	Median	Stdev	Skewness	Kurtosis	Mean VaR		
						90%	95%	99%
Jan 94 - Dez 03 (daily)	0.0003	0.0011	0.0118	-0.2913	5.8013	0.0693	0.0926	0.1434
Jan 94 - Dez 03 (monthly)	0.0080	0.0155	0.0569	-0.4840	4.0043	0.0655	0.0883	0.1479
Jan 90 - Dez 03 (monthly)	0.0087	0.0166	0.0553	-0.5120	3.8354	0.0665	0.0891	0.1421

Table 11
Out-of-Sample VaR Evaluation Test Results

Historical Simulation out-of-sample VaR estimates, over the period January 1995 to December 2003 (108 monthly observations). The LR_{uc} and LR_{cc} are asymptotically distributed $\chi^2(1)$ and $\chi^2(2)$, respectively. The cells in bold font indicate the rejection of the null hypothesis at the 5% significance level.

	Exception rates			***LR uc***			***LR cc***		
	90%	95%	99%	90%	95%	99%	90%	95%	99%
HFRI Fund Index	0.0463	0.0185	0.0093	**0.0423**	0.0901	0.9457	0.0996	0.2288	0.9883
Russell 2000	0.0926	0.0648	0.0278	0.8214	0.4841	0.1244	0.9722	0.5877	**0.0465**

Figure 1
Hedge Fund returns versus Stocks and Bonds

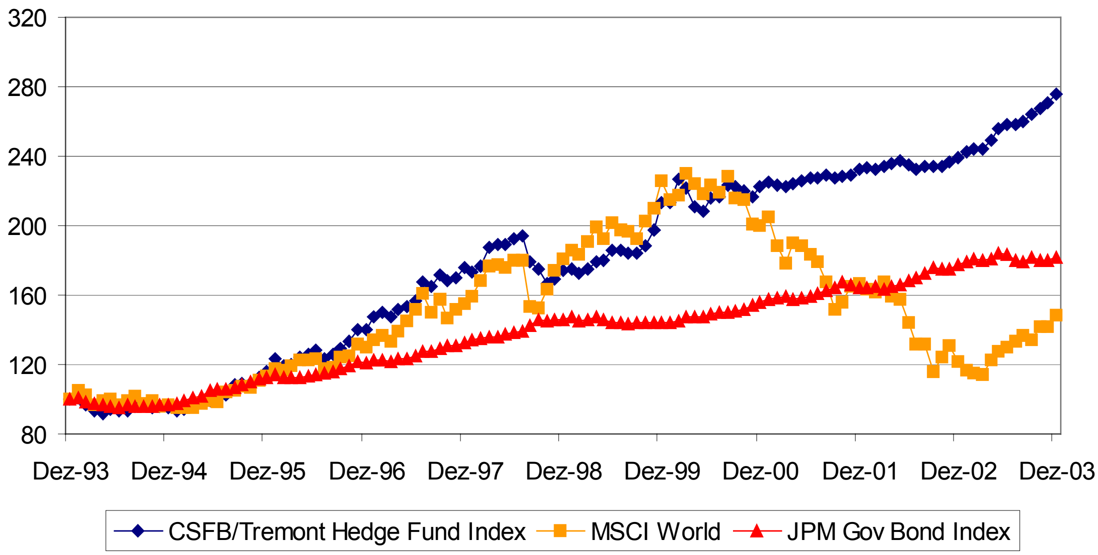

Figure 2
Hedge Funds volatility versus Stocks and Bonds
Out-of sample monthly volatility measured by the EWMA(60) model.