On the Performance of Alternative Investments: CTAs, Hedge Funds, and Funds-of-Funds

Bing Liang

Isenberg School of Management
University of Massachusetts, Amherst
Amherst, MA 01003
Phone: (413) 545-3180
Fax: (413) 545-3858
bliang@som.umass.edu

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Abstract

In this paper, we study alternative investment vehicles such as hedge funds, funds-of-funds, and commodity trading advisors (CTAs) by investigating their performance, risk, and fund characteristics. Differing from the previous studies that pool these investment vehicles, we consider them as three distinctive investment classes. We study them not only on a stand-alone basis but also on a portfolio basis. We find several interesting results. First, CTAs differ from hedge funds and funds-of-funds in terms of trading strategies, attrition rates and survivorship bias, liquidities, and correlation structures in different market environments. However, funds-of-funds are similar to hedge funds in these dimensions. Second, during the period of 1994 to 2001, hedge funds outperform funds-of-funds, which in turn outperform CTAs on a stand-alone basis. These results can be explained by the double fee structure but not survivorship bias. Third, correlation structures for alternative investment vehicles are different under different market conditions. Hedge funds are highly correlated to each other and are not well hedged in the down markets with liquidity squeeze. The negative correlations with other instruments make CTAs suitable hedging instruments for insuring downside risk. When adding CTAs to the hedge fund portfolio or the fund-of-fund portfolio, investors can benefit significantly from the risk-return trade-off.

I. Introduction

Alternative investments differ from traditional investments in low correlation with traditional asset classes, managers' involvement in their personal wealth, dynamic trading strategies, and use of a wide range of techniques and instruments. Hungry for positive returns in the recent bear markets, institutional investors such as investment banks, insurance companies, pension funds, and even university endowments are flocking to the alternative investment markets. Due to the special features, lack of regulatory oversight, and demands from both wealthy and institutional investors, alternative investment vehicles have gained popularity lately. Alternative investments include, but are not limited to, hedge funds, fund-of-hedge funds, commodity trading advisors (CTAs), private equity, partnerships, and venture capital. In this paper, we focus on three major alternative investment vehicles: hedge funds, funds-of-funds, and CTAs. In fact, major data vendors such as TASS Management Ltd. and Zurich Capital Markets Inc. (Zurich) collect data for all three categories. [1] There are certainly similarities among these three investment classes.

Several papers have addressed hedge fund performance and risk issues. In their pioneer study, Fung and Hsieh (1997a) extend Sharpe's (1992) style analysis to both buy-and-hold strategy and dynamic trading strategy and conclude that hedge fund strategies are highly dynamic. Brown, Goetzmann, and Ibbotson (1999) study the performance of offshore hedge funds. They attribute offshore fund performance to style effects rather than managerial skills. Ackermann, McEnally, and Ravenscraft (1999) compare hedge

[1] Previously, the Zurich data was known as Managed Accounts Reports (MAR) data.

funds with different market indexes and document mixed findings. They conclude that hedge funds outperform mutual funds. Liang (1999) documents that hedge funds dominate mutual funds in the mean-variance efficient world, with hedge fund investment strategies dramatically different from mutual funds. Agarwal and Naik (2002) extend Fung and Hsieh's (1997a) dynamic asset class factor model to both option-based strategies and buy-and-hold strategies and find that the option-based factors can significantly enhance the power of explaining hedge fund returns.

With rapid growth in the hedge fund industry, funds-of-hedge funds (FOF) have become more and more popular. A fund-of-funds invests in underlying hedge funds and serves the purposes of diversifying fund specific risk, relieving burdens on investors to select and monitor managers, and providing asset allocation in dynamic market environments. In addition, funds-of-funds usually require less initial investment so they are more affordable to investors than the regular hedge funds. As such they may provide the only way a small investor can invest in the hedge fund arena. These smaller investors may be willing to pay extra fees in order to participate. The question is whether it is worth investors paying these extra fees.

Previous studies in the area of hedge funds have pooled hedge funds with funds-of-funds (see Ackermann, McEnally, and Ravenscraft (1999) and Liang (1999)). Combining hedge funds with funds-of-funds would not only cause a double counting problem but also would hide the difference in fee structures between hedge funds and funds-of-funds (see Brown, Goetzmann, and Liang (2002)). A hedge fund charges a management fee and incentive fee while a fund-of-funds not only charges these fees at the fund-of-fund level but also passes on hedge fund level fees in the form of after fee returns to the fund-of-

fund investors. In fact, underlying hedge fund fees will be transferred to the fund-of-fund investors regardless of whether the funds-of-funds makes a profit or not. As a result, total fees from a fund-of-fund can exceed the total realized return on the fund. Brown, Goetzmann, and Liang (2002) examine this issue and propose an alternative fee arrangement for funds-of-funds, under which the fund-of-fund managers will absorb the underlying hedge funds fees and establish their own incentive fees at the fund-of-fund level. This will provide a better incentive for fund-of-fund managers and reduce the dead-loss costs for investors under the current fee arrangement. Because of the above issues, we need to separate funds-of-funds from hedge funds in academic studies and address the differences in performance, risk, and fee structures.

Although hedge funds and funds-of-funds are new to academics, CTAs have been investigated by scholars previously. Elton, Gruber, and Rentzler (1987) find that randomly selected commodity funds offer neither an attractive alternative to bonds and stocks nor a profitable addition to a portfolio of stocks and bonds. In contrast, Irwin and Brorsen and Irwin (1985) and Murphy (1986) conclude that commodity funds produce favorable or appropriate investment returns. Fung and Hsieh (1997b) find CTAs have much higher dissolution rates than mutual funds. They conclude that CTA returns show option-like return patterns with respect to global equity markets.

Previous studies have also pooled hedge funds with CTAs (see Fung and Hsieh (1997a)). Although there are certain similarities between the two groups, such as management and incentive fee structures, high initial investment requirements, use of leverage and derivatives, systematic differences can also exist. For example, hedge funds are involved in varieties of dynamic trading strategies using different financial

instruments in different markets while CTAs mainly consist of technical trading strategies in commodity and financial futures markets. Investing in different instruments from different markets can result in differences in risk and returns. In addition, CTAs must register with the Commodity Futures Trading Commission (CFTC) while hedge funds and funds-of-funds are largely exempt from government regulations.[2] Most importantly, correlations among various hedge fund styles are very high while correlations among CTAs and hedge fund styles are almost zero or negative. This correlation structure of CTAs with others may make them an excellent candidate for hedging downside risk. Therefore, it is necessary to distinguish CTAs from hedge funds or funds-of-funds in academic studies.

In this paper, we simultaneously evaluate the three major alternative investment vehicles: hedge funds, funds-of-funds, and CTAs in terms of performance, risk, and fee structures of these investment classes. Unlike the previous studies that pool them together, we separate the three groups as three distinctive investment classes. By doing so, we can investigate the similarities and differences among them and further explore the investment strategies that are employed by fund managers. In addition, our study is conducted not only on a stand-alone basis but also on a portfolio basis of adding one investment class to another. In particular, we study the relationship among different investment strategies under different market environments in order to see how market conditions impact fund returns and risks and how investors can benefit from combining CTAs with their hedge fund or fund-of-fund portfolios.

[2] Although there is a trend for CTAs to switch names to hedge funds in order to avoid regulation, this nominal change does not affect their fundamental trading strategies.

This paper differs from Brown, Goetzmann, and Park (2001), who study hedge fund and CTA managers' variance strategy based on past performance and survival. Similar to Elton, Gruber, and Rentzler (1987), who apply a portfolio approach to examine the commodity markets, we adopt a portfolio approach to those three alternative investment vehicles. While Edwards and Caglayan (2001) examine correlations between hedge funds/commodity funds and the S&P 500 Index, we study the relationship among hedge fund, fund-of-fund, and CTA groups. We also study the non-linearity of fund returns with respect to the equity markets. We study the three alternative investment classes not only at the style level, but also at the individual fund level. As emphasized by Edwards and Caglayan (2001), it is important to examine these alternative investment vehicles in both up and down markets because these instruments are designed to hedge against downside risk and payoffs of these investment vehicles are non-linear. By examining correlations in the up and down markets, we search for best hedge tools or optimal portfolio combinations when a regular hedge fund or fund-of-fund is not well hedged. By evaluating all three alternative investment vehicles together and examining their risks, returns, and fund characteristics, we can add not only understanding to the literature of alternative investments but also contribution to the investment communities.

In this paper, we find several interesting results. First, funds-of-funds are highly correlated with each hedge fund style; both being linked to some common asset class factors. This is consistent with the notion that funds-of-funds invest in different hedge fund styles. However, funds-of-funds underperform their hedge fund components, due to the double fee structure and incomplete coverage (hence ineffective diversification) of

the hedge fund universe.[3] Some superior hedge funds may be closed to investment so funds-of-funds will not be able to access them. Because of these, investors who invested in funds-of-funds will face inferior risk-return trade-off than that of hedge funds. Secondly, CTA styles are slightly or negatively correlated with hedge fund styles or funds-of-funds depending on the general market conditions. Asset class factor analysis also indicates that CTAs follow very different trading strategies from those of hedge funds or funds-of-funds. Especially, the only significant factors to explain CTA returns are the option trading factors, which cannot explain hedge fund or fund-of-fund returns. Although CTAs in general have higher attrition rates than others, they have relatively lower attrition rate in the down market than that in the up market, forming a strong contrast with hedge funds and funds-of-funds. Fourth, we indicate that funds within the same style are less correlated; making a style index less useful than one expects. Finally, we find that correlation structures are different in the up markets from those in the down markets. Hedge funds and funds-of-funds are highly correlated with each other in the down markets, they are not well hedged. Because of the negative correlation with other instruments, CTAs are suitable candidates for hedging the downside risk. Adding CTAs to the hedge fund portfolio or the fund-of-fund portfolio, investors can significantly benefit from the risk-return trade-off.

The rest of the paper is organized as follows. Section II describes the data. Section III studies attrition rate and survivorship. Section IV compares performance, risk, and fee structures of hedge funds, funds-of-funds, and CTAs on a stand-alone basis. Section V

[3] Our survey indicates that an average fund-of-funds invests in only 13 hedge funds. However, Park and Staum (1998) indicate that well diversified funds-of-funds need more hedge funds.

analyzes correlation structures of these different investment vehicles and considers them in a portfolio framework. Section VI concludes the paper.

II. Data

The data is provided by Zurich Capital Markets Inc. (Zurich). As of March 2002, there are 2,357 hedge funds (1,164 live funds and 1,193 dead funds), 597 funds-of-funds (including 349 live and 248 dead), and 1,510 CTAs (294 live CTAs and 1,216 dead CTAs).[4] Zurich classifies CTAs into live CTAs and dead CTAs and defines a hedge fund or a fund-of-funds dead if it fails to report to the data vendor in three consecutive months or more.

Table 1 reports the basic statistics of the data. The median management fees for hedge funds, funds-of-funds, and CTAs are 1%, 1%, and 2%, respectively. Apparently, hedge funds charge the least amount of management fees, compared with funds-of-funds and CTAs. Note that a fund-of-fund invests in different hedge funds and hence charges two-tier fees: a fee that is indirectly paid to the individual hedge fund (1% on average) in which the funds-of-funds invest and a fee that is paid directly to the funds-of-funds (1% on average). The two-tier fees are all borne by investors in the form of after fee returns. All things being equal, returns from hedge funds will be higher than returns from funds-of-funds since lower management fees are charged. Apart from the management fee, the median incentive fees for hedge funds, funds-of-funds, and CTAs are all 20%. Again, a

[4] There are three ways in which investors can invest in managed futures. Public commodity funds are similar to equity or bond mutual funds except they invest in commodity or financial futures. Privately placed funds pool investors' money and hire one or more CTAs to manage the pooled funds. Finally, investors can have one or more CTAs directly manage their money on an individual basis. Therefore, a CTA can engage in both public and private funds. To avoid double counting, we only use the CTA sample from Zurich.

fund-of-funds may deliver lower after fee returns than a hedge fund due to the two-tier fee structure.

The median minimum investment for hedge funds, funds-of-funds, and CTAs are $300,000, $250,000, and $250,000, respectively. They are all designed for accredited investors or institutional investors. As of December 2001, the median fund assets for hedge funds, funds-of-funds, and CTAs are $36 million, $34 million, and $13 million, respectively. Hence, most funds or CTAs are relatively small. It seems that the average size for a CTA is smaller than those of hedge funds or funds-of-funds. Consistent with the small asset base, Table 1 also indicates that on average a CTA has only four employees. The median fund ages (of both live and dead funds) for the three portfolio groups are 44 months, 52 months, and 46 months. Fund-of-funds has the longest average life because of the diversification effect across different hedge fund components. If one or more hedge funds die in the fund-of-fund portfolio, other hedge funds can still remain in the portfolio and funds-of-funds managers can easily switch to other hedge funds to replace the dead ones.

III. Attrition Rates and Survivorship Biases

A. Attrition Rates

We expect that hedge funds, funds-of-funds, and CTAs all have different attrition rates due to different trading strategies and risks involved. Also, the attrition rates will be different under different market environments because down markets may put constraints on liquidity and hence induce higher fund failure rate than that in up markets. We define up and down markets according to the S&P 500 index returns. Up markets are defined

when the monthly S&P 500 returns are positive while down markets are defined when the index returns are non-positive.

In Table 2 we report the attrition rates for all three groups in the up and down markets, respectively. We begin with 1994 because Zurich started collecting dissolved hedge funds and funds-of-funds information in that year. In Panel A, hedge funds show fairly steady attrition rates from 1994 to 2001, with an average attrition rate of 13.2% per year in the up markets. However, in the down markets the attrition rates are much higher especially in bad years such as 2000 to 2001. On average, the 17% attrition rate is almost 4% higher than that in the up markets. This difference may reflect that hedge funds undergo stress in the down markets when investors flee to liquidity and withdraw monies from the funds while funds receive margin calls and are forced to liquidate their positions or close the funds. The results for funds-of-funds in Panel B are similar to those of hedge funds in Panel A except the magnitudes of the attrition rates are smaller. The relatively lower attrition rates for funds-of-funds may reflect that a fund-of-funds is better diversified than a hedge fund, hence relatively less funds-of-funds die when markets experience difficulties.

It is interesting to note that CTAs in Panel C exhibit lower average attrition rate in the down markets (20.3%) than that in the up market (23.5%). This is very different from hedge funds and funds-of-funds. CTAs are natural hedge instruments against the general equity or bond markets while hedge funds or funds-of-funds are closely related to those markets because they invest in various assets from the equity or bond markets. However, due to high risk involved from derivatives and leverage, CTAs generally have higher attrition rate than hedge funds and funds-of-funds.

B. Survivorship Bias

We define survivorship bias as the return difference between two portfolios: the survived fund portfolio and the entire portfolio. The survived portfolio contains funds with returns from inception (or the time when the first return data is recorded, whichever is the latter) all the way to the current reference date, and the entire portfolio has included all funds (both live and dead funds). Funds may drop off the database due to various reasons such as mergers and acquisitions, closure or liquidation, and voluntary withdrawal. Poor performance may also be a major reason. In fact, Liang (2000) indicates that poor performance on hedge funds is the main reason for a fund to die. The analysis on survivorship bias below confirms this point.

Table 3 displays survivorship biases over an 8-year period from 1994 to 2001. In Panel A, the average survivorship bias for hedge funds is 0.191% per month or 2.32% per year. The 2.32% bias is almost the same as the 2.2% bias reported by Liang (2000) and consistent with the 1.5% reported by Fung and Hsieh (1997b). The survivorship bias for funds-of-funds is reported in Panel B. The 8-year average is only 0.098% per month or 1.18% per year. Consistent with our previous argument, a fund-of-funds contains more than a single hedge fund and poor performance or death of one or more hedge funds should not materially affect the others in the funds-of-funds. Therefore, the attrition rate for funds-of-funds is much lower than that of the hedge funds and hence the survivorship bias is lower. Panel C reports the bias for CTAs. Surprisingly, over the 8-year period, the average survivorship bias is 0.478% per month or 5.89% per year. This is much higher than the 3.54% bias reported by Fung and Hsieh (1997b) over a 7-year period from 1989

to 1995. Differences can be explained by different time periods and different data used. The results of survivorship in Table 3 are consistent with the results of attrition rates in Table 2: The higher the attrition rate, the higher the survivorship bias.

In summary, CTAs have the highest attrition rate and survivorship bias; hedge funds the second, and funds-of-funds the lowest. The difference in the magnitude of survivorship bias can affect the performance analysis in the next section. Excluding dead funds can significantly inflate the performance numbers. Therefore, we will include all funds both live and dead in our following analysis.

IV. Performance, Risk, and Fee Structures

A. Performance and Risk

One of the conventional measures for hedge fund returns and risks is Sharpe ratio. However, recent studies have challenged the effectiveness of using Sharpe ratio to evaluate hedge fund performance when returns are negatively skewed, have high kurtosis, and show strong autocorrelations. Lo (2002) documents that the positive autocorrelation in hedge fund returns can overstate the Sharpe ratio. He recommends using the autocorrelation adjusted Sharpe ratio instead of the regular Sharpe ratios in the following way:

$$\eta(q)\,\mathrm{SR} \text{ with } \eta(q) = \frac{q}{\sqrt{q + 2\sum_{k=1}^{q-1}(q-k)\rho_k}} \tag{1}$$

where SR is the regular Sharpe ratio on a monthly basis, ρ_k is the kth autocorrelation for hedge fund returns, and $\eta(q)\,\mathrm{SR}$ is the annualized autocorrelation adjusted Sharpe ratio

with q=12. Note when returns are independently and identically distributed (i.i.d.), the annualize Sharpe ratio is $\sqrt{12}$ SR, which may overstate the true Sharpe ratio if the returns are positively autocorrelated as $\eta(q)$ in (1) is less than $\sqrt{q}$.

We estimate the autocorrelation coefficients up to lag 11 by using a rolling 24-month window. For example, for the year 1994, we estimate autocorrelations using the data from 1994-1995, and so on.[5] Table 4 reports raw returns, standard deviations, $\sqrt{12}$ SR and the autocorrelation adjusted Sharpe ratios $\eta(q)$ SR over a seven-year period from 1994 to 2000. There are several interesting findings in Table 4. First, in Panel A hedge funds outperform funds-of-funds in six out of seven years when performance is measured by raw returns (all of the *t*-statistics for return differences are significant at the 1% level). This proportion falls to five out of seven years when the autocorrelation adjusted Sharpe ratio is used (see column $\Delta\eta(12)$ SR, which is equal to the difference in two autocorrelation adjusted Sharpe ratios). Hence, we conclude that hedge funds outperform funds-of-funds during this seven-year period on both a risk adjusted and a non-adjusted basis. Note that the $\sqrt{12}$ SRs are different from the $\eta(q)$ SRs, reflecting the nature of non-normality and non i.i.d. distribution in hedge fund returns. However, the results of outperformance of hedge funds over funds-of-funds are only slightly changed when we use $\sqrt{12}$ SR (measured by $\Delta\sqrt{12}$ SR, which is the difference in two $\sqrt{12}$ SRs). There are four out of seven years when hedge funds outperform funds-of-funds, compared with five out seven years when $\Delta\eta(12)$ SR is used.

[5] We only report the adjusted Sharpe ratios from 1994 to 2000 (not 2001) because we need the data in 2001 to estimate the autocorrelation structures for year 2000.

We can attribute the outperformance to the two-tier fee structure of funds-of-funds, which reduces the after fee performances. This argument is consistent with Brown, Goetzmann, and Liang (2002). Although a fund-of-funds offers diversification it comes with a cost: the fees may not justify the diversification effect. Fung and Hsieh (2000) argue that the underperformance of funds-of-funds can be largely attributed to the survivorship bias. However, the difference in the survivorship between hedge funds and funds-of-funds is only 0.093% on a monthly basis while the return difference between the two is 0.4108%, much higher than the survivorship difference. In addition, the overall fund-of-fund portfolio that contains both live and dead funds-of-funds is bias free and generates an average monthly return of only 0.75% from 1994 to 2001. The bias free benchmark S&P 500 index generates an average monthly return of 1.04% during the same period. Therefore, the underperformance of funds-of-funds cannot be explained by survivorship bias.

Second, hedge funds also outperform CTAs during the same time period as displayed in Panel B. When raw return is used, hedge funds earn higher returns than CTAs in four out of seven years (all *t*-statistics are significant at the 1% level) while CTA is the winner in only one out of seven years (significant at the 10% level only). When the autocorrelation adjusted Sharpe ratio is used, the result is very dramatic: CTAs underperform hedge funds in all seven years no matter whether we use $\Delta\sqrt{12}\,\mathrm{SR}$ or $\Delta\,\eta(q)\,\mathrm{SR}$. We may attribute this underperformance to high attrition rate and survivorship bias, high fees, relatively less diversified positions/high volatility, and high leverage of CTAs.

Third, CTAs even underperform funds-of-funds in Panel C. When the autocorrelation adjusted Sharpe ratio is used, CTAs underperform funds-of-funds in all seven years. The results are similar when $\sqrt{12}$ SR is used. The results from raw returns are mixed. Note that the $\sqrt{12}$ SRs are not necessarily higher than $\eta(q)$ SRs (see $\Delta \text{SR}_{\text{HF}}$, $\Delta \text{SR}_{\text{FOF}}$, and Δ_{CTA} in all panels, which measure the difference between $\eta(q)$ SR and $\sqrt{12}$ SR). It depends on the autocorrelation structure of fund returns. In the CTA case, $\sqrt{12}$ SR is overwhelmingly higher than $\eta(q)$ SR but for hedge funds or funds-of-funds the results are mixed, reflecting different autocorrelation structures among the three investment classes.[6]

In summary, according the risk-return analysis, we rank hedge funds the highest, funds-of-funds are the second, and CTAs the lowest on a stand-alone basis. This ranking order may have to do with the fee structures, risks, and the autocorrelation structures of these different investment classes. We know that hedge funds charge fewer fees than those of funds-of-funds and CTAs and those CTAs are mostly likely trend followers while hedge funds are different arbitragers.

B. The Asset Class Factor Model

For performance attribution and evaluation of these investment vehicles, we adopt a multi-asset class factor model and regress asset returns on several asset class factors and risk factors. Similar kinds of analyses have been conducted by Sharpe (1992) for mutual funds, Fung and Hsieh (1997a), Ackermann, Ravenscraft, and McEnally (1999), and

[6] The η values for CTAs are relatively high, compared with those of hedge funds and funds-of-funds. Because of the negative unadjusted Sharpe ratio for CTAs, the autocorrelation adjusted Sharpe ratios are even more negative.

Liang (1999) for hedge funds. Recently, Agarwal and Naik (2002) document that adding the Fama-French factors and the option-based trading factors can significantly enhance the power of explaining hedge fund returns. Therefore, we adopt a similar setting as Agarwal and Naik. First, we have eight basic asset class factors that are the same as those used in the previous studies. In particular, we use the S&P 500 index for the US equity market, Morgan Stanley Capital International's (MSCI) developed country index for other developed equity markets, MSCI emerging market index for emerging markets, Salomon Brothers world government bond index and Salomon Brothers Broad Investment Grade (BIG) index for government bond and broad bond markets, Federal Reserve Bank trade-weighted dollar index for currency, gold price for commodities, and one-month US dollar deposit for cash. In addition, we have added the Fama-French's (1993) size (small-minus-big or SMB) and value/book-to-market (high-minus-low or HML) factors on top of the eight basic factors. Finally, four option-based risk factors are added; they are the highly liquid at-the-money (ATM) and out-of-the money (OTM) European call and put options on the S&P 500 index trading on the Chicago Mercantile Exchange. These option factors are exactly the same as those of Agarwal and Naik (2002). They are designed to capture the non-linearity in fund returns. As a result, the asset class factor model can be expressed as: [7]

$$R_{it} = \alpha_k + \sum_{k=1}^{N} \beta_k F_{kt} + \varepsilon_{it}. \qquad (2)$$

To test the different roles of various factors and check the robustness of the model, we run several regressions for each of the three investment classes. These regressions

[7] We have also tried the yield spread factor (Baa corporate bond yield minus the ten-year Treasury yield), but it is insignificant for any of the four models so that we do not include it in the results.

include either the full 14 factors or a subset of these factors. The model with only the eight basic asset class factors is called the base model. The model with the eight factors, two Fama-French factors, and four option factors is called the full model. We also have the basic factor plus the Fama-French factor model and the basic factor plus the option factor model. As a result, we have four regressions for each of the three investment classes.

Table 5 reports these regression results. For the results of hedge funds in Panel A, across four different regression models, returns are significantly related to MSCI developed country index (excluding US), MSCI emerging market index, Salomon Brothers world government bond index, the BIG index, and the Fama-French size factor. Apparently, hedge funds invest in both the equity and bond markets. Especially, hedge funds long securities in the developed equity and emerging equity markets, short government bonds and long broad investment grade bonds, and long small stocks while going short on large stocks during the time period we study. We know that many hedge funds have net long equity positions which will benefit from up equity markets in general. Note that the coefficients on the two bond factors have opposite signs; we can interpret the reverse signs as something such as fixed income arbitrage: long the broad investment grade bonds and short sell government bonds. This is based on betting that the credit spread between the two will converge, which is a popular bond trading strategy during that time period. The adjusted R^2s for the four models range from 72.9% to 91.6%, indicating very high explanatory powers of the model. Interestingly, the marginal benefit of adding the Fama-French size and value factors to the base model is highly significant, reflected by the increased R^2 from 74.5% to 91%. Hedge funds may long

small stocks while short selling large stocks, and long growth stocks and short selling value stocks to make arbitrage profits. In contrast, the marginal benefit of adding the four option-based factors to the base model is not significant; the adjusted R^2 is actually declined from 74.5% to 72.9%. This is in contrast to the results by Agarwal and Naik (2002), who find that option factors are significant for different hedge fund strategies. While Agarwal and Naik examine hedge fund factor loadings at each style, we focus on hedge funds as one investment class as our interest is to distinguish hedge funds from CTAs at the aggregate level. In addition, we run several regressions to check the robustness of the results.

The regression results for funds-of-funds in Panel B are similar to those for hedge funds although the regressions are not as strong: the models pick up exactly the same asset class factors and the estimates have the same signs as those for hedge funds. This is not surprising because funds-of-funds invest in different hedge funds, they should cover similar investment styles on average. The adjusted R^2s for the fund-of-fund regressions range from 65.4% to 79.4%, lower than those of the hedge funds. Again, the marginal benefits of adding the Fama-French factors and the option factors to the base model are very similar to those of hedge funds.

In a strong contrast, the models have very low explanatory powers for CTAs in panel C. The adjusted R^2s range from -7.2% to 14.3%. Comparisons across three groups indicate that CTAs follow very different investment strategies from hedge funds or funds-of-funds. The signs of factor loadings for CTAs are very different from those of the other two classes. It is well known that CTAs mainly invest in futures markets and often are used for hedging equity market risk. This can be reflected from the negative signs of the

S&P 500 index and the MSCI developed market index. In addition, CTAs are long and short timers in commodities or financial futures, which may result in no correlation with the commodity index as long and short positions can cancel each other out. This can explain why the coefficient on factor "gold" is insignificant. The Fama-French size and value factors are not significant, reflecting that CTAs are generally not arbitragers in the equity markets. The only significant factors for CTAs are the three out of four option factors, which are insignificant for hedge funds and funds-of-funds. Although CTAs may not trade in the option markets directly, their returns may show non-linear or option-like patterns due to some long-short combinations. As a result, CTA returns may be relatively high under extreme market conditions than the normal conditions, which will lead to concavity in returns. In fact, our result here is consistent with Fung and Hsieh (1997b) that CTAs exhibit option-like conditional return patterns with respect to equity markets.

Once again, across all three panels we can see that hedge funds outperform the other two classes: the intercept term or the unexplained return from the full factor model is 1.1% per month and significant at the 1% level for hedge funds, it is 0.81% per month for funds-of-funds and significant at the 1% level while the intercept term for CTAs is not significantly different from zero. These results are consistent with the Sharpe ratio analyses that are reported in Table 4.

In summary, we find that CTAs are different from hedge funds or fund-of-funds in trading strategies. The only significant factors for CTAs are option-related factors while equity market and bond market factors are picked up by hedge fund or fund-of-fund styles. On a stand-alone basis, the pecking order of performance is hedge funds, funds-of-funds, and CTAs.

V. Performance Evaluation in a Portfolio Framework and under Different Market Environments

The above section indicates that CTAs are different from either hedge funds or funds-of-funds in investment strategies. In this section, we further study the correlation structures among hedge funds, funds-of-funds, CTAs, and the market index. We perform this analysis first at the aggregate/style level then at the individual fund level to better utilize fund specific information. We conduct the simple correlation analysis not only in the up markets but also in the down markets. We study autocorrelations for liquidity issues and we run piecewise regressions for non-linearities in fund returns.

It is important to distinguish the correlation structure in the up markets from that of the down markets. This is because of the following reasons. First, due to the option-like payoff or fee structures, CTAs exhibit return complexity rather than linearity with respect to equity market returns. Hedge fund returns may also show non-linearity due to the option-like fee structures and the derivative securities involved. Second, if the market is doing well, there should be plenty of instruments and strategies available for fund managers to maneuver, active trading and dynamic strategies will produce varieties of trading positions, and different timing skills will further make these positions less correlated. In contrast, if the market is down, the supply of liquidity can quickly vanish, fund managers may not have much room to maneuver and they are forced to invest in limited securities and follow similar strategies. Therefore correlations among different funds even different styles can be very high. For example, during the Russian debt crisis in 1998, managers of fixed income arbitrage funds are driven to liquid government

securities and escape the illiquid debt instruments. This herding behavior makes fixed income arbitrage funds highly correlated among each other. Kyle (1985) summarizes market liquidity by using three components: "tightness" (the cost of turning around a position during a short period), "depth" (the size of an order flow innovation required to change prices by a given amount), and "resiliency" (the speed with which prices can recover from a random shock). Third, it is well known that CTAs offer natural hedges for traditional investment vehicles such as bonds and stocks. In the up markets, CTAs may be less attractive to hedge fund investors due to inferior returns to bonds or stocks. However, in the down markets, CTAs may be desired due to the negative correlations with other asset classes and relative sound performance compared to the others (the negative correlations are not low in magnitude as shown in Table 6). Therefore, in the following analysis, we will study correlation structures in both up and down markets.

A. **Non-Linearities in Fund Returns**

We use the following model to capture the non-linearity of fund returns with respect to the S&P 500 index:

$$R_{it} = \alpha_i + \beta_i^+ I_t^+ + \beta_i^- I_t^- + \varepsilon_{it}, \tag{3}$$

where $I_t^+ = R_{mt}$, if $R_{mt} > 0$ and $I_t^+ = 0$ otherwise, $I_t^- = R_{mt}$, if $R_{mt} \le 0$ and $I_t^- = 0$ otherwise, and R_{mt} is the monthly return on the S&P 500 index.

From Table 6 we observe several results. First, beta asymmetry in the up and down markets is very obvious. In Panel A, the up market betas are generally insignificantly different from zero except for the global established, long only, and short selling styles.

Note that they are directional strategies, which are related to the stock markets directly. The non-directional strategies may offer a certain hedge so that the market exposure is not significant. In Panel B, the only significant beta for CTAs is from the stock trading program. In a strong contrast, the 15 down market betas are all significant at the conventional level except for CTA's currency program. Second, the down market betas are all positive for hedge fund or fund-of-fund styles (except for the short selling strategy) while they are all significantly negative for the CTA styles (except for the stock trading program). In other words, hedge funds or funds-of-funds are positively related to the S&P 500 index in the down market while the CTAs are negatively related to the index. This confirms our earlier conjecture of liquidity squeeze in the down markets. Note that the market neutral hedge funds are "market neutral" only in the up market with a zero beta; the 0.19 beta in the down market is significantly different from zero. Therefore, hedge funds are not well hedged in the down markets as in the up markets. This is particularly true for emerging market, long only, and sector funds, all having betas higher than one. Again, they are all directional strategies. Third, the R^2s are higher for the hedge fund or fund-of-fund styles than those of CTA styles. This reinforces the notion that CTAs are generally not invested in the equity markets and they are different from hedge funds and funds-of-funds in trading strategies, which generally long equities and bonds. This pattern of beta asymmetry supports Mitchell and Pulvino (2001) who show that most risk arbitrage funds are positively correlated with the markets returns in the down markets but uncorrelated with the market returns in the up markets.

B. Correlations at the Investment Style Level

Although Table 6 offers equity market betas in both the up and down markets, it does tell us the cross correlations among different fund styles. Because of this, in Table 7 we report the simple correlation coefficients across ten hedge fund or fund-of-fund styles and across five CTA styles in the up markets.[8] We define up market when the S&P 500 index has positive returns. We also report the cross correlation among hedge funds, funds-of-funds, and CTAs. Across hedge fund styles, we observe two results: first, all styles are moderately to highly correlated, with coefficients ranging from a low of 0.306 to a high of 0.926.[9] All 36 coefficients except for 4 (all 4 from the short selling style) are significant at the 5% level. This can be explained by two possible reasons: aggregation at each style level reduces variability of an individual fund and, different funds correlate through some net long positions in the equity markets or bond markets. Styles may also be connected through some common factors that affect equity markets or bond markets. This is confirmed by the significant equity market factor and bond market factor loadings in Table 5. Second, the style short sale is negatively correlated with other styles, indicating an opposite bet on the direction of asset price movement. For funds-of-funds, the correlation is positive with all hedge fund styles except for short sale. Again, this is consistent with the notion that funds-of-funds invest in different hedge funds. Across

[8] The sample period from 1998-2000 includes both the bull and bear markets. We require all funds having 36 monthly consecutive returns to calculate the correlation. We separate the up markets from the down markets to deal with the non- linearity problem.

[9] Other studies such as Ackermann, McEnally, and Ravenscraft (1999) and Liang (1999) have found much lower correlations. The difference comes from different datasets and different time periods used. For example, based on Zurich data, the average positive correlation coefficient during the 1992-1994 and 1995-1997 periods are 0.5007 and 0.6714, respectively, compared with 0.8296 in the 1998-2000 periods. It seems that there is an increasing correlation pattern among hedge fund styles over these time periods.

CTA styles, there are some correlations among diversified trading programs and financial trading programs. However, the remaining styles are not significantly correlated.

Across hedge funds, funds-of-funds, and CTAs, all 50 correlation coefficients except for one are not significant (inside the box). This forms a very strong contrast with the high correlations among hedge fund styles. This result is consistent with the analysis from the asset class factor regression in the previous section, where we show that CTAs are different from hedge funds or funds-of-funds in asset class factors. The low correlation between CTAs and hedge fund or fund-of-fund styles may have strong implications for portfolio managers' investment decisions and asset allocation decisions: adding CTAs to hedge funds or funds-of-funds may increase the diversification effect hence improve the risk-return trade-off of an investor's portfolio. We will discuss this further in the next section.

Table 8 is the mirror image of Table 7 in the down markets. Comparing Table 8 with Table 7, we can find that the magnitudes of correlations in the down markets are higher than those in the up markets, consistent with our conjecture of limited liquidity supplies in the down markets. Across hedge fund styles, all 36 correlation coefficients except for 4 (again from the short selling style) are higher than the corresponding numbers in Table 7. They are ranging from a low of 0.67 to a high of 0.985 (comparing with 0.306 to 0.926 in Table 7). Among hedge funds, funds-of-funds, and CTAs, agriculture, currency, diversified, and financial trading programs are all negatively correlated with hedge fund or fund-of-fund styles except for the short selling strategy. Stock trading program is positively correlated with hedge fund styles. 24 out of 50 coefficients are significant,

compared with only 1 significant coefficient in Table 7. Note that most coefficients under diversified, financial, and stock trading programs are significantly different from zero.

In summary, combining the non-linear piecewise regression analysis with the simple correlation analysis in both up and down markets, we find that all funds exhibit beta asymmetry in different market environments. They are related to the market index more in the down markets than in the up markets. In particular, hedge funds and funds-of-funds are highly correlated each other, which is especially true in the down markets. Hedge funds and funds-of-funds have highly positive betas with respect to the S&P 500 Index in the down market. CTAs have zero correlation with hedge funds or funds-of-funds in the up markets but have significantly negative correlations in the down markets. CTAs also have significantly negative market betas (and relatively high in magnitude) in the down markets. This correlation structure can make CTAs a suitable hedging instrument for other alternative investment vehicles, especially in the down markets.

C. Illiquidity and Autocorrelation in Fund Returns

Asness, Krail, and Liew (2001) use contemporaneous and lagged market betas to show that hedge funds may have more market exposure than one expects. They argue that hedge fund returns may be hard to determine due to stale prices or illiquidity from the securities that the funds trade. Getmansky, Lo, and Makarov (2003) report that hedge fund managers may smooth returns in order to reduce volatilities and manage Sharpe ratios. One implication of illiquidity or return smoothing is that fund returns will show certain autocorrelations. Taking the extreme case, for hard-to-value mortgage derivatives

with thin trading volumes, the prices will hardly change every day. This means that the autocorrelation is close to one. In a strong contrast, for a highly liquid stock, the price will change quickly and randomly in an efficient market, and then the autocorrelation is close to zero. Return smoothing will generate high autocorrelation as well. Further, we know that when markets are melt down investors will have a behavior of flight to liquidity, hence the autocorrelation structure in the up market will differ from that in the down market. During market crisis, the spillover effect from some falling funds may affect the other funds, hence causing further liquidity constraints.

Note that we need consecutive return observations in the bull and bear markets to estimate autocorrelations. For this reason, we choose the most recent four-year history: 1998-1999 for the bull markets and 2000-2001 for the bear markets.[10] The following Q-statistic by Ljung and Box (1978) is used to test the hypothesis that the autocorrelations up to lag p is jointly zero:

$$Q = T(T+2)\sum_{i}^{p} \rho_i^2 /(T-i) \tag{4}$$

which is asymptotically distributed as Chi-square with p degrees of freedom.

Table 9 reports the autocorrelation coefficients up to lag 6 for different hedge fund or fund-of-fund styles under different market environments. Table 10 reports similar statistics for CTAs. For majority fund styles, the Chi-square values increase from the up markets to the down markets, reflecting more liquidity squeeze and correlation changes in the down markets. Especially, the styles of global macro, emerging markets, and CTA's energy trading program have significant Chi-square values in the down markets

[10] Another bear market is from 1990 to 1991, which is relative short. In addition, Zurich starts to collected dead funds only from 1994 and onwards. We need to include both the survived and dead funds to study autocorrelations because the autocorrelation structure for the dead funds may be different from that of the live funds.

although none of them is significant in the up markets. This may reflect the fact that foreign securities and energy related commodities or derivatives exhibit more illiquidity and difficulties for valuation, especially in the down markets. Note the most fund styles have insignificant Chi-square values, which is different from Lo (2001) who studies several individual hedge funds while we are investigating different fund styles. The autocorrelation may not be as strong at the style level as that at the individual fund level. Negative and positive autocorrelations in individual funds may be cancelled each other out at the style level. The autocorrelation analysis in Table 9 supports our previous results from correlation analysis that funds are more correlated in the down markets than in the up markets.

D. Correlations at the Individual Fund Level

Since aggregation reduces individual fund variability, the true correlation structure may not be revealed at the aggregate level. Hence, we turn to examine correlations at the individual hedge fund level within the same style in both the up and down markets. Although correlations are high across different styles in Tables 7 and 8, correlations among different funds within the same style could be very low due to fund specific variability. Panel A of Table 11 reports these intra-style correlations for hedge funds in the up and down markets, respectively. We find two interesting results. First, correlations among different hedge funds within a specific style are generally low, varying from 0.08 to 0.56. Second, correlations in the down markets are significantly higher than those in the up markets (except for the global international style). For some styles, the correlations in the down markets are about twice as high as those in the up markets. Under the market

neutral style, the average correlation among different funds is only 0.09 (p-value<0.0001) and 0.13 (p-value<0.0001) in the up and down markets, respectively. The difference is significantly different from zero. Hence the market neutral funds are not truly market neutral. The above results suggest that two randomly selected funds can be fairly independent from each other. The instruments may be very different across the two funds and the timing skills to buy and sell securities may be very different between the two fund managers. As a result, the long positions and short positions in these market neutral portfolios cancel each other out.[11] A similar situation happens to styles such as global macro and global international. The average correlations within these two styles are only 0.08 and 0.14, and 0.13 and 0.11, respectively. For the other styles, the average correlation ranges from 0.09 to 0.49. Contrary to the traditional definition of "hedge funds", many hedge funds are not hedged as that done by market neutral fund managers. As a result, the net long positions in equities will transfer to some moderate correlations among different funds through some common risk factors that are linked to equity or bond markets.

In Panel C of Table 11, we also report correlations among different CTA styles. Similar to the results of hedge funds, these average correlations are also very low, indicating that long and short commodity/financial futures positions may cancel each other out. The correlations in the down markets are consistently higher than those in the up markets. In Panel B of Table 11, the correlation coefficients are 0.39 and 0.50 for funds-of-funds. Remember that a fund-of-funds is aggregated hedge funds; aggregating can reduce firm specific variabilities and produce a similarly high correlation as those

[11] Note that the manager's self-proclaimed style may not be accurate enough so that the correlation between two funds under the same style may not truly reflect what they invest.

reported in Tables 7 and 8. However, because of the limited numbers of hedge funds invested by each fund-of-funds, the 0.39 or 0.50 correlation is much lower than the numbers reported in Tables 7 and 8, where aggregation is done by all funds under each style.

The above results of higher correlations in the down markets than in the up markets are not desirable for investors. In the down markets, more diversification is needed for investors to reduce the downside risk, not the opposite. The fact that correlations depend on the market conditions implied that hedge funds are not truly market neutral and not well hedged. A market neutral fund will have a zero correlation with the market index no matter what the index level is. However, the reverse implication does not follow: a zero correlation with the market index does not mean market neutral. A hedge fund could have a zero correlation with the market index in the up market but have a very high correlation in the down market due to liquidity constraint and drain in cash flows. Therefore, hedge funds may not be well hedged against the down markets; we need some other instruments to protect investors from the downside risk. This is precisely the task of the next section.

The above low correlation structure at the individual fund level also have important implications to constructing hedge funds indices. It is becoming more and more popular for hedge fund consulting companies, data vendors, even investment banks to construct different style indices to meet the increasing demand from the investment communities. These indices are built either from equally weighted or value weighted averages on hedge funds under the same style.[12] The only exception from the above is the index from Zurich

[12] See www.hfr.com, www.henessegroup.com, www.vanhadge.com, www.altvest.com, and www.hedgeindex.com.

Capital Markets, Inc., who uses medians instead of weighted averages as the benchmarks.[13]

Because of the low correlation among different funds within the same style, constructing a style index using hedge funds within each style may not be fruitful: aggregating may cancel long and short positions hence, the index may not be representative of the funds that the index covers. This is especially true for the up markets when the correlations are relative low. Since up markets are more prevailing than down markets in general, the above problem of building a hedge fund index is not trivial. We know that the goal for a hedge fund index is to reflect fund performance under each style. If the funds within the same style behave differently because of different instruments and timing abilities involved, then it is not constructive to build the index by using the funds under the same style. Oberuc (2002) indicates that indices of financial CTAs, currency CTAs, bond arbitrage hedge funds, and international hedge funds do not represent the asset classes because two sub-samples of each asset class from different time periods do not deliver similar index results.

The difficulty of building a hedge fund index may be also reflected by the nature of hedge funds: they are absolute performers rather than relative performers. A relative performer compares its performance with a certain benchmark such as equity market index or bond market index while an absolute performer does not compare its performance with others. Most hedge funds have hurdle rates and high watermark provisions. Fund managers only need to cross the predetermined hurdle rate and assume

[13] See www.marhedge.com. Zurich ranks each fund within the same style from high performance to low performance. The median is the 50th percentile. If fund numbers are even, the median is then defined as the average return of the two middle funds.

responsibilities for making up previous losses. There is no need to compare themselves with other benchmarks.

E. Benefits of Adding CTAs to Other Investment Classes

The performance analysis in Section IV only focuses on a stand-alone basis: we do not mix one investment class with another. Poor stand-alone performance from CTAs does not prevent them from becoming good candidates for adding to other investment portfolios, especially when CTAs and other portfolios have negative or low correlations as indicated previously. As a matter of fact, CTAs may be very well suited for excellent hedging instruments for the other investment classes. It is well known that CTAs or commodity funds offer good hedges against the equity and bond market downturns (see Sharpe, Alexander and Bailey (1999), and Irwin, Krukemyer, and Zulauf (1993)).

With the low or negative correlations between CTAs and others in mind, we now build portfolios of CTAs and hedge funds, and portfolios between CTAs and funds-of-funds. Because we need the autocorrelation adjusted Sharpe ratios to measure performance and risk, we focus on four consecutive years: the bull markets from 1998-1999 and the bear markets from 2000-2001. In Panel A of Table 12, we report the regular Sharpe ratios, $\sqrt{12}$ SRs, and the autocorrelation adjusted Sharpe ratios of hedge fund, fund-of-fund, and CTA portfolios. Although the pecking order of performance during the up markets is hedge funds, funds-of-funds, and CTAs, this order is totally reversed in the down markets. Actually, CTAs offer higher Sharpe ratios in the down markets than those in the up markets. In the down markets, funds-of-funds may offer better diversification than the individual hedge funds, which can help reduce risk significantly. The negative

correlation between CTAs and the others can certainly play an important role in achieving higher risk adjusted performance for CTAs in the market downturn.

We also report these Sharpe ratios of various portfolio combinations between CTAs and hedge funds, and between CTAs and funds-of-funds in Panels B and C. Interestingly, adding CTAs to hedge funds or funds-of-funds can improve the Sharpe ratios in a majority of the portfolio combinations. For example, in the up market, when we add CTAs to hedge funds (with the stand-alone Sharpe ratios 0.44 and 1.07 for the two groups, respectively), the combined Sharpe ratios in Panel B are higher than both of the stand-alone hedge fund Sharpe ratios and the CTA Sharpe ratios for all but the 10/90 combination. Investors can benefit from combining the two investment classes. Amazingly, CTAs can add benefits to funds-of-funds for all portfolio combinations in the up markets. The results in Panel C show that the combined Sharpe ratios are all higher than 0.63, the stand-alone Sharpe ratio for funds-of-funds. The optimal portfolio combination for hedge funds and CTAs is 30% hedge funds and 70% CTAs (with the highest Sharpe ratio 2.08) while the optimal combination for funds-of-funds and CTAs is 40% funds-of-funds and 60% CTAs with a Sharpe ratio 1.74.

The results for the down markets are similar to those of the up markets. Hedge fund investors will benefit from adding CTAs to their portfolios in all portfolio combinations with 40% or more allocations in CTAs. Similarly, fund-of-fund investors can benefit from adding CTAs with a portfolio weight 30% or more in CTAs. The optimal portfolio combination for hedge funds and CTAs is 40% hedge funds and 60% CTAs (the highest Sharpe ratio is 0.83) while the optimal combination for funds-of-funds and CTAs is 50% funds-of-funds and 50% CTAs with a Sharpe ratio of 0.79.

These results can be explained by the low or negative correlation between CTAs and other investment classes, by different investment strategies, and by the different autocorrelation structures of these investment vehicles. The results are robust no matter whether we use $\eta(12)$ SRs or $\sqrt{12}$ SRs for comparison. Actually, the autocorrelation adjusted Sharpe ratios can only make our results stronger.

VI. Conclusion

Using a large database on hedge funds, funds-of-funds, and CTAs, we study the issues of risk, return, and fee structures of these alternative investment vehicles. By comprehensively evaluating all these investment vehicles and differing from the previous studies that pool these vehicles together, we distinguish one investment class from the other in order to study the differences and similarities. We examine these investment classes not only on a stand-alone basis but also on a portfolio basis of combining one class with another. The following is our results:

First, hedge funds and funds-of-funds invest in similar asset classes. Their performance can be attributed to similar asset class factors. These factors are MSCI developed country index, MSCI emerging market index, Salomon Brothers world government bond index, Salomon Brothers BIG index, and the Fama-French size factor. Apparently, hedge funds primarily invest in equity markets or bond markets. However, due to the double fee structure of funds-of-funds, hedge funds outperform funds-of-funds during the period from 1994 to 2001. This underperformance is unlikely to be explained by survivorship bias. Unlike the previous findings (see Agarwal and Naik (2002)), we

find only the Fama-French factors can add significantly to the power of explaining hedge fund returns; the option strategy factors cannot.

Second, CTAs differ from the other two asset classes in several ways. They have higher attrition rate and survivorship bias than the other two classes. The only significant factor loadings for CTA returns are the option-based factors, not equity or bond factors. This reflects the option-like payoffs (or concavity in returns) with respect to the equity markets and the fact that CTAs generally do not invest in equity or bond markets. In addition, CTAs have zero or negative correlation with the other two investment classes and with the equity market index.

Third, correlation coefficients, autocorrelations, and equity market betas from piecewise regressions in the up markets are generally lower than those in the down markets. This can be explained by the drain of liquidity supply during market crisis, when fund managers don't have much flexibility to maneuver and have to herd. Hedge funds or funds-of-funds offer lower risk-return trade-off than CTAs in the down markets. Therefore, hedge funds are not well hedged in the down markets; rather they are highly correlated with each other and with the market index. In contrast, CTA styles are not or only negatively correlated with hedge funds, funds-of-funds, and the market index.

Fourth, on a stand-alone basis, CTAs trail behind hedge funds and funds-of-funds during the same time period. This underperformance can be attributed to high management fees, high attrition rate and survivorship bias, under-diversified portfolio positions in futures markets, and high leverage in futures contracts. However, due to the negative correlation, CTAs provide significant diversification benefits to other investment classes: adding CTAs to investors' hedge fund portfolio or fund-of-fund

portfolio can significantly improve their risk-return trade-off. In other words, CTAs are good hedging instruments for hedge funds, funds-of-funds, and the equity markets when the others are not well hedged. This is especially true in the down markets.

Last, although the correlations among different styles are high at the aggregate level, intra-style correlations among various funds within the same style are fairly low. This makes a style index less useful than one expects: the style index may not be representative for the asset class at all.

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TABLE 1
Basic Statistics of Hedge Funds, Funds-of-Funds, and CTAs

	Hedge Funds				Funds-of -Funds				CTA			
	N	Mean	Std dev	Median	N	Mean	Std dev	Median	N	Mean	Std dev	Median
Mfee	2357	0.910	0.737	1.00	597	0.908	0.786	1.00	1510	2.295	1.494	2.00
Ifee	2357	12.764	9.844	20.00	597	14.497	7.591	20.00	1510	19.340	5.879	20.00
Min	2357	670,339	2,369,825	300,000	597	573,798	1,955,354	250,000	1510	998,754	2,706,656	250,000
Staff	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1170	10.32	88.11	4.00
Asset*	1118	116.489	279.491	36.315	346	111.042	243.829	34.265	297	106.928	323.736	13.14
Age	2297	53.256	38.611	44.00	580	59.545	40.060	52.00	1508	59.942	49.415	46.00

As of March 2002, there are 2,357 hedge funds (1,164 live funds and 1,193 dead funds), 597 funds-of-funds (349 live and 248 dead), and 1,510 CTAs (294 live and 1216 dead). Mfee is the management fee in percentage, Ifee is the incentive fee in percentage, Min is the minimum dollar investment, and staff is the number of staff for a CTA. Assets are in millions of dollars. Age is the number of months from a fund's inception or the time when the first monthly return is recorded (whichever is the latter).
*As of December 2001

TABLE 2
Attrition Rates of Hedge Funds, Funds-of-Funds, and CTAs in Up and Down Markets

Panel A: Hedge Funds[a]

			Up					Down		
Year	Year Start	Entry	Dissolution	Year End	Attrition rate	Year Start	Entry	Dissolution	Year End	Attrition rate
1993				307					192	
1994	307	142	19	430	6.19	192	80	7	265	3.65
1995	430	177	97	510	22.56	265	36	7	294	2.64
1996	510	243	68	685	13.33	294	34	21	307	7.14
1997	685	255	87	853	12.70	307	56	32	331	10.42
1998	853	184	134	903	15.71	331	78	56	353	16.92
1999	903	166	109	960	12.07	353	95	95	353	26.91
2000	960	34	65	929	6.77	353	129	133	349	37.68
2001	929	44	153	820	16.47	349	44	106	287	30.37
Total		1245	732		13.23		552	457		16.97

Panel B: FOF[b]

			Up					Down		
Year	Year Start	Entry	Dissolution	Year End	Attrition rate	Year Start	Entry	Dissolution	Year End	Attrition rate
1993				74					54	
1994	74	59	3	130	4.05	54	17	3	68	5.56
1995	130	59	19	170	14.62	68	5	4	69	5.88
1996	170	49	8	211	4.71	69	14	5	78	7.25
1997	211	57	17	251	8.06	78	11	1	88	1.28
1998	251	40	32	259	12.75	88	10	7	91	7.95
1999	259	44	26	277	10.04	91	18	7	102	7.69

TABLE 2 (Continued)

2000	277	15	25	267	9.03	102	40	26	116	25.49
2001	267	8	34	241	12.73	116	6	27	95	23.28
Total		331	164		9.50		121	80		10.55

Panel C: CTA[c]

			Up					Down		
Year	Year Start	Entry	Dissolution	Year End	Attrition rate	Year Start	Entry	Dissolution	Year End	Attrition rate
1993				378					221	
1994	378	75	72	381	19.05	221	53	35	239	15.84
1995	381	105	105	381	27.56	239	20	32	227	13.39
1996	381	74	113	342	29.66	227	15	26	216	11.45
1997	342	62	82	322	23.98	216	19	56	179	25.93
1998	322	59	86	295	26.71	179	15	30	164	16.76
1999	295	33	69	259	23.39	164	22	26	160	15.85
2000	259	6	31	234	11.97	160	20	58	122	36.25
2001	234	3	42	195	17.95	122	1	33	90	27.05
Total		417	600		22.53		165	296		20.31

As of March 2002, there are 2,357 hedge funds (1,164 live funds and 1,193 dead funds), 597 funds-of-funds (349 live and 248 dead), and 1,510 CTAs (294 live and 1216 dead). Attrition rate is calculated as the ratio of the number of dissolved funds to the number that existed at the start of the year. Panels A, B, and C represent for the attrition rates for hedge funds, funds-of-funds, and CTAs, respectively.

[a]There are 60 hedge funds with missing birth and death dates.

[b]There are 17 funds-of-funds with missing birth and death dates.

[c]There are 22 CTAs with missing birth and death dates.

TABLE 3
Survivorship Bias for Hedge Funds, Funds-of-Funds, and CTAs

Panel A: Hedge Funds

	Live			Dead				All			
Year	N	Mean	Std dev	N	Mean	Std dev	Difference[a]	N	Mean	Std dev	Bias
1994	2512	0.393	4.268	4827	0.221	13.851	0.172	7339	0.280	11.507	0.113
1995	3466	1.848	3.966	5577	1.471	5.782	0.377	9043	1.616	5.165	0.232
1996	4892	1.848	4.619	6187	1.568	6.410	0.280	11079	1.691	5.691	0.157
1997	6668	1.789	5.164	6834	1.460	7.060	0.329	13502	1.622	6.199	0.167
1998	8372	0.676	7.601	6863	0.020	9.025	0.656	15235	0.380	8.279	0.296
1999	10284	2.797	7.356	5302	2.493	9.136	0.304	15586	2.693	8.007	0.104
2000	12249	0.994	8.024	3781	-0.486	12.384	1.480	16030	0.645	9.261	0.349
2001	13653	0.439	5.733	1450	-0.738	11.098	1.177	15103	0.326	6.453	0.113
Average		1.348			0.751		0.597		1.157		0.191

Panel B: Funds-of-Funds

	Live			Dead				All			
Year	N	Mean	Std dev	N	Mean	Std dev	Difference[a]	N	Mean	Std dev	Bias
1994	1112	-0.300	2.477	936	-0.431	3.000	0.131	2048	-0.360	2.729	0.060
1995	1474	0.968	2.185	1275	0.732	2.696	0.236	2749	0.859	2.438	0.109
1996	1831	1.361	2.375	1384	1.190	3.280	0.171	3215	1.288	2.801	0.073
1997	2306	1.377	2.601	1561	1.256	4.321	0.121	3867	1.329	3.402	0.048
1998	2725	0.166	3.784	1551	-0.436	6.144	0.602	4276	-0.052	4.785	0.218

TABLE 3 (Continued)

1999	3195	2.090	3.408	1272	1.910	4.579	0.180	4467	2.039	3.779	0.051
2000	3788	0.756	3.625	1005	-0.004	6.302	0.760	4793	0.597	4.336	0.159
2001	4150	0.373	2.125	385	-0.369	3.341	0.742	4535	0.310	2.263	0.063
Average		0.849			0.481		0.368		0.751		0.098

Panel C: CTA

	Live			Dead				All			
Year	N	Mean	Std dev	N	Mean	Std dev	Difference[a]	N	Mean	Std dev	Bias
1994	1410	0.968	8.874	5918	0.485	9.902	0.483	7328	0.578	9.714	0.390
1995	1832	2.218	8.140	5644	0.942	8.101	1.276	7476	1.255	8.129	0.963
1996	2191	1.943	8.713	4966	0.756	8.316	1.187	7157	1.119	8.457	0.824
1997	2455	1.579	6.999	4114	0.912	8.619	0.667	6569	1.162	8.058	0.417
1998	2786	1.594	7.423	3161	0.367	8.604	1.227	5947	0.942	8.095	0.652
1999	3163	0.462	6.044	2286	-0.086	6.676	0.548	5449	0.232	6.322	0.230
2000	3412	1.225	7.536	1211	-0.112	7.058	1.337	4623	0.875	7.436	0.350
2001	3500	0.369	6.285	577	0.395	7.961	-0.026	4077	0.373	6.547	-0.004
Average		1.295			0.457		0.837		0.817		0.478

As of March 2002, there are 2,357 hedge funds (1,164 live funds and 1,193 dead funds), 597 funds-of-funds (349 live and 248 dead), and 1,510 CTAs (294 live and 1216 dead). Survivorship bias is defined as the return difference between the portfolio without dead funds (live) and the one with dead funds (all). Panel A reports the bias for hedge funds, Panel B reports the bias for funds-of-funds, and Panel C reports the bias for CTAs. All returns are on a monthly basis. N is the number of performance months for all funds. The averages in the last raw are simple averages over 8 years.

[a]The return difference between the live portfolio and the dead portfolio.

TABLE 4
Performance and Risk for Hedge Funds, Funds-of-Funds, and CTAs

Panel A: HF vs. FOF

			FOF				HF							
Year	No.	Return	Std	$\sqrt{12}$ SR	$\eta(12)$ SR	No.	Return	Std	$\sqrt{12}$ SR	$\eta(12)$ SR	Δ SR$_{HF}$	$\Delta\sqrt{12}$ SR	$\Delta\eta(12)$ SR	*t*-ret
1994	203	-0.3655	0.9422	-1.3856	-0.9736	716	0.2901	3.3910	0.3225	0.2512	-0.0713	1.7081	1.2248	4.59 ***
1995	253	0.8258	1.3527	1.5786	2.1372	870	1.5178	2.4490	1.8897	3.5387	1.6490	0.3111	1.4014	5.82 ***
1996	299	1.3159	0.8739	2.6864	5.0369	1062	1.7100	2.2916	3.5441	6.8486	3.3045	0.8577	1.8118	4.55 ***
1997	356	1.3286	1.4231	1.7556	1.4804	1277	1.6820	2.7125	1.5200	1.5727	0.0526	-0.2356	0.0923	3.30 ***
1998	384	-0.0082	1.7804	-0.1230	-0.0962	1421	0.4761	3.0361	0.5560	0.4776	-0.0783	0.6790	0.5739	3.99 ***
1999	404	1.9966	1.7981	2.2752	2.2318	1476	2.7614	4.1453	2.0604	1.9646	-0.0958	-0.2148	-0.2672	5.46 ***
2000	430	0.5754	1.3129	0.7860	1.2824	1451	0.6442	3.1927	0.7604	1.1739	0.4135	-0.0256	-0.1086	0.65

Panel B: CTA vs. HF

			CTA				HF							
Year	No.	Return	Std dev	$\sqrt{12}$ SR	$\eta(12)$ SR	No.	Return	Std dev	$\sqrt{12}$ SR	$\eta(12)$ SR	Δ SR$_{CTA}$	$\Delta\sqrt{12}$ SR	$\Delta\eta(12)$ SR	*t*-ret
1994	712	0.4714	3.5695	-0.5875	-1.0217	716	0.2901	3.3910	0.3225	0.2512	-0.4342	0.9100	1.2729	-0.98
1995	718	1.1573	2.8632	-0.1410	-0.3075	870	1.5178	2.4490	1.8897	3.5387	-0.1665	2.0307	3.8462	2.66***
1996	675	1.0330	3.1151	-0.7160	-1.4446	1062	1.7100	2.2916	3.5441	6.8486	-0.7286	4.2602	8.2933	4.87***
1997	617	1.2289	2.8440	0.3523	0.6152	1277	1.6820	2.7125	1.5200	1.5727	0.2629	1.1677	0.9575	3.30***
1998	564	0.7811	3.3264	-1.3309	-1.6870	1421	0.4761	3.0361	0.5560	0.4776	-0.3561	1.8869	2.1647	-1.89*
1999	503	0.2373	2.1070	-0.4084	-0.4504	1476	2.7614	4.1453	2.0604	1.9646	-0.0420	2.4689	2.4150	17.64***
2000	433	0.6837	2.6110	-0.1334	-0.2383	1451	0.6442	3.1927	0.7604	1.1739	-0.1049	0.8937	1.4122	-0.26

TABLE 4 (Continued)

Panel C: CTA vs. FOF

	CTA					FOF							
Year	No.	Return	Std dev	$\sqrt{12}$ SR	$\eta(12)$ SR	No.	Return	Std dev	$\sqrt{12}$ SR	$\eta(12)$ SR	Δ SR$_{FOF}$	$\Delta\sqrt{12}$ SR	$\Delta\eta(12)$ SR	*t*-ret
1994	712	0.4714	3.5695	-0.5875	-1.0217	203	-0.3655	0.9422	-1.3856	-0.9736	0.4120	-0.7981	0.0481	-5.61***
1995	718	1.1573	2.8632	-0.1410	-0.3075	253	0.8258	1.3527	1.5786	2.1372	0.5586	1.7196	2.4448	-2.43**
1996	675	1.0330	3.1151	-0.7160	-1.4446	299	1.3159	0.8739	2.6864	5.0369	2.3505	3.4024	6.4815	2.17**
1997	617	1.2289	2.8440	0.3523	0.6152	356	1.3286	1.4231	1.7556	1.4804	-0.2752	1.4033	0.8652	0.73
1998	564	0.7811	3.3264	-1.3309	-1.6870	384	-0.0082	1.7804	-0.1230	-0.0962	0.0267	1.2079	1.5908	-4.73***
1999	503	0.2373	2.1070	-0.4084	-0.4504	404	1.9966	1.7981	2.2752	2.2318	-0.0434	2.6836	2.6822	13.56***
2000	433	0.6837	2.6110	-0.1334	-0.2383	430	0.5754	1.3129	0.7860	1.2824	0.4964	0.9194	1.5207	-0.77

As of March 2002, there are 2,357 hedge funds (1,164 live funds and 1,193 dead funds), 597 funds-of-funds (349 live and 248 dead), and 1,510 CTAs (294 live and 1216 dead). $\sqrt{12}$ SR is the annualized Sharpe ratio when returns are i.i.d. while $\eta(12)$ SR is the autocorrelation adjusted Sharpe ratio on an annual basis. Δ SR $_{HF}$, Δ SR$_{FOF}$, and Δ SR $_{CTA}$ represent the difference for the two Sharpe ratios ($\eta(12)$ SR- $\sqrt{12}$ SR) for hedge funds, FOF, and CTAs, respectively. $\Delta\sqrt{12}$ SR is the difference between the two $\sqrt{12}$ SRs and $\Delta\eta(12)$ SR is the difference between the two $\eta(12)$ SRs.

***Significant at the 1% level.

**Significant at the 5% level.

*Significant at the 10% level.

TABLE 5
Asset Class Factor Regressions for Hedge Funds, Funds-of-Funds, and CTAs

Panel A: HF

	Full model			Base+Op			Base+FF			Base model		
Variable	estimate	std error	*t*-value	estimate	std error	*t*-value	estimate	std error	*t*-value	estimate	std error	*t*-value
Intercept	1.0982	0.2401	4.57 ***	0.8277	0.4204	1.97 **	0.9415	0.2241	4.20 ***	0.6611	0.3712	1.78 *
SPret	0.0061	0.1945	0.03	-0.6014	0.3133	-1.92 *	0.0325	0.1304	0.25	-0.4270	0.1912	-2.23 **
Developed	0.2111	0.1494	1.41	0.6583	0.2407	2.73 ***	0.2466	0.1496	1.65 *	0.6798	0.2257	3.01 ***
Emerging	0.1035	0.0504	2.05 **	0.2294	0.0852	2.69 ***	0.1004	0.0460	2.18 **	0.2246	0.0713	3.15 ***
Deposit	-0.0219	0.0497	-0.44	-0.0958	0.0867	-1.11	-0.0391	0.0473	-0.83	-0.0976	0.0783	-1.25
Fed	-0.4066	0.3302	-1.23	-0.1702	0.5708	-0.30	-0.3611	0.3199	-1.13	-0.1402	0.5273	-0.27
Gold	-0.0867	0.0525	-1.65 *	-0.0313	0.0934	-0.33	-0.0634	0.0483	-1.31	0.0097	0.0794	0.12
Gov	-0.5524	0.2164	-2.55 **	-0.6431	0.3771	-1.71 *	-0.5579	0.2050	-2.72 ***	-0.7415	0.3371	-2.20 **
BIG	0.6802	0.3217	2.11 **	1.2569	0.5592	2.25 **	0.6946	0.3195	2.17 **	1.2998	0.5161	2.52 **
SMB	0.2769	0.0610	4.54 ***				0.2623	0.0608	4.31 ***			
HML	-0.0546	0.0415	-1.32				-0.0652	0.0406	-1.61			
ATMC	-0.0071	0.0058	-1.23	-0.0006	0.0102	-0.06						
OTMC	0.0082	0.0062	1.32	0.0030	0.0110	0.27						
ATMP	-0.0354	0.0193	-1.83 *	-0.0501	0.0345	-1.45						
OTMP	0.0327	0.0179	1.83 *	0.0414	0.0321	1.29						
R^2	94.98			82.19			93.59			80.36		
Adj R^2	91.64			72.90			91.03			74.54		

Table 5 (Continued)

Panel B: FOF

Variable	Full model estimate	std error	*t*-value	Base+Op estimate	std error	*t*-value	Base+FF estimate	std error	*t*-value	Base model estimate	std error	*t*-value
Intercept	0.8062	0.2802	2.88 ***	0.6138	0.3528	1.74 *	0.6251	0.2535	2.47 **	0.4297	0.3194	1.35
SPret	-0.3490	0.2271	-1.54	-0.7467	0.2629	-2.84 ***	-0.1409	0.1475	-0.95	-0.4597	0.1645	-2.79 ***
Developed	0.2802	0.1744	1.61	0.5708	0.2021	2.82 ***	0.3078	0.1692	1.82 *	0.6052	0.1942	3.12 ***
Emerging	0.1018	0.0589	1.73 *	0.1848	0.0715	2.59 ***	0.0852	0.0521	1.64	0.1717	0.0613	2.80 ***
Deposit	-0.0164	0.0580	-0.28	-0.0636	0.0728	-0.87	-0.0170	0.0535	-0.32	-0.0572	0.0674	-0.85
Fed	-0.2348	0.3854	-0.61	-0.1020	0.4791	-0.21	-0.2311	0.3619	-0.64	-0.0837	0.4538	-0.18
Gold	-0.1283	0.0613	-2.09 **	-0.0921	0.0784	-1.18	-0.0844	0.0547	-1.54	-0.0341	0.0684	-0.50
Gov	-0.4218	0.2526	-1.67 *	-0.4976	0.3165	-1.57	-0.5235	0.2318	-2.26 **	-0.6540	0.2901	-2.25 **
BIG	0.6848	0.3755	1.82 *	1.0777	0.4693	2.30 **	0.6278	0.3614	1.74 *	1.0500	0.4441	2.36 **
SMB	0.1985	0.0712	2.79 ***				0.1862	0.0688	2.71 ***			
HML	-0.0247	0.0485	-0.51				-0.0414	0.0459	-0.90			
ATMC	-0.0030	0.0067	-0.45	0.0011	0.0086	0.13						
OTMC	0.0076	0.0073	1.04	0.0038	0.0092	0.42						
ATMP	-0.0349	0.0225	-1.55	-0.0443	0.0290	-1.53						
OTMP	0.0254	0.0209	1.21	0.0309	0.0269	1.15						
R^2	87.62			77.28			85.15			73.66		
Adj R^2	79.37			65.42			79.21			65.85		

Table 5 (Continued)

Panel C: CTA

Variable	Full model estimate	std error	*t*-value		Base+Op estimate	std error	*t*-value		Base+FF estimate	std error	*t*-value		Base model estimate	std error	*t*-value	
Intercept	0.8758	0.5528	1.58		0.8705	0.5195	1.68	*	0.5416	0.5383	1.01		0.5493	0.5094	1.08	
S&P	-0.6310	0.4480	-1.41		-0.5101	0.3871	-1.32		-0.0591	0.3133	-0.19		-0.0501	0.2623	-0.19	
Developed	-0.0691	0.3441	-0.20		-0.1664	0.2975	-0.56		-0.2219	0.3593	-0.62		-0.2216	0.3098	-0.72	
Emerging	0.1771	0.1161	1.52		0.1545	0.1052	1.47		0.1028	0.1105	0.93		0.0994	0.0978	1.02	
Deposit	-0.1409	0.1145	-1.23		-0.1219	0.1071	-1.14		-0.0530	0.1136	-0.47		-0.0528	0.1075	-0.49	
Fed	0.5453	0.7604	0.72		0.4135	0.7053	0.59		0.0648	0.7685	0.08		0.0764	0.7237	0.11	
Gold	-0.0641	0.1209	-0.53		-0.0755	0.1154	-0.65		-0.0597	0.1161	-0.51		-0.0601	0.1090	-0.55	
Gov	0.7234	0.4984	1.45		0.6783	0.4659	1.46		0.3055	0.4923	0.62		0.3178	0.4627	0.69	
BIG	0.3135	0.7409	0.42		0.2582	0.6909	0.37		0.6301	0.7675	0.82		0.6119	0.7083	0.86	
SMB	0.0111	0.1405	0.08						-0.0167	0.1462	-0.11					
HML	0.0536	0.0957	0.56						-0.0091	0.0975	-0.09					
ATMC	0.0252	0.0133	1.90	*	0.0235	0.0126	1.87	*								
OTMC	-0.0103	0.0143	-0.72		-0.0106	0.0136	-0.78									
ATMP	-0.0857	0.0445	-1.93	*	-0.0823	0.0426	-1.93	*								
OTMP	0.0738	0.0412	1.79	*	0.0717	0.0397	1.81	*								
R^2	44.90				43.68				23.43				23.39			
Adj R^2	8.16				14.30				-7.20				0.69			

As of March 2002, there are 2,357 hedge funds (1,164 live funds and 1,193 dead funds), 597 funds-of-funds (349 live and 248 dead), and 1,510 CTAs (294 live and 1216 dead). The dependent variable is the average monthly returns from 1998-2000. The independent variables are the S&P 500 index (S&P), MSCI developed country index (Developed) , MSCI emerging market index (Emerging) , Salomon Brothers world government bond index (Gov) and Salomon Brothers Broad Investment Grade (BIG) index, Federal Reserve Bank trade-weighted dollar index (Fed), gold price (Gold), one-month US dollar deposit rate (Deposit), Fama-French size factor (SMB) and Book-to-Market factor (HML), Agarwal-Naik at-the-money (ATMC) and out-of-money (OTMC) European call option factors, and at-the-money (ATMP) and out-of-money (OTMP) European put option factors.

***Significant at the 1% level.

**Significant at the 5% level.

*Significant at the 10% level.

TABLE 6
Piecewise Regression Results in the Up and Down Markets

Style	alpha	*t*-alpha		beta+	*t*(beta+)		beta-	*t*(beta-)		Adj R^2
				Panel A: HF/FOF						
Event Driven	1.88	3.74	***	-0.03	-0.30		0.62	5.40	***	0.50
Global Macro	1.44	2.44	**	0.06	0.46		0.47	3.50	***	0.32
Global Emerging	1.80	1.13		0.42	1.18		1.41	3.89	***	0.43
Global Established	1.86	2.11	**	0.50	2.54	**	0.94	4.76	***	0.60
Global International	1.55	2.26	**	0.20	1.32		0.50	3.19	***	0.36
Long-only	1.62	1.07		0.75	2.20	**	1.36	3.95	***	0.51
Market neutral	1.45	4.53	***	0.00	0.02		0.19	2.61	***	0.17
Sector	3.50	2.71	***	0.40	1.37		1.29	4.41	***	0.49
Short	-0.04	-0.02		-0.68	-1.65	*	-1.58	-3.77	***	0.45
FOF	1.77	2.87	***	0.17	1.26		0.63	4.54	***	0.50
				Panel B: CTA						
Agriculture	0.15	0.20		0.02	0.14		-0.44	-2.60	***	0.16
Currency	1.36	2.63	***	-0.13	-1.11		0.15	1.31		0.00
Diversified	-0.20	-0.22		0.09	0.46		-0.56	-2.68	***	0.15
Financial	-0.43	-0.57		0.20	1.22		-0.46	-2.74	***	0.14
Stock	1.41	3.03	***	0.19	1.79	*	0.18	1.72	*	0.23

Alphas and Betas are estimated from the following regression: $R_{it} = \alpha_i + \beta_i^+ I_t^+ + \beta_i^- I_t^- + \varepsilon_{it}$, where $I_t^+ = R_{mt}$, if R_{mt}>0 and $I_t^+ = 0$ otherwise; $I_t^- = R_{mt}$, if $R_{mt} \le 0$ and $I_t^- = 0$ otherwise. R_{mt} is the monthly return on the S&P 500 index. As of March 2002, there are 2,357 hedge funds (1,164 live funds and 1,193 dead funds), 597 funds-of-funds (349 live and 248 dead), and 1,510 CTAs (294 live and 1216 dead). The regression is conducted from 1998 to 2000 using 36 monthly returns.

***Significant at 1% level.
**Significant at 5% level.
*Significant at 10% level.

TABLE 7
Correlation Coefficients Across Hedge Fund, Fund-of-Fund, and CTA Styles in Up Markets

	Ev	Ma	Em	Es	In	Lo	Ne	Se	Sh	Ff	**Ag**	**Cu**	**Di**	**Fi**	**St**
Ev	1.000	**0.672***	**0.565***	**0.616***	**0.720***	**0.485***	**0.802***	**0.520***	**-0.354**	**0.769***	0.432	-0.033	0.120	-0.166	0.092
Ma		1.000	**0.555***	**0.676***	**0.711***	**0.475***	**0.784***	**0.580***	**-0.306**	**0.799***	0.206	0.164	0.389	0.134	0.274
Em			1.000	**0.725***	**0.870***	**0.636***	**0.684***	**0.543***	**-0.453***	**0.853***	-0.076	-0.206	-0.053	-0.180	0.109
Es				1.000	**0.779***	**0.781***	**0.761***	**0.838***	**-0.727***	**0.926***	0.252	-0.128	0.072	-0.072	0.317
In					1.000	**0.594***	**0.873***	**0.489***	**-0.463***	**0.913***	0.180	-0.132	0.020	-0.209	0.026
Lo						1.000	**0.558***	**0.797***	**-0.779**	**0.745***	0.183	-0.394	0.001	-0.158	0.186
Ne							1.000	**0.539***	**-0.401**	**0.890***	0.459*	-0.174	0.126	-0.203	0.114
Se								1.000	**-0.731***	**0.766***	0.122	-0.099	0.089	-0.006	0.326
Sh									1.000	**-0.577***	-0.135	0.203	0.023	0.144	-0.017
Ff										1.000	0.230	-0.139	0.081	-0.140	0.240
Ag											1.000	**-0.311**	**-0.157**	**-0.312**	**-0.088**
Cu												1.000	**0.648***	**0.710***	**-0.081**
Di													1.000	**0.882***	**-0.045**
Fi														1.000	**0.014**
St															1.000

All hedge funds and futures funds have 36 consecutive monthly returns from January 1998 to December 2000. Strategy codes for hedge funds or funds-of-funds: EV: Event driven, MA: Global macro, EM: Global emerging market, ES: Global established markets, IN: Global international markets, LO: Long only, NE: Market neutral, SE: Sector, SH: Short sale, FF: Funds-of-funds. Strategy code for CTAs: DIV: Diversified trading program, CUR: Currency trading program, AG: Agricultural trading program, STX: Stock trading program, FI: Financial trading program. Note that one of the hedge fund styles US opportunities dropped out since its latest available return date is September 1996. Up markets are defined according to the S&P 500 Index returns during the same time period, where returns are positive in 20 out of the 36 months. The numbers inside the box represent the cross correlations among hedge funds, funds-of-funds, and CTAs.
*Significant at the 5% level.

TABLE 8
Correlation Coefficients Across Hedge Fund, Fund-of-Fund, and CTA Styles in Down Markets

	Ev	Ma	Em	Es	In	Lo	Ne	Se	Sh	Ff	**Ag**	**Cu**	**Di**	**Fi**	**St**
Ev	1.000	**0.737***	**0.889***	**0.924***	**0.886***	**0.842***	**0.894***	**0.891***	**-0.816**	**0.960***	-0.497*	-0.111	-0.770*	-0.730*	0.443
Ma		1.000	**0.670***	**0.878***	**0.677***	**0.853***	**0.753***	**0.823***	**-0.905**	**0.853***	-0.216	-0.040	-0.446	-0.497*	0.699*
Em			1.000	**0.802***	**0.897***	**0.692***	**0.760***	**0.752***	**-0.734***	**0.880***	-0.281	-0.108	-0.688*	-0.661*	0.344
Es				1.000	**0.789***	**0.962***	**0.923***	**0.975***	**-0.950***	**0.985***	-0.477	-0.110	-0.643*	-0.650*	0.581*
In					1.000	**0.690***	**0.827***	**0.732***	**-0.745***	**0.866***	-0.225	-0.114	-0.510*	-0.507*	0.383
Lo						1.000	**0.877***	**0.965***	**-0.916**	**0.930***	-0.439	-0.120	-0.561*	-0.618*	0.588*
Ne							1.000	**0.917***	**-0.870**	**0.936***	-0.394	-0.192	-0.539*	-0.514*	0.481
Se								1.000	**-0.917***	**0.960***	-0.486	-0.182	-0.629*	-0.644*	0.565*
Sh									1.000	**-0.926***	0.266	0.118	0.419	0.429	-0.705*
Ff										1.000	-0.435	-0.127	-0.670*	-0.663*	0.554*
Ag											1.000	**0.215**	**0.728***	**0.727***	**0.091**
Cu												1.000	**0.115**	**0.142**	**0.204**
Di													1.000	**0.938***	**-0.049**
Fi														1.000	**-0.050**
St															1.000

All hedge funds and futures funds have 36 consecutive monthly returns from January 1998 to December 2000. Strategy codes for hedge funds or funds-of-funds: EV: Event driven, MA: Global macro, EM: Global emerging market, ES: Global established markets, IN: Global international markets, LO: Long only, NE: Market neutral, SE: Sector, SH: Short sale, FF: Funds-of-funds. Strategy code for CTAs: DIV: Diversified trading program, CUR: Currency trading program, AG: Agricultural trading program, STX: Stock trading program, FI: Financial trading program. Note that one of the hedge fund styles US opportunities dropped out since its latest available return date is September 1996. Down markets are defined according to the S&P 500 Index returns during the same time period, where returns are negative in 16 out of the 36 months. The numbers inside the box represent the cross correlations among hedge funds, funds-of-funds, and CTAs.

*Significant at the 5% level.

Table 9
Autocorrelation for Hedge Fund and FOF Returns in Up and Down Markets

	Panel A:		Bull market		1998-1999				
	Chi-square		*p*-value		ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_4
Event driven	5.26		0.511		0.352	0.074	-0.050	-0.172	-0.137	-0.061
Global macro	3.15		0.789		0.241	-0.126	-0.131	-0.128	-0.015	0.053
Global emerging	3.10		0.797		0.292	0.102	0.041	0.097	-0.004	-0.065
Global established	4.84		0.564		0.246	-0.062	-0.082	-0.206	-0.195	0.098
Global international	5.53		0.478		0.426	0.103	0.012	-0.052	-0.019	-0.076
Long only	3.52		0.742		0.289	0.008	-0.079	-0.146	-0.094	0.054
Market neutral	7.18		0.304		0.429	0.227	-0.024	-0.064	-0.080	-0.105
Sector	2.82		0.831		0.132	0.027	0.114	-0.114	-0.192	0.096
Short	5.32		0.503		0.208	-0.088	-0.097	-0.289	-0.175	0.036
FOF	4.08		0.666		0.305	0.090	0.006	-0.041	-0.152	-0.136
	Panel B:		Bear market		2000-2001				
	Chi-square		*p*-value		ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_4
Event driven	9.54	#	0.145		0.027	-0.412	-0.301	0.155	0.076	0.176
Global macro	12.93	#	0.044	**	-0.042	-0.269	-0.453	0.080	0.146	0.332
Global emerging	11.41	#	0.077	*	0.162	-0.323	-0.406	0.018	0.209	0.200
Global established	7.81	#	0.253		0.003	-0.341	-0.235	0.168	0.014	0.240
Global international	5.09		0.533		0.011	-0.250	-0.208	0.062	-0.031	0.233
Long only	5.71	#	0.456		0.014	-0.396	-0.126	0.059	-0.025	0.138
Market neutral	2.47		0.872		0.142	0.050	-0.155	0.137	0.035	0.122
Sector	7.79	#	0.254		0.026	-0.289	-0.262	0.190	-0.049	0.249
Short	5.18		0.520		-0.021	-0.297	-0.199	0.062	-0.049	0.194
FOF	9.56	#	0.145		0.009	-0.405	-0.269	0.155	0.004	0.258

Autocorrelation coefficients are estimated up to lag 6 using 24 monthly observations. The null hypothesis is that all these 6 autocorrelations are jointly zero. The test statistic is distributed as Chi-square with 6 degrees of freedom. The bull markets are from 1998 to 1999 while the bear markets are from 2000 to 2001.
#Higher Chi-square values in the bear markets than those in the bull markets.
**Significant at the 5% level.
*Significant at the 10% level.

Table 10
Autocorrelation for CTA Returns in Up and Down Markets

Panel A: Bull market 1998-1999

	Chi-square		*p*-value		ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_4
Agriculture	8.37		0.212		0.261	-0.191	-0.267	-0.213	0.139	0.195
Currency	2.93		0.818		-0.276	-0.063	-0.085	0.051	0.030	-0.110
Diversified	2.38		0.882		-0.137	0.107	-0.094	-0.151	-0.130	-0.024
Energy	4.56		0.601		-0.106	-0.298	-0.203	-0.065	-0.099	0.046
Financial	3.54		0.738		0.129	0.078	-0.053	-0.185	-0.228	0.043
Stock	1.80		0.937		-0.043	-0.039	0.072	-0.140	-0.167	-0.021

Panel B: Bear Market 2000-2001

	Chi-square		*p*-value		ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_4
Agriculture	3.43		0.753		0.013	-0.131	0.022	-0.117	0.217	0.166
Currency	8.66	#	0.194		-0.209	0.106	0.242	-0.177	0.168	-0.318
Diversified	3.97	#	0.681		-0.173	-0.135	0.130	-0.080	-0.160	-0.178
Energy	11.32	#	0.079	*	0.229	0.160	0.093	-0.243	-0.346	-0.301
Financial	6.37	#	0.383		-0.082	0.098	-0.068	-0.142	0.072	-0.379
Stock	6.78	#	0.342		-0.085	-0.424	-0.127	0.017	0.086	0.147

Autocorrelation coefficients are estimated up to lag 6 using 24 monthly observations. The null hypothesis is that all these 6 autocorrelations are jointly zero. The test statistic is distributed as Chi-square with 6 degrees of freedom. The bull markets are from 1998 to 1999 while the bear markets are from 2000 to 2001.
#Higher Chi-square values in the bear markets than those in the bull markets.
*Significant at the 10% level.

TABLE 11
Correlation Coefficients at the Individual Fund Level Within Each Investment Style

Style	State	Average corr	*t*-value	*p*-value	# of funds	# of corr	Compare up & down *t*-value	Compare up & down *p*-value
			Panel A: Hedge funds					
Event Driven	Up	0.2132	61.25	<0.0001	109	5,886	-52.58	<0.0001
Event Driven	Down	0.4892	124.47	<0.0001	109	5,886		
Global Macro	Up	0.0769	7.84	<0.0001	40	780	-3.85	<0.0001
Global Macro	Down	0.1366	11.37	<0.0001	40	780		
Global Emerging	Up	0.3765	62.62	<0.0001	66	2,45	-6.86	<0.0001
Global Emerging	Down	0.4410	60.96	<0.0001	66	2,45		
Global Established	Up	0.1634	92.17	<0.0001	223	24,753	-66.65	<0.0001
Global Established	Down	0.3514	160.28	<0.0001	223	24,753		
Global International	Up	0.1269	10.47	<0.0001	37	666	0.61	0.5420
Global International	Down	0.1149	7.40	<0.0001	37	666		
Long Only	Up	0.1186	3.26	0.0017	13	78	-3.84	0.0002
Long Only	Down	0.3515	7.25	<0.0001	13	78		
Market Neutral	Up	0.0861	44.21	<0.0001	206	21,114	-14.66	<0.0001
Market Neutral	Down	0.1298	57.51	<0.0001	206	21,114		
Sector	Up	0.0865	9.79	<0.0001	65	2,079	-25.38	<0.0001
Sector	Down	0.3909	48.17	<0.0001	65	2,079		
Short Sale	Up	0.2487	6.31	<0.0001	15	105	-2.67	0.0082
Short Sale	Down	0.4117	8.81	<0.0001	15	105		

TABLE 11 (Continued)

Panel B: FOF								
Funds-of-funds	Up	0.3903	240.92	<0.0001	262	34,191	-44.94	<0.0001
Funds-of-funds	Down	0.5037	260.25	<0.0001	262	34,191		
Panel C: CTAs								
Agriculture trading program	Up	0.2993	6.96	<0.0001	10	45	-4.54	<0.0001
Agriculture trading program	Down	0.5570	15.07	<0.0001	10	45		
Currency trading program	Up	0.2657	21.94	<0.0001	37	666	-8.46	<0.0001
Currency trading program	Down	0.4259	29.29	<0.0001	37	666		
Diversified trading program	Up	0.3814	123.87	<0.0001	151	11,325	-32.07	<0.0001
Diversified trading program	Down	0.5288	155.00	<0.0001	151	11,325		
Financial trading program	Up	0.2723	32.15	<0.0001	53	1,378	-15.86	<0.0001
Financial trading program	Down	0.4728	50.37	<0.0001	53	1,378		
Stock trading program	Up	0.2491	8.38	0.6686	16	120	-7.64	<0.0001
Stock trading program	Down	0.5307	24.40	0.6686	16	120		

As of March 2002, there are 2,357 hedge funds (1,164 live funds and 1,193 dead funds), 597 funds-of-funds (349 live and 248 dead), and 1,510 CTAs (294 live and 1216 dead). We restrict funds having 36 consecutive monthly returns from 1998 to 2000. Correlations are calculated for every two-fund pair and the average correlation is the average number across all independent pairs. Up and down markets are classified according to the S&P 500 Index returns during the same time period. Up markets are defined when the S&P index has positive returns (20 months) while down markets are defined when the S&P Index has negative returns (16 months).

Table 12
Sharpe Ratios of Hedge Funds, Funds-of-Funds, CTAs, and Portfolio Combinations

	Sharpe	$\sqrt{12}$ SR	$\eta(12)$ SR	Sharpe	$\sqrt{12}$ SR	$\eta(12)$ SR
Portfolio		Bull market	1998-1999		Bear market	2000-2001
Panel A: Three Groups						
Hedge Funds	0.3610	1.2505	1.0743	0.0265	0.0918	0.1417
Funds-of-funds	0.2321	0.8040	0.6292	0.0345	0.1195	0.1950
CTAs	0.1005	0.3481	0.4413	0.0890	0.3083	0.5508
Panel B: HF+CTA						
0.1/0.9	0.1708	0.5917	0.8489	0.0930	0.3222 *	0.6263 *
0.2/0.8	0.2599	0.9003	1.4871 *	0.0949	0.3287 *	0.7109 *
0.3/0.7	0.3558	1.2325	2.0786 *#	0.0946	0.3277 *	0.7956 *
0.4/0.6	0.4277	1.4816 *	2.0303 *	0.0909	0.3149 *	0.8293 *#
0.5/0.5	0.4539	1.5724 *	1.7357 *	0.0830	0.2875	0.7315 *
0.6/0.4	0.4458	1.5443 *	1.5015 *	0.0718	0.2487	0.5566 *
0.7/0.3	0.4241	1.4691 *	1.3368 *	0.0592	0.2051	0.4013
0.8/0.2	0.4005	1.3874 *	1.2219 *	0.0468	0.1621	0.2851
0.9/0.1	0.3792	1.3136 *	1.1372 *	0.0358	0.1240	0.2019

Table 12 (Continued)

Panel C: FOF+CTA		Bull market		1998-1999			Bear market		2000-2001	
0.1/0.9	0.1379	0.4777		0.6929	*	0.0919	0.3184	*	0.5956	*
0.2/0.8	0.1854	0.6422		1.1269	*	0.0937	0.3246	*	0.6409	*
0.3/0.7	0.2407	0.8338	*	1.7224	*	0.0948	0.3284	*	0.6977	*
0.4/0.6	0.2912	1.0087	*	1.7373	*#	0.0947	0.3281	*	0.7379	*
0.5/0.5	0.3179	1.1012	*	1.3438	*	0.0922	0.3194	*	0.7875	*#
0.6/0.4	0.3152	1.0919	*	1.0584	*	0.0864	0.2993		0.7443	*
0.7/0.3	0.2957	1.0243	*	0.8824	*	0.0766	0.2654		0.5969	*
0.8/0.2	0.2722	0.9429	*	0.7668	*	0.0634	0.2196		0.4471	
0.9/0.1	0.2505	0.8678	*	0.6869	*	0.0487	0.1687		0.3033	

As of March 2002, there are 2,357 hedge funds (1,164 live funds and 1,193 dead funds), 597 funds-of-funds (349 live and 248 dead), and 1,510 CTAs (294 live and 1216 dead). Every month, we calculate portfolio returns as the equally weighted average of all funds in the portfolio. Different portfolios are formed between hedge funds and CTAs, and between funds-of-funds and CTAs. A 0.1/0.9 combination represents for a 10% investment in hedge funds/funds-of-funds and a 90% investment in CTAs. Up markets are from 1998 to 1999 while down markets are from 2000 to 2001. Sharpe ratios are estimated using 24 monthly return observations in the up and down markets, respectively. $\sqrt{12}$ SR is the annualized Sharpe ratio when returns are i.i.d. while $\eta(12)$ SR is the autocorrelation adjusted Sharpe ratio on an annualized basis where $\eta(12) = \frac{12}{\sqrt{12 + 2\sum_{k=1}^{11}(12-k)\rho_k}}$ is used for calculating the autocorrelation adjusted Sharpe ratios.

*Improvement on Sharpe ratios when adding CTAs to the portfolio.
#Indicate the highest autocorrelation adjusted Sharpe ratio.