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# Hedge Fund Behavior: An Ex-Post Analysis

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## 1 Introduction

Hedge funds, while representing a relatively small portion of the financial markets, have grown significantly in size and influence in recent years. Based on current estimates of the SEC in a recent report<sup>1</sup>, only in the United States there are 6,000 to 7,000 hedge funds managing approximately \$600 to \$650 billion in assets. "In the next five to ten years, hedge fund assets have been predicted to exceed \$1 trillion". The growth in hedge funds has been fueled by the increased demand of both wealthy individual and institutional investors such as pension plans, endowments and foundations. There seem to be several reasons that might explain the growing interest in hedge funds. The first and perhaps the superficial one is the investor strong desire for high absolute returns of two-digit number once generated by George Soros' Quantum Fund and the remarkable success of the alternative investment industry during the long bull equity market of the 1990s. A more profound reason behind this growing popularity of hedge funds lies in the recognition that the latter offer a more sophisticated approach of investing through the frequent use of derivatives, short-selling and highly dynamic strategies, which might result in low correlations with traditional asset classes. As a result, they make an ideal investment vehicle to enhance returns and (or) reduce risk exposure and thus diversify portfolios investing in traditional assets.

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<sup>1</sup>United States Securities and Exchange Commission, "Implications of the Growth of Hedge Funds", September 2003.

This quality appears to be more attractive than ever in the context where both international diversification and sectorial diversification are shown to attain their limits when it is most needed, i.e. in downside markets.

In fact, hedge funds are similar to mutual funds in that they are all actively managed investment portfolios holding positions in traditional investment vehicles such as bonds, equities, options, futures, etc...But unlike mutual funds, they are largely exempt from federal regulation, while mutual funds are not<sup>2</sup>. In most cases, the SEC does not require hedge funds to disclose informations about their investment activities and financial results, and many funds operate offshore to avoid any sort of US government regulation<sup>3</sup>. The fact that hedge funds are subject to few legal restrictions offers their managers high degree of freedom in the proportion of securities they hold, the type of positions (long or short) they take and the leverage of portfolio they use in the portfolio composition<sup>4</sup>. They are also characterized by their short-term movements across diverse asset categories involving frequent use of short sales, leverage and derivatives to attempt to time the market. Another important point that makes hedge funds differ deeply from their counterparts is the strong bonus incentive fees usually referred to as a "free call option" on a portion of the profits that hedge fund managers earns for their investors<sup>5</sup>.

Given the wide range of structural liberty and dynamic strategies of hedge funds, it is not surprising that their return characteristics are far from similar to those of traditional assets as well as ordinary investment pools. Brooks and Kat (2002), Kat and Lu (2002) show that hedge fund returns are far to be normally distributed because their skewness and kurtosis levels are remarkably significant. Schneeweis and Spurgin (1999) find that the simple correlations between the returns on some alternative investments and stock returns are often quite different during extreme up and down movements in stock prices. Edwards and Caglayan (2001) prove that hedge fund returns are generally negative in bear markets, and almost all hedge fund styles exhibit significantly higher positive correlations with stock returns in bear markets than in bull markets. Brooks and Kat (2002), Okunev and White (2003)

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<sup>2</sup>The SEC allowed hedge funds to have up to 499 limited partners without any registration and disclosure requirements. However, 65% of investors must be accredited investors with a net worth of at least US\$1 million, or steady annual income of US\$200 000 or typically US\$250 000.

<sup>3</sup>Litterature on offshore hedge funds can be found in Goetzmann and Ibbotson (1997)

<sup>4</sup>For more details about hedge fund characteristics, see Ackermann, McEnally and Ravenscraft (1999).

<sup>5</sup>Applying Black-Scholes to evaluate hedge funds incentive fees considered as a call option, Anson (2001) found that the contingent claim nature of the incentive fee call option makes higher variance desirable to the hedge fund manager.

find evidence of smoothing phenomenon in hedge fund returns which induces downside bias in risk determination<sup>6</sup>. Cvitanic' *et al.*(2001) show that low beta hedge funds may serve as natural substitutes for a significant portion of an investor risk-free asset holdings. Edwards and Liew (1999), Favre and Galinao (2000), Karavas (2000), Schneeweis and Spurgin (2002), Amenc and Martellini (2002) show that adding hedge funds to a long-only stock and bond portfolio tends to leave returns stable, decrease the standard deviation and reduce the downside risk.

The main purpose of this paper is to provide an empirical analysis of hedge fund behavior first as a stand-alone alternative investment and then as a potential means of diversifying traditional portfolios. This issue is addressed in many studies and we are not the first that are interested in the question. Nonetheless, most studies do not distinguish between up and down stock markets. Yet, it has long been recognized that hedge fund managers follow highly dynamic strategies with strongly fluctuating risk exposures through time. As a consequence, their risk-return characteristics are often quite different following stock market environment. In this context, the contribution of this study is twofold. First, it attempts to fill the above gap by examining in greater details the risk-return behavior of hedge funds with respect to traditional asset classes in bear versus bull stock markets. Second, it extends hedge fund analysis to a longer and more recent period (1994-2002). I especially focus on examining conditional and trailing correlations within the hedge fund universe as well as between hedge funds and other traditional asset classes to investigate portfolio diversifying perspective of hedge funds.

The rest of the paper is organized as follows. In section 2, I make some description of data used in this research. Section 3 reports risk-return characteristics of 10 hedge fund indices in comparison to 31 traditional asset class indices. In section 4 and 5, conditional and rolling correlations are computed to identify potential relationship between different hedge fund styles within hedge fund group as well as with other asset classes. In section 6, I perform a hierachical clustering analysis to identify the group of asset classes to which different hedge fund styles might belong in order to validate the results obtained in the previous sections. Finally, section 7 concludes.

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<sup>6</sup>As explained in Okunev and White (2003): "Many hedge funds trade in illiquid markets where it is difficult to price positions on any given day. Fund managers who operate in these markets have a degree of freedom to report their returns as they may wish. Why not necessarily guilty of outright fraud, some of these fund managers may "smooth" their returns in very much the same manner as many companies have for their reported earnings. To the extent that this type of smoothing does occur in reported individual hedge fund returns, the true realised volatility will exceed disclosed volatility and the underlying relation between the hedge fund returns and factor exposures will be obscured".

## 2 Data Description

To represent hedge fund universe, I choose 10 indices of Credit Suisse First Boston/Tremont (CSFB/Tremont)<sup>7</sup> which stand for 10 strategies commonly followed by alternative investment managers. It is necessary to note that there are at least a dozen of competing indices on hedge funds. The advantage of CSFB/Tremont hedge fund indices is twofold. First, they are transparent both in their calculation and composition, and constructed in a disciplined and objective manner. Second, they are currently the industry's only asset-weighted hedge fund indices<sup>8</sup>. Regarding traditional investment universe, I decided to analyze hedge funds with respect to an important number of market indices in order to better characterize their risk-return behavior. These market indices represent different segments of equities, government and corporate bonds, real estate and commodities.

In total, I had 108 monthly returns of 41 indices and factors over the period running from January 1994 to December 2002. This means that our data set includes a long period of the IT bubble as well as important sharp fall markets like ones during the Asian, Russian and LTCM crisis, which allows a better understanding about hedge fund risk-return characteristics in extreme market movements with respect to previous studies. Taking the S&P500 index as market benchmark, I divided the 108-month period into 2 subperiods according to the evolution of the S&P500. From January 1994 to September 2000, the S&P500 constantly rose with a phenomenal speed and began going down from October 2000. As a result, the first 81 months (1994:1-2000:9) seem likely to represent bullish market and the last 27 months bearish one. Additionally, in order to capture hedge fund behavior during the Asian and Russian crisis, each analysis is also conducted over the period 1996:1-1998:6.

## 3 Hedge Fund Risk-Return Characteristics

### 3.1 Entire period analysis

Exhibit 1 reports the annualized average mean return, standard deviation, Sharpe ratio<sup>9</sup>, skewness, kurtosis, and normality tests (Jarque-Bera, Shapiro-

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<sup>7</sup>For a definition of these hedge fund strategies, see Amenc and Martellini (2002).

<sup>8</sup>For further details, see Amenc and Martellini (2001).

<sup>9</sup>Sharpe Ratio =  $\frac{R_i - R_f}{\sigma_i}$  where  $R_i$  is the annualized average rate of return of the  $i$ -th asset class during the 9 year period,  $R_f$  is the annualized average risk-free rate approximated by US 3 month T-bill return during the 9 year period,  $\sigma_i$  is the annualized standard deviation of rates of return on the  $i$ -th asset class during the 9 year period.

Wilk and Kolmogorov-Smirnov) of 10 hedge fund indices and 31 market indices over the 9-year sample period. The first thing we can say from Exhibit 1 is that the risk-return properties of different hedge fund strategies are very heterogeneous. The annualized mean returns range from a low of 0.8% for Dedicated Short Bias to a high 13.19% for Global Macro funds. In terms of total risk measured by the annualized standard deviation of monthly rates of return, it seems that hedge funds form two groups. The first one including Dedicated Short Bias, Emerging Markets, Global Macro, Long Short Equity and Managed Futures has a level of risk comparable to that of developed stock market indices. Meanwhile, standard deviations of the second containing the other hedge fund styles are just comparable to those of government bond indices. Note that during this period, the S&P500 displays a mean return of 7.42% and a volatility of 16.49%. A comparison of Sharpe ratio confirms the interesting risk-return profiles of hedge funds in relation to other traditional assets. Except for Dedicated Short Bias (-0.21), Emerging Markets (0.01) and Managed Futures (0.13), other hedge fund styles have relatively high Sharpe ratios. In particular, Equity Market Neutral and Convertible Arbitrage earn the highest performance with Sharpe ratios of 1.87 and 1.06 respectively.

<< Insert Exhibit 1 here >>

However, should one conclude to a better risk-return performance of hedge funds? In reality, after looking at higher moments of hedge fund return distributions, it does not seem straightforward to conclude anything about hedge fund risks because nearly all of them exhibit significantly negative skewness and (or) high excess kurtosis except for Market Neutral and Managed Futures. This is especially true for two strategies: Event-Driven and Fixed Income Arbitrage. The presence of these features conducts naturally to reject the null hypothesis of normality distribution regardless of the test used (Jarque-Bera, Shapiro-Wilk or Kolmogorov-Smirnov). However, it is not the case for Equity Market Neutral and Long Short Equity indices as their return distributions are statistically close to normal ones. Until now, these results are consistent with those obtained in Brooks and Kat (2002), Amin and Kat (2003).

What really came to me as a surprise was the fact that although the data are on a monthly basis, hedge fund indices are not the only ones whose returns are not normally distributed. Whichever test used, the hypothesis of a gaussian law could be rejected with a low level of risk. This has important implications for investors in that it proves the inefficiency of traditional performance measures as well as Markowitz portfolio analysis which are traditionally based upon mean-variance framework. From a certain point of

view, higher moment analysis is no longer the problem specific to only alternative investments. Nonetheless, dealing with these questions is beyond the purpose of this paper.

An other issue which has recently received an increasing interest in hedge fund research involves a so-called stale price bias or smoothing bias. In some markets, especially in real estate market, lack of liquidity may lead to stale price bias which, in turn, leads to bad risk measures (beta and standard deviation)<sup>10</sup> As documented in Asness, Krail, and Liew (2001), and Okunev and White (2003), this problem is undoubtedly present in hedge fund market and this is because of two reasons. First, it is widely accepted that "many hedge funds trade in illiquid markets where it is quite difficult to price positions on any given day. Fund managers who operate in these markets have a certain degree of freedom to report their returns as they may wish"<sup>11</sup>. Second, "many in the hedge fund industry have verified that, at least for some categories and some managers, a significant amount of intentional smoothing does occur"<sup>12</sup> to lower the volatility and the asset market exposure. In order to verify this last phenomenon, we have computed the autocorrelation coefficients at lags ranging from 1 to 10. The results are summarized in Exhibit 2<sup>13</sup>.

<<Insert Exhibit 2 here >>

Among 41 indices, no one exhibits longer lags than five. Among the 10 hedge fund indices, 6 exhibit significant positive first order autocorrelations. Those are Convertible Arbitrage, Emerging Markets, Equity Market Neutral, Event Driven, Fixed Income Arbitrage and Risk Arbitrage. Regarding to Convertible Arbitrage, it is lagged to all three first orders (the third order is negative), Global Macro style is positively lagged only to the fifth order, and Risk Arbitrage positively lagged to the first and fifth orders. The other hedge fund indices are independent from their previous values.

This brings out a question: *What can we say about this phenomenon?*

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<sup>10</sup>For securities with stale prices, estimated beta may be lower than the actual beta and, depending on the time period chosen measured, standard deviation may be higher or lower than it would exist if actual prices existed. In some markets, especially in real estate market, prices are often computed using benchmark lattice, appraisal values, etc., such that reported prices do not reflect current market prices.

<sup>11</sup>Okunev and White(2003)

<sup>12</sup>Asness, Krail, and Liew (2001)

<sup>13</sup>In table 3, we only present the first five autoregression coefficients from AR(1) to AR(5) because no indices exhibits a higher order of autocorrelation.

The answer to this question has not been yet completely clear. Further investigations would be made to assess the feature of these hedge fund styles.

The results also show a strong heterogeneity in serial autocorrelation level of market indices. In total, 16 indices exhibit significant autocorrelations whose orders vary widely from one to another. But despite this divergence, it reveals an interesting point: the majority of these indices are characterized by their illiquid nature, i.e. small capitalization equities, bonds and equities of emerging markets, high yield bonds, real estate.

### 3.2 Subperiod analysis

As indicated in the literature on alternative investments, hedge funds are supposed to be largely market-neutral and often qualified as "pure alpha" funds, meaning their ability not only to make money independently from market conditions but also to outperform the market. If it is the case, hedge funds seem likely to be an appealing investment vehicle in bullish period as well as an ideal downside protection when stock market declines. To investigate this apparently interesting feature of hedge funds, an analysis of risk-return behavior of hedge funds in relation to traditional assets during bull, crisis and bear periods is conducted. The results obtained are detailed in Exhibit 3.

<< Insert Exhibit 3 here >>

The results highlight several important points: The historical risk-return profiles of most hedge fund strategies differ one from another and vary substantially over time, depending on market states. Contrarily to what people usually believe, in bull market, most hedge funds did not necessarily do better than the market (the S&P500 index) and some other equity indices (Russell 3000, MSCI North America, Wilshire Large Growth, Wilshire Large Value,...). It is quite surprising that during upside period, Dedicated Short Bias and Managed Futures had negative Sharpe ratios (-0.49 and -0.17 respectively) compared to 0.96 obtained by the S&P500. The Emerging Markets style with a Sharpe ratio of 0 had a performance nearly equivalent to the US 3 month T-bill. The highest Sharpe ratios were found for 3 hedge fund strategies: Equity Market Neutral, Risk Arbitrage and Convertible Arbitrage (1.78, 1.07 and 0.99 respectively), which are also market overperformers.

What really make hedge funds appealing alternative vehicles is their surprisingly attractive performance in bear market. And this is because of two reasons. First, their mean returns are primarily positive while the majority of market indices' returns are primarily negative, meaning that they did make



money whereas others lost. The only exception is Long Short Equity with a negative return of -3.74% but this negative return is far better than the -22.59% average annualized decline in S&P500 stocks. This feature becomes more striking when the performance is achieved at a price of relatively low volatility during this extremely volatile period. Excepting Dedicated Short Bias and Managed Futures, the standard deviations of hedge fund strategies are just similar to fixed-income securities' and much lower than stock indices' ones. As a result, 6 hedge fund styles have positive Sharpe ratios, among which the highest belong to Global Macro and Equity Market Neutral (3.17 and 1.60 respectively). Note that during this period, in terms of Sharpe ratios, 26 among 31 market indices suffered significant losses.

The analysis of hedge fund behavior during the Asian crisis (1997:1-1998:6) suggests three noteworthy points. First, in terms of mean returns, hedge funds do poorly compared to other equity indices (emerging market indices excluded) with two exceptions: Global Macro with a relatively high mean return of 31.56% and Emerging Market with a negative return of -0.93%. However, during this highly volatile period, 5 among 10 hedge fund strategies (Convertible Arbitrage, Equity Market Neutral, Event Driven, Fixed-Income Arbitrage and Risk Arbitrage) have surprisingly significantly low standard deviations, just comparable to those of fixed-income indices. The results of risk-adjusted returns measured by the Sharpe ratio show that hedge fund strategies seem likely to form three groups. The first including Convertible Arbitrage (2.86), Event-Driven (2.32), Equity Market Neutral (1.92) and Global Macro (1.91) overperformed the market approximated by the S&P500 index (1.59), meaning that they took advantage from this crisis. The second with two strategies: Risk Arbitrage and Long Short Equity had Sharpe ratios comparable to those of equity indices (excluding emerging market stocks). Fixed-Income Arbitrage, Emerging Markets, Dedicated Short Bias and Managed Futures with Sharpe ratios of 0.31, 0, -0.37 and 0.19 respectively form the last group which suffered from the Asian crisis.

Another important finding is that Fixed-Income Arbitrage and Equity Market Neutral are likely to have risk-return characteristics which are fairly stable over time, regardless of market environment. Interestingly, their level of risk measured by the standard deviation is remarkably low, just comparable to fixed-income securities. But if the latter's returns are very low compared to other asset classes, the former offers constantly high returns. Given this feature, Equity Market Neutral appears to be the most historically efficient strategy among other hedge fund styles and traditional assets.

## 4 Hedge Fund Inter-Strategy Correlations

This section examines the inter-relation within the alternative investment industry through the inter-correlation coefficients of different hedge fund styles. It is widely known that the hedge fund universe encompasses a wide range of different locations and strategies. According to Fung and Hsieh (1997), "location" tells us the asset categories in which the manager invests, "strategy" reflects the manager's style of trading - that is the way how the long and short positions (and their derivatives) are traded and levered to reach the investment objective. These factors are combined harmoniously to form the so-called investment "style". To illustrate this point, let us take a look on the Global Macro and the Market Neutral style. The former bets on the directions of markets dynamically by being long or short markets to capture their rise and fall. It is a directional, risk-seeking approach that offers potentially sizeable rewards if their forecasts come true. In contrast, market neutral approach seeks to neutralize market risks while attempting to extract value from a set of market diversified arbitrage opportunities and structural anomalies. Since these approaches and specialities vary greatly from funds to funds, one should expect that their return behavior would not be the same in a given market condition. Understanding each hedge fund style's distinct features in relation with the others is crucial for investors as it may serve as a guide for the latter to decide properly which style to invest in and this is in which market condition. In practice, in selecting hedge funds, investors attach considerable importance to management style. According to a recent Deutsche Bank survey of 376 hedge fund investors, 42% of them recognize hedge fund style as the most important factor in their fund selection decisions<sup>14</sup>. In the previous section, we have seen that different hedge fund styles generate different risk-return profiles and the profile of each hedge fund style varies greatly according to market environment. However, it does not tell much about the manner and the extent of their comovements. As a result, inter-strategy correlations between hedge fund styles are computed both on a static and rolling basis. The results of static conditional correlations are summarized in Exhibit 4.

<< Insert Exhibit 4 here >>

The first thing one can remark from Exhibit 4 is that the correlations between hedge fund styles although generally positive are quite low, which shows stylistic differences exist across hedge funds and the classification works with a certain success. Two exceptions are the Dedicated Short Bias and the

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<sup>14</sup>"Alternative Investment Survey Results Part 2", 2003, p.8.

Managed Futures styles. The Dedicated Short Bias style always exhibits significant negative correlations with all others. The Managed Futures style is slightly and positively correlated with the Equity Market Neutral, Global Macro, Dedicated Short Bias and negatively correlated with the others. Note however that these are the only alternative investment strategies that make generally poorest returns at high volatility levels during the bullish market (*cf.* previous section). Being fairly correlated with other styles in bull market, the Fixed-Income Arbitrage and Global Macro styles see their correlations with the others decrease significantly in bear market. It is necessary to note that in this declining environment, while nearly all the stock indices had negative Sharpe ratios, Global Macro had surprisingly a Sharpe ratio of 3.17.

As important as the fundamental inter-relationship between different hedge fund styles is the consistency of these relationships over time. In Exhibit 5, 24-month rolling correlation of 10 hedge fund strategies are shown.

<< Insert Exhibit 5 here >>

Empirical results demonstrate that the correlations of Emerging Markets, Event-Driven and Long Short Equity styles with the others remain fairly constant while correlations of other strategies display high variation over time. It appears that this relation was dramatically changed after the Asian crisis. This finding has important implications for the construction of funds of hedge funds as it implies that using static average correlation might not be appropriate for determining the portfolio risk.

## 5 Correlations between Hedge Funds and Traditional Assets

Analyzing correlations between different hedge fund styles and traditional asset classes is of crucial importance in diversification decision making. If hedge fund returns are really not affected by the direction of equity, debt or other markets, then it could be beneficial to add hedge funds to portfolios composed of traditional assets. The literature on this issue has surged. The classical way to asset hedge fund diversification benefits for a traditional portfolios is to optimize portfolio's risk-return trade-off which is in turn determined by the nature of the correlation between hedge funds and the assets in portfolios. Nonetheless, previous studies focused only on the static average correlations. Yet, the consistency of these relations is crucial to the analysis of portfolios with hedge funds. As a result, in this section, conditional

and rolling correlations between hedge funds and traditional assets are computed to gain insights into the dynamic evolution between them. Exhibit 6 summarizes our main findings.

<< Insert Exhibit 6 here >>

The results reveal that in bull market, correlations between almost hedge fund styles and stock indices remain permanently at fairly high levels. This is particularly true for two styles: Emerging Markets and Event-Driven. As would be expected, this tight correlation tends to decrease in bear market, which is a good signal for traditional portfolio diversification. However, contrarily to what investors may hope for, during the Asian stock market re-trenchment, almost hedge fund styles prove fairly high correlations with stock indices, especially emerging ones. It is likely that over the period preceding the crisis, almost hedge funds were oriented towards less mature financial markets where it can make big gambles on large-scale economic structural changes, especially interest rate shifts. In contrast with other styles, Dedicated Short Bias and Managed Futures exhibit permanently negative correlations. Fixed-Income Arbitrage is the least correlated versus stock returns and this is regardless of market environment.

A review of the relation between hedge fund styles and bond indices suggests that hedge funds have primarily no correlation or insignificant negative correlation with bond index returns. A closer look at the correlation between bond and equity indices reveals that hedge funds and bonds are about equally correlated with equities. Given the fact that some hedge fund styles (like Convertible Arbitrage, Equity Market Neutral, Event-Driven, Fixed-Income Arbitrage and Risk Arbitrage) and bonds are comparable in terms of risk whereas hedge fund returns are much higher than bonds'<sup>15</sup>, from a diversification perspective, hedge funds appear to be a superior substitute for bonds in portfolios.

## 6 Cluster Analysis

In the previous sections, we have used several standard statistical measures to analyze hedge fund risk-return behavior with respect to those of traditional asset classes. In other words, we seek to know if hedge funds "behave", in one way or another, differently from stocks, or fixed-income securities or high yield bonds....If it is the case, adding hedge funds into traditional portfolios

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<sup>15</sup> *cf.* previous section.

could help enhancing risk diversification. In this section, I performed a supplementary analysis to validate the results previously obtained by conducting a hierarchical clustering.

In the hierarchical method, clustering begins by finding the closest pair of indices according to a distance measure and combines them to form a cluster. The algorithm continues one step at a time, joining pairs of indices, pairs of clusters or an index with a cluster, until all the data are in one cluster. The method is hierarchical because once two indices or clusters are joined, they remain together until the final step. That is, a cluster formed in a later stage of the analysis contains clusters from an earlier stage which contain clusters from a still earlier stage. On the one hand, hierarchical dendograms provide an excellent picture of just when each index is joined with one another, and distance matrices can also be informative. On the other hand, it allows visualizing how an (several) index(indices) is (are) attributed to a certain group once the number of cluster increases. These two features help us to determine a reasonable number of groups so that suspect cases can be mapped properly. The results are summarized in Exhibit 7, 8A, 8B, 8C.

<< Insert Exhibit 7, 8A, 8B, 8C here >>

The Exhibit 7 reports the members of each cluster when the cluster number varies from 10 to 15. In fact, I tried some different numbers and found that 10 to 15 is a reasonable one that reveals properly hedge fund behavior in relation with other asset classes. A review of these results suggests that 5 among 10 hedge fund styles (Convertible Arbitrage, Equity Market Neutral, Event-Driven, Fixed-Income Arbitrage and Risk Arbitrage) are in the same group with bond indices (numbered from 27 to 38) and this in whatever market environment. As revealed by their names, these strategies are non-directional with relatively low exposure to stock market movements. For this reason, their relations with other asset classes remain primarily unchanged over time. The Dedicated Short Bias seem likely to behave much differently from the other alternative styles as well as traditional asset classes, this behavior is also fairly consistent through time. In contrast, Emerging Markets, Global Macro, Long Short Equity and Managed Futures react differently according to market conditions. What is interesting here is that in bull market, they have similar behavior to equity indices and to bond indices in bear market. This might explain why hedge fund returns are considerably positive during the bubble burst while many equity index returns are significantly negative.

## 7 Conclusion

An argument that hedge fund managers usually do to attract investors is the ability of hedge funds to generate interesting risk-return profiles independently from market environment. If it is the case, hedge funds might be an ideal investment vehicle both on stand-alone and portfolio diversification basis. This study examines the risk-return behavior of hedge funds with respect to a number of traditional asset classes during periods of both rising and falling stock prices.

Using monthly data of 10 CSFB/Tremont hedge fund indices and 31 other market indices representing traditional asset classes during the period 1994:1 through 2002:12, I conclude that the historical risk-return profiles of most hedge fund strategies differ one from another and vary substantially over time, depending on market states. In bull market, almost hedge fund styles did not do as well as some equity classes, but in bear market they offered a good downside protection. In bear market, hedge funds generally produced significantly positive returns at a price of relatively low volatility level, just equivalent to those of fixed-income securities. The results of hedge fund correlations with traditional asset classes indicate that hedge funds display permanently slight positive correlations with bonds, fairly low positive correlations with equities in bear market. Combining these findings with the fact that hedge funds and bonds are about equally correlated with equities, hedge funds might be a superior substitute for bonds in portfolios. Even when included in a traditional stock and bond portfolios, hedge funds might help reduce risk or/and increase absolute returns of portfolios. But which proportion of traditional portfolios to invest in hedge funds remains until now an open question that needs much further investigations.

From funds of hedge funds diversification perspective, 24-month rolling correlation analysis suggests that before and after the Asian crisis and the IT bubble, hedge fund inter-strategy correlations although generally positive are quite low. During the Asian crisis and the IT bubble formation, it is likely that the correlations between different styles become slightly tighter. Even so, one can conclude to a relatively stable and low correlation structure between different hedge fund styles. Two exceptions are Dedicated Short Bias and Managed Futures styles. With respect to the others, these styles exhibits permanently negative correlations while the others display positive correlations and fairly negative correlations all through these two events. Given these results, the idea of diversifying among loosely correlated funds is therefore very natural end beneficial.

However, analyzing hedge fund behavior either as a stand-alone investment or in a diversification perspective has to face up to a challenging dif-

ficuity. As indicated by our results, hedge fund return distributions tend to exhibit skewness and fat tails. Surprisingly, it is also the case for many other asset class indices. These findings imply that further research needs to be done in order to take into account these features and thus to verify the validity of the results obtained by mean-variance analysis.

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### Exhibit 1: Entire Period Risk-Return Characteristics (1994:1-2002:12)

Sharpe Ratio (SR) measures risk-adjusted returns.  $SR = \frac{R_i - R_f}{\sigma_i}$  where  $R_i$  is the annualized average rates of return of the i-th asset class during the 9 year period,  $R_f$  is the annualized average risk-free rate approximated by US 3 month T-bill return during the 9 year period,  $\sigma_i$  is the annualized standard deviation of rates of return on the i-th asset class during the 9 year period. Jarque-Bera (JB), Shapiro-Wilk (SW) and Kolmogorov-Smirnov (KS) are three tests on normal distribution hypothesis; \*\*\*, \*\* and \* denote significance at the 1%, 5% and 10% respectively.

Indices	Mean	Std Er	SR	Skewness	Kurtosis	JB	SW	KS
HF Convertible Arbitrage	9.74	4.88	1.06	-1.69	4.38	138***	0.86***	0.16***
HF Dedicated Short Bias	0.80	18.05	-0.21	0.61	1.13	12.47***	0.97***	0.07
HF Emerging Markets	4.82	18.85	0.01	-0.91	4.69	114.2***	0.94***	0.07
HF Equity Market Neutral	10.49	3.16	1.87	0.10	0.03	0.19	0.99	0.04
HF Event Driven	9.97	6.43	0.84	-3.65	24.36	2910***	0.74***	0.14***
HF Fixed Income Arbitrage	6.46	4.16	0.45	-3.33	16.88	1481***	0.72***	0.21***
HF Global Macro	13.19	12.60	0.68	-0.21	1.78	15.08***	0.96***	0.09**
HF Risk Arbitrage	8.03	4.61	0.75	-1.49	6.78	247***	0.91***	0.13***
HF Long Short Equity	10.98	11.39	0.56	0.00	3.04	41.48***	0.96***	0.08*
HF Managed Futures	6.13	11.94	0.13	-0.10	0.90	3.85	0.98	0.08
NASDAQ	6.02	30.38	0.05	-0.60	0.69	8.71**	0.97**	0.09**
RUSSELL 2000	4.90	19.65	0.02	-0.54	1.23	11.97***	0.97**	0.11***
RUSSELL 3000	7.01	16.55	0.15	-0.39	1.39	11.43***	0.97**	0.09**
S&P 500	7.42	16.49	0.17	-0.39	1.52	13.10***	0.97**	0.09**
DJ Euro Stoxx	3.75	19.07	-0.04	-0.79	1.68	24.01***	0.96***	0.10***
MSCI North America	8.78	16.53	0.25	-0.69	0.36	9.10**	0.97***	0.08
MSCI EAFE	1.52	15.27	-0.20	-0.56	0.36	6.23**	0.98*	0.09**
MSCI EMF Asia	-9.13	28.13	-0.49	-0.13	0.34	0.82	0.99	0.07
MSCI EMF Far East	-11.63	31.38	-0.52	0.04	0.80	2.9	0.98*	0.07
MSCI EMF Latin America	-0.71	32.24	-0.16	-1.08	3.06	63.06***	0.95***	0.10***
WILSHIRE Large Growth	10.71	19.03	0.32	-0.96	1.63	28.50***	0.95***	0.07
WILSHIRE Large Value	12.47	14.06	0.56	-1.03	3.48	73.56***	0.95***	0.09**
WILSHIRE Midcap Growth	10.95	24.28	0.26	-0.58	2.17	27.29***	0.95***	0.10**
WILSHIRE Midcap Value	13.43	14.29	0.62	-1.10	4.85	128***	0.93***	0.08
WILSHIRE Small Growth	7.85	25.98	0.13	-0.69	1.86	24.18***	0.96***	0.11***
WILSHIRE Small Value	12.74	15.77	0.52	-0.64	5.83	160***	0.91***	0.10***
MSCI US Treasury	6.99	4.46	0.54	-0.25	0.04	1.1	0.99***	0.06***
MSCI EMU Sovereign	6.27	9.41	0.18	0.35	0.53	3.49	0.98***	0.04
MSCI World Sovereign	5.70	6.28	0.18	0.38	0.44	3.46	0.98	0.08
LEHMAN US Agg Bond	-0.11	4.47	-1.05	-0.30	0.07	1.67	0.98***	0.08
LEHMAN HYield: Default Ex	-2.36	7.71	-0.90	-0.44	3.39	55.23***	0.92***	0.13***
LEHMAN Global Govt Ex US	-0.37	3.22	-1.54	-0.25	0.33	1.59	0.99***	0.08*
LEHMAN Em Sovereign	-1.71	16.85	-0.37	-3.30	21.90	2354***	0.76***	0.13***
LEHMAN Em Corp	-2.10	13.51	-0.49	-2.36	17.12	1418***	0.79***	0.17***
LEHMAN US HYield Corp	-2.15	7.78	-0.87	-0.44	3.20	49.57***	0.93*	0.15***
LEHMAN HYield Corp Interm	-1.97	7.68	-0.85	-0.43	3.41	55.54***	0.92***	0.16***
LEHMAN HYield Corp Long	-3.38	10.62	-0.75	-0.15	1.76	14.37***	0.98***	0.08*
LEHMAN Gov/Credit 1-5 Yr	0.07	2.53	-1.78	0.16	0.59	2.03	0.98***	0.07***
World Ex US Real Estate	-2.89	19.86	-0.38	-0.67	3.33	58.01***	0.95	0.07*
US Real Estate	4.79	17.29	0.01	-0.03	1.63	11.91***	0.97***	0.08***
GSCI Commodity	5.40	17.98	0.05	-0.03	0.23	0.24	0.99*	0.04

## Exhibit 2: Time Series Properties (1994:1 – 2002:12)

LB-Q (5): Ljung-Box Q\* tests autocorrelation of order up to 5. \*\*\*, \*\* and \* denote significance at the 1%, 5% and 10% respectively.

Indices	AR(1)	AR(2)	AR(3)	AR(4)	AR(5)	LB-Q (5)
HF Convertible Arbitrage	0.49***	0.26**	-0.26**	0.05	0.07	15.36
HF Dedicated Short Bias	0.06	-0.09	-0.04	-0.09	-0.14	15.67
HF Emerging Markets	0.31***	-0.08	0.06	-0.06	-0.05	26.98
HF Equity Market Neutral	0.25**	0.09	0.01	-0.06	0.05	29.60
HF Event Driven	0.33***	0.04	-0.02	0.01	-0.05	9.37
HF Fixed Income Arbitrage	0.44***	-0.07	-0.02	0.11	-0.08	13.30
HF Global Macro	0.06	0.02	0.09	-0.12	0.24**	29.75*
HF Risk Arbitrage	0.31***	-0.07	-0.06	-0.07	0.27***	10.37
HF Long Short Equity	0.12	0.02	-0.04	-0.06	-0.16	15.67
HF Managed Futures	0.03	-0.10	0.02	-0.04	-0.04	22.19
NASDAQ	0.06	-0.03	0.02	0.01	-0.03	19.46
RUSSELL 2000	0.04	-0.05	-0.16	-0.02	-0.26**	14.42
RUSSELL 3000	-0.06	0.10	0.03	-0.05	-0.04	13.01*
S&P 500	-0.08	0.13	0.03	-0.02	0.00	16.92
DJ Euro Stoxx	-0.07	0.03	0.05	-0.01	-0.09	19.95
MSCI North America	-0.01	-0.02	0.13	-0.06	0.09	16.77
MSCI EAFE	-0.03	-0.09	0.01	-0.01	-0.06	14.73
MSCI EMF Asia	0.22**	0.15	-0.05	-0.19*	0.12	24.92
MSCI EMF Far East	0.18*	0.15	-0.08	-0.15	0.11	26.36
MSCI EMF Latin America	0.00	-0.03	-0.04	-0.10	-0.11	17.42
WILSHIRE Large Growth	0.00	-0.03	0.17*	0.04	0.03	17.67
WILSHIRE Large Value	0.01	-0.11	-0.06	-0.08	0.06	19.04
WILSHIRE Midcap Growth	0.09	-0.10	-0.12	0.08	-0.20*	26.28
WILSHIRE Midcap Value	0.11	-0.18*	-0.10	-0.11	-0.02	15.61
WILSHIRE Small Growth	0.08	-0.11	-0.11	0.08	-0.21**	18.78
WILSHIRE Small Value	0.11	-0.28**	-0.02	-0.14	-0.04	9.70
MSCI US Treasury	0.17	-0.11	0.16	-0.10	-0.08	19.16*
MSCI EMU Sovereign	0.23**	-0.06	0.12	-0.15	-0.08	18.02
MSCI World Sovereign	0.21**	-0.05	0.09	-0.18*	-0.21**	18.71
LEHMAN US Agg Bond	-0.06	0.05	0.08	0.05	-0.12	23.87
LEHMAN HYield: Default Ex	0.03	-0.18*	-0.06	0.00	-0.19*	15.14
LEHMAN Global Govt Ex US	0.08	0.25**	0.10	0.00	-0.05	14.98
LEHMAN Em Sovereign	0.01	0.01	-0.07	-0.08	-0.13	16.80
LEHMAN Em Corp	0.14	-0.03	-0.10	-0.12	-0.03	12.71
LEHMAN US HYield Corp	0.07	-0.20*	-0.03	-0.02	-0.21**	9.58
LEHMAN HYield Corp Intern	0.05	-0.22**	-0.06	-0.02	-0.21**	10.42
LEHMAN HYield Corp Long	0.09	-0.07	0.10	-0.06	-0.09	11.64
LEHMAN Gov/Credit 1-5 Yr	0.13	-0.06	0.12	-0.05	-0.12	18.93
World Ex US Real Estate	-0.01	0.27***	-0.29***	-0.12	0.04	21.23
US Real Estate	0.01	-0.06	-0.03	0.08	-0.09	14.02
GSCI Commodity	0.08	-0.06	0.25**	0.08	0.04	17.74

### Exhibit 3: Subperiod Risk-Return Characteristics

Sharpe Ratio (SR) measures risk-adjusted returns.  $SR = \frac{R_i - R_f}{\sigma_i}$  where  $R_i$  is the annualized average rates of return of the i-th asset class during the 9-year period,  $R_f$  is the annualized average risk-free rate approximated by US 3 month T-bill return during the 9-year period,  $\sigma_i$  is the annualized standard deviation of rates of return on the i-th asset class during the 9-year period; Bu: Bull market (1994:01-2000:9), Be: Bear market (2000:10-2002:12), C: Asian crisis period (1997:1-1998-6).

Indices	Mean			Std. Deviation			Sharpe Ratio			Skewness			Kurtosis		
	Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	B	C	Bu	Be	C
HF Convertible Arbitrage	10.23	8.28	12.62	5.15	4.02	2.61	0.99	0.79	2.86	-1.74	-1.57	-1.05	4.41	4.14	1.42
HF Dedicated Short Bias	-3.79	14.55	-0.93	18.19	17.35	16.66	-0.49	0.54	-0.37	0.79	0.15	0.57	1.81	-0.23	0.13
HF Emerging Markets	5.11	3.94	5.19	21.12	9.48	19.54	0.00	-0.12	0.00	-0.88	-0.13	-0.36	3.60	-1.21	-0.87
HF Equity Market Neutral	11.26	8.19	13.72	3.46	1.92	4.46	1.78	1.60	1.92	-0.07	0.80	-0.07	-0.25	0.51	-0.58
HF Event Driven	11.71	4.73	15.75	6.88	4.63	4.57	0.96	-0.08	2.32	-4.03	-1.18	-0.34	26.22	1.89	-0.69
HF Fixed Income Arbitrage	6.45	6.51	6.13	4.51	2.94	3.13	0.30	0.48	0.31	-3.37	-1.70	-1.16	16.22	3.90	0.48
HF Global Macro	11.62	17.91	31.56	14.35	4.04	13.80	0.45	3.17	1.91	-0.11	1.15	0.34	0.78	1.71	-0.79
HF Risk Arbitrage	10.11	1.79	10.84	4.67	3.97	4.53	1.07	-0.83	1.25	-1.80	-1.17	0.12	9.22	1.30	0.19
HF Long Short Equity	15.88	-3.74	21.11	12.49	5.43	10.24	0.86	-1.63	1.56	-0.26	-0.29	0.26	2.61	0.44	-1.37
HF Managed Futures	3.22	14.85	3.13	11.02	14.29	10.54	-0.17	0.68	-0.19	-0.01	-0.47	-0.81	1.66	0.18	1.50
NASDAQ	23.02	-44.96	25.58	24.96	39.76	18.93	0.72	-1.26	1.08	-0.46	-0.04	-0.17	1.40	-0.66	-0.99
RUSSELL 2000	11.16	-13.88	15.68	17.33	24.99	13.80	0.35	-0.76	0.76	-0.50	-0.23	-0.50	2.48	-0.42	-0.49
RUSSELL 3000	16.81	-22.38	24.91	12.91	22.67	12.97	0.91	-1.21	1.52	-0.18	0.31	-0.12	2.33	0.19	-0.05
S&P 500	17.42	-22.59	26.87	12.87	22.48	13.66	0.96	-1.23	1.59	-0.08	0.26	0.02	1.64	0.53	-0.19
DJ Euro Stoxx	12.71	-23.13	32.32	15.61	25.74	16.40	0.49	-1.10	1.66	-0.44	-0.45	-0.89	1.45	0.15	1.03
MSCI North America	18.81	-21.31	29.79	14.38	19.61	14.25	0.95	-1.35	1.73	-0.95	0.14	-0.77	2.03	-0.87	-0.45
MSCI EAFE	8.47	-19.34	11.30	14.02	17.46	14.47	0.24	-1.40	0.42	-0.54	-0.30	-0.84	0.90	-0.62	0.53
MSCI EMF Asia	-9.55	-7.87	-60.73	28.60	27.20	34.78	-0.51	-0.48	-1.89	-0.23	0.26	0.32	0.44	0.19	0.93
MSCI EMF Far East	-12.95	-7.69	-72.39	32.37	28.77	38.54	-0.56	-0.44	-2.01	-0.04	0.40	0.45	0.91	0.30	1.53
MSCI EMF Latin America	4.13	-15.25	3.62	32.43	31.89	31.73	-0.03	-0.64	-0.05	-1.31	-0.42	-1.07	4.45	-0.54	0.06
WILSHIRE Large Growth	18.50	-12.64	26.00	14.01	28.68	13.67	0.96	-0.62	1.52	-0.80	-0.33	-0.56	1.77	-0.61	-0.31
WILSHIRE Large Value	16.76	-0.40	24.03	13.29	15.83	10.60	0.88	-0.35	1.78	-1.60	0.14	-0.51	6.75	-0.24	-0.09
WILSHIRE Midcap Growth	13.85	2.26	14.28	16.85	39.30	15.85	0.52	-0.07	0.57	-1.60	-0.03	-0.45	6.47	-0.79	-0.36
WILSHIRE Midcap Value	12.90	14.99	22.80	13.62	16.40	10.49	0.57	0.60	1.68	-1.65	-0.13	-0.76	6.85	1.86	1.29
WILSHIRE Small Growth	12.18	-5.13	11.74	18.77	40.92	20.63	0.38	-0.25	0.32	-1.43	-0.09	-0.24	5.20	-0.81	0.05
WILSHIRE Small Value	12.24	14.26	23.01	14.14	20.21	10.82	0.50	0.45	1.65	-1.80	0.64	-0.74	6.98	4.00	1.55
MSCI US Treasury	5.97	10.05	8.88	4.15	5.28	3.42	0.21	0.94	1.09	-0.05	-0.77	-0.12	0.49	-0.18	0.39
MSCI EMU Sovereign	3.09	15.82	-1.86	8.33	11.86	8.33	-0.24	0.90	-0.84	-0.10	0.50	-0.47	0.16	-0.27	-0.46
MSCI World Sovereign	4.52	9.25	1.97	5.90	7.33	4.94	-0.10	0.57	-0.65	0.35	0.30	0.01	1.00	-0.54	-0.40
LEHMAN US Agg Bond	-1.09	2.84	0.72	4.73	3.54	3.45	-1.31	-0.64	-1.29	-0.24	-0.18	0.04	-0.14	0.79	-1.28
LEHMAN HYield: Default Ex	-2.91	-0.71	0.68	5.45	12.35	4.45	-1.47	-0.47	-1.01	-1.21	-0.23	-0.49	4.94	0.34	0.10
LEHMAN Global Govt Ex US	-0.89	1.21	1.46	3.51	2.12	2.64	-1.71	-1.84	-1.41	-0.20	0.40	-0.11	-0.02	-0.13	-0.34
LEHMAN Em Sovereign	-3.04	2.26	-10.21	17.75	14.03	16.76	-0.46	-0.20	-0.92	-3.87	0.63	-1.57	23.57	1.89	2.85
LEHMAN Em Corp	-2.67	-0.39	-6.08	14.26	11.20	9.88	-0.55	-0.49	-1.14	-2.86	1.12	-0.13	18.03	5.07	0.33
LEHMAN US HYield Corp	-2.63	-0.71	0.93	5.59	12.35	4.57	-1.38	-0.47	-0.93	-1.11	-0.23	-0.61	4.42	0.34	0.73
LEHMAN HYield Corp Interm	-2.61	-0.05	0.58	5.44	12.30	3.92	-1.42	-0.42	-1.17	-1.22	-0.23	-0.30	5.98	0.22	-0.17
LEHMAN HYield Corp Long	-3.49	-3.06	4.11	9.01	14.66	10.13	-0.95	-0.56	-0.10	-0.03	-0.24	-0.68	0.18	1.49	2.40
LEHMAN Gov/Credit 1-5 Yr	-0.68	2.31	-0.17	2.48	2.60	1.80	-2.33	-1.07	-2.96	0.09	0.31	-0.13	0.43	1.25	-0.53
World Ex US Real Estate	-0.53	-9.97	-29.25	21.21	15.28	29.15	-0.27	-0.99	-1.18	-0.76	-0.24	-1.20	3.45	-0.26	1.57
US Real Estate	6.41	-0.09	17.44	18.45	13.40	18.54	0.07	-0.39	0.66	0.02	-0.78	0.20	1.43	1.24	-0.04
GSCI Commodity	9.31	-6.33	-24.14	18.21	17.13	16.16	0.23	-0.67	-1.81	0.02	-0.30	0.43	0.10	0.84	0.08

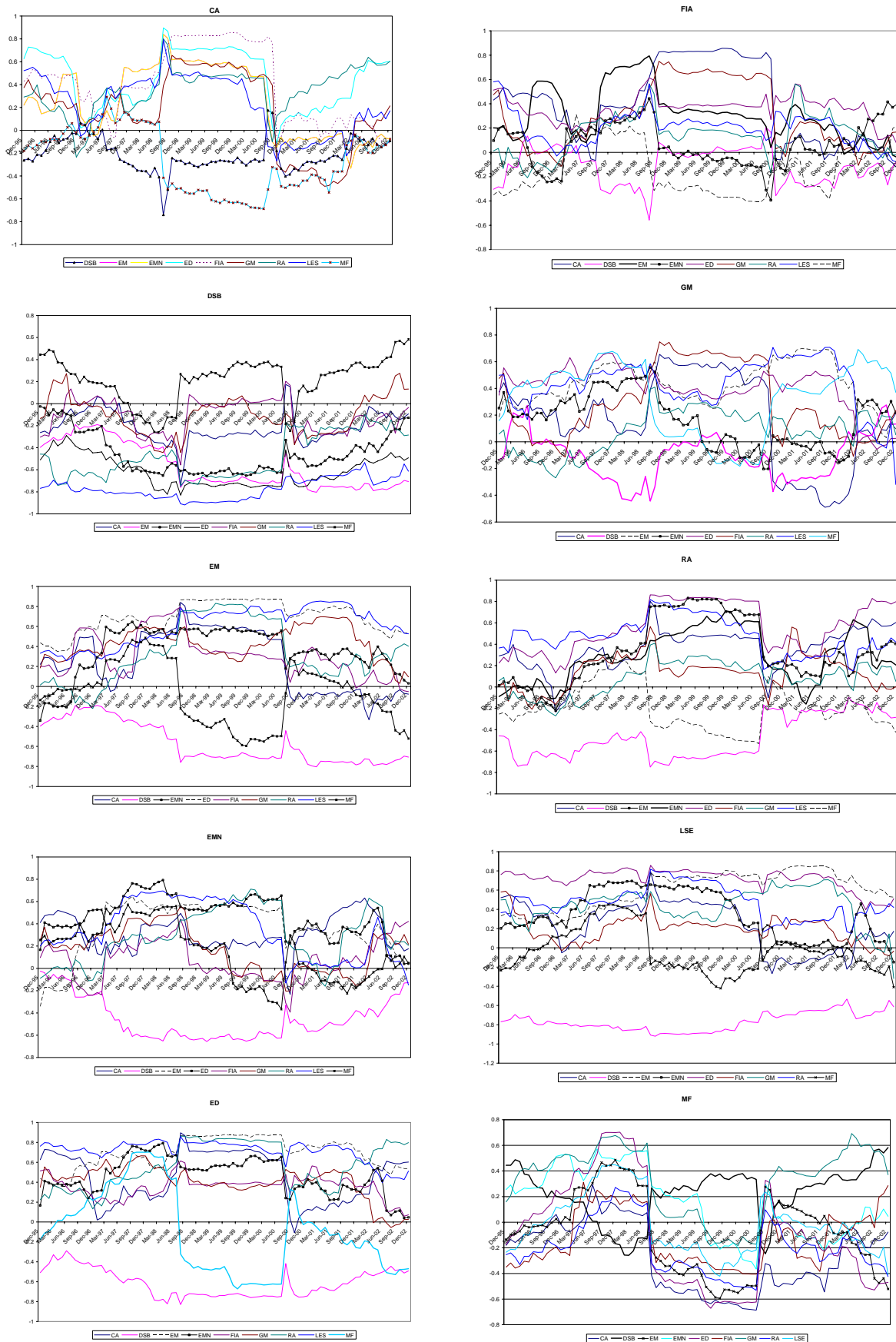
**Exhibit 4: Hedge Fund Inter-Strategy Correlations in Bull versus Bear Markets (1994:1 – 2002:12)**

	CA			DSB			EM			EMN			ED			FIA			GM			RA			LSE		
	Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	Be	C
<b>CA</b>	1	1	1																								
<b>DSB</b>	-0.24	-0.16	-0.43	1	1	1																					
<b>EM</b>	0.40	-0.03	0.59	-0.57	-0.74	-0.55	1	1	1																		
<b>EMN</b>	0.34	0.19	0.42	-0.43	-0.16	-0.56	0.25	0.09	0.54	1	1	1															
<b>ED</b>	0.60	0.61	0.48	-0.63	-0.51	-0.71	0.73	0.55	0.70	0.42	0.06	0.65	1	1	1												
<b>FIA</b>	0.66	-0.11	0.54	-0.07	-0.03	-0.41	0.34	-0.05	0.79	0.06	0.39	0.37	0.43	0.07	0.54	1	1	1									
<b>GM</b>	0.33	0.05	0.05	-0.16	0.25	-0.27	0.42	0.04	0.49	0.22	0.22	0.48	0.41	-0.04	0.35	0.49	0.15	0.48	1	1	1						
<b>RA</b>	0.41	0.56	0.41	-0.52	-0.22	-0.45	0.47	0.37	0.43	0.30	0.24	0.28	0.68	0.76	0.60	0.16	-0.01	0.39	0.14	0.18	0.20	1	1	1			
<b>LSE</b>	0.28	0.17	0.43	-0.77	-0.65	-0.86	0.60	0.60	0.52	0.36	0.04	0.64	0.68	0.46	0.68	0.24	-0.05	0.41	0.47	-0.05	0.47	0.50	0.37	0.60	1	1	1
<b>MF</b>	-0.34	-0.14	-0.03	0.17	0.58	-0.11	-0.12	-0.47	0.29	0.21	0.07	0.59	-0.21	-0.47	0.44	-0.23	0.25	0.10	0.23	0.52	0.57	-0.24	-0.31	0.17	-0.04	-0.24	0.35

Notes : CA : Convertible Arbitrage ; DSB : Dedicated Short Bias ; EM : Emerging Markets ; EMN : Equity Market Neutral ; ED : Event-Driven ; FIA : Fixed-Income Arbitrage ; GM: Global Marco ; RA : Risk Arbitrage; LSE: Long Short Equity; MF: Managed Futures.

Bu: Bull market (1994:01-2000:9), Be: Bear market (2000:10-2002:12), C: Asian crisis period (1997:1-1998-6).

### Exhibit 5: 24-Month Rolling Correlations between 10 Hedge Fund Styles (1994:1-2002:12)



Notes : CA : Convertible Arbitrage ; DSB : Dedicated Short Bias ; EM : Emerging Markets ; EMN : Equity Market Neutral ; ED : Event-Driven ; FIA : Fixed-Income Arbitrage ; GM : Global Macro ; RA : Risk Arbitrage ; LSE : Long Short Equity ; MF : Managed Futures.

**Exhibit 6: Conditional Correlations between Hedge Funds and Traditional Assets (1994:1-2002:12)**

Indices	CA			DSB			EM			EMN			ED			FIA			GM			RA			LSE			MF		
	Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	Be	C
NASDAQ	0.14	0.20	0.29	-0.85	-0.89	-0.93	0.54	0.73	0.41	0.34	0.21	0.63	0.58	0.44	0.62	0.12	-0.11	0.31	0.32	-0.23	0.34	0.40	0.26	0.38	0.91	0.56	0.87	-0.04	-0.59	0.21
RUSSELL 2000	0.49	0.22	0.62	-0.31	-0.08	-0.16	0.40	0.22	0.18	0.16	-0.20	0.21	0.54	0.45	0.35	0.30	-0.14	0.09	0.21	-0.06	-0.28	0.36	0.42	0.50	0.38	0.13	0.28	-0.27	-0.24	-0.18
RUSSELL 3000	0.47	0.18	0.56	-0.30	-0.11	-0.21	0.34	0.20	0.24	0.19	-0.27	0.19	0.49	0.39	0.36	0.33	-0.24	0.06	0.15	-0.08	-0.19	0.34	0.36	0.43	0.33	0.14	0.29	-0.22	-0.15	-0.09
S&P 500	0.44	0.18	0.52	-0.26	-0.12	-0.22	0.31	0.21	0.25	0.20	-0.25	0.19	0.45	0.38	0.35	0.32	-0.25	0.06	0.14	-0.06	-0.15	0.31	0.36	0.39	0.29	0.15	0.29	-0.18	-0.14	-0.06
DJ Euro Stoxx	0.15	0.05	0.20	-0.54	-0.63	-0.34	0.50	0.56	0.35	0.31	0.11	0.37	0.59	0.41	0.52	0.12	-0.08	0.37	0.34	-0.08	0.40	0.46	0.45	0.55	0.65	0.53	0.49	0.05	-0.48	0.57
MSCI North America	0.14	0.12	0.12	-0.76	-0.84	-0.75	0.53	0.70	0.57	0.47	0.18	0.71	0.61	0.45	0.68	0.10	-0.15	0.42	0.37	-0.18	0.63	0.40	0.35	0.38	0.64	0.51	0.71	0.00	-0.67	0.47
MSCI EAFE	0.10	0.03	0.29	-0.62	-0.70	-0.52	0.55	0.60	0.38	0.35	0.16	0.39	0.59	0.45	0.53	0.04	0.00	0.31	0.19	-0.15	0.11	0.37	0.47	0.38	0.59	0.60	0.45	0.10	-0.51	0.37
MSCI EMF Asia	0.07	0.06	0.50	-0.55	-0.66	-0.58	0.51	0.84	0.71	0.38	0.23	0.54	0.43	0.52	0.68	0.04	0.08	0.56	0.04	-0.04	0.20	0.31	0.44	0.52	0.46	0.38	0.46	0.05	-0.54	0.29
MSCI EMF Far East	0.05	0.08	0.45	-0.54	-0.67	-0.57	0.49	0.84	0.64	0.40	0.25	0.51	0.44	0.53	0.64	0.04	0.08	0.52	0.05	-0.05	0.15	0.33	0.43	0.49	0.42	0.38	0.43	0.04	-0.55	0.29
MSCI EMF Latin America	0.27	0.18	0.34	-0.55	-0.70	-0.57	0.88	0.82	0.88	0.24	0.15	0.44	0.66	0.63	0.68	0.21	0.00	0.85	0.36	0.04	0.54	0.49	0.54	0.48	0.58	0.58	0.54	-0.03	-0.52	0.31
WILSHIRE Large Growth	0.11	0.39	-0.52	-0.16	0.28	0.26	0.22	-0.22	-0.47	0.00	0.09	-0.22	0.16	0.14	-0.41	0.16	-0.09	-0.38	0.08	0.47	-0.38	-0.01	0.28	-0.33	0.20	-0.05	-0.38	-0.08	0.24	-0.20
WILSHIRE Large Value	0.05	0.21	-0.66	-0.03	-0.03	0.44	0.12	-0.04	-0.67	-0.06	0.04	-0.39	0.06	0.15	-0.54	0.09	0.11	-0.55	-0.01	0.34	-0.48	0.00	0.21	-0.34	-0.01	0.04	-0.51	-0.04	0.18	-0.27
WILSHIRE Midcap Growth	-0.02	0.30	-0.45	0.08	0.32	0.45	0.05	-0.14	-0.45	-0.16	0.07	-0.34	-0.10	0.19	-0.64	0.12	-0.01	-0.17	-0.01	0.48	-0.33	-0.16	0.35	-0.56	-0.08	0.03	-0.54	-0.05	0.26	-0.26
WILSHIRE Midcap Value	-0.03	0.12	-0.62	0.06	-0.12	0.45	0.01	0.05	-0.67	-0.15	-0.01	-0.54	-0.07	0.13	-0.64	0.08	0.06	-0.42	-0.03	0.18	-0.49	-0.06	0.19	-0.30	-0.11	0.11	-0.54	-0.01	0.04	-0.37
WILSHIRE Small Growth	-0.05	0.29	-0.38	0.12	0.31	0.45	-0.01	-0.16	-0.44	-0.21	0.02	-0.33	-0.14	0.18	-0.63	0.11	-0.02	-0.13	-0.03	0.44	-0.31	-0.22	0.30	-0.55	-0.11	0.02	-0.51	-0.03	0.22	-0.25
WILSHIRE Small Value	-0.11	0.10	-0.62	0.09	-0.26	0.49	-0.02	0.15	-0.65	-0.22	-0.15	-0.54	-0.12	0.25	-0.71	0.06	-0.12	-0.38	-0.04	0.14	-0.47	-0.12	0.17	-0.37	-0.14	0.13	-0.56	0.00	-0.16	-0.36
MSCI US Treasury	0.05	-0.03	-0.03	-0.05	0.63	-0.21	-0.12	-0.53	-0.01	0.11	-0.03	0.45	-0.05	-0.31	0.27	0.02	0.37	-0.27	0.27	0.32	0.38	-0.13	-0.30	-0.14	0.12	-0.32	0.29	0.17	0.67	0.56
MSCI EMU Sovereign	-0.28	-0.08	-0.03	0.11	0.35	0.18	-0.35	-0.32	-0.53	-0.19	0.04	-0.37	-0.23	-0.23	-0.30	-0.26	0.17	-0.41	-0.27	0.15	-0.61	-0.10	-0.06	0.14	-0.08	0.24	-0.07	0.15	0.51	-0.40
MSCI World Sovereign	-0.26	-0.07	0.20	-0.04	0.36	-0.14	-0.25	-0.41	-0.27	0.05	0.12	0.03	-0.18	-0.26	0.03	-0.34	0.30	-0.40	-0.25	0.02	-0.55	-0.10	-0.09	0.14	0.01	0.15	0.17	0.23	0.48	-0.16
LEHMAN US Agg Bond	0.07	0.02	0.09	-0.15	0.02	-0.13	0.00	0.02	-0.20	0.11	0.45	-0.03	0.07	-0.05	0.14	-0.16	0.14	-0.54	-0.04	0.08	-0.42	0.04	-0.09	-0.03	0.10	0.06	-0.02	-0.09	0.20	-0.10
LEHMAN HYield: Default Ex	0.32	0.30	0.40	-0.01	0.13	-0.12	0.12	0.05	0.14	0.10	-0.14	-0.08	0.22	0.38	0.16	0.19	0.02	0.01	0.13	-0.23	-0.46	0.18	0.33	0.44	0.10	0.11	0.16	-0.08	-0.18	-0.22
LEHMAN Global Govt Ex US	0.07	0.06	0.21	-0.18	0.04	-0.02	0.02	0.01	-0.19	0.18	0.38	-0.08	0.10	-0.11	0.04	-0.07	0.03	-0.51	0.02	0.12	-0.34	0.07	-0.17	-0.01	0.10	0.07	0.01	-0.05	0.18	-0.08
LEHMAN Em Sovereign	0.41	0.31	0.65	-0.11	-0.04	0.01	0.34	0.22	0.34	0.12	-0.28	0.12	0.29	0.33	-0.01	0.37	-0.20	0.24	0.12	-0.02	0.04	0.26	0.16	0.20	0.11	0.12	0.18	-0.30	-0.25	-0.11
LEHMAN Em Corp	0.40	0.30	0.59	-0.06	-0.44	0.13	0.28	0.06	-0.04	0.01	-0.02	-0.23	0.25	0.38	-0.22	0.40	0.06	0.04	0.10	-0.38	-0.33	0.20	0.24	0.11	0.06	0.36	-0.12	-0.36	-0.45	-0.46
LEHMAN US HYield Corp	0.33	0.30	0.41	-0.05	0.13	-0.13	0.15	0.05	0.11	0.12	-0.14	-0.06	0.24	0.38	0.18	0.21	0.02	-0.01	0.12	-0.23	-0.49	0.17	0.33	0.44	0.14	0.11	0.17	-0.09	-0.18	-0.21
LEHMAN HYield Corp Interm	0.33	0.28	0.47	-0.03	0.14	-0.12	0.15	0.04	0.16	0.11	-0.13	-0.06	0.24	0.35	0.18	0.25	0.01	0.04	0.16	-0.23	-0.47	0.17	0.31	0.47	0.13	0.11	0.17	-0.08	-0.17	-0.22
LEHMAN HYield Corp Long	0.15	0.43	0.11	-0.13	0.08	-0.15	0.07	0.03	-0.05	0.06	-0.18	-0.11	0.15	0.54	0.12	-0.05	0.03	-0.18	-0.02	-0.19	-0.46	0.10	0.41	0.25	0.14	0.11	0.13	-0.12	-0.23	-0.15
LEHMAN Gov/Credit 1-5 Yr	0.05	0.13	0.08	-0.17	-0.09	-0.10	-0.04	0.00	-0.38	0.12	0.52	-0.22	0.05	-0.01	-0.06	-0.26	0.23	-0.36	-0.13	0.11	-0.59	0.12	-0.08	0.20	0.08	0.02	-0.02	-0.04	0.19	-0.35
World Ex US Real Estate	0.35	0.16	0.76	-0.31	-0.11	-0.22	0.43	0.29	0.42	0.21	0.16	0.27	0.40	0.26	0.23	0.23	-0.01	0.30	0.02	0.20	-0.13	0.39	0.33	0.45	0.31	0.23	0.34	-0.08	0.12	-0.14
US Real Estate	0.46	0.05	0.42	0.01	-0.05	0.17	0.17	0.16	0.21	0.15	-0.06	0.05	0.36	0.23	0.11	0.26	0.16	-0.06	0.07	0.20	-0.24	0.33	0.23	0.15	-0.02	0.30	-0.06	-0.19	0.20	-0.05
GSCI Commodity	0.26	0.04	0.23	-0.07	0.29	-0.04	0.20	-0.06	-0.15	0.07	0.11	0.05	0.25	-0.14	-0.10	0.02	-0.10	-0.03	-0.04	0.24	-0.39	0.26	0.06	0.05	0.14	0.09	0.04	-0.24	0.22	-0.55

Notes : CA : Convertible Arbitrage ; DSB : Dedicated Short Bias ; EM : Emerging Markets ; EMN : Equity Market Neutral ; ED : Event-Driven ; FIA : Fixed-Income Arbitrage ; GM : Global Marco ; RA : Risk Arbitrage ; LSE : Long Short Equity ; MF : Managed Futures.

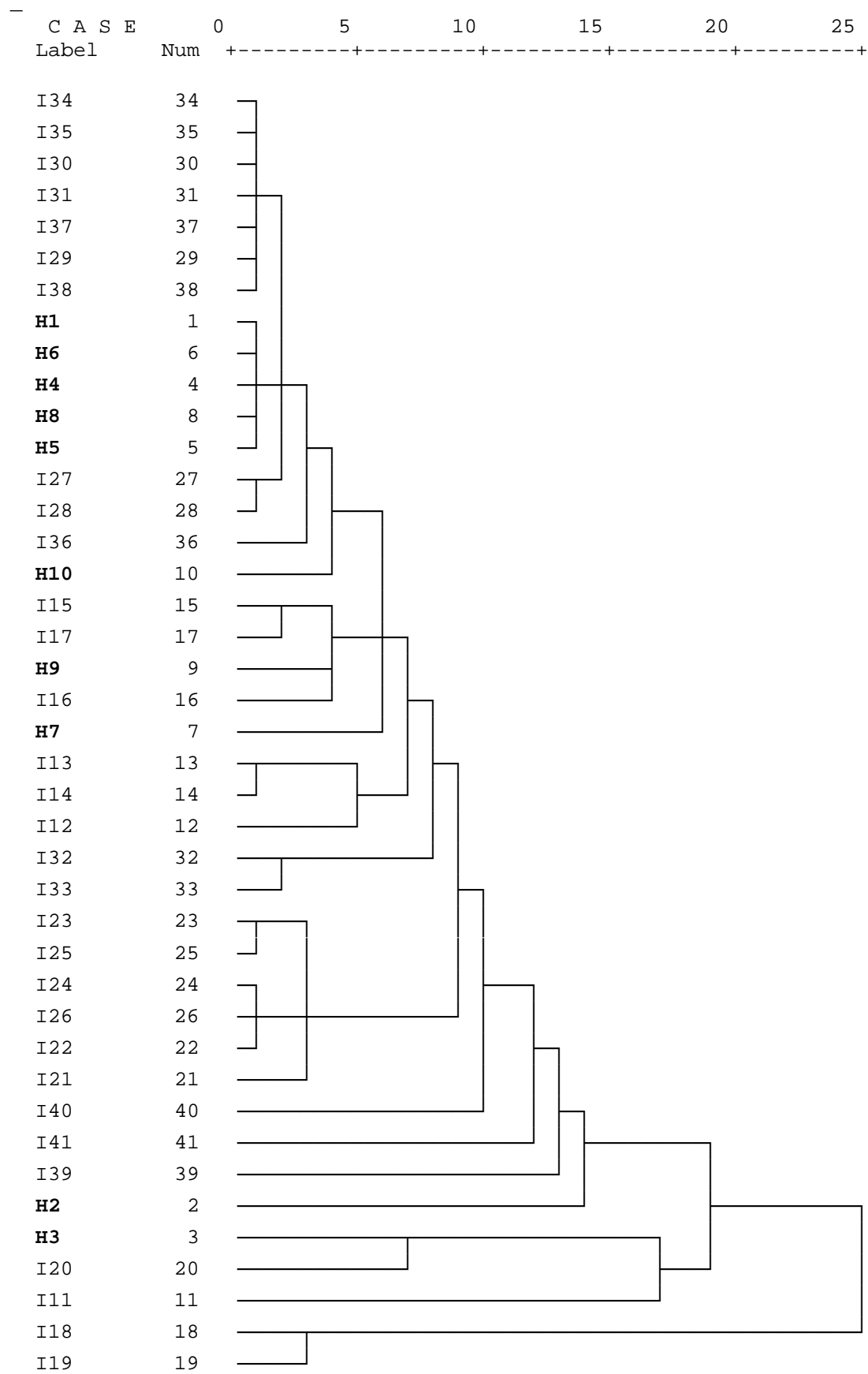
Bu: Bull market (1994:01-2000:9), Be: Bear market (2000:10-2002:12), C: Asian crisis period (1997:1-1998-6).

## Exhibit 7 : Cluster Membership

Indices	Case	15 Clusters			14 Clusters			13 Clusters			12 Clusters			11 Clusters			10 Clusters		
		Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	Be	C	Bu	Be	C
HF Convertible Arbitrage	H1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HF Dedicated Short Bias	H2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
HF Emerging Markets	H3	3	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3	1	3
HF Equity Market Neutral	H4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HF Event Driven	H5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HF Fixed Income Arbitrage	H6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HF Global Macro	H7	4	1	4	4	1	4	4	1	4	1	1	4	1	1	4	1	1	4
HF Risk Arbitrage	H8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HF Long Short Equity	H9	5	1	5	5	1	5	1	1	5	1	1	4	1	1	4	1	1	4
HF Managed Futures	H10	1	3	1	1	3	1	1	3	1	1	2	1	1	2	1	1	2	1
NASDAQ	I11	6	4	5	6	4	5	5	4	5	4	3	4	4	3	4	4	3	4
RUSSELL 2000	I12	7	5	6	7	5	6	6	5	1	5	4	1	1	4	1	1	4	1
RUSSELL 3000	I13	8	5	6	7	5	6	6	5	1	5	4	1	1	4	1	1	4	1
S&P 500	I14	8	5	6	7	5	6	6	5	1	5	4	1	1	4	1	1	4	1
DJ Euro Stoxx	I15	5	6	7	5	6	7	1	6	6	1	5	5	1	5	4	1	5	4
MSCI North America	I16	5	6	5	5	6	5	1	6	5	1	5	4	1	5	4	1	5	4
MSCI EAFE	I17	5	6	7	5	6	7	1	6	6	1	5	5	1	5	4	1	5	4
MSCI EMF Asia	I18	9	7	8	8	7	8	7	7	7	6	6	6	5	6	5	5	6	5
MSCI EMF Far East	I19	9	7	8	8	7	8	7	7	7	6	6	6	5	6	5	5	6	5
MSCI EMF Latin America	I20	10	8	9	9	8	9	8	8	8	7	7	7	6	7	6	3	7	3
WILSHIRE Large Growth	I21	11	9	10	10	9	10	9	9	9	8	8	8	7	8	7	6	8	6
WILSHIRE Large Value	I22	11	10	10	10	10	10	9	10	9	8	9	8	7	9	7	6	9	6
WILSHIRE Midcap Growth	I23	11	11	11	10	11	10	9	11	9	8	10	8	7	10	7	6	10	6
WILSHIRE Midcap Value	I24	11	10	10	10	10	10	9	10	9	8	9	8	7	9	7	6	9	6
WILSHIRE Small Growth	I25	11	11	11	10	11	10	9	11	9	8	10	8	7	10	7	6	10	6
WILSHIRE Small Value	I26	11	12	10	10	10	10	9	10	9	8	9	8	7	9	7	6	9	6
MSCI US Treasury	I27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MSCI EMU Sovereign	I28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MSCI World Sovereign	I29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
LEHMAN US Agg Bond	I30	1	13	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	1
LEHMAN HYield: Default Ex	I31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
LEHMAN Global Govt Ex US	I32	12	13	12	11	12	11	10	1	10	9	1	9	8	1	8	7	1	7
LEHMAN Em Sovereign	I33	12	1	1	11	1	1	10	1	1	9	1	1	8	1	1	7	1	1
LEHMAN Em Corp	I34	1	13	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	1
LEHMAN US HYield Corp	I35	1	13	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	1
LEHMAN HYield Corp Intern	I36	1	13	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	1
LEHMAN HYield Corp Long	I37	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
LEHMAN Gov/Credit 1-5 Yr	I38	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
World Ex US Real Estate	I39	13	14	13	12	13	12	11	12	11	10	11	10	9	1	9	8	1	8
US Real Estate	I40	14	14	14	13	13	13	12	12	12	11	11	11	10	1	10	9	1	9
GSCI Commodity	I41	15	15	15	14	14	14	13	13	13	12	12	12	11	11	11	10	1	10

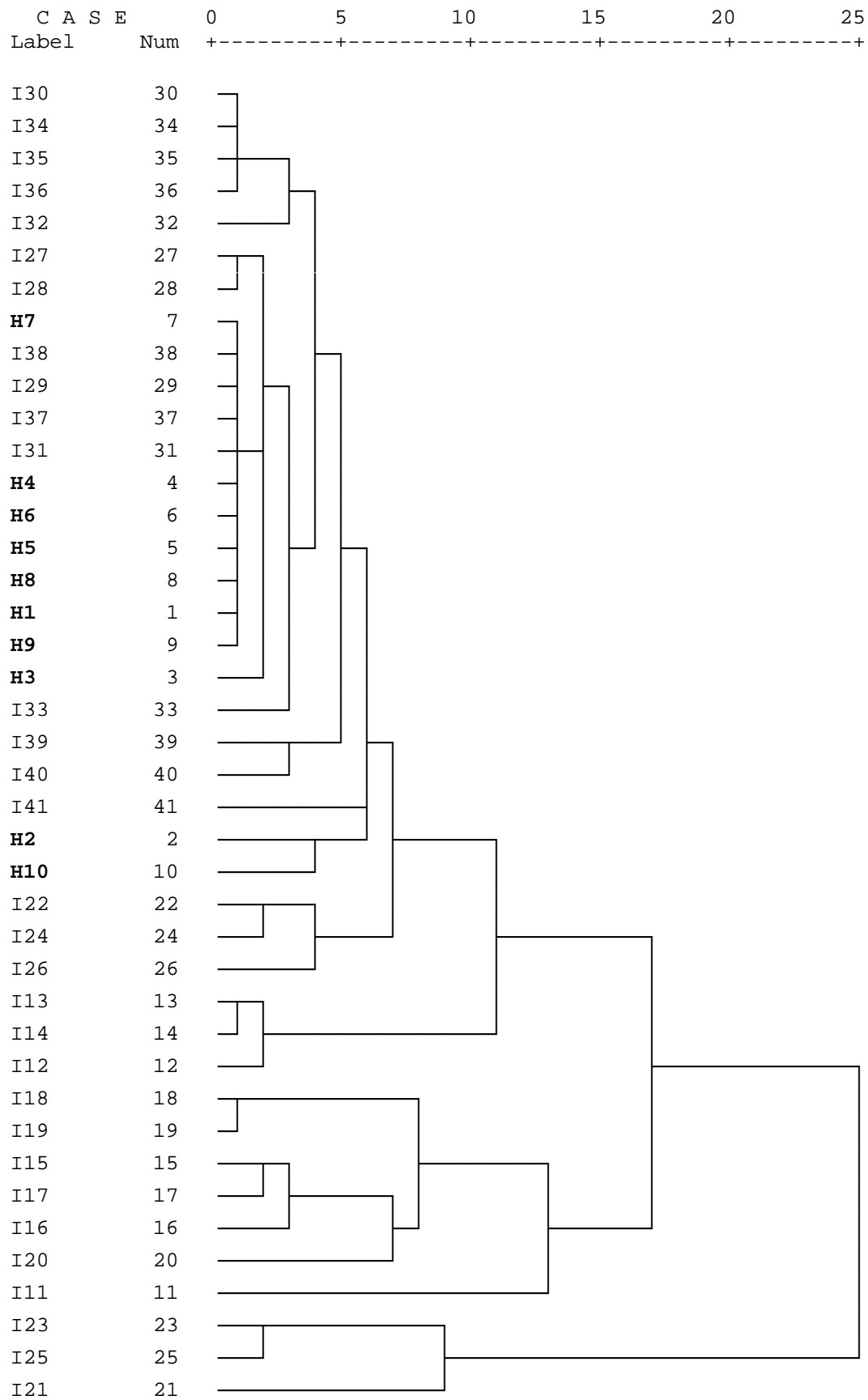
Notes: Bu: Bull market (1994:01-2000:9), Be: Bear market (2000:10-2002:12), C: Asian crisis period (1997:1-1998:6).

**Exhibit 8A: Dendrogram of Hierarchical Analysis in Bull Market (1994:1-2000:9)**





**Exhibit 8B: Dendrogram of Hierarchical Analysis in Bear Market (2000:10-2002:12)**



**Exhibit 8C: Dendrogram of Hierarchical Analysis for the Asian crisis period (1997:1-1998:6)**

