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HEDGE FUND DIVERSIFICATION: HOW MUCH IS ENOUGH?

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Hedge Fund Diversification:

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Abstract: There are many benefits to investing in hedge funds, particularly when using a diversified multi-strategy approach. Over the recent years, multi-strategy funds of hedge funds have flourished and are now the favorite investment vehicles of institutional investors to discover the world of alternative investments. More recently, funds of hedge funds that specialize within an investment style have also emerged. Both types of funds put forward their ability to diversify risks by spreading them over several managers. However, diversifying a hedge fund portfolio also raises a number of issues, such as the optimal number of hedge funds to really benefit from diversification, and the influence of diversification on the various statistics of the return distribution (e.g. expected return, skewness, kurtosis, correlation with traditional asset classes, value at risk and other tail statistics). In this paper, using a large database of hedge funds over the 1990-2001 period, we study the impact of diversification on naively constructed (randomly chosen and equally weighted) hedge fund portfolios. We also provide some insight into style diversification benefits, as well as the inter-temporal evolution of diversification effects on hedge funds.

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Executive summary

After two years of bear markets, traditional assets such as equities, fixed income and even real estate are no longer considered to generate attractive returns. Family offices, discretionary portfolio managers, institutional investors, high-net work individuals and the private banks that manage their own funds are therefore looking for more sophisticated ways to reach their investment objectives. Most of these investors have now allocated up to 5% or more of their portfolios to alternative strategies, and even the most conservative ones are dipping a toe in the water. Among the set of potential candidates, hedge funds have progressively gained acceptance as a core asset class, thanks to their consistent absolute returns and low correlation with traditional assets. This makes them a valuable tool for the diversification of conventional equity market risk. Consequently, the hedge fund industry is getting larger and larger every day, to the point that the capacity of hedge fund managers to digest the flows of new money regularly pouring into their funds is regularly questioned.

Despite this apparent success, there is still a remarkable lack of understanding and information about the hedge funds industry amongst individual investors, advisers, and institutions. Keynes' observation that diversification is protection against ignorance is best illustrated by the fact that most institutions prefer gaining their exposure through funds of hedge funds, which give them instant diversification ... and free them from the responsibility of monitoring individual managers. However, the proliferation of funds of hedge funds - which vary greatly in the number of underlying managers (5 to 100), the strategies on which they focus (diversified vs. sector or geographically focused) as well as their asset allocation strategy, if any – should not hide the fact that diversification in hedge funds is not as easy as it seems. In particular, diversification in hedge funds can be made at two levels. Diversification by investment style involves investment in a number of strategies (long-short, global macro, convertible arbitrage, etc.) to reduce exposure to individual style exposures, while diversification by judgment recommends that investors diversify across a number of managers within a particular investment style, in order to avoid performance solely being determined by one manager's skills.

While the benefits of diversification have been widely studied and documented for traditional assets, the research on hedge fund diversification has been rather scarce. For a long time, it was limited to measuring the effects of including a hedge fund index in a traditional strategic asset allocation. It is only recently that a few papers started investing in the issue of how many hedge funds were required in a hedge fund portfolio to efficiently reduce volatility. The answers vary greatly depending on the sample considered and the time-period investigated. In this paper, we therefore reconsider the problem of hedge fund diversification. Our approach relies on the naïve diversification strategies that were suggested in the early 1950s: we simply build equally weighted portfolios of randomly selected hedge funds. By repeating the process several times and studying the characteristics of the resulting portfolios (50,000 in total), we are able to study the impact of naively increasing the number of hedge funds in a portfolio.

Our first empirical findings tend to demonstrate that diversification works well in a mean-variance space. That is, increasing the number of hedge funds in a hedge fund portfolio decreases the portfolio's volatility, while maintaining its average return level. Downside risk statistics (such as maximum monthly loss, maximum drawdown or value at risk) are also reduced in larger-size hedge fund portfolios. This seems to validate the existence of funds of funds as useful investment vehicles. However, when one goes beyond the mean-variance framework and considers additional factors such as skewness and kurtosis, diversification is far from being a free lunch. For several strategies, diversification reduces positive skewness, may even generate negative skewness, and increases kurtosis, i.e. there is a trade-off between profit potential and reduced probability of loss. In addition, the correlation with the S&P 500 of large-sized hedge fund portfolios increases, which clearly evidences the dangers of diversification overkill, that is, the attempt of advisors to incorporate an unwieldy number of hedge funds in their portfolio construction process. Since most of the diversification benefits are reached for small-sized portfolios (typically 5 to 10 hedge funds), it therefore seems that hedge fund portfolios should rather be cautious on their allocations past this number of funds.

Our empirical findings also illustrate the difference between diversification by investment style and diversification by judgement. Clearly, the benefit of increasing managers within a strategy is a function of the homogeneity or heterogeneity of the sample from which the managers are drawn. Style diversification (diversification by investment style) obviously provides better opportunities for diversification than diversification by judgment. In that

respect, it also seems that information about investment style reported by fund managers should be used in the portfolio construction process, albeit naïve, to increase the diversification benefits.

“If you have a harem of 40 women, you never get to know any of them very well.”

The world's most famous value investor

1 Introduction

They were exotic products created by unregulated, renegade stock-pickers and exclusively held by a private club of high-net-worth individuals for financial snobbery motives. They have progressively become the darlings of the investment industry, as evidenced by financial publications, analysts' reports, boardrooms and even happy hour cocktails. Their success was fuelled by the wealth created by the long bull equity market of the 1990s, and is now supported by the difficult and highly volatile environment that has prevailed since the early 2000s. Indeed, by focusing on absolute performance and abstracting from benchmarks, hedge funds are able to generate superior returns in virtually all types of market environments. Consequently, they offer the much-needed diversification to portfolios invested in traditional asset classes such as equities and bonds. This provides a strong argument for using them in wealth management and contributes to making this new asset class – or new way to manage traditional asset classes – an increasingly popular investment choice.

However, we all know that there is “no such thing as a free lunch” in finance. Thus, private and institutional investors willing to include hedge funds in their portfolios must realize that to deliver their favorable return/risk characteristics, hedge funds must carry additional risks, which are not common to traditional stock and bond investments. These risks are inherent to the strategies pursued, the instruments and markets used, the amount of leverage employed, and last, but not least, the specific skills of the selected hedge fund managers.

Since choosing a bad manager may easily wipe out all the benefits of a hedge fund allocation, investing in only one hedge fund is likely to be sub-optimal. The reasons are threefold. Firstly, dramatic performance differentials between competing funds raise the issue of whether a single investment instrument can deliver consistent returns close to those of the broad hedge-fund indices that are used at the strategic asset-allocation level. Secondly, a number of individual hedge funds have collapsed under the weight of spectacular frauds or investment debacles (*Manhattan Capital Management, Maricopa Investment Corporation, Lipper Convertible Arbitrage*, etc.). This has raised concerns among investors, who often lack sufficient information to evaluate comparative hedge fund performance and to perform the necessary exhaustive on-site due diligence checks. Finally, investing only with managers who have a good reputation and an established track record does not provide a complete hedge, as illustrated by the debacle of the brain trust that was *Long Term Capital Management LP*.

Consequently, risk-conscious investors are coming back to the central tenet of modern portfolio theory, namely, diversification. By combining several hedge funds with differing return distributions and risk profiles in a portfolio, investors are able to diversify specific risk away and ensure a more disciplined exposure to the overall hedge fund asset class. This is likely to result in better long-term risk-adjusted returns. Those willing to avoid the logistical problems and record-keeping headaches of tracking several hedge funds may even delegate the portfolio construction and monitoring activities to a fund of hedge funds. This is the preferred investment structure for most institutional investors, since it gives them instant diversification and frees them from the responsibility of monitoring managers¹.

Funds of hedge funds were initially diversified across investment styles, sectors and/or regions. However, more recently, funds of hedge funds focusing on a single investment style, a particular asset class, a single sector or region have also emerged. They are usually more concentrated in terms of risks as well as in terms of number of underlying hedge funds than the larger diversified funds of funds. Their adage could be: "Put all your eggs in one basket, but then don't take your eyes off that basket". Nevertheless, focused-hedge fund managers still

¹ There are in fact other benefits of funds of hedge funds, such as lower minimum investments, access to proven and successful hedge fund managers – including those that have closed their fund to new investors – as well as reduced lock-up periods and better liquidity. On the downside, funds of hedge funds add a layer of fees, which reduces the overall return. For an exhaustive discussion of these advantages and disadvantages, see Lhabitant (2002b).

invest in more than one underlying fund and therefore rely on the risk-reduction power of diversification.

Intuitively, the existence of hedge fund diversification benefits will depend upon the number of hedge funds in a portfolio. Beyond the agreement that holding only a few funds may imply under-diversification, exposure concentration, and, therefore, too much risk, while holding too many funds may result in over-diversification, the dilution of each fund's contribution and the neutralization of most diversification benefits, there seems to be no consensus on the optimal number of funds. On the academic side, the literature suggests that approximately eight to ten managers should be sufficient to reduce significantly the overall risk of the portfolio – see Billingsley and Chance (1996) for managed futures, Henker and Martin (1998) for CTAs and Henker (1998) for hedge funds. However, Amin and Kat (2000) show that one has to hold at least twenty funds to fully realize the diversification potential in hedge funds. From the practitioner's perspective, the consensus seems to be that at least twenty to thirty managers are necessary to diversify effectively, as shown by the information released by funds of hedge funds. The short note by Ruddick (2002) evidences that the maximum benefits of diversification are reached with around 20 funds, and that it is still possible to have them at around 40 funds if the quality of new additions can be maintained.

Most of the attention is dedicated to the diversification benefits accrued by adding hedge funds to traditional asset portfolios. There has thus far been very little large-scale research done on the topic of pure alternative assets diversification. For example: do the diversification benefits, if any, go beyond volatility and also affect other important statistics (e.g. average returns, skewness², kurtosis, correlation with other asset classes, value at risk, maximum drawdown, etc.)? Do they differ within styles and across styles? These questions are still largely unanswered. In this paper we aim, therefore, to fill the gap. We believe our contribution is unique for three primary reasons. Firstly, our database is more comprehensive than any of those used in previous studies. Secondly, we include trials of the various

² Skewness is a measure of the symmetry of a return distribution around its mean. If the return distribution is skewed to the left (returns lower than the mean have higher probability), skewness is negative, while when the return distribution is skewed to the right (returns higher than the mean have higher probability), skewness is positive. As a reference, the standard normal distribution is perfectly symmetrical and has a skewness of zero. Kurtosis refers to the weight of the tails of a distribution, or “peakedness”. Distributions where a large proportion of the observed values lie towards the extremes are said to be “platykurtic” and display positive kurtosis. If, on the other hand, the observed values are bunched near the mean, the distribution is said to be “leptokurtic” and kurtosis is negative. A normal distribution is said to be “mesokurtic” and has a kurtosis equal to 0.

investment styles followed by hedge fund managers. Thirdly, we analyze the inter-temporal variations in the diversification benefits.

The structure of this paper is as follows. Section 2 reviews the various arguments for diversification, both in the world of traditional investments and that of the hedge funds. Section 3 describes our methodology and discusses our major findings. Finally, Section 4 draws conclusions and opens the way for further research.

2 Diversification: from stocks to hedge funds

Portfolio diversification - the practice of spreading one's money among many different investments - is a common sense concept that has many parallels in popular language and culture³. Its theoretical foundations were introduced in the normative work of Harry Markowitz (1952, 1959), and later confirmed by the work of William Sharpe (1964).

2.1 The pioneers

Markowitz's initial assumption was that risk-averse, mean-variance utility agents were concerned with only two elements of their portfolios – the expected return, as measured by the mean rate of return, and the risk, as quantified by the standard deviation or variance of the mean rate of return. When risky assets are aggregated, their correlation often determines the majority of the total risk rather than individual volatilities. Consequently, the total risk of a carefully constructed portfolio should be less than the sum of the risks in the portfolio's component pieces. Markowitz thus suggested a quadratic programming algorithm to calculate the optimal combination of assets.

Given the lack of computing power that existed in the 1950s, Markowitz's approach was considered as a poignant but useless exercise. Nevertheless, his formulation contributed directly to the subsequent Capital Asset Pricing Model (CAPM) of Sharpe (1964), Lintner (1965), and Mossin (1966). Their respective works clearly delineated the partitioning of risk into two parts. The systematic part is the portion that is unavoidable once the investor invests in a particular asset class, while the unsystematic, or specific, part can be reduced, or even

³ For example, "Don't put all your eggs in one basket."

eliminated at the portfolio level, by creating a mixed-asset portfolio. Since diversification is inexpensive, specific risk is not rewarded and should be eliminated while systematic risk remains and will be rewarded by markets.

Until the late 1980s, these results remained somewhat abstruse bits of theory that were admired by academics but had only limited influence on practitioners. Then, the situation changed dramatically, thanks to the availability of computing power and the development of econometric methods. Diversification is now shaping the way sophisticated investors view their portfolios.

2.2 *The magic number: between 8 and 40*

The issue of how many assets should be included in a diversified portfolio has been extensively debated in the finance literature for over 30 years; see for instance Elton and Gruber (1977), Evans and Archer (1968), Latane and Young (1969), Fischer and Lorie (1970), Mokkelbost (1971), Wagner and Lau (1971), Johnson and Shannon (1974), Lorie (1975), Upson, Jessup and Matsumoto (1975), Lloyd, Hand and Modani, (1981), Tole (1982), Statman (1987), Newbould and Poon (1993) or O'Neal (1997), among others. Nevertheless, the definitive answer to that question has not yet been found. Even worse, several studies contradict each other. As an illustration, Evans and Archer (1968) observed that most of the effects of diversification take place with the aggregation of eight to ten securities and raised doubts about the usefulness of increasing portfolio sizes beyond that point, while Statman (1987) concluded that at least thirty to forty stocks were needed to achieve sufficient portfolio diversification.

In our opinion, the truth is likely to be somewhere in between the two. It depends on the country under investigation, the types and individual characteristics of the assets considered, the market conditions and the level of transaction costs. To get a precise answer, investors should perform a marginal analysis of the costs and benefits associated with increased diversification. This is precisely what Markowitz did when developing the modern portfolio theory.

2.3 Diversification in practice: Naive Diversification

Although diversification has become the unquestioned bedrock of investment allocation decisions, in practice, it is frequently the case that asset allocation does not just blindly apply the diversification principles set forth by Markowitz. For example, very few investors effectively take correlations (that is, the non-linearity of risk) into account when making complex portfolio decisions. Rather, they prefer to allocate assets using simpler rules, such as dividing allocations evenly among the assets available. This approach, also known as the “1/N heuristics” or “naïve diversification”, has a long history in asset allocation. In fact, it was even recommended in the Talmud. Writing in about the 4th century, a certain Rabbi Issac bar Aha gave the following asset allocation advice: “A man should always place his money, a third into land, a third into merchandise, and keep a third on hand”. Harry Markowitz reported that he used this rule himself and justified his choice on psychological grounds: “My intention was to minimize my future regret. So I split my contributions fifty-fifty between bonds and equities”.

Simply stated, naïve diversification is a protection against ignorance. It aims to spread assets evenly in the portfolio in order to reduce overall risk, while at the same time ignoring the mathematical complexities underlying modern portfolio theory. According to the latter, naïve diversification does not give proper consideration to the correlations among the assets and should therefore result in sub-optimal portfolios. However, in practice, naïve diversification usually results in reasonably diversified portfolios that are surprisingly close to some point on the efficient frontier⁴. In contrast, the consequences of fuelling an optimizer with an incorrect number can be potentially quite significant in terms of lost benefits, as evidenced by Brennan and Torous (1999). The implementation of a naïve diversification strategy, however, is likely to revolve around transaction and portfolio management costs. There are diminishing marginal returns, and eventually, absolute returns when increasing portfolio size, since transaction costs remain relatively constant while incremental reductions in portfolio risk get smaller. Therefore, the question of the number of optimal securities necessary in a naively diversified portfolio is still open.

⁴ See for instance Fisher and Statman (1997).

2.4 From mutual funds to hedge funds

At about the same time Markowitz was polishing his portfolio diversification theory, Alfred Winslow Jones was working on exactly the opposite objective – namely, the isolation of specific risk and the elimination of market risk. Jones was convinced that he had superior stock-selection ability, but no market-timing skills. Therefore, his strategy consisted of combining long positions in undervalued stocks with short positions in overvalued ones. This allowed him to make a (small) net profit in all markets, capitalizing on his stock-picking abilities while simultaneously reducing overall risk through lesser net-market exposure. To magnify his portfolio's returns, Jones added leverage, that is, he used the proceeds from his short sales to finance the purchase of additional long positions. This provided the basic principles for what was the first hedge fund.

More than half a century later, hedge funds have significantly evolved from the original model. Indeed, most of them do not actually hedge anything. Nowadays, the term “hedge fund” is applied somewhat indiscriminately and beyond the scope of its original meaning. It refers to any pooled investment instrument that is not a conventional investment fund - that is, any fund using a strategy or set of strategies other than investing long in bonds, equities, money markets, or a mix of these assets. Consequently, hedge funds are better identified by their common structural characteristics than by their “hedged” nature. These characteristics include, but are not limited to, active management, long-term commitment of investors, use of incentive fees, leverage, broad discretion over the investment styles, asset classes and investment vehicles, as well as the aim of insulating the skills of their advisors against the vagaries of the market.

Given the diversity of their strategies, hedge fund returns generally display moderate to low correlations with traditional equity and bond indices. In addition, hedge fund strategies have moderate to low correlations with each other. The idea of diversifying among loosely correlated funds is therefore very natural. But which approach should be selected: Markowitz's, or naïve? Intuitively, it appears that very few hedge fund portfolios are optimized along the lines of Markowitz's recommendations. The reasons are threefold:

- **Non-normality.** Hedge fund return distributions tend to exhibit skewness and fat tails. Both characteristics are important for investors' portfolio decisions⁵, but are superbly ignored by mean-variance optimizers who consequently produce myopic and biased results.
- **Econometric difficulties.** Mean-variance optimizers require precise forecasts of risks, returns, and correlations to put together optimum, forward-looking portfolios. One commonly employed simplification is to focus on expected returns and accept historic risk and correlation as reasonable approximations of the future⁶. However, while the quantity and quality of hedge fund information has improved considerably in recent years, adequate time-series are still largely unavailable to obtain robust estimates of historical hedge fund data. In addition, hedge fund returns and strategies are not necessarily stable over time, which complicates the forecasting of future returns and questions the use of historical estimates as a forecast.
- **Operational difficulties.** The process of hedge fund selections has been essentially qualitative so far, due to the specificities of the individual vehicles (e.g. minimum investments, lock-up periods, exit notifications, restrictions to access, etc.). Most optimizers are unable to incorporate these constraints, and therefore, their use often result in non-feasible portfolios.

A recent survey by Arthur Andersen (2002) of Swiss hedge fund investors and fund of hedge funds managers confirms our intuition. It appears that most participants do not use a quantitative approach for their asset-allocation strategy. Many respondents even admitted to having no asset-allocation strategy at all! Naïve diversification is therefore well suited to provide, at least, a starting point that is much better than simply leaving things to intuition. It also simplifies the asset-allocation process while still enjoying the benefits of risk reduction.

⁵ See for instance Scott and Horvath (1980), Kane (1982), Kraus and Litzenberger (1976) or Lhabitant (2000, 2002).

⁶ As evidenced by Chopra (1993), the return forecast is the most critical aspect of constructing efficient portfolios.

3 Empirical tests

3.1 Data and methodology

The data we use in this paper are taken from a series of historical quarterly snapshots by a number of hedge fund information providers (Managed Account Reports, Hedge Fund Research, TASS+ and Evaluation Associates Capital Management), as well as from data received directly from several hedge fund administrators. In total, our database contains 6,985 distinct hedge funds, with no restriction whatsoever on their assets under management or their lifespan. In particular, it includes a large number of now defunct funds for the duration of their existence.

Since we want to test naïve diversification of hedge funds, we proceed by using Monte Carlo simulation based on the effective hedge fund returns. We create equally weighted portfolios of increasing size ($N=1, 2, \dots, 50$) by randomly selecting hedge funds from our data set. For each portfolio, we build a time series of returns and use it to generate various statistics (average return, volatility, etc.). For each portfolio size, this process is repeated 1,000 times to obtain 1,000 observations of each statistic. This is necessary to estimate the "typical" behavior of a portfolio of size N , but also to build confidence intervals for our results. It is important to note that each portfolio is independently assembled, that is, a portfolio of size $N+1$ is not built from the portfolio of size N obtained at a previous stage of the simulation. Furthermore, each portfolio sampling is conducted without replacement to effectively ensure equal weighting of the hedge funds in the portfolio.

In order to assess the diversification benefits for different strategies, we split our sample arbitrarily into 10 representative investment styles, which can be described as follows:

- Convertible arbitrage hedge funds focus on the mis-pricing of convertible bonds. Their rationale is that (i) since convertibles are hybrid in nature, they do not attract pure bond and pure stock investors, so that price discrepancies are frequent; and (ii) convertible securities often contain several call, put or exercise-date options that are often neglected by the market. A typical position involves a long position in the convertible bond and a short position in the underlying asset. Credit risk and interest rate risk of the convertible position may also be hedged using adequate instruments.

- Fixed income arbitrage hedge funds tend to profit from price anomalies between related securities and/or bet on the evolution of interest rates spread. Typical trading strategies are butterfly-like structures (e.g. sell expensive 3-year and 5-year bonds while buying a cheap 4-year bond), cash/futures basis trading strategies (the cheapest to deliver often trades either rich or cheap to the fitted yield curve), or relative swap spread trades (e.g. buy a government bond and short a strip of euro-dollar contracts to buy the Treasury/Euro-Dollar spread).
- Event-driven hedge funds focus on price movements generated by an anticipated corporate event, such as a merger, an acquisition, a bankruptcy, etc. The funds in this category cover a wide range of strategies. The most popular ones are distressed securities (bets on the likelihood of a bankruptcy and the estimation of the recovery rate) and merger arbitrage (bets on the completion of announced mergers). In the latter category, some of the funds get involved in the restructuring process and are at the frontier of private equity, while others only invest in the most liquid and senior part of the debt. Note that several funds in the latter category had to reorient themselves to the recent drastic diminution of the merger activity.
- Long-short equity hedge funds represent the original hedge fund model. They invest in equities, both on the long and the short sides, and generally have a small net long exposure. They are genuinely opportunistic strategies capitalizing on the stock picking abilities of their managers and could be classified as “double alpha, low beta” funds.
- Market neutral hedge funds that seek to neutralize certain market risks by taking offsetting long and short positions in instruments with actual or theoretical relationships. Most of them are in fact essentially long-short equity hedge funds that maintain long and short portfolios of the same size and/or risk, so that they have no exposure to the stock market.
- Dedicated short bias hedge funds are essentially long-short equity hedge funds that maintain a consistent net short exposure. Very few of them are only short, as pure short-sellers were progressively eliminated during the bull market of the 1990s.
- Emerging market hedge funds invest in equities and fixed-income securities of emerging markets around the world. Because shorting is not permitted in many emerging markets, and there are no viable futures or other derivative products with which to hedge, emerging market hedge fund managers must often go to cash or other markets when valuations make being long unattractive.

- Global macro funds take leveraged views on overall market directions as influenced by major economic trends and/or events. Their existence was revealed to the public in 1992 when G. Soros and his *Quantum Fund* cashed in a gain of several billion by forcing the British pound to exit the European Monetary System.
- Managed futures funds implement discretionary or systematic trading in listed financial, commodity and currency futures around the world. The managers of these funds are also known as commodity trading advisors (CTAs).
- Multi-strategy funds recently emerged as a new concept. They implement the diversification concept within a single investment vehicle in the sense that they regroup managers acting in several of the above-mentioned strategies.

The next step was to group our hedge funds according the above-mentioned classification. We decided to rely on the self-proclaimed strategy stated by the fund managers. Although there is increasing evidence that hedge fund managers are sometimes subject to style drifts and do not fully disclose the true nature of their strategies, we believe that relying on what the manager says is the only classification scheme that is effectively accessible to most investors. Indeed, it would be rather surprising to see an investor capable of performing sophisticated techniques, such as style analysis or cluster partitioning, while at the same time relying on naïve diversification for his portfolio construction!

Once our funds were classified, we then ran the tests described above for each investment style, as well as for the overall data set without any style consideration (the true “naive diversification” across styles). We also tested a more elaborate strategy that we call “smart diversification”. The latter consists in selecting hedge funds naively, but while imposing diversification across styles. That is, a portfolio of size N will contain randomly selected and equally weighted funds, but the number of funds in the most represented investment style should not exceed by more than one the number of funds in the least represented investment style. This corresponds to the strategy of an investor that would attempt to use the available information on fund styles.

In order to assess the inter-temporal variations of diversification benefits, we also split our sample in three periods, namely, 1990-1993, 1994-1997 and 1998-2001, and ran the above tests on each sub-sample. The issue of survivorship bias was resolved by creating two

different samples for each period. One contains all the funds that existed at some point during that period. Assets are then balanced anew each time a new fund is included in, or excluded from, the portfolio. The second one contains only hedge funds that survived the entire period. Hereafter, we will present and discuss the results for the first sample. The results for the survivor-funds sample will be commented later on.

3.2 Results

Despite its numerous deficiencies, Markowitz's venerable mean-variance framework is still widely used to assess the performance of hedge funds. We, therefore, began by focusing on the average return and the volatility of the hedge fund portfolio.

Return and Volatility

Figure 1 and Table 1 show the evolution of the average return of a hedge fund portfolio as a function of its number of underlying funds. Similarly to Amin and Kat (2002), we observe that the mean portfolio return does not seem significantly affected by the number of hedge funds it contains. This result is not surprising, due to the linearity of the average operator⁷. Of course, the mean return diverges widely across strategies and over time. During the first period (1990-1993), the Global Macro style provides an impressive 22% to 23% return. However this strategy loses favor during the latter half of the decade. Convertible Arbitrage too does well during the first period with returns around 20%, but drops to around 10% by the end of the decade. More consistent styles are Long/short Equity with around 16 to 17% return on average, while Emerging Markets hovers at the bottom of the grouping with returns around 8% to 9%.

Figure 2 and Table 2 show the evolution of the average volatility of a hedge fund portfolio as a function of the number of its underlying funds. Whatever the period and the investment style, as the number of funds increases, volatility decreases and then stabilizes. Once again, this result is not surprising, since it just depends on the correlation between the underlying funds (which cannot exceed one). Our result is therefore similar to the ones traditionally observed for stocks.

The number of hedge funds necessary to effectively diversify is surprisingly low. Whatever the time period and the style, it seems that between 5 and 10 hedge funds are sufficient to eliminate 75% of the specific risk in the portfolio. This raises the question of the number of hedge funds in fund of funds portfolios, since the latter is usually much larger. The drop in the overall volatility is sharpest for Market Neutral and Short Selling, whereas the volatility of Convertible Arbitrage decreases the least, and the others reach a diversification benefit in the range of about 23%. Whereas in the first two periods, the volatility among the different styles is more evenly distributed in the total range of about 4%-16%, the third time period show two groupings of styles: those in the range of 16%-22% (Emerging, Multi-strategies, Long/short), and those in the 5%-11% range (all remaining strategies). We also observe that smart diversification outperforms the naive diversification in terms of risk reduction.

Skewness and Kurtosis

Our previous results suggest that increasing the number of hedge funds in a portfolio reduces volatility while maintaining the expected return. However, hedge funds have properties that go beyond these two parameters. In particular, their returns do not conform to the normal (bell-curve) distribution, but tend to display asymmetries and fat tails. Therefore, higher distribution moments, such as skewness and kurtosis, should also be included in the analysis. Skewness is expected to disappear with diversification as funds with negative skewness are mixed with positively skewed ones so that, at the aggregate level, these individual effects are cancelled. For the same reason, we expect excess kurtosis to be somehow reduced by diversification.

Figure 3 and Table 3 show the evolution of the average skewness of a hedge fund portfolio as a function of the number of its underlying funds. The graph has several interesting features. In particular, it shows clearly that skewness variations are not uniform across styles. For instance, when the number of funds increases, the skewness drops systematically and is negative for Fixed Income Arbitrage, Convertible Arbitrage and Event Driven strategies, while it increases slightly and is positive for Short Sellers, Managed Futures and Long Short

⁷ The average operator is linear. In a sense, the figure we obtain for a one-fund portfolio is the average of 1,000 hedge funds returns, while the figure for a two-fund portfolio will simply be the average of 2,000 hedge funds. The number will therefore rapidly converge to the sample average.

Equity strategies. It also demonstrates that the observed range of skewness widens, particularly on the downside. While the skewness of all strategies remains between -1 and 0.75 in the 1990-1993 and 1994-1997 periods, it jumps to -4.5 to 1.25 during the 1998-2001 period.

Figure 4 and Table 4 show the evolution of the average kurtosis of a hedge fund portfolio as a function of the number of its underlying funds. We find that most kurtosis results tend to be concentrated in the -0.5 to $+0.5$ range. Changes in kurtosis tend to be less predictable, and differ widely over time and across investment styles. For instance, the 1994-1997 period seems to validate the positive influence of diversification on kurtosis, except for the Fixed Income Arbitrage style. However, the situation changes in 1998-2001, when several style portfolios exhibit an increase in their kurtosis as the number of funds increases. Note however that the dramatic Fixed Income Arbitrage pattern may be due to the LTCM crisis pattern (the more funds one invests in, the more likely the crisis will affect the portfolio), while the Event Driven pattern may result from the failure of several mega-mergers (e.g. Alcatel-Honeywell is a good example of a deal whose spreads diverged instead of narrowed).

Given these results, assessing hedge funds based on return and volatility criteria may be misleading because of the potential underestimation of return volatilities⁸. In particular, diversification within some hedge fund strategies may appear highly attractive in mean-variance terms, but this is much less so when skewness and kurtosis are taken into account.

Downside risk statistics

Since downside risk is of great concern to many investors, we have also examined the impact of hedge fund diversification on three commonly accepted downside risk measures, namely, the largest monthly loss, the maximum draw-down, and the value at risk (VaR). The largest monthly loss is the greatest decline in net asset value for a particular hedge fund for any one-month period over the period considered. The maximum draw-down is the biggest percentage-losing period ("peak to valley") experienced by a particular fund, regardless of whether or not the draw-down consisted of consecutive months of negative performance. It corresponds to the loss that an investor would experience buying shares at the highest net

⁸ See Lhabitant (2000)

asset value and selling them at the lowest subsequent net asset value over a period. Finally, the value at risk (VaR) is an estimate of the maximum amount a particular fund could lose over a one-month period in normal market conditions. In our case, we defined "normal market conditions" as being 95% of the time and we calculated value at risk by simply taking the 5% percentile of the empirical return distribution over the considered period.

Figure 5 and Table 5 show the evolution of the average worst-month return of a hedge fund portfolio as a function of its number of underlying funds. The worst returns and the lowest benefits from diversification are observed for the Emerging Markets investment style, which is not surprising given the contagion effect that affected these markets during all past crises (e.g. Asia in 1997, Russia in 1998, etc.) thus mitigating the gains from portfolio diversification. Otherwise, increasing the number of funds in a portfolio is obviously beneficial for all strategies. Looking at the temporal variations is also quite instructive. It is very clear that the most recent period we considered (1998-2001) was a period with an increased downside risk for hedge funds as an asset class, and particularly for directional strategies such as Dedicated Short Bias and Emerging Markets. Risk reduction opportunities also seem to be shrinking in some arbitrage strategies, such as Event Driven and Fixed Income Arbitrage. This results from an increasing number of hedge funds arbitraging a limited pool of arbitrage situations, so that these funds tend to be invested in the same deals. If one of these deals collapses, most of the funds acting in the sector will be negatively affected. This was the case with recent mega-mergers that failed (e.g. the \$42 billion deal between General Electric and Honeywell), as well as for distressed situations that went bankrupt (e.g. Kmart, Global Crossing, WorldCom, and Qwest Communications) or the planned elimination of the 30-year T-Bond contract. It seriously raises the issue of the existence of any benefits linked to diversifying within a style for arbitrage funds. Fortunately, it seems that diversifying across styles still provides important benefits, particularly when selecting the smart diversification approach.

Figure 6 and Table 6 show the evolution of the maximum draw-down of a hedge fund portfolio as a function of its number of underlying funds, while Figure 7 and Table 7 list the same information for the empirical value at risk. For both measures, diversification seems to work well in terms of downside risk reduction. However, once again, we observe that most of the diversification benefits are obtained with a number of funds that varies between 5 and 10, depending on the strategy. Adding more funds still provides benefits, but the gains seem

marginal compared to the drawbacks of managing the corresponding portfolio (minimum requirements, multiple lock-up periods, etc.). Once again, we also observe that smart diversification outperforms the naive diversification in terms of downside risk reduction, whatever the performance measure considered.

Comparing the worst monthly return (Table 5) with the value at risk (Table 6) is noteworthy. Here, we can see that investment styles that display a negative skewness tend to have a worst month far below the value at risk. Consider for instance the Fixed Income Arbitrage strategy over the 1998-2001 time-period. This strategy has an average value at risk of -0.54% (the lowest of the group) while at the same time displaying the highest average worst-case return (-10.85%) and the lowest average skewness (-4.40). A similar point can be made about the Event-Driven strategy over the same period, with an average value at risk of -1.54% (among the lowest ones of the group) while at the same time displaying a large average worst-case return (-10.55%) and the second lowest average skewness (-2.54). This is a clear illustration that arbitrage strategies in general tend to have low risk statistics, but are significantly affected by a single tail event when the latter occurs (“the LTCM syndrome”).

Correlation statistics

Finally, the last statistic we examined was correlation. On the one hand, sophisticated investors are increasingly looking to alternative investments such as hedge funds to provide diversification in their traditional portfolios, particularly the equity-oriented ones. On the other hand, these investors prefer to take a diversified approach and allocate their capital in more than one hedge fund. It is, therefore, essential to examine the impact of the number of funds in a portfolio on its correlation attributes with equities (represented hereafter by the S&P 500).

Figure 8 and Table 8 summarize our findings. It appears that diversification within a style leads to a small increase in the absolute value of the correlation with the S&P 500. That is, positive correlations with the S&P 500 tend to increase, while negative correlations with the S&P 500 tend to decrease as the number of funds increases. However, note that the correlation coefficient is not stable over the three periods we considered. As an illustration, the Managed Futures and the Multi-strategy categories exhibited a continuous decrease of their correlation with the S&P 500 over the three periods, while the Market Neutral category

exhibits exactly the opposite trend. The final correlation figure of 0.79 for a 50-fund portfolio invested in the latter category raises serious doubts about the validity of the self-proclaimed market-neutral classification for this group, which is more likely to be made of long-short equity managers. It also questions any conclusion drawn from an asset allocation that would assume constant correlations or rely on the stability of historical estimates of correlation coefficients, as this is obviously not the case.

It is interesting to observe the correlation effects when diversifying across all styles. Although the average correlation of a single-fund portfolio with the S&P 500 is still low (0.33 to 0.38, depending on the period), it tends to increase rapidly with the number of funds in the portfolio. As one could expect, portfolios built according to the smart diversification strategy tend to be less correlated with the S&P 500 than equally-sized naively built portfolios, but the correlation increase is still perceivable. This is a strong case against over-diversifying a hedge fund portfolio, as the result would be a dramatic reduction of the potential diversification benefits when mixing this hedge fund portfolio with traditional assets. It is therefore essential to specify the desired final correlation properties of a hedge fund portfolio prior to building it rather than just relying on the fact that the portfolio constituents taken individually are loosely correlated with traditional assets and should transfer this property to the portfolio.

Since many investors use hedge-fund indices at the strategic asset-allocation level and switch to hedge funds in the effective implementation of their decisions, another essential point is therefore the correlation that exists between the hedge-fund indices and the portfolio of hedge funds. For example, how many funds in a portfolio are necessary for the correlation of the portfolio with a hedge fund index to be sufficiently high? That is, what is the necessary number of funds for a portfolio to be sufficiently correlated with a hedge fund index? Figure 9 provides the answer, in the case of the HFR indices (which use equal weights to build their indices). The results are sound: the larger the number of funds, the higher is the correlation with the corresponding strategy index. However, some strategies (e.g. Market Neutral, Global Macro) are hard to track, since even a 50-fund portfolio provides a loose correlation with the Market Neutral or Global Macro index. Other strategies (e.g. Long Short Equity or Event Driven) are easier to track, even with a 10 or 20-fund portfolio. Over time, we also observe an increase in the correlation properties for most strategies. That is, it appears that correlation coefficients with the HFR indices seem to increase.

Survivorship bias

As mentioned previously, we also investigated the impact of hedge fund survivorship bias on our previous findings by running the same analysis over a set of hedge funds that survived each considered period. Given the comprehensive nature of our database, it is clear that most hedge funds that disappear from our universe do it for poor performance reasons. Indeed, if a manager with extraordinary good performance stops reporting to hedge fund information providers, but still runs its fund with its existing investors (e.g. Monroe Trout's *Trout Trading Fund* in 1993), we would still obtain the information about the fund from its offshore administrator. Therefore, it is not surprising that our results on the surviving sample were in line with our expectations.

Overall, we obtained the same behavior as with the complete sample: increasing the number of hedge funds in a portfolio increased the portfolio's average return, decreased its volatility, skewness and kurtosis, significantly reduced its downside risk, and increased correlations with both traditional and alternative equity indices. The magnitude of these changes was somehow comparable across the two samples, although the initial value of these statistics was different. Indeed, surviving funds tend to display higher average return, lower volatility, limited skewness and kurtosis, lower downside risk and stronger correlation with both traditional and alternative equity indices. However, these desirable features are impossible to arbitrage ex-ante, since survivorship is by definition an ex-post feature.

4 Conclusions

There is a wide array of barriers to hedge fund investing for consultants and investors alike, such as the scarcity of historical data, the complexity of strategies, the lack of meaningful benchmarks, poor transparency of the industry and the clear limitation of mean-variance optimization tools. Nevertheless, diversification is still a good tool against risk. In this paper, we offer a fresh look at hedge fund diversification and go a step further than other studies. We find that naively adding more funds to a portfolio tends to leave returns stable, decrease the standard deviation, and reduce downside risk. Thus, diversification should be increased as long as the marginal benefits of adding a new asset to a portfolio exceeds the marginal cost.

Of course, we do not advocate that diversification should be implemented in such a naïve approach. Hedge funds are complex instruments, which are very different from what most investors are used to. Investment decisions should therefore be more elaborate than a simple coin-toss approach. As an illustration, naïve diversification has important – and sometimes dramatic - side effects on skewness, kurtosis, as well as on correlation properties with respect to both traditional and alternative indices. Hedge fund portfolio construction should therefore include more research - not just into the performance of individual funds, but into the effects of a given hedge fund allocation upon an entire portfolio structure. Otherwise, if investors diversify naively, they may wrongly believe that they hold diversified portfolios.

In addition, naïve diversification (the 1/N heuristics) as implemented so far suffers from a well-known bias: allocation choices are dependent on the set of hedge funds provided to the investors. For example, given the popularity of macro strategies in the early 1990s and the explosion of long/short strategies in the late 1990s, the naively built portfolios would tend to hold more funds of these two styles during their popular years. It is therefore imperative to carefully choose the hedge funds that are included in portfolios to achieve adequate diversification. In other words, the investor must seek out varied styles despite the limited choice of the “flavor of the day”. With that respect, the number of funds in a portfolio is not the sole determinant of the degree of diversification and randomly picking hedge funds is not the most intelligent way to diversify. An investor could significantly reduce risk in his portfolio with fewer hedge funds if he chooses them wisely across different stated investment styles, so they do not move up and down in lockstep. In practice, this approach can also be implemented naively by randomly selecting each additional fund in an investment style not yet represented in the portfolio⁹. We call this approach "skilled naïve diversification". Since the stated style is publicly available information, all but the most naïve diversification strategies should attempt to make some use of this information. More sophisticated investors should also investigate the homogeneity or heterogeneity of the sample from which the hedge fund managers are drawn. If a sample of managers is relatively style pure, then a fewer number of managers will minimize the unsystematic risk of that style. On the contrary, if the sample is really heterogeneous, increasing the number of managers may still provide important diversification benefits.

Nevertheless, beyond the diversification strategy selected, our results raise an interesting question: why are funds of hedge funds so diversified? With a few exceptions, they seem to hold between 15 and 40 underlying funds, while our results indicate that 5 to 10 would provide most of the diversification benefits, even, in certain cases, avoiding some of the negative side effects. We will leave that question open for further research.

⁹ If all investment styles are equally represented, the fund is selected randomly without any style consideration.

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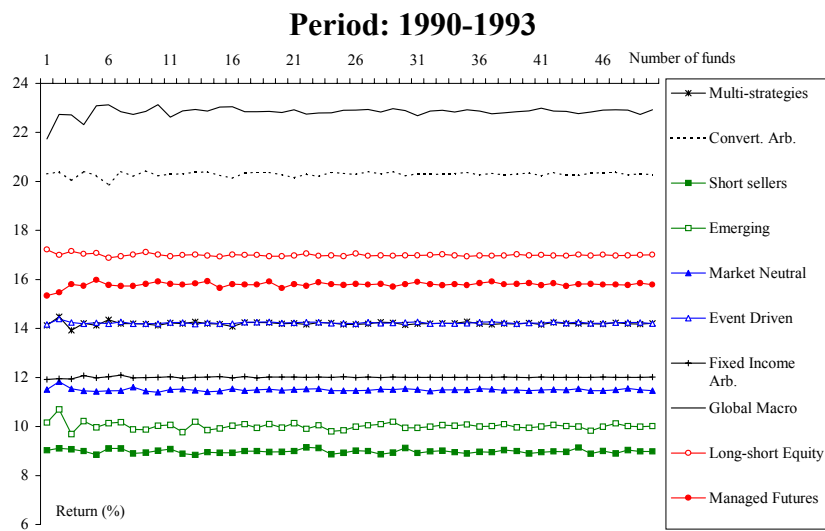
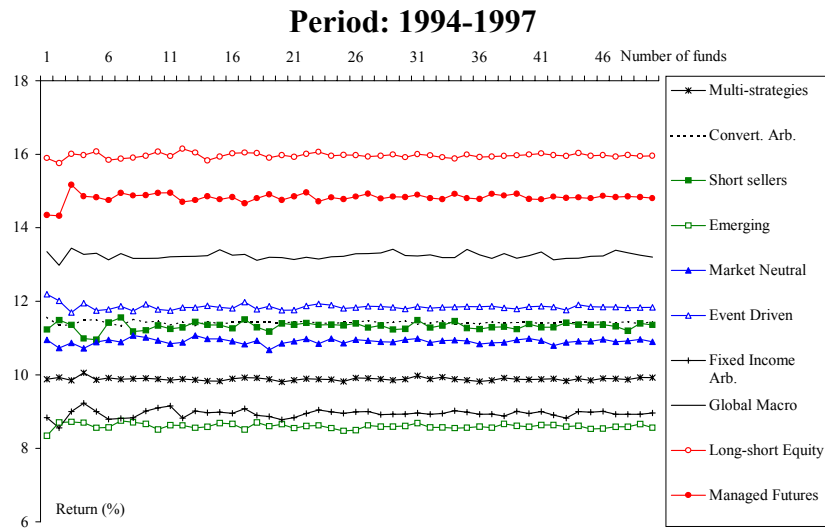
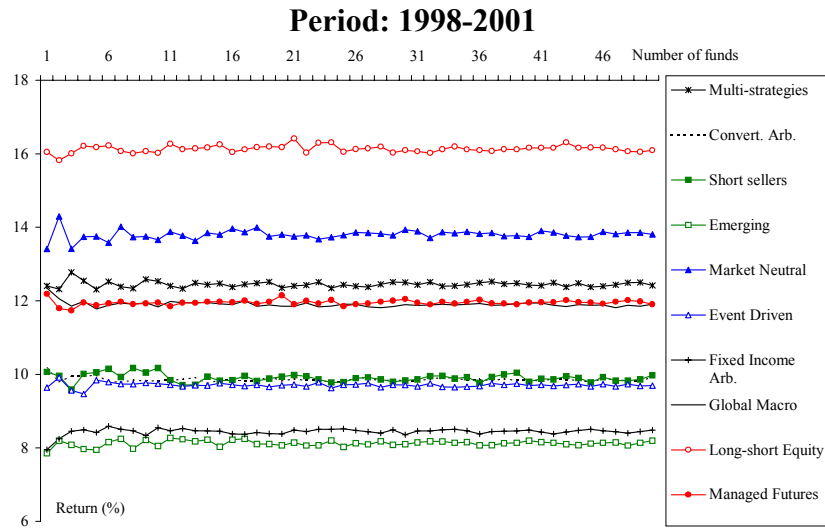


Figure 1: Evolution of the mean return of a hedge fund portfolio as a function of the number of underlying hedge funds.

1998-2001	Initial Return (%)	Number of hedge funds in the portfolio						Final Return (%)
		2	5	10	20	30	50	
Multi-strategies	12.41	-1%	-1%	1%	0%	1%	0%	12.42
Convertible Arbitrage	10.17	-4%	-2%	-3%	-3%	-3%	-2%	9.92
Dedicated Short Bias	10.06	-1%	0%	1%	-1%	-2%	-1%	9.98
Emerging Markets	7.85	4%	1%	3%	3%	3%	4%	8.20
Equity Market Neutral	13.41	7%	3%	2%	3%	4%	3%	13.81
Event Driven	9.64	3%	2%	1%	1%	1%	1%	9.69
Fixed Income Arbitrage	7.95	4%	6%	8%	5%	5%	7%	8.48
Global Macro	12.35	-2%	-5%	-4%	-4%	-4%	-4%	11.91
Long/Short Equity	16.05	-1%	1%	0%	1%	0%	0%	16.09
Managed Futures	12.18	-3%	-2%	-2%	0%	-1%	-2%	11.91
<i>All styles, naïve diversif.</i>	<i>12.29</i>	<i>0%</i>	<i>-2%</i>	<i>-1%</i>	<i>0%</i>	<i>-1%</i>	<i>-1%</i>	<i>12.18</i>
<i>All styles, smart diversif.</i>	<i>12.29</i>	<i>-1%</i>	<i>-6%</i>	<i>-5%</i>	<i>-6%</i>	<i>-5%</i>	<i>-7%</i>	<i>11.42</i>

1994-1997	Initial Return (%)	Number of hedge funds in the portfolio						Final Return (%)
		2	5	10	20	30	50	
Multi-strategies	9.88	1%	0%	0%	-1%	0%	0%	9.93
Convertible Arbitrage	11.57	-2%	-1%	-1%	-1%	-1%	-1%	11.46
Dedicated Short Bias	11.23	2%	-2%	1%	1%	0%	1%	11.35
Emerging Markets	8.34	4%	3%	2%	4%	3%	3%	8.56
Equity Market Neutral	10.95	-2%	-1%	0%	-1%	0%	0%	10.90
Event Driven	12.19	-1%	-4%	-3%	-4%	-3%	-3%	11.84
Fixed Income Arbitrage	8.84	-3%	2%	3%	-1%	1%	1%	8.96
Global Macro	13.35	-3%	0%	-1%	-1%	-1%	-1%	13.21
Long/Short Equity	15.89	-1%	1%	1%	1%	0%	0%	15.96
Managed Futures	14.35	0%	3%	4%	3%	3%	3%	14.81
<i>All styles, naïve diversif.</i>	<i>13.36</i>	<i>2%</i>	<i>0%</i>	<i>0%</i>	<i>0%</i>	<i>0%</i>	<i>0%</i>	<i>13.39</i>
<i>All styles, smart diversif.</i>	<i>13.36</i>	<i>4%</i>	<i>-1%</i>	<i>-1%</i>	<i>-4%</i>	<i>-3%</i>	<i>-4%</i>	<i>12.83</i>

1990-1993	Initial Return (%)	Number of hedge funds in the portfolio						Final Return (%)
		2	5	10	20	30	50	
Multi-strategies	14.13	3%	0%	0%	0%	0%	1%	14.21
Convertible Arbitrage	20.31	0%	0%	0%	0%	0%	0%	20.28
Dedicated Short Bias	9.03	1%	-2%	0%	-1%	1%	-1%	8.98
Emerging Markets	10.16	5%	-2%	-1%	-2%	-2%	-1%	10.01
Equity Market Neutral	11.51	3%	-1%	-1%	0%	0%	0%	11.47
Event Driven	14.16	2%	0%	0%	0%	1%	0%	14.20
Fixed Income Arbitrage	11.92	0%	1%	1%	1%	1%	1%	12.02
Global Macro	21.74	5%	6%	6%	5%	5%	5%	22.92
Long/Short Equity	17.21	-1%	-1%	-1%	-2%	-1%	-1%	17.01
Managed Futures	15.34	1%	4%	4%	2%	3%	3%	15.79
<i>All styles, naïve diversif.</i>	<i>14.27</i>	<i>0%</i>	<i>1%</i>	<i>-1%</i>	<i>1%</i>	<i>0%</i>	<i>0%</i>	<i>14.31</i>
<i>All styles, smart diversif.</i>	<i>14.27</i>	<i>1%</i>	<i>3%</i>	<i>1%</i>	<i>3%</i>	<i>3%</i>	<i>4%</i>	<i>14.86</i>

Table 1: Evolution of the mean return of a hedge fund portfolio as a function of the number of underlying hedge funds.

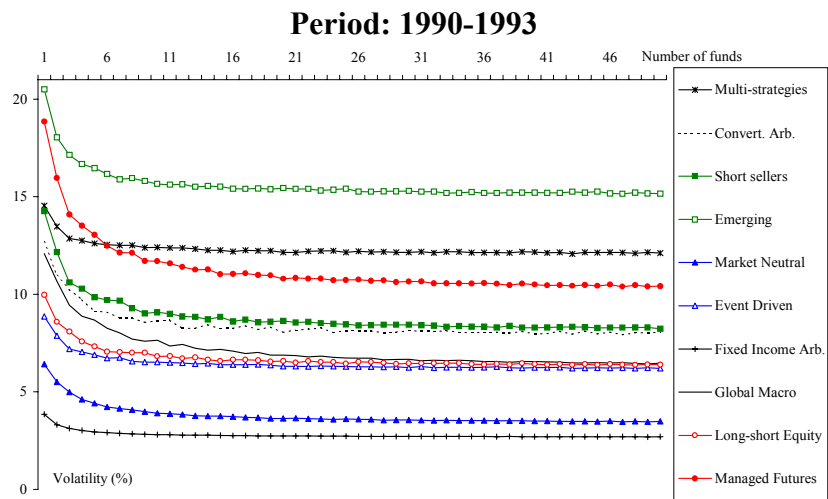
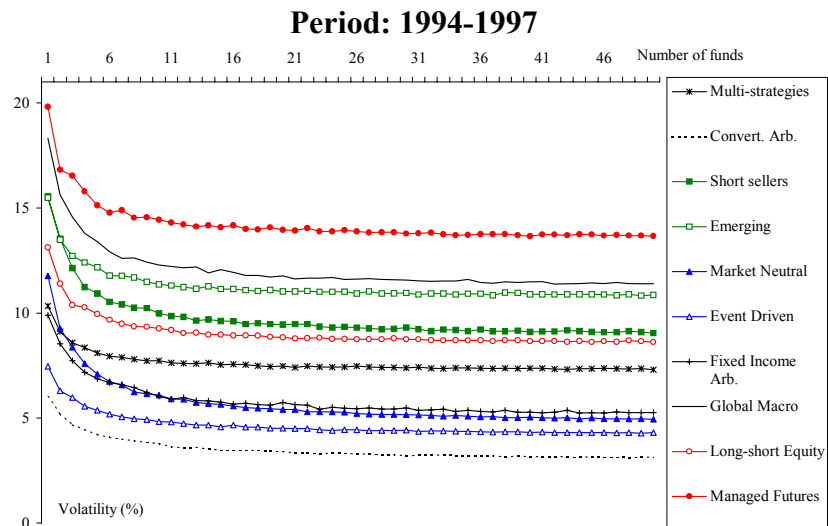
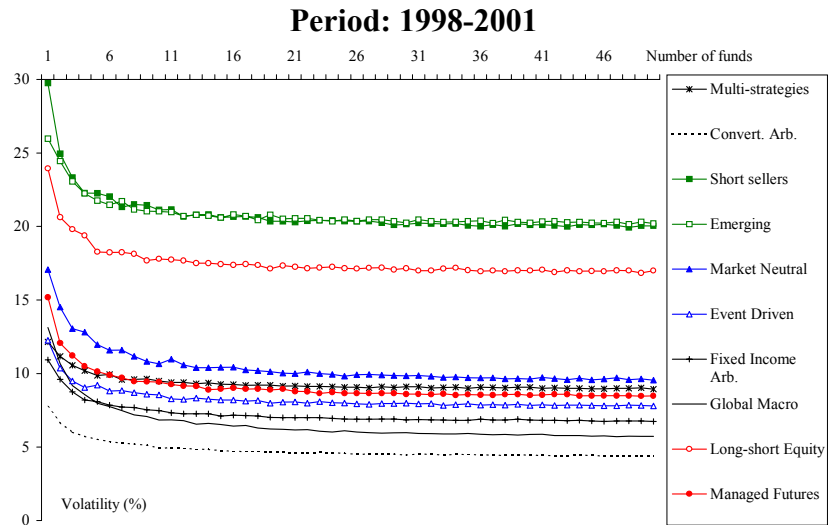


Figure 2: Impact of diversification on volatility

1998-2001	Initial	Number of hedge funds in the portfolio						Final
	Volat. (%)	2	5	10	20	30	50	Volat. (%)
Multi-strategies	12.16	-8%	-19%	-22%	-25%	-25%	-26%	8.95
Convertible Arbitrage	7.74	-14%	-29%	-36%	-40%	-42%	-43%	4.38
Dedicated Short Bias	29.75	-16%	-25%	-29%	-32%	-32%	-33%	20.04
Emerging Markets	25.97	-6%	-16%	-19%	-21%	-22%	-22%	20.21
Equity Market Neutral	17.06	-15%	-30%	-37%	-41%	-42%	-44%	9.56
Event Driven	12.26	-15%	-25%	-30%	-34%	-35%	-36%	7.79
Fixed Income Arbitrage	10.93	-12%	-26%	-32%	-36%	-37%	-38%	6.75
Global Macro	13.13	-19%	-39%	-48%	-53%	-54%	-56%	5.73
Long/Short Equity	23.95	-14%	-24%	-26%	-28%	-28%	-29%	17.00
Managed Futures	15.19	-21%	-33%	-38%	-41%	-43%	-44%	8.48
<i>All styles, naïve divers.</i>	<i>18.09</i>	<i>-16%</i>	<i>-37%</i>	<i>-42%</i>	<i>-49%</i>	<i>-50%</i>	<i>-51%</i>	<i>8.78</i>
<i>All styles, smart divers.</i>	<i>18.09</i>	<i>-17%</i>	<i>-43%</i>	<i>-49%</i>	<i>-58%</i>	<i>-62%</i>	<i>-67%</i>	<i>5.96</i>

1994-1997	Initial	Number of hedge funds in the portfolio						Final
	Volat. (%)	2	5	10	20	30	50	Volat. (%)
Multi-strategies	10.33	-12%	-22%	-25%	-28%	-28%	-29%	7.31
Convertible Arbitrage	6.02	-13%	-30%	-37%	-44%	-47%	-48%	3.14
Dedicated Short Bias	15.56	-13%	-30%	-36%	-39%	-40%	-42%	9.04
Emerging Markets	15.49	-13%	-21%	-27%	-29%	-29%	-30%	10.86
Equity Market Neutral	11.77	-21%	-40%	-48%	-54%	-56%	-58%	4.93
Event Driven	7.46	-16%	-28%	-35%	-39%	-41%	-42%	4.30
Fixed Income Arbitrage	9.90	-14%	-31%	-39%	-42%	-45%	-47%	5.26
Global Macro	18.31	-15%	-27%	-33%	-36%	-37%	-38%	11.39
Long/Short Equity	13.13	-13%	-24%	-29%	-33%	-33%	-34%	8.62
Managed Futures	19.82	-15%	-24%	-27%	-30%	-31%	-31%	13.67
<i>All styles, naïve divers.</i>	<i>13.35</i>	<i>-14%</i>	<i>-35%</i>	<i>-45%</i>	<i>-50%</i>	<i>-53%</i>	<i>-55%</i>	<i>6.05</i>
<i>All styles, smart divers.</i>	<i>13.35</i>	<i>-15%</i>	<i>-39%</i>	<i>-48%</i>	<i>-56%</i>	<i>-58%</i>	<i>-61%</i>	<i>5.21</i>

1990-1993	Initial	Number of hedge funds in the portfolio						Final
	Volat. (%)	2	5	10	20	30	50	Volat. (%)
Multi-strategies	14.54	-7%	-13%	-15%	-16%	-16%	-17%	12.10
Convertible Arbitrage	12.71	-14%	-28%	-32%	-37%	-36%	-37%	8.05
Dedicated Short Bias	14.25	-15%	-31%	-36%	-39%	-41%	-42%	8.23
Emerging Markets	20.51	-12%	-20%	-24%	-25%	-25%	-26%	15.16
Equity Market Neutral	6.42	-14%	-31%	-39%	-43%	-45%	-46%	3.49
Event Driven	8.86	-11%	-22%	-26%	-29%	-29%	-30%	6.20
Fixed Income Arbitrage	3.85	-14%	-24%	-27%	-29%	-29%	-30%	2.70
Global Macro	12.09	-12%	-28%	-37%	-43%	-45%	-47%	6.47
Long/Short Equity	9.97	-14%	-27%	-32%	-34%	-35%	-36%	6.38
Managed Futures	18.85	-15%	-31%	-38%	-43%	-44%	-45%	10.41
<i>All styles, naïve divers.</i>	<i>13.59</i>	<i>-17%</i>	<i>-35%</i>	<i>-43%</i>	<i>-49%</i>	<i>-50%</i>	<i>-52%</i>	<i>6.54</i>
<i>All styles, smart divers.</i>	<i>13.59</i>	<i>-20%</i>	<i>-44%</i>	<i>-51%</i>	<i>-59%</i>	<i>-63%</i>	<i>-66%</i>	<i>4.65</i>

Table 2: Impact of diversification on volatility

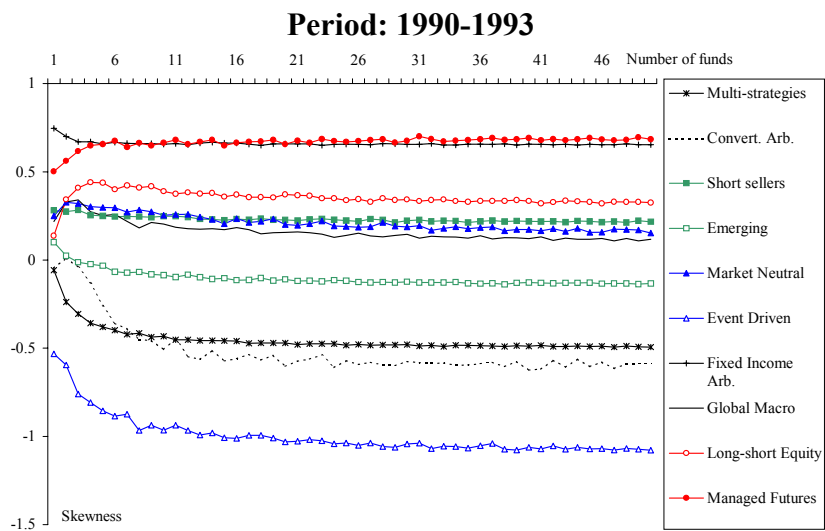
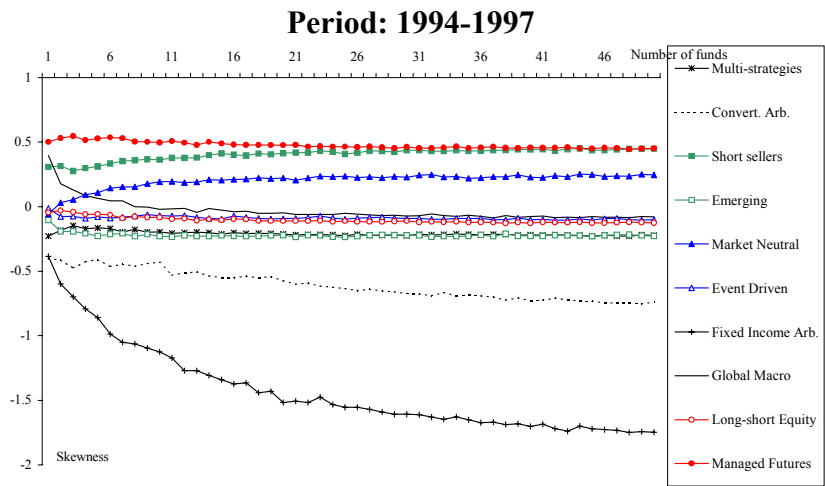
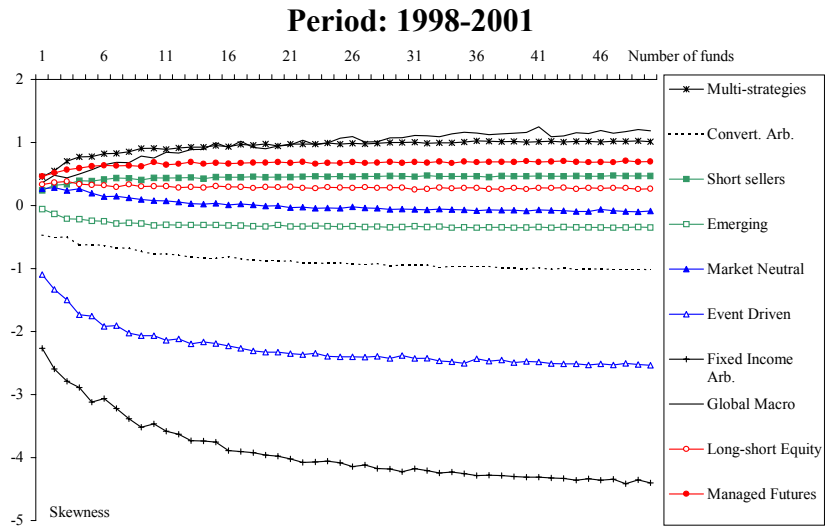


Figure 3: Impact of diversification on skewness

1998-2001	Initial	Number of hedge funds in the portfolio						Final
	Skew (%)	2	5	10	20	30	50	Skew (%)
Multi-strategies	0.46	21%	70%	99%	107%	119%	122%	1.01
Convertible Arbitrage	-0.47	9%	33%	65%	89%	102%	118%	-1.02
Dedicated Short Bias	0.24	33%	61%	82%	87%	93%	95%	0.47
Emerging Markets	-0.06	136%	323%	450%	449%	496%	516%	-0.35
Equity Market Neutral	0.27	7%	-27%	-71%	-101%	-122%	-132%	-0.08
Event Driven	-1.10	22%	60%	88%	113%	117%	132%	-2.54
Fixed Income Arbitrage	-2.27	15%	38%	53%	75%	86%	94%	-4.40
Global Macro	0.36	33%	57%	109%	161%	198%	228%	1.19
Long/Short Equity	0.33	11%	-1%	-8%	-13%	-15%	-19%	0.27
Managed Futures	0.47	12%	34%	47%	48%	45%	50%	0.70
<i>All styles, naïve divers.</i>	-0.15	-95%	-74%	-55%	-19%	22%	55%	-0.24
<i>All styles, smart divers.</i>	-0.15	-117%	-54%	-49%	-36%	-46%	-97%	0

1994-1997	Initial	Number of hedge funds in the portfolio						Final
	Ddwn (%)	2	5	10	20	30	50	Ddwn (%)
Multi-strategies	-0.23	-20%	-27%	-14%	-7%	-1%	-3%	-0.22
Convertible Arbitrage	-0.40	2%	1%	7%	42%	66%	83%	-0.74
Dedicated Short Bias	0.31	2%	1%	18%	34%	42%	45%	0.45
Emerging Markets	-0.10	84%	117%	120%	112%	111%	118%	-0.23
Equity Market Neutral	-0.06	-150%	-285%	-430%	-480%	-492%	-522%	0.25
Event Driven	-0.01	452%	470%	394%	574%	564%	636%	-0.10
Fixed Income Arbitrage	-0.39	55%	123%	192%	293%	317%	353%	-1.75
Global Macro	0.40	-55%	-84%	-106%	-112%	-118%	-120%	-0.08
Long/Short Equity	-0.05	-35%	31%	84%	146%	148%	178%	-0.13
Managed Futures	0.50	6%	5%	-1%	-5%	-8%	-10%	0.45
<i>All styles, naïve divers.</i>	0.05	2%	87%	39%	39%	61%	24%	0.07
<i>All styles, smart divers.</i>	0.05	246%	128%	126%	-23%	-67%	-190%	-0.05

1990-1993	Initial	Number of hedge funds in the portfolio						Final
	Ddwn (%)	2	5	10	20	30	50	Ddwn (%)
Multi-strategies	-0.06	313%	560%	652%	719%	734%	759%	-0.49
Convertible Arbitrage	-0.05	-126%	471%	1018%	1231%	1170%	1195%	-0.59
Dedicated Short Bias	0.28	-2%	-11%	-11%	-19%	-21%	-23%	0.22
Emerging Markets	0.10	-76%	-133%	-185%	-208%	-223%	-231%	-0.13
Equity Market Neutral	0.25	31%	19%	1%	-20%	-25%	-38%	0.15
Event Driven	-0.53	12%	61%	82%	94%	96%	103%	-1.08
Fixed Income Arbitrage	0.75	-6%	-12%	-12%	-12%	-12%	-12%	0.65
Global Macro	0.22	51%	16%	-6%	-28%	-33%	-46%	0.12
Long/Short Equity	0.14	148%	217%	182%	170%	148%	136%	0.33
Managed Futures	0.50	11%	31%	32%	30%	34%	36%	0.68
<i>All styles, naïve divers.</i>	0.03	14%	-309%	-736%	-1093%	-1376%	-1620%	-0.51
<i>All styles, smart divers.</i>	0.03	49%	34%	-454%	-542%	-483%	-449%	-0.12

Table 3: Impact of diversification on skewness

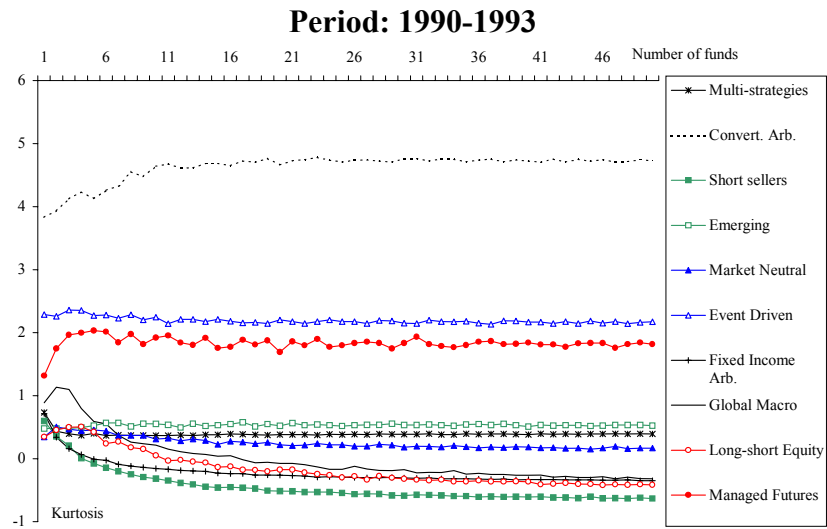
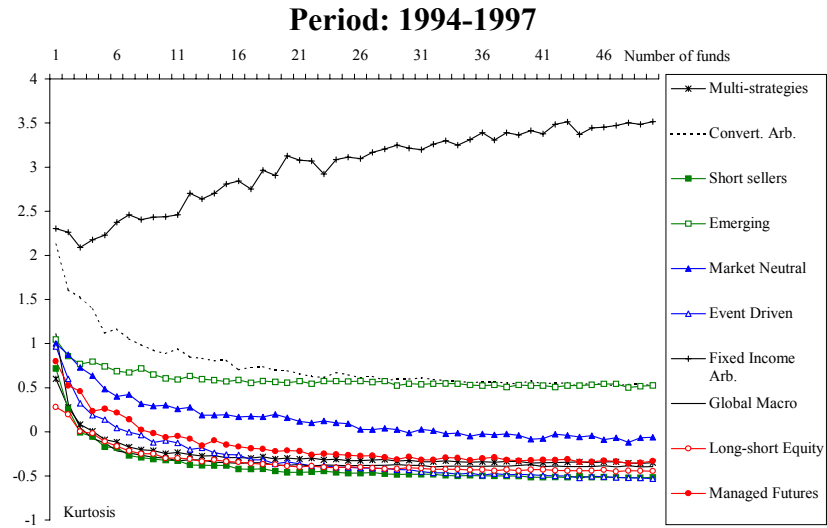
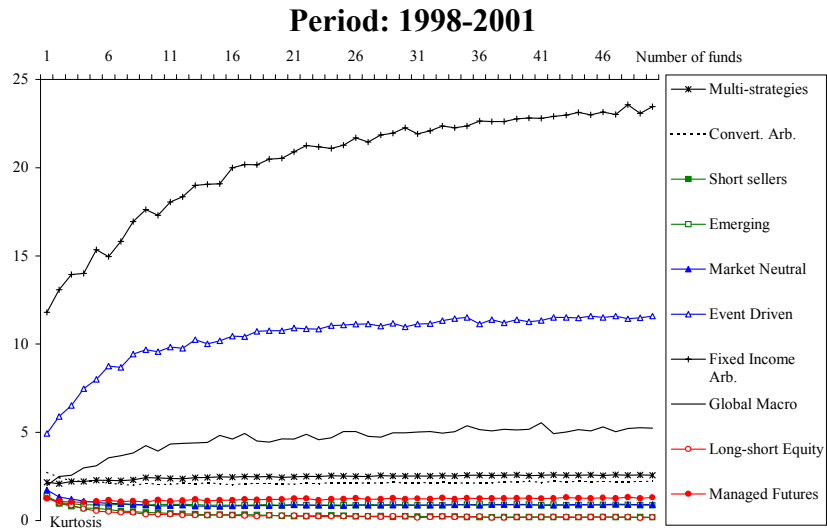


Figure 4: Impact of diversification on kurtosis

1998-2001	Initial Kurtosis	Number of hedge funds in the portfolio						Final Kurtosis
		2	5	10	20	30	50	
Multi-strategies	2.18	-4%	5%	11%	13%	16%	18%	2.57
Convertible Arbitrage	2.74	-11%	-18%	-24%	-24%	-23%	-19%	2.23
Dedicated Short Bias	1.35	-28%	-49%	-67%	-79%	-82%	-86%	0.18
Emerging Markets	1.37	-25%	-35%	-33%	-38%	-35%	-35%	0.88
Equity Market Neutral	1.74	-23%	-41%	-54%	-51%	-50%	-48%	0.90
Event Driven	4.94	19%	62%	94%	118%	122%	135%	11.60
Fixed Income Arbitrage	11.81	11%	30%	47%	74%	88%	99%	23.46
Global Macro	1.99	25%	56%	98%	132%	150%	163%	5.24
Long/Short Equity	1.27	-20%	-58%	-73%	-79%	-82%	-85%	0.19
Managed Futures	1.24	-12%	-12%	-6%	-3%	-2%	6%	1.32
<i>All styles, naïve divers.</i>	2.67	-34%	-48%	-59%	-63%	-65%	-65%	0.94
<i>All styles, smart divers.</i>	2.67	-35%	-48%	-56%	-38%	-58%	-63%	0.99

1994-1997	Initial Kurtosis	Number of hedge funds in the portfolio						Final Kurtosis
		2	5	10	20	30	50	
Multi-strategies	0.60	-54%	-115%	-141%	-150%	-154%	-158%	-0.35
Convertible Arbitrage	2.13	-24%	-47%	-58%	-67%	-72%	-76%	0.52
Dedicated Short Bias	0.72	-64%	-124%	-145%	-164%	-167%	-172%	-0.52
Emerging Markets	1.05	-18%	-29%	-42%	-47%	-48%	-50%	0.53
Equity Market Neutral	1.00	-12%	-52%	-70%	-84%	-101%	-106%	-0.06
Event Driven	0.97	-38%	-85%	-110%	-135%	-144%	-155%	-0.53
Fixed Income Arbitrage	2.30	-2%	-3%	6%	36%	40%	53%	3.52
Global Macro	1.11	-71%	-111%	-127%	-134%	-134%	-136%	-0.39
Long/Short Equity	0.28	-29%	-139%	-206%	-238%	-245%	-259%	-0.45
Managed Futures	0.80	-35%	-67%	-108%	-126%	-135%	-141%	-0.33
<i>All styles, naïve divers.</i>	0.83	-48%	-96%	-115%	-137%	-153%	-164%	-0.53
<i>All styles, smart divers.</i>	0.83	-40%	-87%	-116%	-144%	-156%	-168%	-0.56

1990-1993	Initial Kurtosis	Number of hedge funds in the portfolio						Final Kurtosis
		2	5	10	20	30	50	
Multi-strategies	0.73	-41%	-46%	-50%	-48%	-47%	-46%	0.39
Convertible Arbitrage	3.83	3%	8%	21%	22%	24%	23%	4.73
Dedicated Short Bias	0.60	-41%	-112%	-152%	-186%	-198%	-205%	-0.63
Emerging Markets	0.48	0%	11%	16%	10%	12%	10%	0.52
Equity Market Neutral	0.35	45%	32%	-10%	-37%	-48%	-51%	0.17
Event Driven	2.29	-1%	-1%	-2%	-4%	-6%	-5%	2.17
Fixed Income Arbitrage	0.72	-53%	-101%	-122%	-137%	-143%	-149%	-0.35
Global Macro	0.89	28%	-33%	-75%	-108%	-120%	-136%	-0.32
Long/Short Equity	0.35	33%	24%	-85%	-150%	-192%	-220%	-0.42
Managed Futures	1.32	33%	54%	46%	29%	40%	38%	1.82
<i>All styles, naïve divers.</i>	1.01	-18%	-33%	-30%	-15%	-10%	0%	1.00
<i>All styles, smart divers.</i>	1.01	-15%	-32%	-44%	-48%	-51%	-57%	0.43

Table 4: Impact of diversification on kurtosis

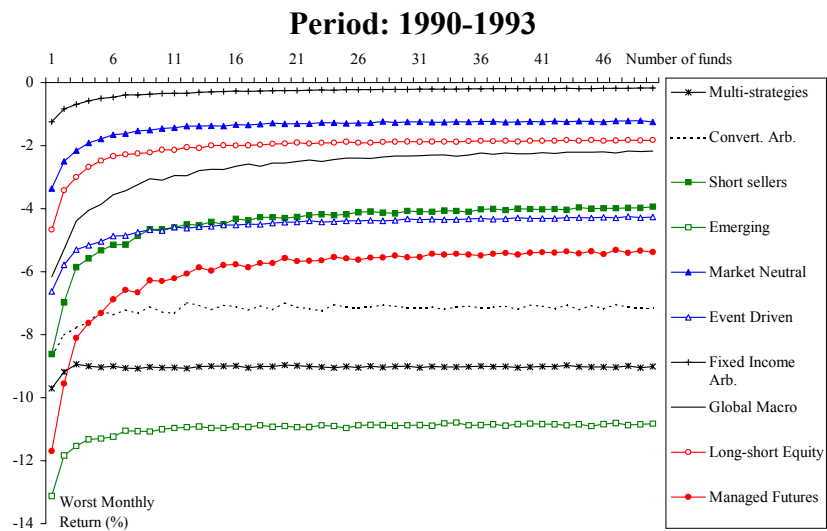
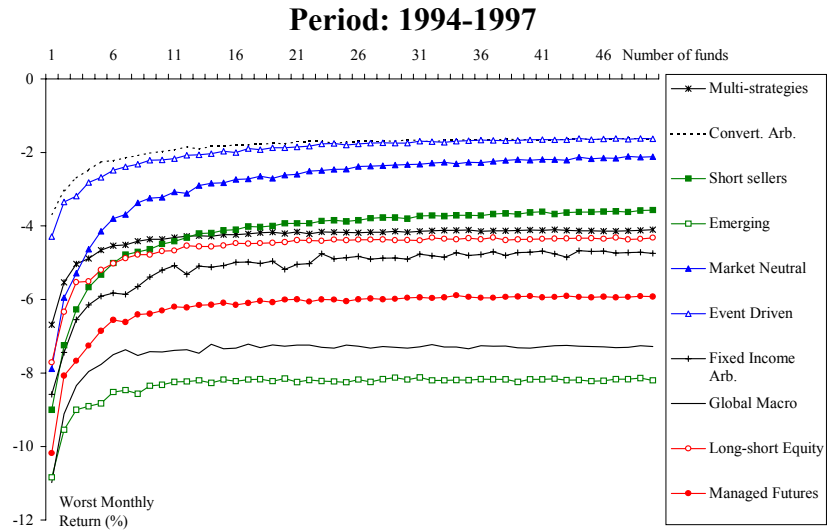
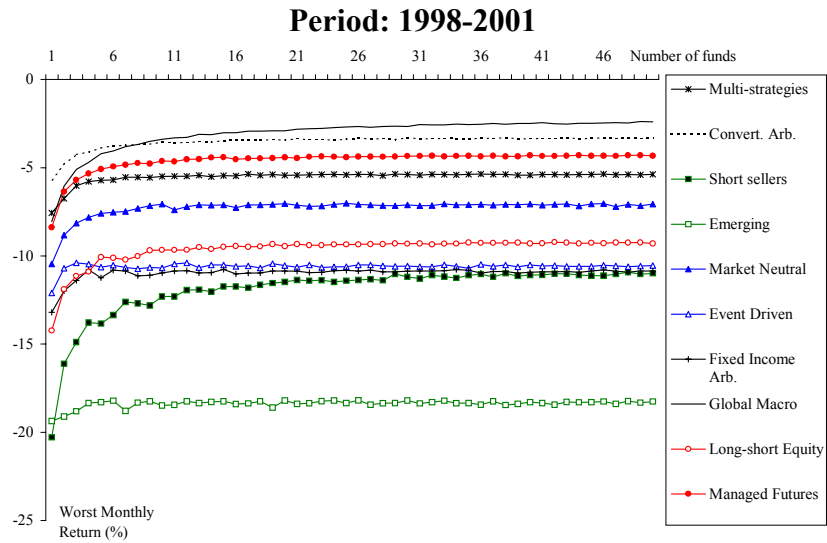


Figure 5: Impact of diversification on worst monthly return

1998-2001	Initial Worst	Number of hedge funds in the portfolio						Final Worst
	Ret. (%)	2	5	10	20	30	50	Ret. (%)
Multi-strategies	-7.55	-11%	-24%	-27%	-28%	-29%	-29%	-5.37
Convertible Arbitrage	-5.69	-15%	-32%	-38%	-40%	-42%	-42%	-3.29
Dedicated Short Bias	-20.30	-21%	-32%	-39%	-43%	-45%	-46%	-10.99
Emerging Markets	-19.34	-1%	-5%	-4%	-6%	-6%	-6%	-18.26
Equity Market Neutral	-10.45	-16%	-27%	-32%	-33%	-32%	-32%	-7.06
Event Driven	-12.10	-12%	-12%	-12%	-13%	-13%	-13%	-10.55
Fixed Income Arbitrage	-13.19	-9%	-15%	-17%	-18%	-18%	-18%	-10.85
Global Macro	-8.05	-25%	-48%	-58%	-64%	-67%	-70%	-2.41
Long/Short Equity	-14.23	-16%	-29%	-32%	-34%	-35%	-35%	-9.29
Managed Futures	-8.37	-24%	-39%	-45%	-47%	-48%	-48%	-4.33
<i>All styles, naïve divers.</i>	-12.79	-21%	-37%	-42%	-47%	-46%	-47%	-6.83
<i>All styles, smart divers.</i>	-12.79	-22%	-44%	-49%	-56%	-61%	-68%	-4.09

1994-1997	Initial Worst	Number of hedge funds in the portfolio						Final Worst
	Ret. (%)	2	5	10	20	30	50	Ret. (%)
Multi-strategies	-6.69	-17%	-30%	-35%	-37%	-38%	-39%	-4.10
Convertible Arbitrage	-3.68	-17%	-39%	-46%	-52%	-55%	-56%	-1.63
Dedicated Short Bias	-9.00	-19%	-41%	-50%	-56%	-58%	-60%	-3.57
Emerging Markets	-10.84	-12%	-19%	-23%	-25%	-25%	-24%	-8.20
Equity Market Neutral	-7.89	-25%	-47%	-59%	-67%	-70%	-73%	-2.11
Event Driven	-4.29	-22%	-38%	-49%	-56%	-59%	-62%	-1.63
Fixed Income Arbitrage	-8.58	-13%	-31%	-39%	-40%	-43%	-45%	-4.74
Global Macro	-10.98	-17%	-29%	-32%	-34%	-33%	-34%	-7.28
Long/Short Equity	-7.72	-18%	-33%	-39%	-42%	-43%	-44%	-4.32
Managed Futures	-10.18	-21%	-33%	-38%	-41%	-42%	-42%	-5.92
<i>All styles, naïve divers.</i>	-7.81	-17%	-44%	-55%	-62%	-66%	-68%	-2.46
<i>All styles, smart divers.</i>	-7.81	-21%	-46%	-59%	-67%	-70%	-74%	-2.03

1990-1993	Initial Worst	Number of hedge funds in the portfolio						Final Worst
	Ret. (%)	2	5	10	20	30	50	Ret. (%)
Multi-strategies	-9.71	-5%	-7%	-7%	-8%	-7%	-7%	-9.01
Convertible Arbitrage	-8.68	-8%	-17%	-16%	-19%	-18%	-17%	-7.17
Dedicated Short Bias	-8.62	-19%	-38%	-46%	-50%	-53%	-54%	-3.94
Emerging Markets	-13.12	-10%	-14%	-16%	-17%	-17%	-17%	-10.83
Equity Market Neutral	-3.37	-26%	-47%	-57%	-61%	-63%	-63%	-1.25
Event Driven	-6.63	-13%	-24%	-29%	-33%	-35%	-36%	-4.27
Fixed Income Arbitrage	-1.24	-32%	-60%	-72%	-80%	-83%	-86%	-0.17
Global Macro	-6.17	-14%	-37%	-50%	-59%	-62%	-65%	-2.17
Long/Short Equity	-4.67	-27%	-47%	-54%	-58%	-60%	-61%	-1.83
Managed Futures	-11.69	-18%	-37%	-46%	-52%	-53%	-54%	-5.38
<i>All styles, naïve divers.</i>	-8.57	-20%	-39%	-45%	-49%	-49%	-49%	-4.35
<i>All styles, smart divers.</i>	-8.57	-24%	-52%	-57%	-66%	-71%	-75%	-2.13

Table 5: Impact of diversification on worst monthly return

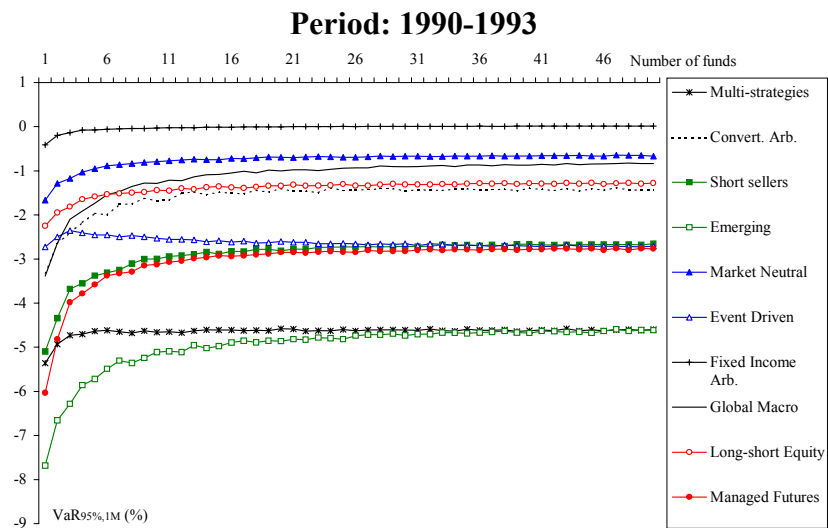
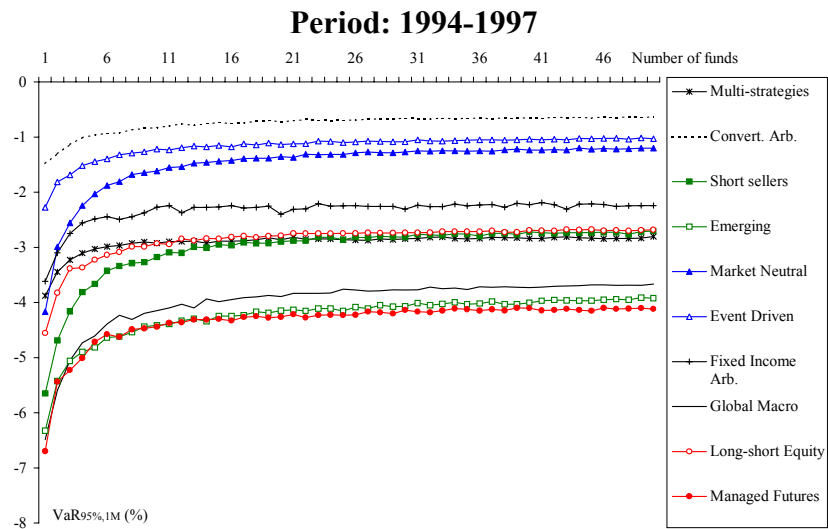
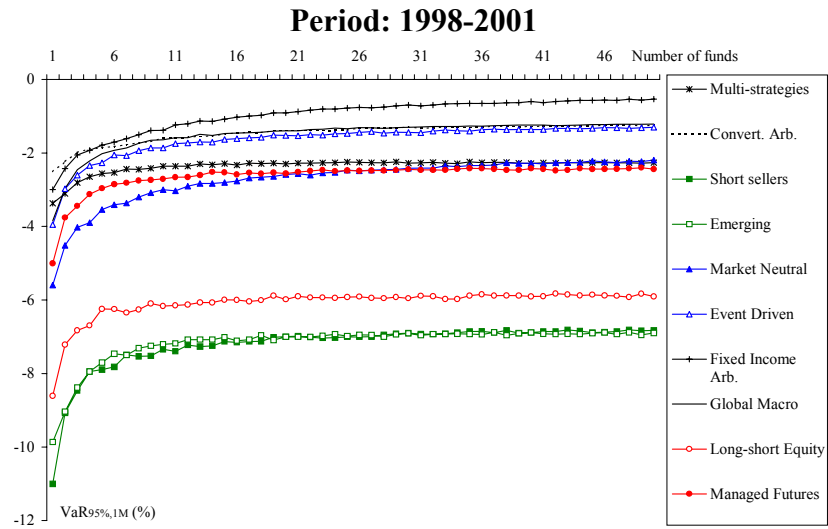


Figure 6: Impact of diversification on value at risk (one month, 95%)

1998-2001	Initial VaR (%)	Number of hedge funds in the portfolio						Final VaR (%)
		2	5	10	20	30	50	
Multi-strategies	-3.37	-8%	-24%	-30%	-32%	-32%	-33%	-2.26
Convertible Arbitrage	-2.51	-11%	-26%	-36%	-44%	-48%	-51%	-1.23
Dedicated Short Bias	-11.00	-18%	-28%	-33%	-36%	-37%	-38%	-6.83
Emerging Markets	-9.87	-8%	-22%	-27%	-29%	-30%	-30%	-6.89
Equity Market Neutral	-5.59	-19%	-37%	-46%	-54%	-57%	-61%	-2.19
Event Driven	-3.95	-25%	-42%	-53%	-61%	-64%	-67%	-1.30
Fixed Income Arbitrage	-2.99	-19%	-40%	-54%	-70%	-77%	-82%	-0.54
Global Macro	-3.84	-23%	-47%	-57%	-64%	-66%	-68%	-1.21
Long/Short Equity	-8.61	-16%	-27%	-28%	-30%	-31%	-31%	-5.91
Managed Futures	-5.00	-25%	-41%	-46%	-49%	-51%	-51%	-2.44
<i>All styles, naïve divers.</i>	-6.16	-18%	-42%	-50%	-59%	-60%	-64%	-2.25
<i>All styles, smart divers.</i>	-6.16	-20%	-50%	-58%	-69%	-76%	-82%	-1.11

1994-1997	Initial VaR (%)	Number of hedge funds in the portfolio						Final VaR (%)
		2	5	10	20	30	50	
Multi-strategies	-3.88	-11%	-22%	-25%	-26%	-27%	-28%	-2.80
Convertible Arbitrage	-1.48	-12%	-35%	-44%	-51%	-56%	-57%	-0.64
Dedicated Short Bias	-5.65	-17%	-35%	-44%	-49%	-50%	-52%	-2.71
Emerging Markets	-6.32	-14%	-24%	-30%	-34%	-36%	-38%	-3.92
Equity Market Neutral	-4.17	-28%	-51%	-61%	-67%	-70%	-71%	-1.20
Event Driven	-2.28	-20%	-36%	-46%	-50%	-52%	-55%	-1.03
Fixed Income Arbitrage	-3.61	-14%	-31%	-37%	-34%	-36%	-38%	-2.24
Global Macro	-6.49	-14%	-29%	-36%	-40%	-42%	-44%	-3.66
Long/Short Equity	-4.55	-16%	-29%	-36%	-39%	-40%	-41%	-2.68
Managed Futures	-6.69	-19%	-30%	-34%	-36%	-38%	-38%	-4.12
<i>All styles, naïve divers.</i>	-4.67	-18%	-43%	-54%	-61%	-65%	-66%	-1.58
<i>All styles, smart divers.</i>	-4.67	-20%	-46%	-58%	-66%	-68%	-71%	-1.35

1990-1993	Initial VaR (%)	Number of hedge funds in the portfolio						Final VaR (%)
		2	5	10	20	30	50	
Multi-strategies	-5.36	-8%	-14%	-13%	-15%	-14%	-14%	-4.60
Convertible Arbitrage	-3.33	-20%	-41%	-49%	-58%	-56%	-57%	-1.44
Dedicated Short Bias	-5.10	-15%	-34%	-41%	-45%	-47%	-48%	-2.65
Emerging Markets	-7.68	-13%	-26%	-34%	-37%	-38%	-40%	-4.62
Equity Market Neutral	-1.67	-23%	-43%	-52%	-58%	-60%	-60%	-0.67
Event Driven	-2.73	-8%	-10%	-7%	-5%	-3%	-1%	-2.70
Fixed Income Arbitrage	-0.41	-52%	-83%	-92%	-99%	-102%	-104%	0.02
Global Macro	-3.38	-22%	-49%	-62%	-70%	-73%	-75%	-0.83
Long/Short Equity	-2.24	-13%	-29%	-36%	-40%	-42%	-43%	-1.28
Managed Futures	-6.03	-20%	-41%	-48%	-53%	-53%	-54%	-2.77
<i>All styles, naïve divers.</i>	-4.56	-20%	-41%	-51%	-57%	-58%	-58%	-1.90
<i>All styles, smart divers.</i>	-4.56	-25%	-53%	-61%	-71%	-76%	-79%	-0.95

Table 6: Impact of diversification on value at risk

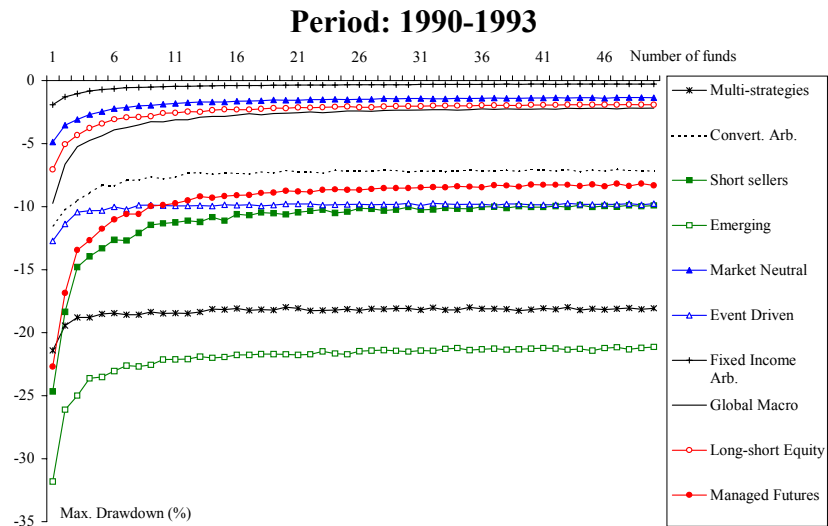
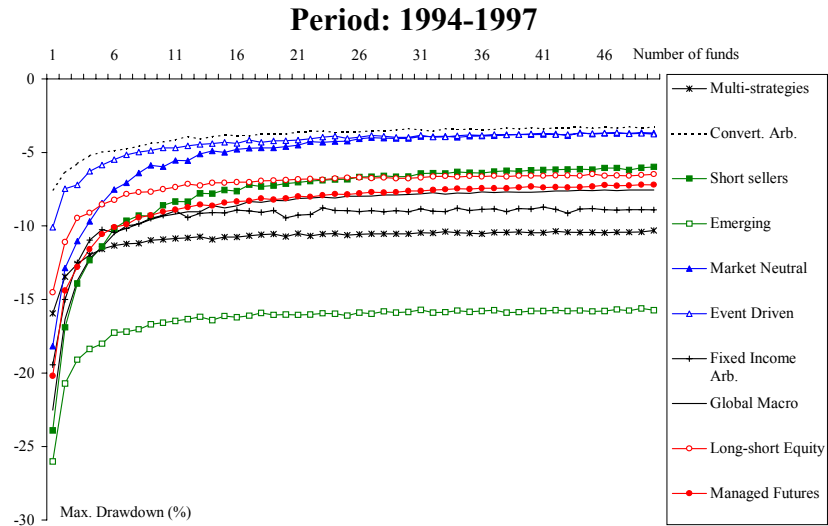
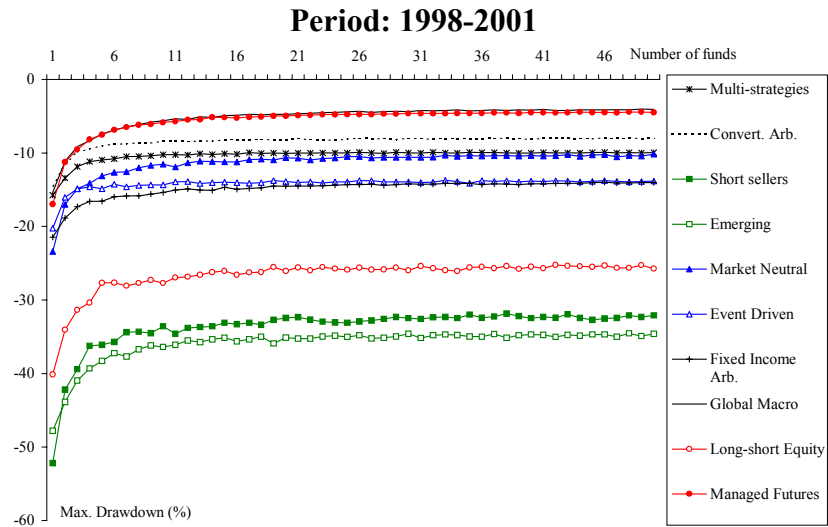


Figure 7: Impact of diversification on maximum draw-down

1998-2001	Initial Ddwn (%)	Number of hedge funds in the portfolio						Final Ddwn (%)
		2	5	10	20	30	50	
Multi-strategies	-15.73	-15%	-31%	-35%	-36%	-36%	-37%	-9.92
Convertible Arbitrage	-14.49	-20%	-38%	-42%	-44%	-45%	-45%	-7.98
Dedicated Short Bias	-52.17	-19%	-31%	-36%	-38%	-38%	-38%	-32.10
Emerging Markets	-47.76	-8%	-20%	-24%	-27%	-28%	-28%	-34.60
Equity Market Neutral	-23.40	-27%	-44%	-51%	-54%	-55%	-57%	-10.17
Event Driven	-20.25	-21%	-27%	-29%	-31%	-31%	-32%	-13.80
Fixed Income Arbitrage	-21.47	-12%	-23%	-28%	-32%	-34%	-35%	-13.99
Global Macro	-15.34	-28%	-52%	-63%	-69%	-72%	-74%	-4.05
Long/Short Equity	-40.11	-15%	-31%	-31%	-35%	-35%	-36%	-25.71
Managed Futures	-16.97	-34%	-56%	-66%	-71%	-73%	-74%	-4.46
<i>All styles, naïve divers.</i>	-29.09	-24%	-49%	-57%	-65%	-66%	-68%	-9.24
<i>All styles, smart divers.</i>	-29.09	-25%	-57%	-64%	-71%	-76%	-80%	-5.82

1994-1997	Initial Ddwn (%)	Number of hedge funds in the portfolio						Final Ddwn (%)
		2	5	10	20	30	50	
Multi-strategies	-15.93	-16%	-27%	-31%	-33%	-34%	-35%	-10.30
Convertible Arbitrage	-7.53	-16%	-34%	-43%	-50%	-55%	-57%	-3.26
Dedicated Short Bias	-23.90	-29%	-52%	-64%	-70%	-72%	-75%	-5.99
Emerging Markets	-26.01	-20%	-31%	-36%	-38%	-39%	-40%	-15.72
Equity Market Neutral	-18.18	-29%	-54%	-67%	-75%	-78%	-80%	-3.67
Event Driven	-10.09	-26%	-42%	-53%	-58%	-61%	-63%	-3.75
Fixed Income Arbitrage	-19.44	-23%	-47%	-52%	-51%	-54%	-54%	-8.91
Global Macro	-22.51	-27%	-49%	-59%	-63%	-65%	-66%	-7.56
Long/Short Equity	-14.51	-24%	-41%	-48%	-53%	-53%	-55%	-6.49
Managed Futures	-20.19	-29%	-48%	-55%	-60%	-62%	-64%	-7.20
<i>All styles, naïve divers.</i>	-16.14	-25%	-54%	-67%	-75%	-78%	-81%	-3.12
<i>All styles, smart divers.</i>	-16.14	-31%	-59%	-71%	-78%	-80%	-83%	-2.74

1990-1993	Initial Ddwn (%)	Number of hedge funds in the portfolio						Final Ddwn (%)
		2	5	10	20	30	50	
Multi-strategies	-21.41	-9%	-14%	-14%	-16%	-15%	-16%	-18.06
Convertible Arbitrage	-11.50	-11%	-28%	-32%	-38%	-37%	-38%	-7.17
Dedicated Short Bias	-24.66	-26%	-46%	-54%	-57%	-59%	-60%	-9.91
Emerging Markets	-31.81	-18%	-26%	-30%	-32%	-32%	-34%	-21.13
Equity Market Neutral	-4.87	-27%	-50%	-61%	-68%	-71%	-72%	-1.37
Event Driven	-12.71	-10%	-19%	-22%	-23%	-23%	-23%	-9.77
Fixed Income Arbitrage	-1.93	-33%	-63%	-75%	-81%	-83%	-86%	-0.27
Global Macro	-9.73	-32%	-55%	-66%	-73%	-76%	-78%	-2.17
Long/Short Equity	-7.04	-28%	-52%	-63%	-69%	-71%	-73%	-1.91
Managed Futures	-22.69	-26%	-48%	-57%	-61%	-62%	-63%	-8.31
<i>All styles, naïve divers.</i>	-18.29	-25%	-47%	-54%	-58%	-58%	-59%	-7.59
<i>All styles, smart divers.</i>	-18.29	-29%	-60%	-65%	-73%	-78%	-81%	-3.48

Table 7: Impact of diversification on maximum draw-down

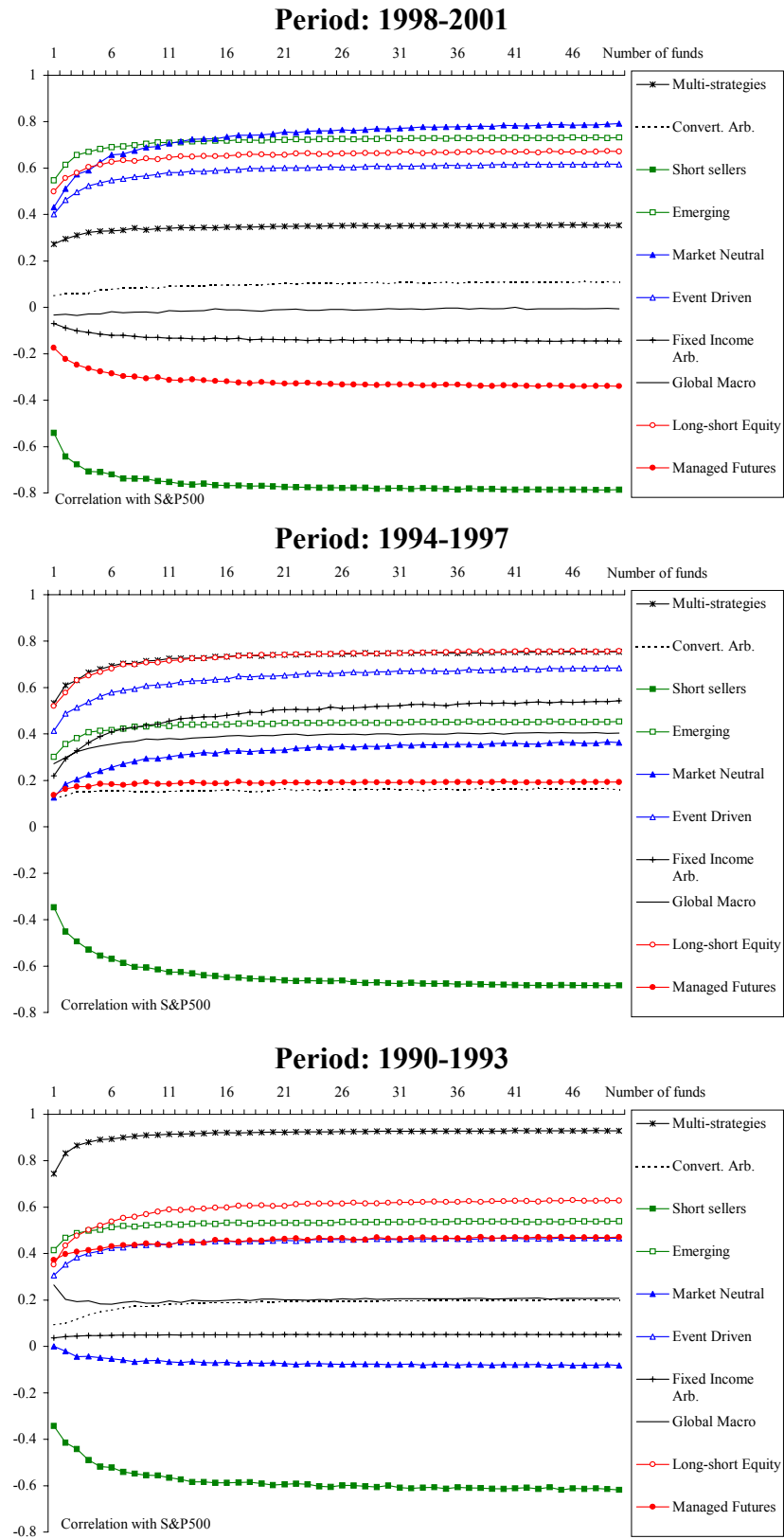


Figure 8: Impact of diversification on correlation with S&P 500

1998-2001	Initial Correl.	Number of hedge funds in the portfolio						Final Correl.
		2	5	10	20	30	50	
Multi-strategies	0.27	8%	20%	24%	28%	28%	30%	0.35
Convertible Arbitrage	0.05	19%	56%	64%	101%	104%	114%	0.11
Dedicated Short Bias	-0.54	19%	31%	38%	43%	44%	45%	-0.79
Emerging Markets	0.55	12%	24%	30%	32%	33%	34%	0.73
Equity Market Neutral	0.43	18%	45%	61%	73%	78%	83%	0.79
Event Driven	0.40	15%	34%	43%	50%	51%	54%	0.62
Fixed Income Arbitrage	-0.07	27%	67%	87%	100%	103%	111%	-0.15
Global Macro	-0.03	-12%	-13%	-28%	-67%	-83%	-81%	-0.01
Long/Short Equity	0.50	12%	23%	28%	32%	33%	35%	0.67
Managed Futures	-0.17	28%	59%	73%	87%	91%	96%	-0.34
<i>All styles, naïve divers.</i>	<i>0.33</i>	<i>17%</i>	<i>49%</i>	<i>77%</i>	<i>94%</i>	<i>105%</i>	<i>112%</i>	<i>0.70</i>
<i>All styles, smart divers.</i>	<i>0.33</i>	<i>13%</i>	<i>36%</i>	<i>65%</i>	<i>75%</i>	<i>77%</i>	<i>72%</i>	<i>0.57</i>

1994-1997	Initial Correl.	Number of hedge funds in the portfolio						Final Correl.
		2	5	10	20	30	50	
Multi-strategies	0.53	14%	28%	35%	39%	40%	41%	0.75
Convertible Arbitrage	0.12	7%	24%	20%	27%	31%	28%	0.16
Dedicated Short Bias	-0.35	30%	60%	78%	90%	94%	97%	-0.68
Emerging Markets	0.30	18%	37%	46%	47%	49%	51%	0.45
Equity Market Neutral	0.13	45%	91%	133%	161%	176%	188%	0.36
Event Driven	0.41	18%	36%	48%	57%	61%	65%	0.68
Fixed Income Arbitrage	0.22	33%	77%	101%	129%	136%	147%	0.54
Global Macro	0.27	10%	28%	38%	44%	47%	48%	0.40
Long/Short Equity	0.52	11%	28%	36%	42%	44%	45%	0.76
Managed Futures	0.14	20%	35%	36%	38%	40%	41%	0.19
<i>All styles, naïve divers.</i>	<i>0.34</i>	<i>11%</i>	<i>37%</i>	<i>56%</i>	<i>75%</i>	<i>83%</i>	<i>89%</i>	<i>0.64</i>
<i>All styles, smart divers.</i>	<i>0.34</i>	<i>12%</i>	<i>27%</i>	<i>48%</i>	<i>58%</i>	<i>66%</i>	<i>74%</i>	<i>0.59</i>

1990-1993	Initial Correl.	Number of hedge funds in the portfolio						Final Correl.
		2	5	10	20	30	50	
Multi-strategies	0.74	12%	20%	23%	24%	25%	25%	0.93
Convertible Arbitrage	0.09	8%	61%	88%	106%	112%	115%	0.20
Dedicated Short Bias	-0.34	21%	51%	63%	75%	75%	81%	-0.62
Emerging Markets	0.42	13%	21%	26%	28%	29%	30%	0.54
Equity Market Neutral	0.00	20400%	48900%	60300%	70600%	78400%	82100%	-0.08
Event Driven	0.31	15%	34%	45%	49%	51%	53%	0.47
Fixed Income Arbitrage	0.04	16%	27%	33%	37%	38%	40%	0.05
Global Macro	0.26	-23%	-31%	-30%	-23%	-23%	-22%	0.21
Long/Short Equity	0.35	23%	48%	65%	72%	76%	78%	0.63
Managed Futures	0.37	7%	13%	18%	24%	25%	27%	0.47
<i>All styles, naïve divers.</i>	<i>0.38</i>	<i>17%</i>	<i>49%</i>	<i>77%</i>	<i>93%</i>	<i>102%</i>	<i>110%</i>	<i>0.79</i>
<i>All styles, smart divers.</i>	<i>0.38</i>	<i>17%</i>	<i>39%</i>	<i>64%</i>	<i>73%</i>	<i>78%</i>	<i>82%</i>	<i>0.69</i>

Table 8: Impact of diversification on correlation with S&P 500

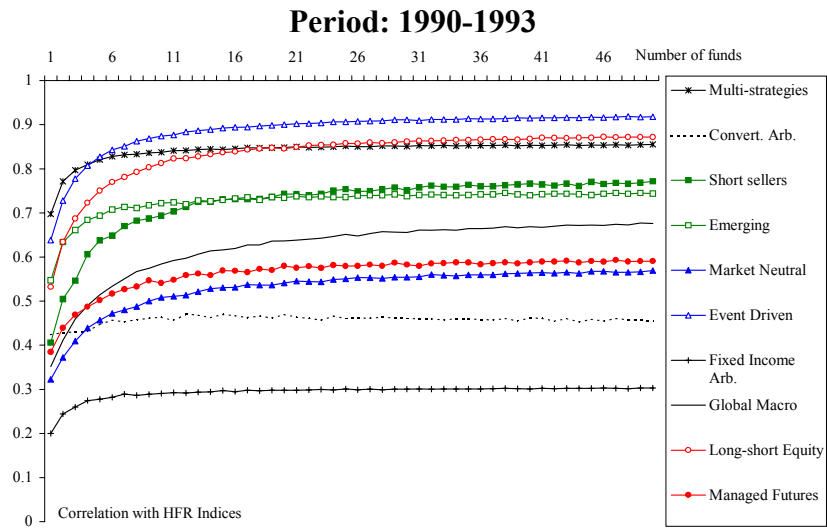
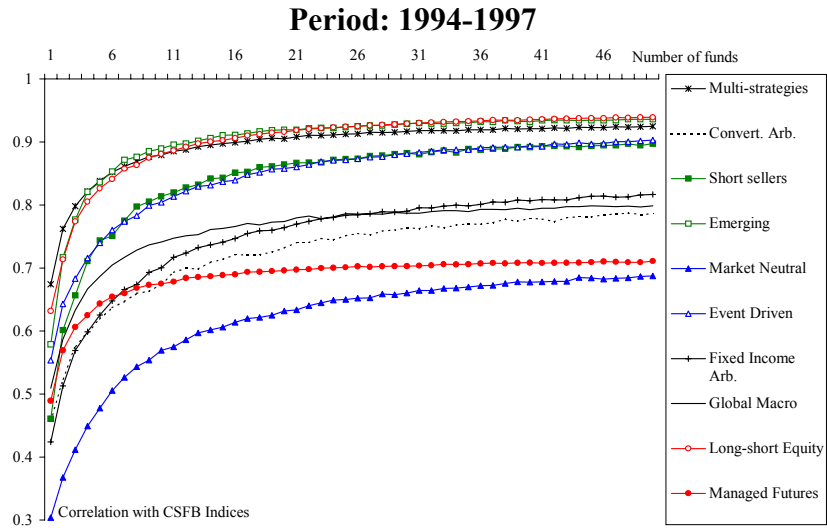
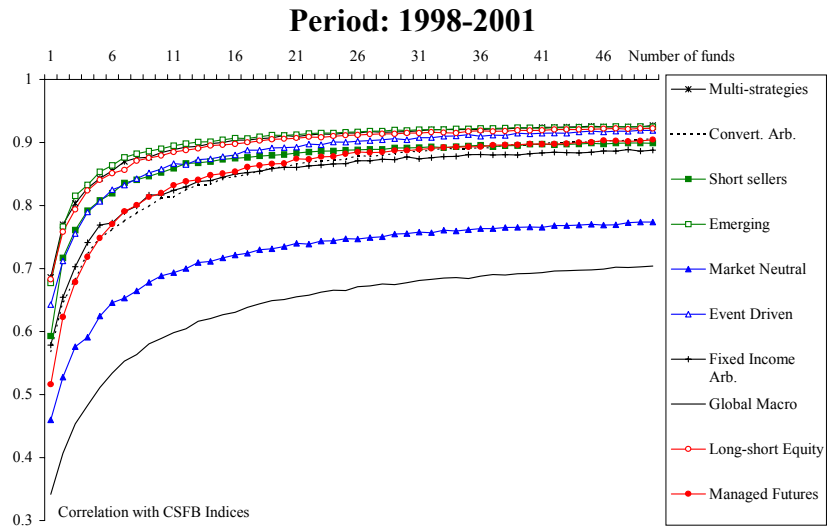


Figure 9: Impact of diversification on correlation with hedge fund style indices

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