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PERFORMANCE OF HEDGE FUND STRATEGIES IN BULL AND BEAR MARKETS

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Abstract

Hedge funds use a wide variety of investment styles, although many people have the perception that they are a relatively homogenous group with similar strategies to generate returns. Understanding the differences in the risk and return structure of hedge fund strategies is crucial to making a good investment decision. This paper examines the performance of 13 hedge fund strategies in the Credit Suisse Hedge Fund Index, during a 20-years long period ranging from 1995 to 2015. In contrast to previous research, our study encompasses performance analysis on multiple long-term bull and bear stock market periods. Our study provides potential hedge fund investors with valuable information about the best performing strategies in different market conditions. The results show that returns vary greatly between different strategies and time periods.

Keywords: Financial Markets, Hedge Funds, Hedging, Institutional Investors, Rate of Return Analysis, Risk Hedging, Risk Return.

JEL-Codes: G11, G23

Contents

The first hedge fund was founded in 1949 by Alfred Winslow Jones, who used a market neutral investment strategy by taking long positions in securities he found undervalued and at the same time taking short positions in overvalued securities. Still today, the popular perception is that hedge funds have a reasonably well-defined market neutral strategy (Brown & Goetzmann, 2001). While this strategy was used by the first hedge funds, modern hedge funds have evolved into a heterogeneous group with multifaceted organizational structures. The term "hedge fund" now covers a broad range of investment philosophies that goes beyond the original long-short strategy. However, there are a few common characteristics that help us define hedge funds. Some of them are: flexible investment strategies, unregulated organizational structure, substantial managerial investment in the fund and strong managerial incentives (Ackermann *et al.* 1999, Brown & Goetzmann, 2001).

This study aims to examine the difference in performance of various hedge fund strategies in bull and bear stock market periods. As Edwards and Caglayan (2001) note, one of the primary motives for investing in hedge funds is to hedge against falling stock prices, it is of great importance to understand how different investment strategies perform in bear markets. We use data from Credit Suisse Hedge Fund Index and analyze the return of their 13 strategy indices to draw a conclusion about their ability to beat the market and also, which strategy is the most successful in both bull and bear market periods.

We test their performance by benchmarking the strategy indices to a global stock market index and see if the hedge fund strategies show statistically significant superior returns compared to the market. Furthermore, we also compare the risk-adjusted returns amongst the individual strategies in different time periods. An analysis of the estimated beta coefficients is also conducted as we make an attempt to derive two beta-neutral hedge fund portfolios.

Our starting point in examining whether hedge funds are able to beat the market is the research conducted by M. C. Jensen in 1968 where he derived a risk-adjusted measure of portfolio performance, which is nowadays known as Jensen's Alpha. He based his research on the CAPM-model which was introduced a few years earlier by Sharpe, Lintner and Treynor (Jensen, 1968). Jensen (1968) finds that the mutual funds in his sample are not able to outperform the market. Very little evidence is found that individual funds can perform significantly better than what could be expected (Jensen, 1968).

A few years later, Fama (1970) introduces the efficient market hypothesis (EMH), which states that the price of an asset fully reflects all available information to investors. The theory supports the findings of previous research that on average, mutual funds should not be able to outperform the market consistently on a risk-adjusted basis (Fama, 1970).

Brown (1995) sets out to answer if the effect of persistence in fund performance is significant for investors to earn excess return over the market, just by choosing the previous

winners. He compares the return of a portfolio strategy where you invest in the highest performing fund of the previous year to one where you do the opposite. The results are that winning funds tend to deliver a higher return in future years, however they bear higher total risk.

Ackermann *et al.* (1999) find that structural advantages of hedge fund strategies can help generate superior returns to the market. They also find that the strategies have an average significant excess return (alpha) of approximately half a percent. Furthermore, they note that there is substantial literature and research on mutual funds but less in the field of hedge funds. One reason for the lower number of studies on hedge funds could be that the industry is self-reporting. The lack of reporting requirements create a bias that makes it problematic for authors to come across reliable data (Capocci & Hubner, 2004).

However, there still exists literature that examines the risk and performance of hedge funds. Brown and Goetzmann (2001) notes that the risk exposure from investing in a hedge fund largely depends on a funds style affiliation. This result builds on an earlier study by Brown *et al.* (1999) where they conclude that performance persistence in hedge funds is due to style effects rather than management skills. Hedge funds often have low correlation with other financial securities. Both Fung and Hsieh (1997) and Liang (1999) find that low correlation between hedge funds and other financial securities can significantly increase the risk-return profile in a portfolio.

Most previous research on hedge fund performance have not distinguished between bull and bear markets since their time window under review (1990–2000 in most cases) has been a particularly bullish period on the stock market (Capocci *et al*, 2005). Moreover, hedge fund data collected prior to 1994 is likely to suffer from significant survivorship bias according to Capocci and Hubner (2004) and Fung and Hsieh (2000). Several studies choose not to include data prior to 1994. An exception to this is Edwards and Caglayan (2001), who studies the performance of hedge funds and commodity funds during 1990–1998 with periods of both falling and rising stock prices.

The results from the research of Edwards and Caglayan (2001) reveal that only three hedge fund strategies[1] protect investors during bear stock market periods. They also find that the best performing strategies in bull periods are the best ones in bear markets. In their paper they define a bull stock market as a period when the monthly return of the S&P 500 is 1 % or more and a bear stock market when the S&P 500 drops by 1 % or more during a month. In our study, we use another definition to see how long-term bull and bear stock market periods affect performance of different hedge fund strategies.

There are a few other studies examining hedge fund performance in longer lasting bear

[1]Market neutral, event driven and macro strategies were superior in bear markets.

market periods. For example, Liang (2001) use data from the time of the Asian crisis in 1997 as their bearish sub-period. While this period is relatively short, Capocci and Hubner (2004) and Capocci *et al.* (2005) use data from 1994–2002 which enables them to study a 32 months bearish period from April 2000 to December 2002. They draw the conclusion that most hedge funds significantly outperforms the market during the whole test period but this result is mostly due to the bullish sub-period between 1994 and 2000. The best performing strategy was the market neutral strategy. We use a different database than Capocci and Hubner (2004) which might lead to that we obtain different results.

In contrast to previous research, our study is more extensive than other authors in the sense that it encompasses data from multiple unambiguously bull and bear sub-periods. This improves the reliability of our results, since it includes more than one period. In addition, much of the prior research that involves hedge fund strategy performances were conducted before the financial crisis, which leaves a gap for our study to fill.

The purpose of this paper is to analyze and investigate the risk-adjusted performance of different hedge fund strategies during unambiguously long-term uptrends or downtrends on the global stock market. We do this by analyzing the monthly returns of different strategies during time periods that shows a clear up or down trend on the market. For example, the rally leading to the IT-bubble in 2000 is considered as a bull period and the financial crisis in 2008 is considered as a bear period. This study contributes to existing research by examining the performance of hedge fund strategies during multiple long-term trends in the market. The study also reveal results that are more up-to-date since the analysis is made on data that is sampled from 1995 to 2015.

This paper is organized as follows: In Section I, we present the hedge fund database that we use along with a subsection with Credit Suisse's definitions of the different hedge fund strategies. We also explain the choice of time periods for our analysis. Our method is explained in Section II. Section III contains the empirical results of our estimations and tests. In this section, we have several subsections where we analyze the different strategies considering absolute return, excess return of the market, and risk-adjusted return. We also make an attempt to construct optimal portfolios by using our obtained results. Section IV explains how various data conditioning biases can affect the obtained results. Section V is the concluding section, where we end with a short discussion about the main findings and its implications along with suggestions for future research.

I. Data

A. Database

The data we use when conducting our research comes from the Credit Suisse Hedge Fund Database which consists of approximately 9 000 funds. In more detail, we use data from an index called the Credit Suisse Hedge Fund Index (CSHFI), which is derived from their database and currently consists of around 375 hedge funds that meet the requirements of the index. The requirements for being in the index is that the fund has a minimum of $50 million in assets under management, a minimum one-year track record, and current audited financial statements.

Credit Suisse does not limit its index to any particular geographical region and may very well include funds that are managed in different countries around the world. The index was the industry's first – and remains the leading – asset-weighted hedge fund index. In contrast to equal-weighted indices, which do not take the size of the fund into account, asset-weighted indices gives a more accurate depiction of the return in an asset class (Credit Suisse, 2016).

Apart from the composite Credit Suisse Hedge Fund Index, there are also strategy indices which has the same constituents as the CSHFI, but is divided into ten (13 including sub-strategies) indices depending on the hedge funds investment style. A calculation agent designates a strategy for every hedge fund that enters the index. The strategy is determined through examination of the hedge fund's documentation, discussions with the fund's personnel and other relevant factors. To ensure the validity of the strategy classifications, a calculation agent conducts statistical checks on an ongoing basis in order to identify potentially misclassified hedge funds. Funds that appear to be statistical outliers are investigated to see if there is a more appropriate strategy for them (Credit Suisse Index Rules, September 2013).

The publicly available data from Credit Suisse's website comes in the form of monthly returns for each hedge fund strategy and the composite index. As Ackermann *et al.* (1999) points out, the use of monthly data has some strong advantages over yearly data. Using monthly returns leads to greatly enhanced accuracy of the risk measure in terms of standard deviation. Another negative consequence that arise from using yearly data is that large fluctuations in returns, due to external market forces and dynamic hedge fund strategies, can be smoothened out and thus overlooked if too few observations are used. This is not a problem, to the same extent, when monthly returns are used. Since risk-adjusted returns are an important part of our analysis, the accuracies of the risk measurements are critical.

Credit Suisse's Definitions of Hedge Fund Strategies

The following definitions are copied from Credit Suisse's "Hedge Fund Index Rules" available as a downloadable document on their website (see references).

- **Convertible Arbitrage:** Aims to profit from the purchase of convertible securities and the subsequent shortening of the corresponding stock when there is a pricing discrepancy made in the conversion factor of the security. Managers typically build long positions of convertible and other equity hybrid securities and then hedge the equity component of the long securities positions by shorting the underlying stock or options. The number of shares sold short usually reflects a delta neutral or market neutral ratio. As a result, under normal market conditions, the arbitrageur generally expects the combined position to be insensitive to fluctuations in the price of the underlying stock.
- **Fixed Income Arbitrage:** Typically funds that attempt to generate profits by exploiting inefficiencies and price anomalies between related fixed income securities. Funds often seek to limit volatility by hedging exposure to the market and interest rate risk. Strategies may include leveraging long and short positions in similar fixed income securities that are related either mathematically or economically. The sector includes credit yield curve relative value trading involving interest rate swaps, government securities and futures; volatility trading involving options; and mortgage-backed securities arbitrage (the mortgage-backed market is primarily in the U.S. and over-the-counter).
- **Dedicated Short Bias:** Takes more short positions than long positions and earn returns by maintaining net short exposure in long and short equities. Detailed individual company research typically forms the core alpha generation driver of dedicated short bias managers, and a focus on companies with weak cash flow generation is common. To affect the short sale, the manager borrows the stock from a counter-party and sells it in the market. Short positions are sometimes implemented by selling forward. Risk management consists of offsetting long positions and stop-loss strategies.
- **Emerging Markets:** Invest in currencies, debt instruments, equities and other instruments of countries with "emerging" or developing markets (typically measured by GDP per capita). Such countries are considered to be in a transitional phase between developing and developed status. Examples of emerging markets include China, India, Latin America, much of Southeast Asia, parts of Eastern Europe, and parts of Africa. There are a number of sub-sectors, including arbitrage, credit and event driven, fixed income bias, and equity bias.
- **Equity Market Neutral:** Takes both long and short positions in stocks while minimizing exposure to the systematic risk of the market (i.e., a beta of zero is desired). Funds seek to exploit investment opportunities unique to a specific group of stocks, while maintaining a neutral exposure to broad groups of stocks defined, for example by sector, industry, market capitalization, country, or region. There are a number of subsectors including statistical arbitrage, quantitative long/short, fundamental long/short and index arbitrage. Managers often apply leverage to enhance returns.
- **Global Macro:** Focus on identifying extreme price valuations and leverage is often applied on the anticipated price movements in equity, currency, interest rate and commodity markets. Managers typically employ a top-down global approach to concentrate on forecasting how political trends and global macroe-

conomic events affect the valuation of financial instruments. Profits are made by correctly anticipating price movements in global markets and having the flexibility to use a broad investment mandate, with the ability to hold positions in practically any market with any instrument. These approaches may be systematic trend following models, or discretionary.

- ▷ **Long/Short Equity:** Invest on both long and short sides of equity markets, generally focusing on diversifying or hedging across particular sectors, regions or market capitalizations. Managers have the flexibility to shift from value to growth; small to medium to large capitalization stocks; and net long to net short. Managers may also trade equity futures and options as well as equity related securities and debt or build portfolios that are more concentrated than traditional long-only equity funds.
- ▷ **Managed Futures:** Often referred to as Commodity Trading Advisors or CTAs focus on investing in listed bond, equity, commodity futures and currency markets, globally. Managers tend to employ systematic trading programs that largely rely upon historical price data and market trends. A significant amount of leverage is employed since the strategy involves the use of futures contracts. CTAs do not have a particular biased towards being net long or net short any particular market.
- ▷ **Multi-Strategy** Characterized by their ability to allocate capital based on perceived opportunities among several hedge fund strategies. Through the diversification of capital, managers seek to deliver consistently positive returns regardless of the directional movement in equity, interest rate or currency markets. The added diversification benefits reduce the risk profile and help to smooth returns, reduce volatility and decrease asset-class and single-strategy risks. Strategies adopted in a multi-strategy fund may include, but are not limited to, convertible bond arbitrage, equity long/short, statistical arbitrage and merger arbitrage.
- ▷ **Event Driven:** Invests in various asset classes and seek to profit from potential mispricing of securities related to a specific corporate or market event. Such events can include: mergers, bankruptcies, financial or operational stress, restructurings, asset sales, recapitalizations, spin-offs, litigation, regulatory and legislative changes as well as other types of corporate events. Event Driven funds can invest in equities, fixed income instruments (investment grade, high yield, bank debt, convertible debt and distressed), options and various other derivatives. Many managers use a combination of strategies and adjust exposures based on the opportunity sets in each sub-sector.

Event Driven Sub-Strategies:

- ▷ **Risk Arbitrage:** Attempts to capture the spreads in merger or acquisition transactions involving public companies after the terms of the transaction have been announced. The spread is the difference between the transaction bid and the trading price. Typically, the target stock trades at a discount to the bid in order to account for the risk of the transaction not closing successfully. In a cash deal, the manager will typically purchase the stock of the target and tender it for the offer price at closing. In a fixed exchange ratio stock merger, one would go long the target stock and short the acquirers stock according to the merger ratio, in order to isolate the spread and hedge out market risk. The principal risk is deal risk, should the deal fail to close.
- ▷ **Distressed:** Focus on distressed situations and invest across the capital structure of companies subject to financial or operational distress or bankruptcy proceedings. Such securities trade at substantial discounts to intrinsic value due to difficulties in assessing their proper value, lack of research coverage, or an inability

of traditional investors to continue holding them. This strategy is generally long-biased in nature, but managers may take outright long, hedged or outright short positions. Distressed managers typically attempt to profit from the issuers ability to improve its operation or the success of the bankruptcy process that ultimately leads to an exit strategy.

- ▷ **Multi-Strategy:** Managers typically invest in a combination of event driven equities and credit. Within the equity space, sub-strategies include risk arbitrage, holding company arbitrage, equity special situations, and value equities with a hard or soft catalyst. Within the credit-oriented portion, sub-strategies include long/short high yield credit (sub-investment grade corporate bonds), leveraged loans (bank debt, mezzanine, or self-originated loans), capital structure arbitrage (debt vs. debt or debt vs. equity), and distressed debt (workout situations or bankruptcies) including post-reorganization equity. Multi Strategy Event Driven managers have the flexibility to pursue event investing across different asset classes and take advantage of shifts in economic cycles.

B. Time Periods

The time period under analysis ranges from January 1995 to May 2015 and our goal is to analyze multiple bull and bear periods in the modern global stock market history. In order to do so, we divide the time period into three particularly bullish, as well as two particularly bearish periods. The cutting points for the different time periods are determined by observing monthly maximum and minimum values within certain time spans of a chart showing the monthly performance of Morgan Stanley's World Index (MSCI WI). To verify that these time periods have strong trends, we calculate the percentage of months with positive and negative return within each chosen time period. We also calculate the yearly average returns and by looking at these results together, we can conclude that we have located significant trends, and that the time periods are strong enough to consider them as either a bull or a bear period. The results of these calculations are presented in Table I.

This above mentioned method is previously used by Capocci *et al.* (2005). In their study they analyzed one bull period and one bear period, they set their cutting point to March 2000 when Russell 3000 peaked. They argued that the period before this date was a bull period since Russell 3000 reported positive returns in 70 % of the months and the average yearly return was 19.4 %. In the succeeding period, which they concluded was a bear period, Russell 3000 had positive returns in 39 % of the months and the average yearly return was -16.3 %. They argue that these trends are sufficiently strong to consider as a bull and a bear period on the stock market without having to use more complex rules for separating bull, bear and neutral months.

In Table I we present the summary statistics of our chosen time periods and we see evidence for trends that are at least as strong as the ones in the study conducted by Capocci *et al.* (2005). We see for example in Bear 1, that the return of MSCI World Index was

positive in 30 % of the months and the average yearly return during that period was -22.3 %. These figures are significantly lower than the average for MSCI WI and therefore we conclude that we have located a time period with a strong down-trend.

Table I

Descriptive Statistics of the Time Periods

The purpose of this table is to clearly show that the time periods we have distinguished are subject to strong trends. The columns contains the five different periods that we decided on, by observing maximum and minimum values of the MSCI World Index. The first row presents the percentage of months that MSCI WI reports a positive return within each of the five time periods. The second row reports the average yearly return for MSCI WI during each of these time periods. By looking at the obtained figures, there is no doubt that the time periods, which we found, had either unambiguously bullish or bearish trends on the global stock market. The exact time periods are shown in Table II.

	Bull 1	**Bear 1**	**Bull 2**	**Bear 2**	**Bull 3**
Months with positive return (%)	70	30	70	19	60
Average yearly return (%)	18.3	-22.3	18.1	-44.0	16.0

The periods are summarized in Table II. The first period we analyze is the bullish period in the 1990s, starting from January 1995 and lasting until February 2000. Following this period comes a sharp decline and a bearish period from March 2000 until September 2002. After that, we have a look at the bullish period from October 2002 all the way to the beginning of the financial crisis in October 2007. The financial crisis will be our next bearish period, which ranges from November 2007 to March 2009. Then we will have a look at the period from May 2009 to May 2015. We consider these six years as a bull market period, even though it contains a declining period in 2011. We chose to not consider this relatively short period as a separate bear period since we believe there to be too few observations. Looking at Table I, we also see that MSCI WI yielded 16 % in the third bull period when the decline in 2011 is included, therefore we do not see any particular need to divide it.

We are aware that the stock market have been declining in the second half of 2015 as well as in the first months of 2016, and were considering to treat this as another bear period. Since we only have very few observations, we finally decided to not include it as another time period.

All sources providing hedge fund performance may contain some conditioning biases, this is because reporting data on hedge funds is voluntary, therefore no source will be comprehensive enough to include all the hedge funds (Ackermann *et al.* 1999). To minimize survivorship bias in the Credit Suisse Hedge Fund Database, funds are not removed from

Table II

Time Periods Under Analysis

This table reports the length and date specifications for each of the five time periods under analysis. The total time period is from January 1995 until May 2015, the total number of months is 245. The shortest time period under review is the financial crisis (16 months) and the longest is the succeeding bull period (75 months or 6 years and 3 months).

Period nickname	**Start Date**	**End Date**	**Nr. of Months**
Pre-IT bubble (Bull 1)	1995–01–31	2000–03–31	63
IT crash (Bear 1)	2000–04–30	2002–09–30	30
Build-up financial crisis (Bull 2)	2002–10–31	2007–10–31	61
Finacial crisis (Bear 2)	2007–11–30	2009–02–28	16
The recovery (Bull 3)	2009–03–31	2015–05–31	75
		Total number of months:	245

Table III

Number of Funds in Each Strategy Index

This table shows the number of individual hedge funds in each of Credit Suisse's strategy indices. There are 13 strategy indices in total, whereof three are sub-indices to event driven. The event driven index is a composite of the three sub-indices seen in the middle column. The Credit Suisse Hedge Fund Index, which is the main index, contains of all the funds in this table. A calculation agent designates a strategy for every hedge fund that enters the index by examination of the hedge fund's documentation and discussions with the fund's personnel.

Convertible Arbitrage:	13	Event Driven:	67	Fixed Income Arbitrage:	35
Dedicated Short Bias:	3	–*Distressed*:	24	Global Macro:	29
Emerging Markets:	49	–*Multi-Strategy*:	38	Long/Short Equity:	96
Equity Market Neutral:	15	–*Risk Arbitrage*:	5	Managed Futures:	33
				Multi-Strategy:	24

the index until they are fully liquidated or fail to meet the financial reporting requirements. A closer look at biases will be presented in a section further down in the paper.

II. Method

In the following section we describe the different methods used to measure performance. Although the retrieved data initially was on a monthly basis, we distinguish between monthly and annual returns in our equations. We have chosen to denote monthly returns with small r and annualized returns with capital R. Furthermore a bar over the letters, such as: $\bar{r}$, denotes the arithmetic mean for the returns.

To begin with, we calculate absolute returns for each hedge fund strategy index for every time period that we observe. To examine the exposure to systematic risk, we estimate the beta statistic using OLS-regression on a sample of all 13 strategy indices. The estimations are not made on every individual fund in an index. Instead we estimate the beta on a strategy index as a whole, where each index itself contains a number of funds. The number of individual hedge funds in each index is shown in Table III.

The beta for a strategy index can be estimated by:

$$\hat{\beta}_j = \frac{\hat{cov}(r, r_m)}{\hat{cov}(r_m, r_m)} = \frac{\sum_{i=1}^{245}(\bar{r} - r_i) \cdot (\bar{r}_m - r_{m,i})}{\sum_{i=1}^{245}(\bar{r}_m - r_{m,i})^2}, \tag{1}$$

where r = return of the index, r_m = return of the market proxy and i = one monthly observation.

Both the expected market return and the expected risk-free interest rate are assumed to be constant throughout the time period. From the CAPM-equation, we can solve for $\hat{\alpha}$, which is the mean excess return for a strategy index, during any time period:

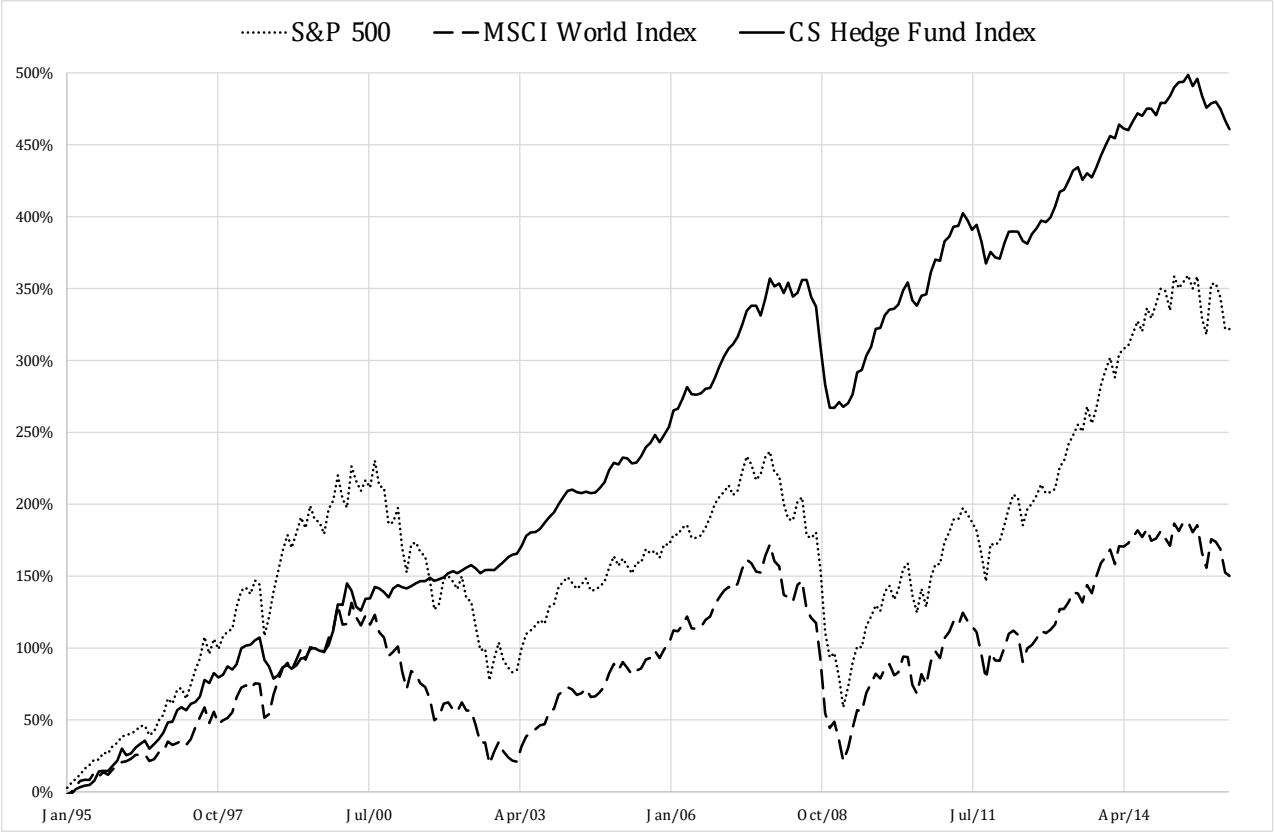
$$\hat{\alpha} = \bar{r} - \bar{r}_f - \hat{\beta} \cdot (\bar{r}_m - \bar{r}_f) = \bar{r} - C, \tag{2}$$

where $C = c(\beta)$ is the security market line and r_f = risk-free interest rate.

To calculate the expected monthly market return, we simply calculate the average monthly return of MSCI World Index during our period from January 1995 to May 2015. To calculate the risk-free interest rate, we use the average monthly returns of a U.S. 90-days treasury bill. This is widely used as a measurement of the risk-free rate and is also used in an article by Ackermann *et al.* (1999). Since risk-free interest rates can be realized on a relative

Figure 1

Cumulative Return of Credit Suisse's Hedge Fund Index vs. Market Indices 1995–2015



This figure shows the cumulative returns over time of Credit Suisse Hedge Fund Index in comparison to the common market proxy indices: S&P 500 and MSCI World. Time is on the horizontal axis and accumulated return is on the vertical axis. The Credit Suisse Hedge Fund Index is a composite of all 13 strategy indices. A quick look at the graph reveals that the CS Hedge Fund Index reports higher returns than both S&P 500 and MSCI World. The returns in the figure are compounded on a monthly basis.

short-term basis of 3 months, we use the realized risk-free interest rate for every time period instead of using a predetermined rate. The risk-free interest rate is therefore adjusted in every time period, depending on the average yield of the U.S. 90-days treasury bill.

In order to account for sampling errors in the estimation, statistical hypothesis testing is used to test whether the strategy indices report statistically significant excess return to the market. This is done using one-sided t-tests with the null-hypothesis: $\alpha = 0$ and the alternative hypothesis: $\alpha > 0$. From the tests we can see which strategies have outperformed the market the most during bull, bear and the whole period and whether the results are significant or not. We use the global MSCI World Index as our benchmark and proxy for

market return, this is the largest global stock market index and therefore commonly used as a proxy for market return.

We also examine the risk-adjusted return of each strategy index using the traditional Sharpe ratio, to see if returns adjusted for risk yield similar results. Sharpe ratios can be estimated from:

$$\hat{SR} = g(\hat{\mu}, \hat{\sigma}) = \frac{\hat{\mu}}{\hat{\sigma}}, \tag{3}$$

where $\hat{\mu} = \bar{R} - \bar{R}_f$ = risk premium of the index and $\hat{\sigma}$ = standard deviation of the index. In our analysis, the returns used to estimate the Sharpe ratios have, accordingly with standards set by other authors, been annualized from monthly returns, using:[2]

$$\begin{aligned} \bar{R} &= (1 + \bar{r})^{12} - 1 \\ \bar{R}_f &= \bar{r}_f \cdot 12 \\ \hat{\sigma} &= \sqrt{12 \cdot \hat{var}(r)} \end{aligned}$$

We also do statistical tests on the Sharpe ratios, as the returns are estimated quantities that can be subject to estimation errors. Not accounting for these errors can potentially lead to inaccurate estimations of the Sharpe ratios (Lo, 2002). Standard errors are used when conducting one-sided t-tests on the Sharpe ratios in order to determine their significance or p-values. In the Appendix, the formulas for the standard error of the Sharpe ratio are presented.

III. Empirical Results

In this section we present the results and do the analysis of our obtained results. In Section A, we present the absolute return of each strategy index in the different time periods and report which strategy that yields the highest return when risk is not accounted for. Section B presents and analyzes the results of the test for excess return in bull periods. In Section C we look at the results of the excess performance test in bear markets and Section D summarizes the results when taking the total period under consideration. In Section E, we adjust the absolute returns for risk and analyze how it affects the results. In Section F we use the results from the previous sections to derive high performing market-neutral hedge fund strategy portfolios.

[2]When you are approximating annual standard deviations from monthly ones, it is considered to be an industry standard to multiply the monthly standard deviation by $\sqrt{12}$.

A. Absolute Returns of Strategy Indices

Table IV reports the absolute returns of all hedge fund strategies during each time period. The "Total"-column to the far right shows the total accumulated return for all time periods.

Table IV

Estimated Betas and Absolute Return of Strategy Indices

This table reports the absolute return (%) of each strategy index and the composite Credit Suisse Hedge Fund Index (CSHFI) in each time period. The far right column reports the total return of each strategy index during the total time period. The table also reports the estimated betas, which measures how closely each strategy index follow the market. The beta of MSCI World Index is equal to 1.00 since it is our benchmark index and our proxy for market return. For example, a 1.00 % increase in MSCI WI should on average result in a 0.55 % increase of the emerging markets strategy index. All returns are compounded on a monthly basis.

	$\hat{\beta}$	**Bull 1**	**Bear 1**	**Bull 2**	**Bear 2**	**Bull 3**	**Total**
Convertible Arbitrage	0.19	91.4	30.4	43.9	-28.5	72.2	342.1
Dedicated Short Bias	-0.80	-36.8	52.0	-36.5	35.7	-65.4	-71.4
Emerging Markets	0.55	37.5	-4.2	157.8	-32.3	60.7	269.0
Equity Market Neutral	0.20	103.0	27.2	47.7	-42.4	22.7	169.5
Event Driven	0.28	110.2	12.0	105.6	-19.1	43.2	460.3
–Distressed	0.27	132.1	15.2	114.0	-22.5	58.9	604.8
–Multi-Strategy	0.29	98.8	10.3	103.8	-17.3	36.2	403.5
–Risk Arbitrage	0.15	73.5	11.4	43.2	-3.6	24.1	231.0
Fixed Income Arbitrage	0.14	48.2	22.1	29.0	-27.8	75.6	196.1
Global Macro	0.14	128.1	48.3	89.1	-0.9	44.8	818.6
Long/Short Equity	0.45	223.9	-11.1	91.7	-22.0	63.4	604.1
Managed Futures	-0.01	19.2	32.6	36.6	16.7	20.5	203.8
Multi-Strategy	0.16	88.6	13.7	75.9	-22.3	80.6	429.2
CSHFI	0.28	139.8	6.1	79.7	-19.5	52.5	460.8
MSCI World Index	1.00	131.5	-48.4	127.9	-55.4	106.1	150.1

The return of the CSHFI, which includes all 13 strategies, is also displayed in this table next to the return of the MSCI WI, which we include for comparison purposes.

It is obvious by looking at Table IV that there is a large variation in return between the strategies. The large differences are very clear when observing the total returns but they are

also distinguishable in each individual period. Ackermann *et al.* (1999) address the question of whether the structural advantages of hedge fund strategies can help generating superior returns to the market. They conclude that hedge funds' ability to outperform the market is dependent on the time period and strategy, which is in line with what we can observe in Table IV.

Every hedge fund strategy index, except for dedicated short bias, earned higher returns than MSCI WI in the total period. The very poor performance for dedicated short bias in the total period is not surprising, since the funds within the index have a net short exposure to the market and lose money when the market rises. On the other hand, dedicated short bias outperforms all other strategy indices in bear stock market periods. Because of the nature of this strategy, it will always be superior to the others in the bear periods and an outlier in all our tests and estimations. We therefore do not put too much effort in analyzing this index in more detail in the rest of the paper.

The returns in the total period ranges from -71.4 % for the dedicated short bias index to +818.6 % for the global macro index. MSCI WI rose 150.1 % in the same time period. CSHFI outperforms MSCI WI in the total period with more than three times (460.8 %). In the bear periods all strategy indices performed better than MSCI WI, which indicates that to some extent, they manage to hedge against down-turns on the stock market. However, worth noting is that in the first bear period only two strategy indices had negative returns, while 11 strategy indices reported negative returns in the second bear period. The composite hedge fund index declined by -19.5 % in Bear 2, which indicates a poor ability for hedge funds in general to hedge their assets in this period.

Edwards and Caglayan (2001) note that the best performing strategies in bull periods are generally also the best ones in bear markets. We do not find any clear evidence of that just by looking at the absolute returns in Table IV. For example, the long/short equity index is the best performing strategy index in Bull 1, but the worst performing index in Bull 2. The strategy index with the third lowest total return (dedicated short bias excluded) was managed futures, but it is also the only strategy index which has positive return in all examined time periods.

While CSHFI yields much lower positive returns in Bull 2 and Bull 3 than MSCI WI, the return in the total time period is still more than three times higher than MSCI WI. This seem to be because the hedge fund strategy indices declined less than MSCI WI in the bear periods. In the first bear period, the IT-crash, only two out of 13 strategy indices reported negative returns, while MSCI World Index declined -48.4 % during the period. The average return of the composite CSHFI was +6.1 % in the first bear period. Hedge funds' superior returns in the total period seem to be more a result of their ability to limit losses

than generating extreme positive returns in bull market periods.

Table IV also reports the estimated betas for each strategy index. The beta tells us how much a strategy index move if MSCI World Index changes 1 %. For example, the estimated beta for using convertible arbitrage as a strategy is 0.19. If MSCI WI increase by 1 %, the funds within the convertible arbitrage index should increase, on average, by 0.19 %. A beta of 1 indicates perfect correlation with MSCI WI and a beta of -1 indicates perfect negative correlation with MSCI WI. All betas for the strategy indices are relatively low compared to stocks. The strategy index with the highest beta is emerging markets, which has a beta of 0.55.

The managed futures index has a beta close to zero (-0.01), which indicates that the return of the funds within this strategy index are, on average, almost completely uncorrelated with MSCI WI. All strategies together have a beta of 0.28. Only by looking at the table, the size of the beta does not seem to be informative about the level of the returns.

B. Excess Performance in Bull Markets

In this section we will interpret and analyze the results of the test for excess return against MSCI WI in bull periods. In Table V we present the realized monthly returns for each strategy in excess of their respective expected returns. We have taken the systematic risk into account using the CAPM-model and examine if the strategy indices generate excess returns over the market and beat investments with similar systematic risk. In our calculations, we have set the expected market return $\bar{r}_m$ in all periods to the average monthly return of MSCI WI from 1995 to May 2015 (0.53 %). Provided in Table V are also p-values which state the probability of the alphas being greater than zero.

By looking at the alphas in the bull periods, we see that all strategy indices seem to have outperformed, or at least performed the same, as their expected return with regard to beta-risk in all three bull periods (dedicated short bias excluded). However, note that not all of the obtained alphas are statistically significant, therefore we cannot state with certainty that all strategy indices have alphas equal to, or greater, than zero.

Starting with a broad analysis of the results, we see evidence that the composite CSHFI, which have all the strategy indices combined, have statistically significant positive alphas in all three bull periods. The CSHFI had its' highest alpha in Bull 1, amounting to 1.2 %. The alpha in Bull 3 was 0.4 %, even though this value is lower than previous bull periods, it is still statistically significant on a 5 % level (p-value = 0.007). An interpretation of this finding is that, with very high probability, the Credit Suisse Hedge Fund Index outperformed the market in these three bull periods.

Table V

Excess Returns of Strategy Indices

This table presents the excess return (Jensen's alpha) for each strategy index in each time period relative to the market. We use the MSCI World Index as a benchmark for market return. The obtained alphas should be interpreted as the average monthly excess return with regards to systematic risk. The test is done with a one sided t-test, with the null-hypothesis being that the strategy indices do not report excess returns ($\alpha = 0$ in the CAPM-model) and the alternative-hypothesis that $\alpha > 0$. Provided in parenthesis are the p-value for these tests, with a * indicating significance on a 5 % significance level.

	↑ Bull 1 ↑	**↓ Bear 1 ↓**	**↑ Bull 2 ↑**	**↓ Bear 2 ↓**	**↑ Bull 3 ↑**	**Total period**
	α (p-value)	α (p-value)	α (p-value)	α (p-value)	α (p-value)	α (p-value)
Convertible Arbitrage	0.8 (0.000)*	0.6 (0.004)*	0.4 (0.009)*	-2.2 (0.960)	0.6 (0.001)*	0.4 (0.001)*
Dedicated Short Bias	-0.6 (0.799)	1.5 (0.065)	-0.7 (0.920)	2.1 (0.072)	-1.6 (0.999)	-0.4 (0.921)
Emerging Markets	0.3 (0.324)	-0.4 (0.744)	1.2 (0.000)*	-2.7 (0.991)	0.4 (0.045)*	0.3 (0.143)
Equity Market Neutral	0.9 (0.000)*	0.6 (0.000)*	0.4 (0.000)*	-3.0 (0.870)	0.0 (0.487)	0.2 (0.168)
Event Driven	0.9 (0.000)*	0.1 (0.322)	0.9 (0.000)*	-1.6 (0.995)	0.4 (0.022)*	0.5 (0.000)*
–Distressed	1.1 (0.000)*	0.2 (0.246)	1.0 (0.000)*	-1.8 (0.998)	0.5 (0.003)*	0.6 (0.000)*
–Multi-Strategy	0.8 (0.002)*	0.1 (0.401)	0.9 (0.000)*	-1.4 (0.988)	0.4 (0.050)	0.4 (0.000)*
–Risk Arbitrage	0.6 (0.000)*	0.1 (0.289)	0.3 (0.001)*	-0.5 (0.890)	0.1 (0.272)	0.2 (0.001)*
Fixed Income Arbitrage	0.4 (0.012)*	0.4 (0.000)*	0.2 (0.049)*	-2.2 (0.971)	0.5 (0.000)*	0.2 (0.019)*
Global Macro	1.2 (0.020)*	1.1 (0.001)*	0.8 (0.000)*	-0.3 (0.628)	0.3 (0.005)*	0.7 (0.000)*
Long/Short Equity	1.6 (0.000)*	-0.7 (0.920)	0.8 (0.000)*	-1.8 (0.984)	0.4 (0.038)*	0.5 (0.002)*
Managed Futures	0.1 (0.379)	0.8 (0.127)	0.4 (0.208)	0.8 (0.152)	0.0 (0.461)	0.3 (0.096)
Multi-Strategy	0.8 (0.000)*	0.2 (0.102)	0.7 (0.000)*	-1.8 (0.988)	0.6 (0.000)*	0.4 (0.000)*
CSHFI	1.2 (0.001)*	-0.1 (0.597)	0.7 (0.000)*	-1.6 (0.988)	0.4 (0.007)*	0.5 (0.000)*

Looking at the individual strategies, the best performing strategy index in Bull 1 was long/short equity, which exceeded similar investments with an average of 1.6 % per month. The global macro index had the second highest excess return in Bull 1(1.2 %).

The worst performing strategy index in all of the bull periods is not surprisingly dedicated short bias. More interesting is to look at the second worst performing strategy, which in the first bull period was the managed futures index. This strategy index only exceeded expectations with 0.1 %. Further on, if we look at its p-value (0.379), which indicates non-significance, we can not say for certain that hedge funds in this index were able to beat the market in Bull 1.

The emerging markets index had the highest alpha in Bull 2. This strategy index was up 0.9 percentage points from Bull 1, amounting to a total average of 1.2 % in the second bullish period. Meanwhile the fixed income arbitrage funds performed second to worst, having the smallest positive alpha of 0.2 %. Most of the hedge fund strategy indices have lower excess returns in Bull 2 than in the in the first bullish period.

Lastly in Bull 3, the best strategy indices were: convertible arbitrage and multi-strategy, with both of them exceeding their expectations with 0.6 % on average per month. Second worst were the equity market neutral and managed futures indices. It is worth noting that these two indices in Bull 3 were the only occasions when realized return equaled the expected return from an investment with similar systematic risk, such that $\hat{\alpha} = 0$.

To summarize, the strategy index with the highest excess return in bull markets is different in each of the three time periods. Long/short equity, emerging markets, multi strategy and convertible arbitrage are the strategy indices that are ranked number one in a bull period. None of the strategy indices that are ranked the highest in one of the bull periods are among the top three best performing in the other two periods. This finding is surprising and makes it hard for us to draw any conclusions. The worst performing strategy index in the bull periods (dedicated short bias excluded) is managed futures, which has the lowest excess return in both Bull 1 and Bull 3 and the third lowest in Bull 2.

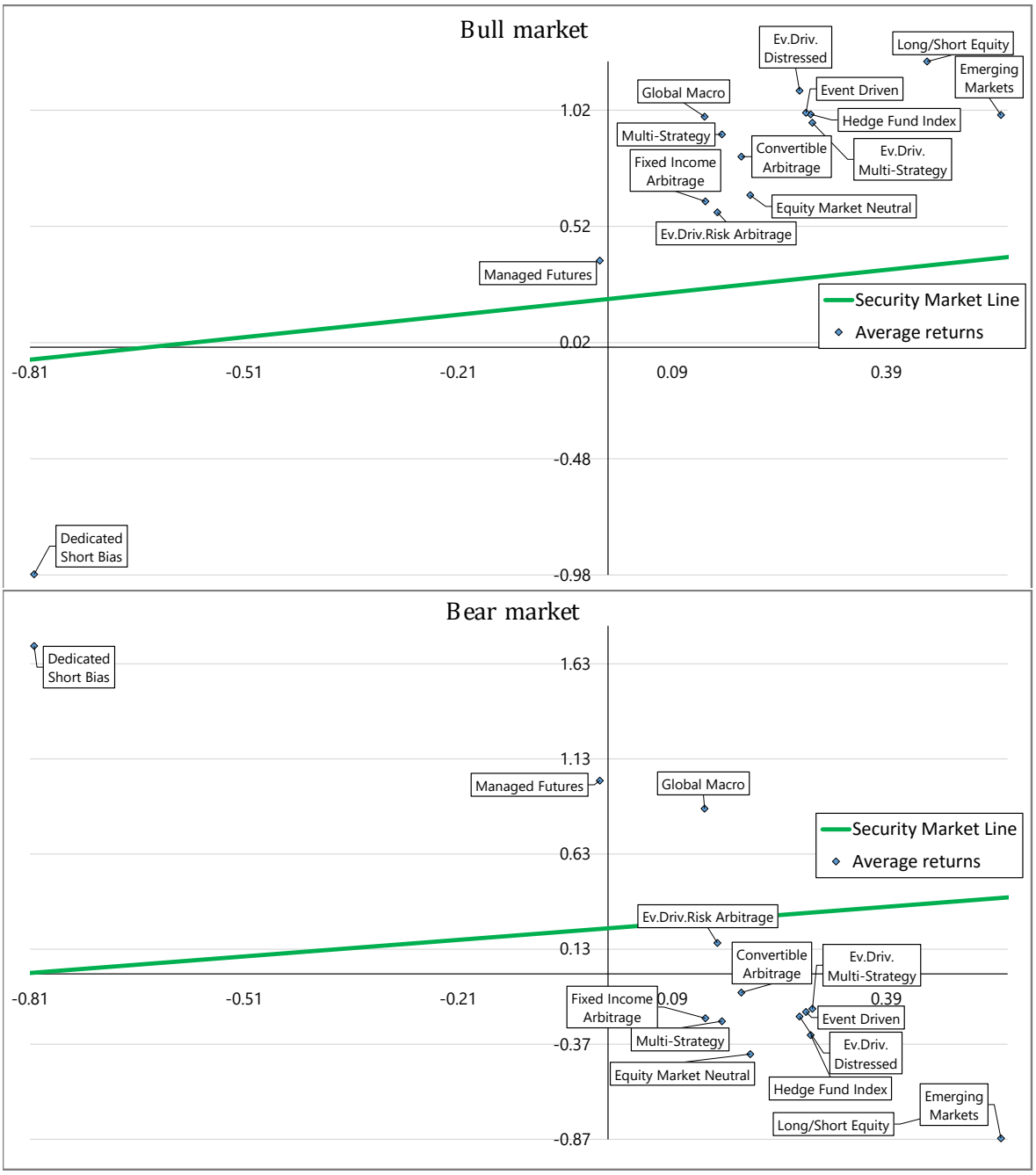
C. Excess Performance in Bear Markets

In the first bear period, two strategy indices had a negative alpha: emerging markets and long/short equity. The other 11 of Credit Suisse's hedge fund indices were able to outperform the market and report excess returns. We see this result as a sign of strength, in a period when the market declined by -48.4 %, most strategy indices seem to maintain excess returns.

Capocci & Hubner (2004) concluded that most hedge funds outperformed the market in their whole test period, which was 1994–2002, and the best performing strategy was the

Figure 2

Deviations from the Security Market Line



This figure shows how much the average monthly return for every strategy in the Credit Suisse Hedge Fund Index deviates from its expected return when considering systematic risk in bull and bear markets respectively. The top picture shows the combined bull periods and the bottom picture shows the combined bear periods. On the horizontal axes are the estimated betas and the vertical axes shows the average monthly returns. The deviation from the security market line (drawn in the figures) can be interpreted as the strategy's alpha. Expected market return is assumed to be the same regardless of bull or bear market. The risk-free interest rate is adjusted between bull and bear periods because the average yield of a 90-days U.S. T-bill varied. (*E.g.* a risk-free investment, $\beta = 0$, was expected to yield $r_f = 0.21\%$ in bull market and $r_f = 0.24\%$ in bear market.)

market neutral strategy. This is partly consistent with our findings, which indicate that almost all strategy indices outperformed the market both before and during the IT-crash. However, equity market neutral is not the best one, but it is among the top three strategies. Only three strategy indices reported statistically significant alphas during the IT-crash, the other two were fixed income arbitrage and global macro. We believe that the differences in results is likely due to the use of different databases.

The best strategy index in Bear 1 seems to be dedicated short bias, delivering a monthly excess return of 1.5 %, but it is not statistically significant (p-value = 0.065). The reason why the alpha is not statistically significant, even though it is well over zero, is because of the high volatility of the funds in this index.

However, as Table III shows, the dedicated short bias index only contains three individual funds. Our results then provides a link to other studies on selection-bias, such as the one by Atiligan *et al.* (2013). Due to the low number of funds in Credit Suisse's version of this index, it will likely not be a good representation of the population of hedge funds that are characterized by using this strategy.

The second best performing strategy index in Bear 1 is global macro with an average excess return of 1.1 %. The managed futures index comes in third place with 0.8 %, although not significant.

Looking at the second bear period, the financial crisis, alphas tends to overall be very low. We see a big difference in the size of the alphas compared to the first bear period and we can easily conclude that the strategy indices overall performed much worse in Bear 2 than in Bear 1.

The only strategy index, except from dedicated short bias, that seem to have a positive alpha in Bear 2 is managed futures, however without significance on a 0.05 significance level. The worst performing strategy indices in Bear 2 seem to be equity market neutral and emerging markets, with alphas of -3.0 % and -2.7 % respectively.

It is easy to be fooled by the low alphas in Bear 2 and draw the conclusion that the strategies have lower returns than MSCI WI. This is not the case, in fact, going back to Table IV, we see that none of the 13 strategy indices decline as much as MSCI WI during the financial crisis. The low obtained alphas in Bear 2 is a result of the fact that we use the same expected market return in both bull and bear periods in our calculations. The expected returns are therefore positive and at the same time almost all indices suffered from big declines. This explains why we obtain negative alphas, while the hedge fund strategy indices still beat the stock market on an absolute measure.

The negative alphas in general in Bear 2 tell us that the hedge fund managers ability to hedge their assets during the financial crisis was much worse than during the IT-crash. An

interesting topic for future research would be to examine the reasons why barely any hedge fund strategy managed to maintain positive returns during the financial crisis, while almost all hedge fund strategies seemed to be able to hedge, and maintain positive returns, during the IT-crash.

To summarize, the two bear periods are very different when comparing the alphas. In Bear 1, we find some statistically significant evidence for excess return while the alphas in Bear 2 indicate no significant excess returns. In the first bear period, 11 of the strategy indices seem to have positive alphas while in our second bear period, 11 strategy indices seem to have negative alphas. The worst hedge fund strategy index in the bear periods seems to be emerging markets, which has the second lowest alpha in both periods. The best performing strategy indices in bear markets (except for dedicated short bias) seem to be global macro and managed futures. Global macro has the second highest alpha in Bear 1 (1.1 %) and the third highest alpha in Bear 2 (-0.3 %). Managed futures seem to outperform expectations in both bear periods with an alpha of 0.8 %.

D. Excess Performance in the Whole Period

If we take a look at the total period from January 1995 until May 2015 in Table V, we see a similar pattern in the ranking of the performance as in the bull periods. The best performing strategy index, with the highest alpha in the total period, is global macro with an alpha of 0.7 %. This value is also statistically significant with a p-value of 0.000.

Our estimated alphas in the total period seem to correspond relatively well with what earlier studies have found. Ackermann *et al.* (1999) find significantly positive alphas in all their time periods, except in 1994–1995, with average values between 0.5 and 0.7 %. Our alphas are not significantly positive in all periods, which could be due to the bear periods, but the alpha of the composite CSHFI is 0.5 % and significant in the total period.

The beta for global macro is estimated to be 0.14. The indices that have around the same beta as global macro (convertible arbitrage, fixed income arbitrage, event driven risk arbitrage and multi-strategy) share similar systematic risk as global macro. In spite of that, they at best delivered 0.3 lower percentage points in alpha than global macro for the whole period (0.4 % for convertible arbitrage). A reason for this result is that global macro is an index that contains more volatile funds than other ones that share the same systematic risk.

Another statistically significant result for the alphas in the whole period comes from the long/short equity, event driven and event driven distressed strategies. They had betas of 0.45, 0.28 and 0.27 respectively, and on average earned excess returns of 0.5 % for long/short and event driven, and 0.6 % for the sub-strategy: event driven distressed.

In the total period the worst performing strategy is obviously dedicated short bias index. Except from that, we cannot draw any further conclusions about other worst performing strategies since many of our estimated alphas in the total period are of similar size and some are also non-significant.

E. Volatility and Sharpe Ratio

Some hedge fund strategies might be more prone to take on risk than others, which would explain the high returns seen in some of the strategies in Table IV. There is also the possibility that it is the other way around, some hedge funds might have the aim to reduce risk, which would provide a rationale for keeping slightly lower returns overall. A measure for risk in terms of volatility is the standard deviation.

In Table VI, the standard deviations of all strategies during all time periods are displayed. Since the total absolute returns for the strategies were much higher than our benchmark, MSCI WI, one could think that the hedge fund strategies in general would have higher standard deviations by taking on higher risks. However, that does not seem to be the case when examining the standard deviation in the total period. Only the dedicated short bias index shows a higher standard deviation than MSCI WI. The standard deviations of the different strategies are in all but one case lower than the market index, ranging between 1.17 for event driven risk arbitrage and 4.76 for dedicated short bias in the total time period.

Global macro, with a total return of 818.6 %, has a standard deviation of 2.60 and event driven distressed (+604.8 %) has a standard deviation of 1.81. One of the least volatile strategies is multi-strategy, which in the case of Credit Suisse's hedge funds, shows a monthly standard deviation of 1.38. A possible explanation for the low standard deviation could be that the manager can freely choose between investment strategies. This might lead to increased diversification and therefore reduced risks compared to only investing in a single asset-class or only using one strategy in all different types of markets.

The Sharpe ratios are reported in Table VII. In this table, we also include p-values, which indicates the probability of the Sharpe ratios being greater than the Sharpe ratios of MSCI WI. In the following analysis of the Sharpe ratios we focus on the Sharpe ratios in the total period, because we do not find it relevant to isolate the risk-adjusted performance to either bull or bear periods. A strategy with a high risk-adjusted return in bull periods but low risk-adjusted return in bear periods does not seem like an attractive investment. Investors looking at Sharpe ratios most likely want to know the risk-adjusted performance over a time period that involves both bull and bear periods.

We can see that when adjusting for this risk, event driven distressed is the strategy

Table VI

Standard Deviation of Strategy Indices

This table reports the monthly standard deviations of each strategy index in each time period. This is a measure of volatility (or risk). A low standard deviation indicates low risk due to small fluctuations in the return of the index. At the bottom of the table, we show the standard deviation of the composite CS Hedge Fund Index and MSCI World.

	Bull 1	**Bear 1**	**Bull 2**	**Bear 2**	**Bull 3**	**Total**
Convertible Arbitrage	1.40	1.24	1.12	4.56	1.55	1.88
Dedicated Short Bias	5.45	5.34	3.68	5.16	3.95	4.76
Emerging Markets	5.83	3.47	2.02	3.91	2.25	3.78
Equity Market Neutral	0.94	0.62	0.54	9.87	1.36	2.80
Event Driven	2.03	1.24	1.02	2.07	1.72	1.80
–Distressed	2.23	1.64	0.97	2.06	1.47	1.81
–Multi-Strategy	2.23	1.15	1.24	2.21	1.94	1.96
–Risk Arbitrage	1.45	1.18	0.87	1.40	0.94	1.17
Fixed Income Arbitrage	1.35	0.55	0.84	4.08	0.89	1.54
Global Macro	4.42	1.74	1.07	2.96	1.15	2.60
Long/Short Equity	3.58	2.52	1.56	2.96	2.02	2.70
Managed Futures	3.46	3.77	3.52	2.96	3.15	3.39
Multi-Strategy	1.24	0.77	0.95	2.71	1.11	1.38
CSHFI	2.92	1.52	1.08	2.48	1.31	2.02
MSCI World Index	3.78	4.49	2.77	6.00	4.20	4.37

index that has delivered the best risk-adjusted performance in the total sample period with a Sharpe ratio of 1.31. Worth noting is that during the financial crisis, this strategy index had the lowest Sharpe ratio of all strategies (-2.60). The Sharpe ratio in the total period remains high due to its' strong risk-adjusted performance in the other periods.

The strategy index with the second highest risk-adjusted performance is multi-strategy which had a ratio of 1.27 in the total period. During the financial crisis, multi-strategy had the second lowest Sharpe ratio. This leaves us with the interesting result that the two strategy indices with the best risk-adjusted return in the total period are also the ones with the worst risk adjusted performance during the financial crisis. It is beyond our article why these indices behave this way, but it is an interesting finding that we would like others to

Table VII

Sharpe Ratios of Strategy Indices

This table reports annual Sharpe ratios (SR). They are calculated using the average of the 3-months U.S. treasury bill for each time period as the risk-free interest rate. Hypothesis testing is done to see if the Sharpe ratios are significantly greater than the Sharpe ratio of MSCI World. Our null-hypothesis is: $SR = SR_m$ and we check if $SR > SR_m$. The p-values are presented in parenthesis. A * indicates significance on a 5 % significance level.

	Bull 1	**Bear 1**	**Bull 2**	**Bear 2**	**Bull 3**	**Total**
Annual risk-free rate (R_f)	5.02 %	3.64 %	2.84 %	1.44 %	0.08 %	2.56 %
Convertible Arbitrage	1.71 (0.000)*	1.79 (0.000)*	1.20 (0.990)	-1.43 (0.017)*	1.87 (0.000)*	0.84 (0.000)*
Dedicated Short Bias	-0.62 (1.000)	0.90 (0.000)*	-0.83 (1.000)	1.47 (0.000)*	-1.26 (1.000)	-0.49 (1.000)
Emerging Markets	0.17 (1.000)	-0.38 (0.000)*	2.56 (0.000)*	-1.93 (0.270)	1.27 (0.120)	0.42 (0.011)*
Equity Market Neutral	2.90 (0.000)*	3.03 (0.000)*	2.74 (0.000)*	-0.87 (0.000)*	0.65 (1.000)	0.30 (0.264)
Event Driven	1.49 (0.005)*	0.25 (0.000)*	3.52 (0.000)*	-2.22 (0.530)	1.43 (0.020)*	1.19 (0.000)*
–*Distressed*	1.65 (0.001)*	0.41 (0.000)*	3.97 (0.000)*	-2.60 (0.786)	1.85 (0.000)*	1.31 (0.000)*
–*Multi-Strategy*	1.21 (0.130)	0.11 (0.000)*	2.87 (0.000)*	-1.89 (0.235)	1.20 (0.227)	1.03 (0.000)*
–*Risk Arbitrage*	1.23 (0.105)	0.21 (0.000)*	1.50 (0.692)	-0.83 (0.000)*	1.14 (0.362)	0.89 (0.000)*
Fixed Income Arbitrage	0.62 (0.998)	2.44 (0.000)*	0.81 (1.000)	-1.58 (0.051)	3.18 (0.000)*	0.59 (0.000)*
Global Macro	0.87 (0.840)	2.27 (0.000)*	2.87 (0.000)*	-0.15 (0.000)*	1.84 (0.000)*	1.07 (0.000)*
Long/Short Equity	1.69 (0.000)*	-0.90 (0.000)*	2.03 (0.025)*	-1.75 (0.136)	1.30 (0.084)	0.87 (0.000)*
Managed Futures	-0.07 (1.000)	0.71 (0.000)*	0.35 (1.000)	1.12 (0.000)*	0.26 (1.000)	0.30 (0.283)
Multi-Strategy	1.85 (0.000)*	0.63 (0.000)*	2.71 (0.000)*	-1.95 (0.286)	2.61 (0.000)*	1.27 (0.000)*
CSHFI	1.36 (0.027)*	-0.21 (0.000)*	2.53 (0.000)*	-1.88 (0.229)	1.8 (0.000)*	0.97 (0.000)*
MSCI World Index	1.02	-1.67	1.59	-2.19	1.09	0.26

further investigate.

The strategy index with the worst Sharpe ratio in the total period (-0.49) is non-surprisingly dedicated short bias. Since the market and the hedge fund index have risen a lot during the total time period, it is obvious that a strategy that only makes money when financial instruments and stocks decline will have a hard time maintaining a positive risk-adjusted return when the long term market trend is upwards.

If we again exclude the dedicated short bias strategy, the two other strategies with the lowest Sharpe ratio in the total period (0.30) is managed futures and equity market neutral. The low Sharpe ratio of equity market neutral is due to the big losses during the financial crisis (this index declined most of all: -42.4 % in absolute return) and the relatively weak bull period afterwards where the index only rose by 22.7 %, while MSCI WI in comparison rose by 106.0 %.

The managed futures strategy index has a low Sharpe ratio due to the absence of time periods with high returns. The period with the highest return for "managed futures" was the bull period before the financial crisis when the index rose by only 36.6 %. Worth noting however, is that managed futures is the only strategy index with higher Sharpe ratios in bear periods than in bull periods (dedicated short bias excluded).

To summarize, multi-strategy and event driven distressed are the two best performing strategy indices on a risk-adjusted basis in the total time period. The strategy indices with the worst risk-adjusted performance in the total time period, apart from dedicated short bias, are managed futures and equity market neutral. However, even though managed futures has the lowest Sharpe ratio in the total time period, it was the strategy index with the highest risk-adjusted performance during the financial crisis.

F. The Optimal Hedge Fund Portfolio

In this section we use our results to construct market neutral portfolios. Since a primary motive of investing in a hedge fund is to hedge against falling stock prices (Edwards & Caglayan 2001), we find it relevant to make an attempt to derive high performing portfolios with zero systematic risk. Inspired by a method used by Edwards & Caglayan (2001), we rank the hedge fund strategies by their Sharpe ratios, then use the results to construct two different portfolios. They rank different hedge fund styles and then compute the weights a strategy should have in an optimal portfolio, based on their contribution to an optimally diversified stock and bond portfolio. We use a similar method, we pick the highest performing strategy indices in the total bull and bear periods respectively, equal-weight these indices in a portfolio, add a short position in MSCI World Index to remove the systematic risk, and

Table VIII

Returns of Market Neutral Portfolios

This table presents predicted and actual returns for three hypothetical portfolios during a 10-months period from 1st of June 2015 – 31st of March 2016. The portfolios are constructed to concretize the implications of our results. All portfolios are balanced with a short position in MSCI WI in order to eliminate systematic risk by making them market neutral ($\beta = 0$). The size of the short position depends on the betas of the strategy indices in the portfolios. Portfolio A consists of the two strategy indices with the highest Sharpe ratios in the total bull period and the two indices with the highest Sharpe ratios in the total bear period. Portfolio B consists of the two strategy indices with the highest alphas in the total bull period and the two indices with the highest alphas in the total bear period. Portfolio C contains the CS Hedge Fund Index which we include as a comparison. The predicted return for each strategy index is computed with CAPM, using our previously estimated alphas and betas. The predicted return for MSCI WI is negative since we short-sell the index, hence the $\beta = -1$.

Portfolio A – Strategy Indices With Highest Sharpe Ratios in Bull and Bear

	Predicted return (%)	Actual return (%)	Weights
Long: Multi-Strategy	7.2	-0.4	22%
Long: Event Driven Distressed	8.9	-8.2	22%
Long: Managed Futures	5.1	1.5	22%
Long: Global Macro	10.1	-6.2	22%
Short: MSCI World Index	-5.2	3.7	12%
Weighted zero-beta portfolio return	6.1	-2.5	100%

Portfolio B – Strategy Indices With Highest Alphas in Bull and Bear

	Predicted return (%)	Actual return (%)	Weights
Long: Long/Short Equity	8.9	-4.3	19%
Long: Event Driven Distressed	8.9	-8.2	19%
Long: Global Macro	10.1	-6.2	19%
Long: Managed Futures	5.1	1.5	19%
Short: MSCI World Index	-5.2	3.7	24%
Weighted zero-beta portfolio return	5.1	-2.5	100%

Portfolio C – The Index Portfolio

	Predicted return (%)	Actual return (%)	Weights
Long: CS Hedge Fund Index	7.8	-6.0	78%
Short: MSCI World Index	-5.2	3.7	22%
Weighted zero-beta portfolio return	4.9	-3.9	100%

The calculations of the predicted returns are explained more in detail in the appendix.

then calculate the predicted returns.

The first portfolio consists of the two strategy indices with the highest Sharpe ratios in the combined bull periods along with the two strategy indices with the highest Sharpe ratio in the combined bear periods (dedicated short bias excluded). The second portfolio consists of the two strategy indices with the highest alphas in the combined bull periods along with the two strategy indices with the highest Sharpe ratio in the combined bear periods (dedicated short bias excluded).

Even though dedicated short bias was the strategy index with the highest alpha and highest Sharpe ratio in the bear period, we do not include it in any portfolio because it is a big outlier. With a beta of -0.8 and an alpha of -1.0 in the bull period, it would not fit in well in an optimal portfolio and it would lower the portfolios' predicted returns.

In order to make both portfolios market neutral, we have to add a short position in MSCI WI to the portfolios. The size of this position depends on the average beta of the portfolio. As an example, consider a portfolio with assets worth 100 000 SEK and an average beta of 0.50. In order to make this portfolio market neutral, you would have to balance it with a short position in MSCI WI ($\beta = -1$) of 50 000 SEK. This will result in an average portfolio beta of zero.

When the portfolios are constructed, the expected returns of each strategy index and the short MSCI WI position are estimated. Taking the weights into account, we can now calculate the predicted return for the whole portfolio. The expected returns are calculated by using the CAPM-model using our estimated alphas and betas. This process is explained in more detail in Appendix. We test the performance of our optimal portfolios by comparing the predicted return to the actual return during a 10-months period from 2015-06-01 to 2016-03-31.

Table VIII shows the predicted and actual returns for the portfolios. By looking at the actual returns of Portfolio A and Portfolio B, we see that both have a negative yield of -2.5 % during the 10-months period. The MSCI WI declined by 3.7 % during the same period. When comparing the actual returns with the predicted returns, we see that neither of the portfolios managed to yield close to what we had predicted.

Portfolio C contains a long position in CSHFI and a short position in MSCI WI. This is included as a comparison, since this portfolio will not be strategy specific. We see that both predicted and actual return, turned out to be lower for this portfolio compared to A and B. This confirms that our strategy index picking for the other two portfolios was somewhat relevant.

Despite the big deviations from the actual returns, we do not see the constructed portfolios as a failure. The predicted returns are based on estimations of alphas and betas that

are derived from data over the total time period 1995–2015 (245 months). The 10-months period might just be too short to draw any conclusions about how well our optimal portfolios will work.

In these discussions it is of interest to examine if past returns are indicative of persistently good performances. If past returns are indicative for future returns, our portfolios should yield at the predicted level of return since the predicted returns are based on historical data. The results of Brown (1995), which shows that winning funds also tend to deliver a higher return in future years, supports our theory that the portfolios should yield a return equal to the predicted rate of return during a longer time period.

One should bear in mind that our constructed portfolios are hypothetical and the transaction costs for investing, or imitating, these portfolios might be high. One way to get around this problem could be to pick a high-performing hedge fund from each of the strategy indices. The predicted returns should be around the same, although the volatility might be higher if individual funds are chosen instead of all the funds in the strategy index it belongs to. Another solution could be to invest in "funds-of-hedge-funds", which is a type of fund that holds a portfolio of many hedge funds.

To summarize, we tried to construct two optimal hedge fund portfolios with zero systematic risk, which in theory should yield 6.1 % and 5.1 % respectively during a 10-months period. When we observe the actual returns of the portfolios and compare them to the predicted returns, we see that the yields were considerably lower than what we had predicted. However, the analyzed time period is only 10 months and we believe that, over a longer time period, these portfolios have the potential to yield at our predicted rate of return.

IV. Data Conditioning Biases

The unregulated nature of the hedge fund industry and the fact that hedge fund managers can choose if they want to report hedge fund performance or not makes it extremely difficult to construct a hedge fund index that does not suffer from various data-conditioning biases. One problem that might cause biased returns is the absence of rules that regulate whether a hedge fund must report their performance. This might lead to a selection bias, because of the risk that the hedge funds in an index is not a random sample from the total population of hedge funds (Atiligan *et al.* 2013).

Another type of bias that is addressed in almost every hedge fund study is survivorship bias. A commonly used definition of survivorship bias in previous hedge fund studies is: "the performance difference between surviving and dissolved funds" (Capocci *et al.* 2005). In other words, the returns reported in hedge fund indices might be biased because the

indices only include existing funds that have survived and managed to stay afloat, not the funds that go bankrupt or stop reporting their performance (Atiligan *et al.* 2013). When studying performance data of hedge fund databases, survivorship bias can be present in the form of upward biased returns, since the dataset will likely contain fewer observations of poor returns than expected (Bollen & Pool, 2009).

A third type of bias that many databases suffer from is backfilling bias. It is caused by the fact that when a new fund enters a database, the database provider often requires the fund to include its performance from previous years. Since inclusion in a database is primarily a marketing tool used by hedge fund managers, the funds that enter a database are the ones with a positive return history and thus causing an upward bias in the database (Ackermann *et al.* 1999). However, in our study we do not have to worry about backfilling bias since new funds in the Credit Suisse Hedge Fund Database are added on a going-forward basis and do not require inclusion of historical performance.

A popular method of examining the presence of survivorship bias, used by Capocci & Hubner (2004), Capocci *et al.* (2005) and Ackermann *et al.* (1999) among others, is to compare the return, median and standard deviation of the surviving funds with the dissolved funds and thereafter measure the size of the differences in order to draw conclusions. Unfortunately, the Credit Suisse Hedge Fund Database that we use do not report sufficient information that we need to conduct the test for survivorship bias. Credit Suisse states that they are minimizing the problem with survivorship bias by not removing the funds from the indices until they are fully liquidated. However, they also state that they exclude funds from the indices that do not comply with the financial reporting requirements and we find it difficult to believe that hedge funds in the liquidation process always continue to provide performance data. Hence, we believe that there is a possibility that survivorship bias is still present in the Credit Suisse Hedge Fund Indices. Since we cannot do the tests ourselves, we will present brief results from other studies that have had access to more comprehensive datasets and conducted survivorship bias tests.

Ackermann *et al.* (1999) present interesting results, as they find direct evidence for survivorship bias, but however this bias is countered by a self-selection bias. They explain that the self-selection is present because funds with superior performance may voluntarily withdraw from the database because they can raise sufficient funds on their own without inclusion in a database, and this will cause a downward bias in the data. Their conclusion is that the upward bias caused by survivorship and the downward bias caused by self-selection appear to offset each other, thus survivorship bias does not pose a problem.

The reader should bear in mind that these tests were conducted on a different dataset and from another database so the results might not be completely transferable to our data.

However other studies, e.g. Capocci *et al.* (2005) and Capocci & Hubner (2004), where they ran similar tests have found that the impact of survivorship bias was kept at very reasonable levels. Hedge fund data after 1994 appears to contain less survivorship bias, because before 1994, databases only kept track of surviving funds (Capocci & Hubner 2004). Hendricks *et al.* (1993) note that hedge fund data for the pre-1994 period contain obvious survivorship bias that is very likely to hinder statistical inference.

In this discussion it is also interesting to examine contributing factors to an individual funds survival as a business. Specifically, we want to look at factors that affect survival of hedge funds. One explanation lies in the compensation structure for managers that are typically seen in hedge funds. Managers usually receive incentive fees for earnings above a watermark and have to make up for past losses before they can earn a profit. If returns fall below the watermark for a period, the manager will not be as willing to invest new money, which ultimately leads to its demise (Brown, 1995).

V. Conclusion

The popular perception is still to this day that hedge funds are a relatively homogenous group that follows a well-defined market neutral strategy. As have been shown throughout the paper, this happens to not be the case, since there instead is a large number of investment strategies used by hedge fund managers. This article investigates the performance between 13 different hedge fund strategies during a 20-years long period from 1995 to 2015. We first determine five distinct sub-periods that have been particularly bullish or bearish on the global stock market and then set out to find the best performing hedge fund strategies in both the bull and bear markets.

With data from the Credit Suisse Hedge Fund Database, reporting monthly returns for 13 strategy indices, we evaluate each index' performance by testing for excess returns using the CAPM-model and analyzing their risk-adjusted returns by calculating Sharpe ratios.

The analysis of performance shows that most hedge fund strategies in the Credit Suisse Hedge Fund Index report statistically significant excess returns, compared to the market in the total time period. There are big differences in performance amongst the individual strategies as well as potentially an enormous issue with data bias. The return for the composite index during the total time period is 460.6 %, compared to 150.1 % for MSCI World Index, despite Credit Suisse's index having a lower volatility. It does not in any regard seem likely that almost all hedge fund strategies would perform better than the MSCI WI, therefore we believe that our results are overly positive.

Global macro is the best hedge fund strategy over the total time period when risk is not

accounted for. When risk is accounted for, the best performing hedge fund strategy in the total time period is event driven distressed, closely followed by multi-strategy.

We cannot draw a clear conclusion about which strategy is best in bull periods, because the strategy indices with the highest excess return were different in each of the periods. The strategies that performed the best in one bull period also performed relatively poor in the other two periods. The strategy indices with highest alphas in one of the bull periods are: long/short equity, emerging markets, multi-strategy and convertible arbitrage. The worst strategy, by a mile, in the bull periods is non-surprisingly dedicated short bias. The second worst strategy is managed futures, due to it's modest absolute returns.

In the bear periods, the overall difference in hedge fund performance between the two examined periods is remarkable. Almost all hedge fund strategies performed well and reported positive absolute returns during the IT-crash, while barely any strategy could maintain positive returns during the financial crisis. The best hedge fund strategy in bear markets is dedicated short bias. The second best strategy during the bear periods is managed futures, which is also the only strategy with positive returns during all five examined time periods.

We made an attempt to construct high-yielding market neutral portfolios by combining the best performing strategy indices and then predict their returns. As our predictions did not correspond with actual returns, we conclude that the negative result was likely due to too few observations.

As a final comment on our results, we believe that our underlying data might be subject to large biases due to the fact that hedge funds with poor performance do not have to disclose their performance. This makes it difficult to prove that hedge funds are in fact performing better than the market. However, the results of our thesis clearly highlights the performance differences between the strategies in Credit Suisse's hedge fund database.

This study contributes to existing research by analyzing hedge fund performance during multiple long-term bull and bear periods on the market and by including data from the financial crisis, when hedge funds performed poorly. Many other studies on hedge fund performance were conducted in the 1990s, while ours presents results that are more up-to-date. The main lesson to be drawn from this paper is that hedge funds use many different strategies and the performance varies greatly, depending on which strategy a fund uses. An investor that is considering investing in a hedge fund should be aware of how the risk exposure and return outcome vary between the different strategies. Our paper can be used as a basis before making a decision about which type of hedge fund to invest in.

One thing that is beyond the scope of this study is breaking down each hedge fund strategy and doing a more in-depth analysis of the determinants of the returns. Another interesting point, which we do not treat in this paper, is analyzing why many hedge funds

managed to maintain good performance during the IT-crash but not during the financial crisis. We leave these two areas open and encourage other financial analysts to investigate it further.

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APPENDIX

Sharpe Ratios' Standard Errors

When doing hypothesis testing and generating a p-value, we first assume that the returns are independent and identically distributed. Since the Sharpe ratio function, $SR = g(\mu, \sigma)$, takes two normally distributed variables as inputs, we have to use a special approach to calculate the standard errors. This method is described by Andrew W. Lo (2002), who shows that the Sharpe ratio variance is weighted by the variance of the inputs:

$$var(SR) = (\frac{\delta g}{\delta \mu})^2 \sigma^2 + (\frac{\delta g}{\delta \sigma^2})^2 2\sigma^4$$

The standard error for the Sharpe ratio can then be approximated to:

$$\hat{SE}(\hat{SR}) = \sqrt{(1 + \frac{1}{2}\hat{SR}^2)/n},$$

where n is the number of observations in the sample and $\hat{SR}$ is the Sharpe ratio calculated using Equation 3.

Strategy Indices Ranking and Calculations of Predicted Return

Table IX below shows the ranking of the top 5 highest performing strategy indices in the total bull period (Panel A) and the total bear period (Panel B). In the left column, they are ranked by their alpha and in the right column they are ranked by their Sharpe ratio. Only the top 5 strategy indices are included in the ranking of performance, as only the top 2 are of interest. When constructing the portfolios in Section III–*F*, the two highest ranked strategy indices were chosen from each performance measurement.

For Portfolio A, we included the two indices with the highest Sharpe ratio in bull and bear markets respectively. We did the same with Portfolio B, but in this portfolio we used the indices with the highest alpha instead. We choose to exclude dedicated short bias, even though it had the highest alpha and Sharpe ratio in the bear periods. Because of it being a big outlier, with a beta of -0.8 and an alpha of -1.0 in bull periods, it would not fit in well in an optimal portfolio. It would also significantly lower the portfolios' predicted returns.

To calculate the predicted monthly return for each strategy index in the portfolios, we use the following equation:

$$E[r] = \hat{\alpha} + \bar{r}_f + \hat{\beta} \cdot (\bar{r}_m - \bar{r}_f),$$

Table IX

Strategy Indices Ranking

Panel A – Bull Markets				
Ranking:	**Strategy**	**Alpha**	**Strategy**	**Sharpe**
# 1	Long/Short Equity	0.9	Multi-Strategy	2.33
# 2	E.D. Distressed	0.8	E.D. Distressed	2.01
# 3	Global Macro	0.7	Event Driven	1.76
# 4	Event Driven	0.7	Convertible Arbitrage	1.61
# 5	CSHFI	0.7	CSHFI	1.50
Panel B – Bear Markets				
Ranking	**Strategy**	**Alpha**	**Strategy**	**Sharpe**
# 1	Dedicated Short Bias	1.8	Dedicated Short Bias	1.12
# 2	Managed Futures	0.8	Managed Futures	0.83
# 3	Global Macro	0.4	Global Macro	0.65
# 4	E.D. Risk Arbitrage	-0.1	E.D. Risk Arbitrage	-0.29
# 5	Convertible Arbitrage	-0.4	Equity Market Neutral	-0.37

where $\hat{\beta}$ is the strategy index' estimated beta, which are shown in Table IV, $\bar{r}_m$ is the average monthly return of MSCI WI from 1995 to 2015 (0.53 %) and $\bar{r}_f$ is the average monthly return of the U.S. 90-days T-bill during 1995–2015 (0.21 %).

We use the estimated $\hat{\alpha}$ from the total time period in our predictions, not any of the estimations during only the bull or bear periods. We do this because we do not know the direction of the market in the future and therefore have to use the alpha that is estimated during the total time period.

After we have calculated the monthly predicted returns we use the following formula to convert them into 10-months predicted returns:

$$\bar{R} = (1 + \bar{r})^{10} - 1$$