Lund University School of Economics and Management

Hedge Fund Strategies

How does risk exposure vary between them?

Department of Economics

Bachelor Thesis

Author: Niklas Linnér Jerreling

Tutor: Erik Norrman

May 25, 2016

Table of Contents

Foreword

I would like to thank my tutor Erik Norrman for all the helpful advice and instructions during the process of performing this research and writing this thesis.

1. Introduction

1.1. The research background

September of 2008 became the start of the worst recession for 80 years. Who bears the most blame is debatable but there is consensus that too much risk was taken on account of incorrect expectations of the future. This caused investors to lose a lot of money (The Economist, 2016).

In the light of this global financial crisis it is clear that even financial experts cannot predict every aspect of the future. What started in the US spread globally with not least stock market indices plummeting consecutively. This shows the interdependence of the financial markets. If you want to invest in them you will be exposed to risk factors, both regional and global, which can be difficult to predict.

Keeping the discussion above in mind this research will turn its attention to a popular form of investing in the financial markets, which are funds. When investing in funds one let professionals worry about the risk factors and hope that they are clever enough to generate returns according to expectations. The main idea of funds is investment pooling and fund managers invest capital on behalf of the clients (Bodie, Kane & Marcus, 2014).

Mutual funds still manage the majority of the capital in the securities markets. Nevertheless hedge funds have generated far better growth rates during the last decade (Bodie et al., 2014). As a result assets under hedge fund management increased from 200 billion US Dollar to 2 trillion US Dollar between 1997 and 2012 (Bodie et al., 2014).

Mutual funds and hedge funds differ in several ways. Whilst the mutual funds are subject to regulations such as limited use of leverage, no short positions taken, disclosure of investment policies etc., hedge funds are relatively free from such regulation. As a result hedge funds have become frequent users of derivatives for arbitrage strategies, hedging and speculation. Short selling is also a common feature with hedge funds. This gives hedge fund managers the possibility to develop more advanced and unconventional investment strategies (Hull, 2012).

However according to a recently published report by the research group Preqin, global investors are planning to decrease the exposure to hedge funds in 2016. This is due to

disappointing returns the previous year. The fees charged by hedge funds, sometimes as high as 2% of assets and 20% of profits, have also come into question (Financial Times, 2016).

1.2. Defining the research

Based on the discussion in the introduction the nature of hedge funds should give them a better chance of showing positive returns, no matter which direction financial markets move in. Yet the limited disclosure of investment policies to the public makes it hard to predict and evaluate performance.

Therefore it is interesting to study how market risk factors effect the return of hedge funds. At the same time it is interesting to investigate how the effects of these risk factors may vary across different hedge fund strategies. In this research the market risk factors are represented by the equity market, the bond market and currency pairs. To define the research further the aim is to answer the following questions:

- *How are hedge fund returns related to market risk factors?*
- *Does exposure to market risk factors vary across hedge fund strategies?*

1.3. Purpose of the research

The purpose of this research is to investigate the dependence between hedge fund returns and market risk factors, which is to relate returns to the risk incurred. It is also to investigate if this dependency is conditioned on the strategy employed by the hedge fund.

1.4. Limitations

The data on hedge fund returns does not date back as long as for the market risk factors considered. Because of that the research period in this study can only go back as long as 1994 which is when the hedge fund indices investigated were first reported.

Also there are larger databases with a more complete description on the investment policies of every hedge fund included. This would help make the analysis more accurate as the strategy definitions discussed in the next chapter are still quite broad. Unfortunately I have not managed to find one of these databases without a significant subscription fee. As a student conducting a research without funding my best option was to work with publically available data.

Another limitation is the likely presence of backfill and survivorship bias in hedge fund data (Bodie et al., 2014). The possible effect of these features has been taken into consideration and will be described further in the data section.

Finally the market risk factors considered are retrieved from the US financial markets. This decision is based on both previous research and my own interest but also the principle of matching data volume with the time limitation of the research.

2. Explaining Hedge Funds and defining Strategies

2.1. Directional and Non-directional Strategies

Hedge funds are usually set up as private partnerships which make them subject to minimal regulation from financial supervisory bodies such as the SEC, Securities and Exchange Commission, in the US. Hedge funds are also normally structured as limited liability partnerships and provide marginal information about their investment strategy and portfolio composition to the public. Just like with mutual funds the idea behind hedge funds is investment pooling. However hedge funds are generally only open to high net worth investors with a minimum investment limit of between 250,000 US Dollar and 1 million US Dollar (Bodie et al., 2014).

Although it may be difficult to define hedge funds as a group it is possible to outline two general strategy categories, directional and non-directional. A directional strategy is a bet that certain sectors of the financial markets will outperform others. The non-directional strategies are designed to take advantage of, what is perceived as, temporary mispricing of securities (Bodie et al., 2014).

2.2. Investment Strategies

The investment strategies described in this section are the ones included in the database used to collect empirical data on hedge fund returns for this study.

2.2.1. Convertible Arbitrage

A Convertible Arbitrage strategy is based on a realization of a spread between interrelated securities. One or several securities of the spread is a convertible fixed income instrument whilst remaining securities are non-convertible instruments. Usually these instruments originate from the same issuer (Hedge Fund Research, 2016).

The securities traded in the Convertible Arbitrage strategy are normally convertible bonds and stocks. A convertible bond can be regarded as an ordinary bond with a call option on the underlying stock. Convertible Arbitrage funds usually follow a market neutral strategy, i.e. no speculation that the market will move either up or down, it would involve a position in the

convertible bond balanced with an opposite position in the stock. If for example the convertible bond is regarded as underpriced, the fund buys it and hedges the exposure to declines in the stock price by short selling the stock (Bodie et al., 2014).

2.2.2. Distressed Securities

The Distressed Security strategy is a so called event driven strategy. The investment process attempts to profit from primarily corporate fixed income instruments trading at discounts to their value at issuance. Formal bankruptcy proceedings are usually the explanation for the discount on the securities. The securities traded are mainly debt instruments but related equity exposure may also be maintained. Hedge fund managers usually negotiate with the management of the involved corporates for the exchange of owned securities for alternative instruments which include equity, swaps of debt or other hybrid securities (Hedge Fund Research, 2016).

2.2.3. Equity Long/Short

An Equity Long/Short strategy maintains positions on both sides of the market, i.e. long positions are offset by short positions. The securities traded are mainly equity and equity derivatives. Portfolio compositions may vary in terms of net long or short exposure, leverage ratios and investment time horizons. At least half the portfolios are usually invested in equity and some hedge funds may be entirely equity invested (Hedge Fund Research, 2016).

Strategies can be dedicated to diversifying or focused on explicit sectors which are perceived as likely to outperform the rest of the market. Investment focus may also be established on regions like the US or European markets. By implication this strategy is not meant to be market neutral (Bodie at al., 2014).

2.2.4. Equity Market Neutral

Hedge funds which implement an Equity Market Neutral strategy usually analyze security price data using quantitative techniques. The objective is to determine future price movements and relationships between these securities. Portfolios can be constructed to be market neutral to one or multiple market variables such as the stock market in currency or

beta terms. Leverage is commonly used to increase the possible returns of the positions to which capital has been committed.

Trading strategies can involve technical analysis of price movements or a more opportunistic approach where investment managers try to benefit from recently published information. The belief is that this information has not been fully or accurately incorporated into the price of the security. A common characteristic of these hedge funds is that the net exposure, long or short, normally do not exceed 10% of the capital invested (Hedge Fund Research, 2016).

2.2.5. Event Driven Strategy

An Event Driven strategy is an opportunistic approach based on a variety of investment methods depending on the outlook of the market. Primarily the portfolio composition may include both long and short positions in equity and equity derivatives. Investments can be diversified or concentrated to explicit sectors subject to views on the future of the market.

Levels of net exposure and leverage ratio can vary broadly and investment decisions can be based on either technical or fundamental analysis or a combination. Event Driven strategy hedge funds usually don not commit more than 50% of the capital invested to a single strategy (Hedge Fund Research, 2016).

2.2.6. Fixed Income Arbitrage

The Fixed Income Arbitrage strategy attempts to profit from spread created by price anomalies in related interest rate securities. Normally the securities traded are government and or corporate bonds. Employing this strategy typically involves recognizing a spread between a corporate and a risk-free government bond or between various sovereign bonds.

Fixed Income arbitrage strategies can include both fundamental and quantitative analysis. The strategies focusing on spreads between sovereign bonds however predominantly implement a fundamental approach with top-down macro-economic influences. The hedge funds employing this strategy would normally invest a minimum of 50% in the sovereign bond markets but keep net exposure lower than other similar strategies based on macro-economic predictions (Hedge Fund Research, 2016).

2.2.7. Fund of funds

The Fund of Funds strategy is a diversification approach where a hedge fund invests in several others. The objective is to take positions in the market in a fashion which decreases the overall volatility of the portfolio compared to investing as a single fund.

Fund of Fund managers have discretion in choosing which other strategies, i.e. hedge funds, to invest in. Capital may be allocated to multiple funds of similar strategies or to funds which employ different strategies. The minimum investment limit may be lower in a fund of funds than other hedge funds. This strategy may therefore offer diversification possibilities to investors with less capital committed (Hedge Fund Research, 2016).

2.2.8. Global Macro

With the Global Macro strategy approach hedge funds will base investment decisions on predictions of macroeconomic variables. The view on these variables will imply an impact on stock, fixed income, currency and commodity markets. A diversity of techniques may be implemented such as combinations of top down fundamental and bottom up technical analysis. The investment time horizons can be either short or long-term depending on the current market conditions.

Even if fundamental characteristics of a company are important indicators for equity trading global macro hedge funds they will use the predictions of macro-economic variables as the predominant investment thesis for these securities (Hedge Fund Research, 2016).

2.2.9. Merger Arbitrage

The Merger Arbitrage strategy is an event driven approach where the objective is to profit from securities related to companies currently involved in a corporate transaction. Merger arbitrage hedge funds primarily engage in announced transactions and the exposure is usually limited to situations where no formal statement of a transaction has yet been made.

Throughout a business cycle a merger arbitrage hedge fund will normally invest 75% of their capital in announced transactions (Hedge Fund Research, 2016).

3. Previous Research

3.1. Strategy analysis on funds

Sharpe (1992) investigates mutual fund performances dependency on strategy. Sharpe employs a multiple regression model where fund returns are regressed on indices representing a variety of 12 asset classes. The estimated coefficients for each asset class measured its contribution to the overall return and hence an investment style can be derived. Sharpe (1992) concludes that mutual fund returns are highly correlated to the returns of major asset classes. The fraction of the return that the regression cannot explain is accredited to security selection within the asset class and or to market timing.

Fung and Hsieh (1997) propose an extension to Sharpe's 12 factor model to better explain fund returns not correlated with the returns of major asset classes i.e. hedge fund returns. The author's model produces reasonably high explanation for 85% of mutual fund and 40% of hedge fund returns, hence showing the importance of developing more sophisticated models for investigating hedge funds.

Bodie, Kane and Marcus (2014) further explain how the fund style analysis introduced by Sharpe is better suited to mutual funds than hedge funds. Since hedge funds are allowed to take short positions in assets the coefficient estimations should not be constrained to be non-negative. They still show significant results on hedge fund return exposure using a linear model. The authors conclude that Long/Short equity fund returns are dependent on the S&P500 index and that Convertible and Fixed Income Arbitrage funds are dependent on US Treasury rates.

3.2. Extended strategy analysis on hedge funds

Fung and Hsieh (2001) conclude that hedge fund returns are difficult to explain using linear models. They use combinations of options, e.g. lookback straddles, to model the proposed option such as returns of hedge funds implementing a so called trend-following strategy. Trend-following is a self-described strategy uncorrelated to equity, bond, commodity and currency indices. The results show that returns for funds following this strategy tended to be best during both the best and the worst performing months of the financial markets. The

authors demonstrate that the lookback straddles better explain the hedge fund returns than typical asset indices.

Agarwal and Naik (2004) show that hedge funds with investment focus on equity display payoffs similar to a short position in a put option with the market index as the underlying asset. As a consequence these funds bear significant left-tail risk ignored by the frequently used mean-variance framework. Agarwal and Naiks (2004) value-at-risk framework shows that the mean-variance framework underestimates this left-tail risk.

Fung and Hsieh (2011) shows that Long/Short equity hedge fund returns conform to a four-factor model using the return of the equity market, the spread between large and small cap stocks, the spread between value and growth stocks and momentum. Another finding of the study is that the data shows no exposure to dynamic option-like factors, unlike some other studies on hedge fund strategies and returns.

After adjusting for the risk associated to each risk factor, 20% of the hedge funds display significant positive alpha values over time. However the authors show that decay of alpha over time is evident. According to the study it is also evident that observed alphas do not appear to originate from the other risk factors. Instead the alpha values are market volume related. The correlation with alpha is positively correlated to market volume and negatively correlated to short sale volume.

Billio, Getmansky and Pellizon (2012) find that hedge fund index returns are dependent on whether the equity market is volatile or tranquil. The authors include a measure of implied volatility on the S&P 500, the VIX, to capture these dynamics. The results suggest that several hedge fund strategies actually change exposure to common risk factors over time, depending on market conditions such as the volatility of the equity market. The exposure to several risk factors can be zero in tranquil times and then significant during volatile time periods. The hedge funds show explicit exposure to the Small-Large risk factor in periods of market downturns which suggest that the Small-Large factor capture liquidity risk.

Bali, Brown and Caglayan (2014) examine how macroeconomic uncertainty effect returns in different hedge fund strategies. Alternative measures of macroeconomic risk are introduced based on the time-varying volatility of common macroeconomic risk factors. These alternative measures generate uncertainty betas upon which hedge fund excess returns are

regressed. The authors conclude that macroeconomic risk is a stronger determining factor, than standard measures to risk, for cross section hedge fund returns. The study also shows that managers of so called directional and semi-directional hedge funds have the ability to time changes in portfolio exposure to respond to macroeconomic risk. They decrease exposure to macroeconomic risk factors when the risk increases and vice versa. However managers of so called non-directional hedge funds do not show that same timing ability.

Bussière, Hoerova and Klaus (2015) investigate the commonality across hedge fund strategy returns. The study shows that hedge funds with high commonality in returns where typically exposed to equity-orientated risk factors. The authors conclude that increased exposure to emerging markets equity, between 2003 and 2006, increased commonality. The results of the study also suggest that during this upmarket period between 2003 and 2006, investment in assets with high downside and risk exposure increased commonality further. Due to commonality, the authors argue, various hedge funds did then not offer the diversification benefits to investors that they claim to do.

4. Theoretical framework

4.1. Holding Period Return

When investing in an asset the return of investment will depend on the asset price paid at the beginning of the holding period and the asset price when it is sold. The time horizon of the investment is called the holding period. The holding period return is defined as:

$$HPR = \frac{P_t - P_{t-1}}{P_{t-1}}$$

HPR is the holding period return measured in percentage terms, P_t is the asset price at the end of the holding period and P_{t-1} is the price at the beginning. This definition of holding period return treats any cash dividends during the investment period as if they were paid at the same time as the asset is sold. Therefore any reinvestment income between the day when the dividend is paid and the end of the holding period is ignored (Bodie et al., 2014).

4.1.1. Hedge Fund Return and Liquidity

As mentioned above hedge funds have in general been outperforming mutual funds during the last decade. According to some researchers this may be due to the fact that hedge funds tend to hold more illiquid assets than for example mutual funds. As illiquidity is regarded as a risk investors will not tolerate holding illiquid assets unless they are compensated with higher returns. Hedge funds often implement lock-up periods of as long as several years during which investors cannot withdraw their capital. This creates such opportunities to invest in illiquid assets. When analyzing hedge fund returns this is important to keep in mind since high returns may be caused by illiquidity compensation rather than excellent trading skills (Bodie et al., 2014).

4.2. Volatility

Volatility, or standard deviation, of the return of an asset is a measure of risk. Standard deviation is defined as the square root of the variance which is the expected value of the

squared deviations from the expected return of the asset. The further historical outcomes of returns have been from the expected return the higher the volatility estimation. The volatility of the rate of return does not differentiate between positive or negative rates of return, it is simply a measurement of deviation from the mean. Volatility is defined as:

$$\sigma^2 = \sum p(s)\ [r(s)\ - E(r)]^2$$

σ is the standard deviation, $\sum p(s)$ represent the probabilities for different outcomes s, $r(s)$is return of outcome s and $E(r)$ is the expected, or mean, return of the asset (Bodie et al., 2014).

It is important to notify that, other things being equal, asset returns increase with the time horizon over which they are measured. This calls for a standardized period over which volatility is quoted. Normally volatility is quoted on an annualized percentage basis. As variance is proportional to time it follows that standard deviation is proportional to the square root of time. This implies that in order to compare for example monthly volatility with annualized volatility one multiplies the monthly figure with the square root of 12 (Dowd, 2005).

4.2.1. Implied Volatility

In the Black-Scholes-Merton option pricing formula the volatility of the stock price cannot be observed. In theory one can compute an estimated volatility from historical stock prices. In practice however traders usually use what is known as implied volatility. This is a measure which implies a specific volatility of the stock given its current option price. Implied volatility is therefore the markets forward looking measure of volatility for the specific asset (Hull, 2012).

The Chicago Board Options Exchange, CBOE, publish indices of implied volatility. Amongst others the CBOE publish the so called VIX which is an implied volatility index of 30-day options with the S&P500 index as the underlying asset. It is calculated from both call and put options on the S&P500 and is a popular index for investors (Hull, 2012).

4.3. Sharpe Ratio

The Sharpe ratio relates investment returns to the risk incurred. This ratio measures the risk premium and standard deviation of excess returns compared to the safe T-bill rate risk and return. The ratio is defined as:

$$Sharpe\ ratio = \frac{Risk\ premium}{Standard\ deviation\ of\ excess\ return}$$

The risk premium is the excess return, i.e. total return less the risk free T-bill rate, and the standard deviation of excess returns is the volatility of these returns. Since the Sharpe ratio divides risk premium, which rises proportionally to every unit of time, with volatility which is proportional with the square root of every unit of time the Sharpe ratio will be higher when annualized the higher the frequency of returns. This implies that when annualizing monthly Sharpe ratios the numerator is multiplied with 12 and the denominator with the square root of 12 (Bodie et al., 2014).

4.4 Multiple Regression Analysis

The multiple regression model is designed to explain a linear relationship between multiple independent variables and a dependent variable. Using appropriate data the objective is to determine if and to what extent the independent variables explain the dependent variable. The independent variables can be either stochastic or non-stochastic. A stochastic variable have random components, which cannot be observed, effecting its value. A non-stochastic variable, however, is predetermined and we can observe its value before conducting the regression analysis (Dougherty, 2011).

For every independent variable included the model will yield an estimation of a parameter β. The value of this estimation explains how this independent variable and the dependent variable are interrelated. The β value for each independent variable respectively is that variables coefficient of slope determining its contribution to the overall linear

relationship. This parameter estimation should be interpreted as the marginal effect of each independent variable. The regression analysis will also determine an intercept, α, and a disturbance term, u. The intercept should be interpreted as the value of Y_t if all β values are zero. The disturbance term is a stochastic variable acknowledging the fact that the model in general cannot fully explain the dependence between the variables (Dougherty, 2011).

The multiple regression analysis equation for observation t is defined as:

$$Y_t = \alpha + \beta_1 X_{1t} + \ldots + \beta_k X_{kt} + u_t$$

Y_t is the dependent variable, α is the intercept, $\beta_1, \ldots, \beta_k$ are k parameters X_{1t}, …, X_{kt}, are k independent variables and u_t is the disturbance term. The following assumptions are made:

1. The model is linear and set up correctly.
2. The sample contains independent variables with some variation.
3. The expected value for the disturbance term is zero for all t.
4. The disturbance term is homoscedastic.
5. The disturbance term is not autocorrelated.
6. The disturbance term is normally distributed.

4.5 Ordinary least squares

For every observation t the estimation of the dependent variable, denoted $\hat{Y}_t$, will normally differ from the true value of the variable Y_t. The difference between these values equals the value of the disturbance term u_t for that data sample t. This estimation of the disturbance term, also called the residual, is denoted ε_t.

The objective of the multiple regression analysis is to minimize the difference between Y_t and $\hat{Y}_t$. A common method of solving this mathematical minimizing problem is called OLS, ordinary least squares. This method will minimize the sum of all residuals squared and

consequently compute the equation of the line best fitted to the data. For every multiple regression analysis a so called goodness of fit is calculated. This measurement, denoted R^2, yields an output between 0 and 1 where a score of 1 means that the independent variables explain the variation in the dependent variable with 100% accuracy and a score of 0 means that 0% is explained (Dougherty, 2011).

4.5.1 Autocorrelation

When condition 5 of the model in section 4.4 is not satisfied the disturbance term u_t is subject to autocorrelation. This is a phenomenon which usually only occurs when conducting regression analysis on time series data. As mentioned before the disturbance term is generated by the effects of every independent variable not included in the multiple regression analysis model. If the value of the disturbance term in any observation *t* is to be independent of the previous value in observation t_{-1}, the value of any variables not included in the model must be uncorrelated to their respective values in the previous observation (Dougherty, 2011).

One can encounter both positive and negative autocorrelation. Positive autocorrelation is when the value of the disturbance term, i.e. the distance between observation *t* and the line best fitted to the data, persists with either net positive or negative effect for a number of successive observations. If the disturbance term were truly stochastic this pattern would most likely not occur. Negative autocorrelation is when successive values of the disturbance term shows negative correlation. This implies that a positive value in observation *t* most likely would be followed by a negative value in observation t_{+1} and vice versa (Dougherty, 2011).

4.5.2 Consequences of autocorrelation

The consequences of autocorrelation for the Ordinary Least Squares method are in general that whilst the estimated coefficients are unbiased, the method is inefficient because one can find an alternative regression technique that yields estimated coefficients with lower variances. This implies that with autocorrelation in data the uncertainty of the estimations

will be biased downwards which effect results so that one cannot tell whether they are significant or not (Dougherty, 2011).

4.5.3 Durbin-Watson test

The Durbin-Watson test to detect autocorrelation is based upon the assumption that the disturbance term follows the process:

$$u_t = \rho u_{t-1} + v_t$$

u_t is the disturbance term, ρ is the correlation between the disturbance term from the previous observation and v_t is a new disturbance term where the assumption is made that it is distributed according to the same principles as in section 4.4. This model implies that if ρ = 0, then u_t = v_t and the disturbance term is not autocorrelated. Consequently if $\rho \neq 0$ the disturbance term is autocorrelated (Dougherty, 2011).

The so called Durbin-Watson d-statistic is defined as:

$$d = \frac{\sum_{t=2}^{T}(\varepsilon_t - \varepsilon_{t-1})^2}{\sum_{t=1}^{T}\varepsilon_t^2}$$

ε_t is the residual, i.e. the estimated disturbance term. For large samples it can be shown that

$d \rightarrow 2 - 2\rho$. This expression implies that if ρ = 0 then d is close to 2 and there is no autocorrelation present. It also implies that if there is positive autocorrelation present the value of the d-statistic will be less than 2 and vice versa. The Durbin-Watson test also assumes that ρ lies in the interval

$-1 < \rho < 1$ which means that the value of d lies between 0 and 4. The critical values of d depend on the number of observations and independent variables in the regression model. It also depends on the respective values of the independent variables and therefore it is only possible to define intervals for the critical values (Dougherty, 2011).

For positive autocorrelation the interval has a lower bound d_L and an upper bound d_U. The interpretation is that if the d statistic is less than the lower bound level the null hypothesis of no autocorrelation is rejected. Consequently if the d statistic is higher than the upper bound the null hypothesis is not rejected. If the value of the d statistic lies inside the interval, between d_L and d_U, it means that the test is inconclusive (Dougherty, 2011).

4.5.4 Heteroscedastic disturbance term

Condition 4 in section 4.4 states that the disturbance term must be homoscedastic. This means that for every observation *t* the distribution of the disturbance term will be identical with the same expected value and standard deviation of returns. If this criterion is not met, the disturbance term u_t is subject to heteroscedasticity. An example of when u_t is heteroscedastic is when the variance of the potential distribution of u_t increases as the value of the independent variable increases. If the values of the disturbance term show these characteristics one will find that when estimating the linear relationship between the variables with Ordinary Least Squares, there will be a tendency of increased dispersion of observations from the line best fitted to the data as the value of the independent variable increases (Dougherty, 2011).

4.5.5 Consequences of heteroscedasticity

The consequence of heteroscedasticity is that although the estimated coefficients are unbiased, the variance of these coefficients are wrong. When estimating the coefficients one wants the variance to be as low as possible in order to analyze the data with the highest possible precision. If there is heteroscedasticity in the data it is possible to find other methods, other than the Ordinary Least Squares, which will yield estimated coefficients that are also unbiased but with smaller variances. Since the variance of the coefficients are biased one cannot state whether results are statistically significant or not (Dougherty, 2011).

4.5.6 White test

In order to test data for heteroscedasticity on can conduct a so called White test. As the variance of the disturbance term in any observation *t* is unobservable the squared value of the observation is used as an alternative.

The White test regresses the squared value of the residuals on the independent variables of the specified model, their squares and their cross-products. Any duplicate variables as for example a squared dummy variable are excluded from the regression. The R^2 value is multiplied with the number of observations *n* to form the test statistic nR^2. This test statistic follows a chi-squared, denoted χ^2, distribution with degrees of freedom equal to the number of independent variables including the constant minus one. If the test statistic value is higher than the critical value the null hypothesis of no heteroscedasticity is rejected (Dougherty, 2011).

4.6 Data bias

When examining data on hedge fund returns there are a number of possible implications which need to be taken into consideration. The problem of so called backfill bias arise because hedge funds will only choose to report their returns if they want to. If the historical performance of a certain hedge fund is deemed not to be good enough to attract investors, the hedge fund may choose not to report returns. Therefore it is possible that prior periods with bad performance are excluded from the data set, skewing returns towards levels which do not truly represent overall performance over time (Bodie et al., 2014).

Another implication is that hedge funds that are unsuccessful may stop reporting returns and eventually leave their respective databases. When this phenomenon of so called survivorship bias is apparent only the successful hedge funds will remain in the database. The effect of survivorship bias is estimated to skew results with 2%-4% according to various studies (Bodie et al., 2014).

5. Methodology

5.1. Business Research Strategies

The main distinction in business research is commonly drawn between quantitative and qualitative research. The major difference between the two methods is the approach to the link between theory and research. Qualitative research regards theory as an outcome of research, which is known as the inductive approach. Quantitative research regards theory as the guidance for research which is known as the deductive approach (Bryman & Bell, 2011).

When conducting research on data which can be quantified into numbers, using mathematical and statistical methods, the quantitative research approach is appropriate (Bryman & Bell, 2011). For that reason this is the approach which will be implemented in this research. One could complement the research with qualitative methods, such as interviews, but the nature of this research and the data validates the chosen method.

5.2 Obtaining Data

The data on hedge fund returns is obtained from the CISDM (the Center for International Securities and Derivatives Markets). This is an institution within the Isenberg School of Management at the University of Massachusetts (Isenberg School of Management, 2016).

The Morningstar CISDM Database of the CISDM is commonly used by academics as a research instrument and also for publications related to the hedge fund industry. The database includes qualitative and quantitative data for more than 5000 hedge funds since 1994. Every month the CISDM produces a set of indices covering hedge fund performance which are publically available free of charge. The indices reflect the median performance of funds, measured as holding period return, within self-reported strategy classifications reporting to the CISDM Morningstar Database (Isenberg School of Management, 2016).

The hedge fund data set in this study includes monthly holding period returns between January 1994 (January 1998 for the Fixed Income arbitrage index) and December 2015 for 9 indices. The indices included are Convertible Arbitrage, Distressed Securities, Equity Long/Short, Equity Market Neutral, Event driven, Fixed Income Arbitrage, Fund of Funds Global Macro and Merger Arbitrage.

The data on market risk factors is obtained from the economic data base Datastream. All data in this research is denominated in US dollars.

5.3 Conducting the Research

Previous research suggests that there is no consensus as to which model to use or which independent variables to include when performing analysis on hedge funds. As discussed above some research like Fung and Hsieh (2001) conclude that hedge fund returns are difficult to explain using linear models. However other studies like Bode, Kane and Marcus (2014) manage to find significant results using a linear model. Taking this discussion into consideration I chose to work with the multiple linear regression analysis. The multiple regression analysis is conducted on monthly returns, measured as holding period return, for the 9 strategies described in the previous section. The time period investigated is January 1994 to December 2015.

The independent variables included in the research are chosen based on both previous research and also the descriptions of the different investment strategies in chapter 2. The investment policies for the various fund strategies in this research vary a lot. As the independent variables in this research are macroeconomic they are more likely to affect the returns of the funds employing directional strategies. Nevertheless all hedge fund indices are regressed on the same independent variables to enable a more complete comparison between them.

I wanted to include independent variables to represent the major asset classes of equity, interest rates, and foreign exchange rates. The reason for including equity variables is that many funds operate in these markets and it is therefore plausible that their returns are depending on these variables. I have also included a measurement of volatility on the equity market since previous research suggest that hedge fund returns show similarities to options payoffs. This is because option payoffs are connected to the volatility of its underlying asset and this variable could capture these effects. As many hedge funds operate in the fixed income markets I have included variables of both short and long term interest rates in the US. As mentioned above many hedge funds trade in foreign markets and therefore are subject to currency risk. To capture possible effects on returns from the value of the US

dollar I have included the exchange rates versus currencies in Europe and Asia where the equities markets are well developed and the trade volume with the US dollar is high.

The variables included are the S&P 500 index, the S&P 500 Volatility index (VIX), the 10 year US T-bond rate, the 3 month US T-bill rate and also the exchange rates between the US dollar against the British pound and the Japanese yen. All regressions are also tested for autocorrelation and heteroscedasticity with Durbin-Watson and White tests respectively.

6. Empirical Results

In this section the results of the multiple regression analysis and all statistical tests are presented. In this research the number of observations *t* are 264 for all tests except for the tests for fixed income arbitrage where *t* is 216.

6.1 Multiple Regression Analysis

In each regression analysis table the entries in the upper columns are the beta estimations, the bottom columns are the test statistics. The significance level I have chosen is the 5% level which with the number of observations mentioned above makes the critical t-values for the hypothesis testing plus minus 1,97 for all regressions.

Convertible Arbitrage

Alpha	S&P500	VIX	T-bond rate	T-bill rate	USD/GBP	USD/JPY
0,0987	-0,0000	-0,0005	-0,0057	0,0035	-0,0307	-0,0007
2,5232	-2,0694	-1,4290	-2,3549	3,0816	-2,8539	-0,0785

Table 6.1 Convertible Arbitrage Index Multiple Regression Results

Distressed Securities

Alpha	S&P500	VIX	T-bond rate	T-bill rate	USD/GBP	USD/JPY
0,1054	-0,0000	-0,0011	-0,0053	0,0021	-0,0182	-0,0085
3,0510	-2,7002	-3,7308	-1,8857	1,6285	-2,3508	-0,7205

Table 6.2 Distressed Securities Index Multiple Regression Results

Equity Long/Short

Alpha	S&P500	VIX	T-bond rate	T-bill rate	USD/GBP	USD/JPY
0,0980	-0,0000	-0,0011	-0,0047	0,0030	-0,0214	-0,0052
2,3921	-1,4619	-4,6712	-1,3621	2,3930	-3,1900	-0,3313

Table 6.3 Equity Long/Short Index Multiple Regression Results

Equity Market Neutral

Alpha	S&P500	VIX	T-bond rate	T-bill rate	USD/GBP	USD/JPY
0,0195	0,0000	-0,0002	-0,0002	0,0010	-0,0077	-0,0003
2,1151	0,3757	-2,8488	-0,2482	2,5101	-2,9817	-0,0808

Table 6.4 Equity Market Neutral Index Multiple Regression Results

Event Driven

Alpha	S&P500	VIX	T-bond rate	T-bill rate	USD/GBP	USD/JPY
0,1141	-0,0000	-0,0010	-0,0065	0,0034	-0,0210	-0,0117
3,5404	-2,6694	-4,2305	-2,5111	3,0232	-3,0065	-1,0105

Table 6.5 Event Driven Index Multiple Regression Results

Fixed Income Arbitrage

Alpha	S&P500	VIX	T-bond rate	T-bill rate	USD/GBP	USD/JPY
0,0722	-0,0000	-0,0009	-0,0002	0,0008	-0,0222	0,0068
2,0165	-2,4896	-2,2088	-0,1129	0,7358	-2,1489	1,1888

Table 6.6 Fixed Income Arbitrage Index Multiple Regression Results

Fund of Funds

Alpha	S&P500	VIX	T-bond rate	T-bill rate	USD/GBP	USD/JPY
0,0573	-0,0000	-0,0007	-0,0027	0,0023	-0,0136	-0,0037
1,9665	-0,8484	-3,7104	-1,1721	2,5155	-2,1164	-0,3645

Table 6.7 Fund of Funds Index Multiple Regression Results

Global Macro

Alpha	S&P500	VIX	T-bond rate	T-bill rate	USD/GBP	USD/JPY
0,0276	-0,0000	-0,0001	-0,0031	0,0024	-0,0021	-0,0032
1,5507	-1,3524	-1,1397	-2,2180	2,7277	-0,4172	-0,5205

Table 6.8 Global Macro Index Multiple Regression Results

Merger Arbitrage

Alpha	S&P500	VIX	T-bond rate	T-bill rate	USD/GBP	USD/JPY
0,0353	-0,0000	-0,0004	-0,0016	0,0019	-0,0106	0,0025
2,7507	-1,4320	-3,1016	-1,3386	3,1771	-2,6619	0,5223

Table 6.9 Merger Arbitrage Index Multiple Regression Results

Goodness of fit

Index	R^2 Score
Convertible Arbitrage	0,2010
Distressed Securities	0,2648
Equity Long/Short	0,1713
Equity Market Neutral	0,1540
Event Driven	0,2631
Fixed Income Arbitrage	0,2789
Fund of Funds	0,1818
Global Macro	0,0435
Merger Arbitrage	0,1817

Table 6.10 Goodness of fit for all Regressions

6.2 Statistical Tests

6.2.1 Durbin-Watson test

As the number of parameters, excluding the constant, in the regressions are 6 and the number of observations are 264 and 216 respectively a table of Durbin-Watson d statistics at the 5% significance level yields a lower bound level d_L of 1,57 and an upper bound level d_U of 1,78 for positive autocorrelation.

Index	d-statistic
Convertible Arbitrage	0,98
Distressed Securities	1,14
Equity Long/Short	1,52
Equity Market Neutral	1,67
Event Driven	1,29
Fixed Income Arbitrage	1,01
Fund of Funds	1,35
Global Macro	1,99
Merger Arbitrage	1,52

Table 6.11 Durbin-Watson test d-statistics for all Regressions

As the table shows the data on all indices data but Global Macro suffer from autocorrelation. The standard errors in the regressions with autocorrelation have therefore been adjusted to yield correct t-statistics and enable hypothesis testing.

6.2.2 White test

The degrees of freedom in the White test are 27 and the variable is chi-squared distributed. Statistical tables therefore yield a critical value of 40,113 at the 5% significance level.

Index	χ^2-statistic
Convertible Arbitrage	160,197
Distressed Securities	117,323
Equity Long/Short	68,667
Equity Market Neutral	37,450
Event Driven	69,584
Fixed Income Arbitrage	138,391
Fund of Funds	69,005
Global Macro	46,833
Merger Arbitrage	100,437

Table 6.11 White test chi-squared-statistics for all Regressions

The results in the table above shows that all regression data but Equity Market Neutral suffer from heteroscedasticity. The standard errors of the effected regressions have been adjusted to enable correct hypothesis testing.

6.3 Sharpe ratios

In this section the hedge funds performances measured as risk-adjusted returns are presented. All the monthly holding period returns and volatility measurements are annualized.

Index	Sharpe ratio
Convertible Arbitrage	1,10
Distressed Securities	1,03
Equity Long/Short	0,91
Equity Market Neutral	2,19
Event Driven	1,11
Fixed Income Arbitrage	0,72
Fund of Funds	0,62
Global Macro	0,76
Merger Arbitrage	1,44

Table 6.12 Annualized Sharpe Ratios for all Indices

7. Discussion

As the average R^2 score for the 9 indices is 0,1933 this means that less than 20% of hedge fund returns may be explained by the independent variables. Previous researchers using a similar model such as Fung and Hsieh (1997) manage to explain 40% of fund returns. As the aim for a multiple regression analysis is to get an R^2 score as high as possible this might be an implication. However a low R^2 score still provide results to interpret and analyze.

The Convertible Arbitrage strategy shows no exposure to the conditions in the equity market, i.e. the S&P 500 and the VIX. Since it is a non-directional strategy trying to take advantage of a temporary mispricing between interrelated securities this is likely. Interest rates can have an impact on the price of a company's stocks which these funds are exposed to. However as the investment strategy usually is market neutral with no speculation on security prices moving up or down it is also unlikely that interest rates would affect their returns. The beta estimations of the interest rate variables are low which does not oppose the previous discussion. As the interrelated securities are expected to be denominated in the same currency the low beta estimation for the USD/GBP and the statistical insignificance for the USD/JPY confirm this view.

The next non-directional strategy is the Distressed Securities strategy and the empirical results show low beta estimations and also statistical insignificance for the interest rate variables and the USD/JPY variable. Bankruptcy proceedings for companies could be explained by the macro variables in the multiple regression analysis. In theory companies are less probable to be threatened by bankruptcy if the S&P500 returns are positive as that would mean that the economy as a whole is growing. That suggests that the beta estimation for this variable would be negative. Also lower interest rates would in theory probably lead to more successful restructuring as this process depends on the access to borrowing money. Again the results do not support such deductions. Microeconomic factors effecting individual companies may offer further explanation of company bankruptcy and hence Distressed Security fund returns.

The Equity Long/Short strategy shows no statistical significant exposure to the S&P500 and negative but low exposure to the VIX. As this strategy implies a net long or short exposure to the equity markets it could be that the fund returns are offsetting each other. The VIX shows

substantial statistical significance however the beta estimation for the coefficient is low. This could imply that funds returns are likely to decrease as the VIX increases but the funds manage to make the impact minimal. The interest and foreign exchange rates variables show little or no impact on the dependent variable. These results suggest that the funds are either not exposed to these currencies, even if some of them may invest in foreign markets, or that they successfully hedge out currency risk.

The Equity Market Neutral strategy shows consistently low beta estimations with the S&P500, the bond rate and the USD/JPY variables statistically insignificant. These results confirm the interpretation that the strategy is in fact market neutral. If the beta estimation for the VIX would have been high this could have been due to the fact that some funds according to theory employ a more opportunistic approach. A more volatile equity market is likely to create such short term opportunities. However the results show low exposure to the VIX thus not supporting these theories.

The Event Driven strategy shows low beta estimations across the variables. Even though this strategy usually is exposed to equity the results does not show considerable exposure to neither the S&P500 nor the VIX. This could be due to the fact that the funds could take advantage of specific events no matter if the markets or the implied volatility move up or down. The result does also show low exposure to interest and foreign exchange rates which supports the theory that portfolios are mainly invested in equity.

The result for the Fixed Income Arbitrage strategy shows no exposure to the interest rate variables. Even if funds implementing this strategy invest in sovereign debt, i.e. variables such as the US Treasury bond and T-bill rates, they also invest in corporate debt which could offer an explanation to the statistical insignificant results for these variables. These funds show no dependency for neither the equity market nor the foreign exchange rates which is probable for this non-directional strategy.

As the Fund of Funds strategy is designed to invest in other funds which could implement any of the strategies described in this research the results with low beta estimations and the S&P500, the bond rate and the USD/JPY variables statistically insignificant is expected when regarding the results of the other strategies.

The Global Macro strategy shows statistically insignificant results for both the S&P500 and the VIX. As the investment strategy is in fact global this means that other equity related variables may offer further explanation for the returns. The fact that the USD/GBP and the USD/JPY variables are statistically insignificant could imply that these funds are exposed to other currencies or that they successfully hedge any currency risk. The variables for interest rates have low beta estimations. This could be explained by the fact that the investment mandate for these funds is global and interest rates in foreign markets are also likely to explain returns.

Finally the Merger Arbitrage strategy result also shows low beta estimations and statistically insignificant results for the S&P500, the bond rate and the USD/JPY variables. This implies that company mergers and thereby the fund returns may be better explained by microeconomic variables connected to the specific company.

Across all strategies the results show low beta estimations and or statistical insignificance for both the S&P500 and the VIX variables. As discussed above this can suggest that the non-directional hedge fund returns are not depending on the equity markets. According to the results neither are the directional equity focused funds which could be explained by the fact that they are successfully hedging exposure. It could also be explained by the fact that they are allowed to short sell which enables positive returns even when the equity markets are declining. The multiple regression analysis is not able to capture such dynamics. These are possible explanations as to why the results are a contradiction to some previous research by Fung and Hsieh (2011) who conclude that Long/Short Equity fund returns are exposed to the equity market and also Billio, Getmansky and Pellizon (2012) who find that hedge fund returns are dependent on the volatility on the equity markets, the VIX.

With the interest rate variables the results once more show low beta estimations and or statistical insignificance for all strategies. In this research the arbitrage strategies investing in fixed income instruments does not show different exposure to interest than the other strategies. This result is different from Bodie, Kane and Marcus (2014) where both Fixed Income Arbitrage and Convertible Arbitrage strategies are exposed to long term US Treasury bonds.

The results across strategies for the USD/JPY variable are uniform and shows no statistical significance. For the USD/GBP variable the Global Macro strategy is the only strategy where the result also is insignificant. As funds of this strategy invest in foreign markets exposure to currency rates are inevitable unless they successfully manage to hedge all that risk exposure. These results cannot confirm the ones in the study by Bodie, Kane and Marcus (2014) where Global Macro funds show negative exposure to an increase in the value of the US dollar.

When analyzing the alpha estimations the result is in accordance with the study by Fung and Hsieh (2011). Out of the 9 indices, 7 show significant positive alpha values over time. In fact the alpha estimations have the highest coefficient estimations in all the separate regression tests. Alpha in this research is interpreted as the hedge fund return when all betas are equal to zero. In this case the alpha value could represent excellent trading ability by the hedge funds. However according to theory it may also represent compensation for holding illiquid assets.

In contrast to the multiple regression analysis the results of the Sharpe Ratio calculations show more varying results. However since the results does not show similarities for funds which employ similar strategies the interpretation is complicated and conclusions if directional or non-directional seemed to be outperforming the other are difficult to draw. The Sharpe Ratio results could have completed the ones from the regression analysis and offered a clarification as to whether some of the asset classes, i.e. the independent variables, seemed to yield higher risk adjusted returns and therefore would have been preferred to the others. Since the combined results are inconclusive no such deductions are possible to make. The likely presence of backfill and or survivorship bias in hedge fund databases might skew returns upwards which would effects the Sharpe ratios. However this research does not compare hedge fund returns to for example mutual funds but rather compare the different strategies to each other. Even if the dataset may suffer from backfill or survivorship bias it is therefore plausible that funds representing any strategy have got the same incentives as the others to start or stop reporting returns. Hence when comparing returns amongst hedge funds the impact of data bias is less likely to have a major impact.

When analyzing the Sharpe ratio calculations the different strategies show variations in both holding period returns and the volatility in these returns. As the purpose of this research is to investigate how hedge fund returns are exposed to different market risk factors, i.e.

assets, the fact that the regression analysis does not show varying risk exposure but the Sharpe ratios does, needs to be analyzed further.

The discussion above indicates that either the multiple linear regression analysis is not well suited to explain hedge fund returns or that there are independent variables better suited to explain these returns than the ones included in the model. It could also be a combination of both these factors. If the conditions above are in fact true it imposes consequences for the analysis on the results. All previous analysis and discussion is done under the assumption I made before conducting the tests which were that the model was sufficient and that the variables were likely to explain the returns. Therefore it is important to keep in mind when reading the previous discussion that the results offer no clear evidence and that using a different model could have yielded different results.

The conclusion by Fung and Hsieh (2001) that a linear model might be insufficient to explain hedge fund returns is hence supported by the results in this research. The fact that other research like Billio, Getmansky and Pellizon (2012) shows hedge fund exposure to the VIX, and this research does not, is another indication that the multiple linear regression model might be insufficient. Relating the results to the studies by Fung and Hsieh (2011) and Bodie, Kane and Marcus (2014) were both studies find that Long/Short equity fund returns are exposed to the equity market, the contradictory result in this research therefore needs to be regarded with these facts in mind. The fact that for example none of the equity focused hedge fund strategies show any exposure to the S&P500 or the VIX is unlikely to be a correct description of the true dependency between them.

Parallel interpretations can be done on the Fixed Income and Convertible Arbitrage strategies were the low beta estimations and insignificant results are the opposite of the results of the study by Bodie, Kane and Marcus (2014). Also even if Bussière, Hoerova and Klaus (2015) found that in particular equity oriented hedge funds showed commonality in returns, which in theory would mean exposure to similar risk if compensated fairly, the similarities in exposure shown in this research does not suggest similar conclusions since all the other strategies show equal results.

Another explanation to the differences in results to previous research and why the independent variables in this research do not prove any impact on returns might be the

hedge fund strategy definitions. The broad hedge fund definition per se offers limited explanation of the actual investment process. Also as hedge funds provide marginal information about their investments to the public investigating their returns becomes even more challenging. Therefore it is difficult to determine whether a fund who claim to employ a certain strategy actually do so. The discussion and analysis is consequently based on the assumption that the strategy definitions in chapter 2 represent a fair view on the investment policies.

.

8. Conclusions and further research

The conclusion after analyzing the results is that this research has not been able to show any exposure, other than independency, of hedge fund returns on the S&P500, VIX, US T-bond rate, US T-bill rate, USD/GBP exchange rate and the USD/JPY exchange rate. Also the research does not suggest any differences in risk exposure across hedge fund strategies.

Considering the fact that hedge funds implementing different strategies are expected to invest in different assets in combination with the results of previous studies, it is unlikely that these conclusions represent the true relationship between the variables and indices.

To study the explanation for hedge fund returns further it would be interesting to investigate if other independent variables might offer conclusive results. Also it would be interesting to investigate the results of a different method. That could be to either implement a nonlinear statistical model or to implement an inductive approach performing interviews with hedge fund managers to possibly understand the risk exposure better. A combination of the deductive and the inductive approach might also be useful. Finally it would be helpful with direct access to a large hedge fund database with data available fund for fund instead of on index basis.

9. References

Agarwal, V & Naik, N. (2004). "Risk and portfolio decisions involving hedge funds", *The Review of financial studies,* 17, 63-98.

Bali, T, G., Brown, J, S., & Caglayan, M, O. (2014). "Macroeconomic risk and hedge fund returns", *Journal of Financial Economics*, 114, 1-9.

Billio, M., Getmansky, M., & Pelizzon, L. (2012). "Dynamic risk exposures in hedge funds", *Computational Statistics and Data Analysis,* 56, 3517-3532.

Bodie, Z., Kane, A., & Marcus, A. J. (2014). *Investments*. 10th ed. Berkshire: McGraw-Hill.

Bryman, A., & Bell, E. (2011). *Business research methods*. 3rd ed. New York: Oxford University Press.

Bussière, M., Hoerova, M., & Klaus, B. (2015). "Commonality in hedge fund returns: Driving factors and implications", *Journal of Banking & Finance*, 54, 266-280.

Dougherty, C. (2011). *Introduction to Econometrics*. 4th ed. New York: Oxford University Press.

Dowd, K. (2005). *Measuring market risk.* 2nd ed. Chichester: John Wiley & Sons Ltd.

Financial Times
http://www.ft.com/intl/cms/s/0/0ae1cba6-b640-11e5-b147-e5e5bba42e51.html#axzz3zZXrEBFp
Accessed: 2016-01-10.

Fung, W., & Hsieh, D, A. (1997). "Empirical characteristics of dynamic trading strategies: The case of hedge funds", *The Review of Financial Studies*, 10, 275-302.

Fung, W., & Hsieh, D, A. (2001). "The Risk in Hedge Fund Strategies: Theory and Evidence from Trend Followers", *The Review of Financial* Studies, 14, 313-341.

Fung, W., & Hsieh, D,A. (2011). "The risk in hedge fund strategies: Theory and evidence from long/short equity hedge funds", *Journal of Empirical Finance*, 18, 547-569.

Hedge Fund Research
https://www.hedgefundresearch.com/index.php?fuse=indices-str
Accessed: 2016-01-15

Hull, J, C. (2012). *Options, Futures, and Other Derivatives.* 8th ed. Harlow: Pearson Education Limited.

Isenberg School of Management
https://www.isenberg.umass.edu/centers/center-for-international-securities-and-derivatives-markets
Accessed: 2016-01-15

Sharpe, W, F. (1992). "Asset Allocation: Management Style and Performance Measurement," *Journal of Portfolio Management*, 18, 7–19.

The Economist
http://www.economist.com/news/schoolsbrief/21584534-effects-financial-crisis-are-still-being-felt-five-years-article
Accessed: 2016-01-10.