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# PERFORMANCE AND NEUTRALITY OF MARKET NEUTRAL HEDGE FUNDS - EVIDENCE DURING THE FINANCIAL CRISIS

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ABSTRACT OF THE MASTER'S THESIS

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Abstract

Hedge funds are able to follow unconventional and dynamic trading strategies that are out of reach for traditional investment vehicles. One of these dynamic trading strategies is market neutral strategy, which aims at providing good and stable returns while simultaneously neutralizing exposure towards the market. Market neutral hedge funds are expected to perform well regardless of market conditions and this thesis focuses on analyzing, whether these funds deliver on their definition during the financial crisis of 2008. We study the performance and persistence of returns generated by market neutral hedge funds, as well as present the results of neutrality analysis during the financial crisis. The data is obtained from Lipper TASS hedge fund database and the model applied in this study is the capital asset pricing model. Results indicate that market neutral hedge funds are able to outperform the market during the financial crisis. However, they are not able to generate positive returns or statistically significant alpha. Based on the most common neutrality measures, market neutral hedge funds do not show neutrality towards the declining markets. Only a quarter of market neutral hedge funds are able to pass the mean neutrality test during the financial crisis. According to analysis in deciles, few hedge funds are able to generate positive returns during the crisis while maintaining a moderate negative exposure towards the market.

Keywords
Persistence, market neutrality, mean neutrality

Additional information

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# 1 INTRODUCTION

While the first hedge fund was founded nearly 70 years ago, it is generally regarded that the first study on hedge funds was published as late as in 1997. During the past two decades, hedge funds have attracted attention in great volumes and been under extensive research. Hedge funds possess a unique status in the finance industry in terms of regulation and disclosure requirements, which allows use of trading strategies that are out of reach for traditional investment vehicles. Hedge funds are not tied to as strict regulation as mutual funds, while for some time the industry has been facing a debate whether hedge funds should be regulated and supervised more closely. After the financial crisis of 2008, the regulatory framework applicable for hedge fund industry has been fine-tuned, but remained relatively loose. Hedge funds are not tied to strict leverage restrictions and the fee structure remarkably differs from the one of mutual funds. In addition, hedge funds are not required to report their performance and all of their positions. Reporting of performance may be done voluntarily to one or several hedge fund databases. This creates biases in hedge fund databases, since reasons for reporting their performance – as well as choosing not to report – vary.

Due to their special characteristics, hedge funds are able to follow unconventional and dynamic trading strategies that are out of reach for traditional investment vehicles. One of these dynamic trading strategies is market neutral strategy, which aims at providing good and stable returns while simultaneously neutralizing exposure to the market. Since hedge funds are not regarded to have significant correlation with standard asset classes, they are generally assumed to be neutral to the market to some extent. Are market neutral hedge funds then able to earn a free lunch, by taking advantage of discrepancies in the market without market exposure? As an investment strategy, market neutrality seems a lucrative one and has been of large interest in the beginning of the 21$^{st}$ century. The definition of market neutrality implies that hedge funds applying this strategy provide protection especially against the declining market. Fortunately for researches, the financial crisis of 2008 presents an interesting opportunity to study market neutral hedge funds during truly bear market conditions. The focus of this thesis is to analyze performance and neutrality of

market neutral hedge funds during this period and to answer the main research question at hand: were market neutral hedge funds actually market neutral during the financial crisis?

In order to study market neutral hedge funds, it is important to understand different concepts of market neutrality and methods of analyzing it. One of the most exploited measures to analyze market neutrality is market beta. This measure is expected to be low for market neutral hedge funds, since it describes the level of exposure to the market. Alpha is regarded as a measure of excess return and usually seen as the original motive of investors for investing in a hedge fund. In this thesis, several other measures and risk ratios as well as methods of analyzing market neutrality are presented. Due to the voluntary performance reporting and the challenges that this causes to performance analysis, a few of the most essential biases are presented as well as methods of omitting them from data.

The data used in this study is obtained from Lipper TASS database and includes the monthly returns of both live and defunct funds. Main focus is on analyzing performance and neutrality of market neutral strategy during the financial crisis period, which is set to start in July 2007 and end in December 2008. Additionally, we study the strategy during a comparison period from January 1995 to December 2004, in order to capture bullish, bearish, as well as average market conditions. Results of market neutral strategy are also compared to 10 other hedge fund strategies. The model used in the analysis is a single index model, the classic capital asset pricing model. Empirical results from performance and persistence analysis indicate that market neutral hedge funds are able to outperform the market during the financial crisis and experience low deviation in monthly returns. However, on average generated annual return is negative for market neutral hedge funds. Based on the neutrality analysis during the financial crisis, none of the measures support hypothesis of market neutrality and only a quarter of market neutral hedge funds are able to pass the mean neutrality test. During the comparison period, market neutral hedge funds generate stable returns and slightly outperform the market. They also provide high risk-adjusted returns and show strong neutrality against market movements. Results are supported by prior studies, where it is observed that both returns and neutrality decrease during bear markets. When studying market neutral

hedge funds in deciles, we can conclude that there are few funds that performed well and were neutral to the declining market during financial crisis as well. The market neutral funds that are able to generate positive returns have a moderate negative exposure towards the market during the crisis.

This thesis proceeds as follows. Chapters 2 to 5 are based on my bachelor's thesis (Vuoti 2015) and form the theoretical part of this master's thesis. In Chapter 2, a brief history of hedge funds, their legal environment, and the special characteristics that hedge funds entail are presented. Chapter 3 forms the theoretical framework of the thesis and focuses on describing market neutrality as an investment strategy. Different definitions of market neutrality and theories behind it are presented, in addition to methods of analyzing neutrality to the market. Chapter 4 focuses on describing the different biases concerning hedge fund analysis, and presents a discussion between previous studies on performance and persistence of market neutral hedge funds. Chapter 5 focuses on concluding whether market neutral hedge funds are truly market neutral based on previous studies. The data used in this study as well as summary statistics and research methods are described in detail in chapter 6. In chapter 7, we present the empirical results of performance and neutrality analysis during the financial crisis and comparison period. Additionally, it includes the results of decile analysis performed on market neutral hedge funds during the financial crisis.

# 2 THE SPECIAL CASE OF HEDGE FUNDS

During the last 20 years hedge funds have attracted attention in great volumes. Hedge funds are an interesting topic of research for their accessibility to several active, unconventional, and even aggressive investment strategies. Even though hedge funds have been under extensive research during the past two decades, they have been able to remain their opaque position in the finance industry since the regulative constrains hedge funds face are relatively loose. For some time, the industry has been facing a debate whether hedge funds should be regulated as mutual funds. Investing in hedge funds has been seen as a privilege of institutions and extremely wealthy individuals, but today even the ordinary investor is able to find exchange-traded funds that mimic the investment styles of hedge funds. Hedge funds' assets under management (AUM) have been rising substantially ever since the founding of the first hedge fund in 1949 (Caldwell 1995). As of the 4$^{th}$ quarter 2017, the total AUM of the hedge fund industry is estimated at $3,538 billion (Barclay Hedge 2018).

Compared to other types of funds and investment vehicles, hedge funds have several special characteristics. Liang (2009) notes that hedge funds and mutual funds, the traditional investment vehicle most often compared to hedge funds, substantially differ from each other in many ways. Zhan (2011) continues that these investment vehicles differ in the degree of regulations they confront, leverage and derivatives usage, investment strategies applied, and the characteristics of typical investors. As hedge funds are not classified as banks, the Securities Exchange Commission's (SEC) regulatory power is limited considering hedge funds in the United States (U.S.). Nevertheless, hedge funds are not fully exempted from regulations that SEC has established in order to monitor and safeguard the integrity of the markets. Large positions in futures have to be filed daily, and there are futures margins and position limits on futures contracts. Large positions in selected foreign currencies and treasury securities, in addition to positions exceeding 5% of the shares of a publicly traded firm are to be reported. However, the reporting of returns and positions is not as transparent in the hedge fund industry as for mutual funds. Reporting of monthly returns to hedge fund databases, such as Hedge Funds Research (HFR) and Lipper Trading Advisor Selection System (TASS), is voluntary. (Fung & Hsieh 1999.)

Most mutual funds employ a static buy-and-hold strategy, as hedge funds utilize dynamic trading strategies in addition to the use of leverage, which is borrowed capital as its aim to increase the amount of possible future profits. For mutual funds the use of leverage is often limited or even restricted, but hedge funds regularly leverage their bets by position margining and short selling. Substantially, on average a quarter of hedge funds' exposure is negative exposure obtained through short sales. (Fung & Hsieh 1999.) As presented, hedge funds follow dynamic trading strategies, such as emerging markets, fixed income, merger arbitrage, market neutral, and fund of funds. Emerging markets funds use primarily long positions to gain exposure in equities and debt in the economies of developing and emerging countries. Fixed income investment strategy focuses on public and private debt instruments, which have fixed interest rates and maturities, and their derivatives. (Liang 2009.) Funds utilizing the merger arbitrage strategy seek returns by investing in announced mergers and acquisitions, usually by buying the equities of the targets and shorting the acquiring party's equities (Fung & Hsieh 1999). According to Liang, merger arbitrage is also known as the risk arbitrage theory, and it takes advantage of event-driven situations such as leveraged buy-outs and hostile takeovers in addition to mergers. He defines market neutral strategy as one that aims to gain profits from pricing inefficiencies, and at the same time neutralizes its market risks using long and short positions. Fund of funds take broad exposure to world economy and generally these funds invest in individual hedge funds that utilize different trading strategies. These and many other unconventional trading strategies are used to categorize hedge funds under different subgroups.

The fee structure that is characteristic for hedge funds is considerably different from the fee structure typical for mutual funds. As acknowledged by Zhan (2011), the ordinary fees used by mutual funds are asset-based fees, in addition to the sales charges, distribution fees, and redemption fees. Both Zhan (2011) and Fung and Hsieh (1999) present the rule of fulcrum, or the fulcrum fee, that concerns mutual funds. Incentive fees of mutual funds must be fixed on a benchmark index. Mutual funds rarely use incentive fees, but when they do the fulcrum fee must be exercised symmetrically by law; outperforming the benchmark index leads to an increase in fees and correspondingly, underperformance leads to a decrease in the incentive fees. The components of hedge funds' fee structure are asset-based fees and flat-rated

management fees, in addition to their performance-based and option-like incentive fees. Considering the incentive fees, hedge funds are not tied to the fulcrum rule and thus underperformance compared to a benchmark index does not lead to a decrease in incentive fees. The average management fees of hedge funds are 1.5% and the incentive fees 20% (Titman & Tiu 2011), while the fees and expenses altogether for mutual funds were 0.95% in 2006 (French 2008). The fee characteristics of hedge funds have made the hedge fund business exceedingly lucrative from a hedge fund manager's point of view, even though the use of high water marks (HWM) mitigates the fee differences between hedge funds and mutual funds to a limited extent. Hedge funds often use HWMs, according to which a fund manager has to exceed the previously achieved maximum value of the share in order to receive the incentive fee (Goetzmann et al. 2003). Liang defines that under the existence of HWMs, a manager has to make up possible previous losses or the incentive fee is not paid. It might be even possible for the manager to owe investors a rebate of fees that have been charged in previous years.

Investment vehicles that are often compared to hedge funds, in addition to mutual funds, are commodity trading pools. These investment pools are operated by commodity trading advisors (CTA) and they are required to register with the Commodity Futures Trading Commission (CFTC). Initially, the distinction between hedge funds and CTAs was straightforward, since CTAs were limited to trading futures contracts only. However, the distinction has become blurrier due to regulatory changes and the growth of financial derivatives. Today, CTAs are able to take exposure, in addition to commodities, in interest rates, currencies, and stock indexes. There are two schools that have different perspectives of CTAs. The other sees CTA funds as a sub-category of hedge funds, and the other considers CTAs and hedge funds as two separate investment vehicles. Nevertheless, hedge funds have kept their special position in the finance industry. Hedge funds are not obliged to register with the CFTC, and by having no more than 499 investors – each of them providing more than $5 million in assets – and by not making any public offerings, a hedge fund is not considered as an investment company. Hence, a hedge fund is not tied to similar registration, disclosure requirements, or leverage restrictions that are obligations of investment companies. (Fung & Hsieh 1999.)

According to Bodellini (2017), the role of hedge funds in posing and spreading systemic risk across the financial markets became an even larger topic of discussion and concern after the global financial crisis of 2008. Even though hedge funds are not deemed to be the cause of the crisis, their involvement in different types of complex and risky transactions with many different counterparties increases the concern of hedge funds' capability to spread systemic risk across several jurisdictions. The significant level of leverage usage characterizing hedge funds adds on to the concern. The Dodd-Frank Wall Street Reform and Consumer Protection Act (the Dodd-Frank Act) was passed in 2010 in the U.S., primarily due to the financial crisis. This was a legislative response to the crisis, set out to reshape the U.S. regulatory system in order to promote financial stability. The main measure adopted by the Dodd-Frank Act is to oblige managers of private funds with AUM above $150 million to register with the SEC, making these managers subject to the rules of the Investment Advisers Act of 1940 and to the supervision of the SEC itself. The registration comes with a duty to disclose a significant amount of data to the SEC, such as information on trades, investment positions, and valuation policies (Kaal 2011). However, Bodellini still sees the new regulation as inconsistent and inappropriate to prevent and face the role of hedge funds in posing and spreading systemic risk. Kaal continues that the exemptions included in the Dodd-Frank Act raise concerns to a large extent, since most hedge funds continue to comply with the exemptions in order to avoid registration.

The voluntary reporting to hedge fund databases creates biases, which have to be taken into consideration when studying hedge fund performance and persistence based on data obtained from hedge fund databases. The databases overlap substantially, but they do include different funds to some extent. That is why in most studies, more than one database is used in order to form a more representative population of hedge funds. (Fung & Hsieh 1999.) Titman and Tiu (2011) note that some of the most noteworthy biases found in all databases are survivorship bias, backfilling bias, and self-selection bias. Since reporting to databases is voluntary, hedge funds may stop and start reporting for many reasons and cause distortions in research results. This is the main cause for survivorship bias. Backfilling bias is created, because hedge funds usually start reporting after a while the operations have begun and are unlikely to report their returns if the past performance has been bad.

Selection bias is related to the backfilling bias, because it also origins from the fact that funds are not likely to report their returns to a database if the returns are not good. Fung and Hsieh (1997) however believe that selection bias is omitted from databases because badly performing funds do not want to publish their returns, and the good ones have closed out quickly and do not have a reason to advertise their good performance in order to attract more investors. Fung and Hsieh find backfilling a more tedious problem and believe it biases the average returns of a hedge fund database substantially upwards. These biases are described further in Chapter 4 and practical methods to omit these distortions from data are presented.

# 3 SEARCH FOR MARKET NEUTRALITY

## 3.1 Explaining Market Neutrality

It is generally regarded that the first hedge fund, called A.W. Jones & Co., was founded in 1949 (Caldwell 1995) and has continued practicing until this very day (A.W. Jones 2018). The interest towards alternative asset classes has grown substantially and hedge funds are regarded to outperform traditional asset classes or at least offer unique diversification possibilities (Bessler et al. 2008). Peltomäki (2009) states that as one of the fastest-growing financial sectors of the economy, hedge funds are today considered as an important part of investors' portfolios. He notes that the largest and fastest growth in the hedge fund industry has happened before and after the last millennium. In 1990 the AUM of hedge funds was $50 billion. By December 2006, the value of AUM of hedge funds has grown to $1.4 trillion (Patton 2009). Correspondingly, from 1990 to 2004 the number of hedge funds has grown from 2000 to an estimated number of 8400 funds (Capocci et al. 2005). The $3.0 trillion AUM milestone was reached for the first time in May 2014 (Laurelli 2014). Finn (1998) proposes that the market neutral strategy might even be the most attractive choice for asset allocation. He presents that market neutrality as an investment strategy is gaining more interest towards themselves, not just among hedge funds but also among mutual funds and institutional plan sponsors. In their study Fung and Hsieh (1999) present that 20% of hedge funds' AUM are managed by market neutral hedge funds, but according to Capocci's (2006) more recent study around 28% of hedge funds apply market neutral trading strategy.

According to Fung and Hsieh (1999), the main objective of funds utilizing market neutral strategy is to deliver a stable stream of returns without betting on the current market trends. Regardless of market conditions investors are able to expect constant returns, for which reason Finn (1998) addresses market neutral strategies also as absolute return strategies. Liang (2009) generalizes that hedge fund managers utilizing market neutral investment strategy seek profits by exploiting pricing inefficiencies and neutralizing exposure to market risk at the same time. To put it even more simply, Patton (2009) states that the aim of market neutral strategy is to maintain a good return regardless of the market. However, the definition of a good

return is debatable and should undergo in-depth research on investor's preferences, expectations, and requirements. This thesis as well as Patton leaves further specification of this definition of market neutrality to future researchers.

Market neutral funds take bets on relative price movements exploiting various trading strategies, while seeking to avoid major risk factors. Fung and Hsieh (1999) present that some of these strategies are long-short equity, stock index arbitrage, and fixed income arbitrage. The long-short equity strategy was applied by the first hedge fund, A.W. Jones & Co. According to Capocci (2006), funds utilizing the long-short equity strategy, which is also known as equity market neutral strategy, simultaneously take equal long and short positions within a certain market. The strategy is typically derived from quantitative models, which take advantage of relative price inefficiencies and select the stocks for long and short positions. As the strategy requires stock picking and exploiting relative price discoveries, it can be difficult for a fund manager to construct a larger and well-diversified portfolio by relying solely on equity market neutral strategy. Stock index arbitrage funds generate profits by trading the spread between index futures contracts and the underlying equities. Fixed income arbitrage funds trade the spread between corporate and government bonds that have similar characteristics. (Fung & Hsieh 1999.)

There are two reasons why it is important to know how a particular hedge fund creates returns. According to Asness et al. (2001), the two reasons are diversification and fees. If a hedge fund generates positive revenue when the markets are going up and has a passive market exposure, it is possible that the fund loses money when the markets are going down. The diversification benefits hedge funds imply to offer are one of the main reasons why investors are interested in investing in hedge funds, and a hedge fund described above would most likely not offer the diversification benefits many investors seek. When it comes to fees, investors do not want to nor should they pay hedge fund fees – or, excess fees – for exposure they can gain from index funds or mutual funds at a lower cost.

In addition, Capocci (2006) presents three reasons, why it is meaningful to focus on analyzing the market neutral strategy individually instead of considering hedge funds as a whole. Firstly, the aim of market neutral strategy is to completely hedge its

exposure to the market, while other hedge fund strategies are generally regarded to be at least partially exposed to the market. Hence, results particular to other strategies may not be applied to market neutral strategy. Secondly, Capocci suggests that a large proportion of hedge funds employ the market neutral strategy; over a quarter of the individual funds of the global MAR/CISDM hedge fund database are market neutral funds and due to the large number of these funds, they can be analyzed in detail and global results can be obtained. Thirdly, the analysis of market neutral investment strategy individually enables the discovery of the particularities of market neutral strategy.

### 3.2 Theory on Market Neutral Investment Strategy

A simple index model, and particularly the classic capital asset pricing model (CAPM), is the most exploited starting point when describing the theoretical background behind market neutral investment strategy. CAPM is a model introduced by Sharpe (1964) and Lintner (1965), and the slope of the model, beta, is a commonly used definition of neutrality from the point of view of risk. Here, beta acts as a measure of correlation and beta is generally seen as a measure of security's exposure to the market risk (Muhtaseb & Colborn 2012). Sharpe and Lintner define beta as follows:

$$\beta_i = \frac{Cov(R_{i,t}, R_{m,t})}{\sigma^2(R_{m,t})}. \quad (1)$$

Beta is obtained by dividing the covariance between the return on a fund and the market by the variance of the market return. Market neutrality rises from the fact that the returns on a fund are uncorrelated with the returns on some market index or alternatively, a collection of market risk factors. To achieve market neutrality beta has to be zero or negative. (Muhtaseb & Colborn 2012.) Hence the name zero-beta strategy, presented by Finn (1998). Patton (2009) claims a simple linear regression can be presented to illustrate the definition, though simple linear correlations and betas are not able to give a full picture of returns generated by hedge funds due to the dynamic trading strategies and nonlinear payoff functions that are the characteristics of most of them.

In contrast to Patton (2009), Asness et al. (2001) state that investors interested in investing in hedge funds do not have any other choice, but to base their evaluations on shallow strategy descriptions and historical returns, since hedge funds do not generally provide more specific information. For this reason, Asness et al. present a simple regression of monthly hedge fund returns against the market return, here the return on S&P 500 index, of the following form:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon_{i,t} \ . \tag{2}$$

The equation can be rewritten as:

$$R_{i,t} - \beta_i R_{m,t} = \alpha_i + \varepsilon_{i,t} \ . \tag{3}$$

Here, $R_{i,t}$ represents return on a hedge fund $i$, and $R_{m,t}$ return on the S&P 500 index. Hedge fund returns are reported as net of fees, thus fees must be excluded from the return on the S&P 500 index as well, and they are in excess of cash and in excess of an annual fee of 20 basis points. The whole left side of the equation 3 is the return on a hedged strategy, where $\beta_i$ units of market index, in this case the S&P 500, is shorted against the purchase of hedge fund $i$. On the right side, the error term $\varepsilon_{i,t}$ represents the factors other than the market return that affect the return of a hedge fund and, according to the fourth assumption of the simple linear regression model, the expected value of the error term is zero (Wooldridge 2009: 21, 45). Hence the error term $\varepsilon_{i,t}$ can be ignored. Hereby, $\alpha_i$ represents an estimate of the added value, alpha, which is created by a hedge fund after accounting for market exposure, beta. Asness et al. also state that alpha is an interpretation of manager's realized skill. S&P 500 is used as a proxy for market risk even though Asness et al. are aware of other possible sources of systematic risk. Their regression takes into consideration only the linear relations between hedge fund returns and market returns, which is an approach criticized by Patton (2009) due to the dynamic trading strategies and nonlinear payoff functions, which are the characteristics of most hedge funds.

Asness et al. (2001) describe alpha as manager's realized skill. Dubil (2011) adds that managerial alpha is usually the original motive for investors to invest in a hedge

fund. According to Kung and Pohlman (2004), the idea behind portable alpha is the separation of asset allocation and the search for alpha. In addition to this, there can also be a separation between the active portfolio and the passive portfolio (Dubil 2011). Kung and Pohlman present that returns are generated from both beta and alpha – in other words, from market exposure and selection skill. Active beta returns derive from market timing, and passive beta returns from index fund exposure. The returns from alpha are generated by security selection, which is to be done within a certain asset class. As Finn (1998) talks about the zero beta strategy and Patton (2009) claims beta has to be zero or negative in order to achieve market neutrality, the aim of the portable alpha strategy is to form a beta-neutral portfolio as well. Kung and Pohlman claim that there are several different ways to generate portable alpha, and that most of the investment strategies that are able to generate alpha can be converted into a portable alpha strategy.

In order to create market neutrality and portable alpha, Dubil (2011) presents a model called the core-satellite model, where fund manager separates passive parts of the portfolio from the active parts. He suggests that management of these active and passive parts should be allocated to separate managers, since they require different kind of management and set of skills. Dubil as well as Kung and Pohlman (2004) acknowledge that in actively managed portfolios market exposure, beta, is mixed with security selection, alpha. According to Dubil, beta exposure is then hedged out by playing a pure portable alpha. Dubil offers a simple example on how portable alpha play and alpha transfer works: A pension fund wants a certain percentage of investment capital to be allocated to an alpha fund manager who specializes in arbitrage of stocks in some certain sector in the U.S. If the manager simply buys the underpriced stocks, the position is exposed to market risk of U.S. equities. If the market goes down, the underpriced stocks might follow and decline further. Thus, here the portable alpha solution is to hedge market exposure by shorting S&P 500 futures or exchange-traded funds of the underlying sector. The pure security selection alpha is expected to generate returns from buying the underpriced stocks, and the pension fund is able to hedge its risks and manage its own allocation to U.S. equities independently from the alpha fund manager. This is called the alpha transfer; the separation of the asset class exposure from specific risk plays.

Patton (2009) explains portable alpha as a trading strategy that creates returns independent of the major market risks, which is quite the same as the general definition of market neutrality in its simplest form. It is possible to combine a strategy that displays a certain amount of exposure to market risks – measured by beta – and a strategy independent of major market risks, so that the overall portfolio's exposure to market risks does not increase. In the next chapter different methods of analyzing market neutrality are presented and according to Patton, these methods can be interpreted as tests of the purity of the portable alpha strategy as well.

The objective of market neutral funds is to create alpha, and at the same time hedge the exposure to the market completely (Capocci 2006). In addition, Capocci presents that market neutrality implies dollar neutral, beta neutral, or both. Beta neutrality targets a zero or negative total portfolio beta, as described further above. Dollar neutrality is a simple measure of neutrality and targets zero net investment, for example equal dollar investment in long and short positions. Patton (2009) explains dollar neutrality as follows; one dollar of long investment is offset with one dollar of short position in the same market or sector. For a fund manager, it is easy to observe the value of the initial investment, but when it comes to the short position, the extent to which it offsets the market exposure is not certain or at least easily observable. This is caused by the unobservable risk characteristics of both short and long portfolios. Capocci concludes that to define whether a strategy is uncorrelated with the market return, beta neutrality should be chosen over dollar neutrality.

Beta is a measure of security's exposure to market risk (Muthaseb & Colborn 2012), thus it expresses security's sensitivity to market movements. Another statistical tool and a risk ratio often used in evaluation of market neutrality is R-squared ($R^2$). $R^2$ is a way of measuring how well the explanatory variable, which in equation 2 is the market return, $R_{m,t}$, explains the dependent variable, which is the return on a hedge fund $i$, $R_{i,t}$. The value of $R^2$ is always between zero and one, and if we want to compute the percentage of the variation in hedge fund returns explained by the market return, we multiply the value of $R^2$ by 100. In general, when statisticians build regression models, the aim is to achieve as high value of $R^2$ as possible. It is a measure of goodness-of-fit. (Wooldridge 2009: 36.) When analyzing market

neutrality of hedge funds with regression model in equation 2, a lower $R^2$ would support the hypothesis of market neutrality. Particularly for market neutral funds, $R^2$ is expected to be low, since investment in market neutral hedge funds is expected to be an alternative investment that is independent from standard asset classes and the return on market. The explanatory power of other hedge fund factor models, for example the 7-factor model presented by Fung and Hsieh (2004), is also measured by regression $R^2$. The problem with $R^2$ in multiple regression models, such as the 7-factor model, is that the value of $R^2$ gets higher the more explanatory variables are added in the model. For this reason, adjusted R-squared ($R^2_{adj}$) is often used and its purpose is to penalize additional explanatory variables by using a degrees of freedom adjustment (Wooldridge 2009: 838). Titman and Tiu (2001) show that a low $R^2$ is not only an indicator of market neutrality, but also a signal of potential managerial skill and activity. For funds that have lower levels of systematic risk, investors are willing to pay more and funds with low $R^2$ are reported to be able to generate superior returns.

The concept of mean neutrality is presented by Patton (2009), and he claims it to be the simplest market neutrality concept. The conditional expected return on a market neutral hedge fund, $R_{i,t}$, should be independent of the return on the market, $R_{m,t}$, for all possible outcomes of the return on the market, which can be presented in the form of equation 4:

$$E\left[R_{i,t}\middle|R_{m,t}\right] = E\left[R_{i,t}\right] \forall\, R_{m,t}\ . \tag{4}$$

Patton shows there are problems with this concept of neutrality and in analyzing it. This concept excludes all relations between the expected return of a hedge fund at time $t$ and the market return at time $t$. However, between the return of a hedge fund and the market are relations that are disliked by risk-averse investors, but also relations that they desire. Risk-averse investors hope a fund has a positive relation with the market when the market is going up and correspondingly, a negative relation when the market return is negative. Patton proposes that a restricted type of dependence between the fund and the market is a desired relation by both risk-averse investors and a hedge fund manager. Patton calls this refinement of mean neutrality

as mean neutrality on the downside and presents a new definition of mean neutrality, according to which the expected return of a fund is neutral or negatively related to the market when the market return is negative.

### 3.3 Methods of Analyzing Market Neutrality

There are several theories behind market neutrality and accordingly, there are several methods of analyzing it. One of the most comprehensive studies on analyzing market neutrality is presented by Patton (2009). According to Patton, one of the simplest and most commonly used definitions of market neutrality is based on beta, thus analyzing the betas obtained from the simple regression model in equation 2 is a way of analyzing market neutrality of hedge funds. In addition to beta, another simple way to analyze market neutrality is based on correlation between hedge fund returns and the market return. To analyze the correlation neutrality of market neutral hedge funds, Patton uses standard linear correlation to study the relationship between the funds and the market index. According to Patton's findings, 28.1% of the market neutral funds in his sample display significant correlation with the market portfolio. Patton adds that risk-averse investors prefer zero correlation compared to positive correlation. However, they prefer negative correlation to zero correlation. The percentage decreases to 23.4%, if the test focuses only on deviations from zero correlation to positive correlation with the market. Hence, now less than a quarter of sample funds have significant positive correlation with the market, which is typically something that especially risk-averse investors dislike. The value is still surprisingly high for funds that claim to be market neutral.

Patton (2009) states that correlation and beta can be easily computed and interpreted, but their information value might be low and thus might give misleading results about the diversification benefits of hedge funds. Because investors seldom require only linear correlation as the measure of dependence, other alternative types of market neutrality need to be considered. Patton offers five additional sophisticated neutrality concepts and methods of analyzing market neutrality and expected returns of hedge funds. The first actual neutrality concept presented by Patton is mean neutrality, which applies to the very basic correlation- and beta-based definitions of neutrality. He presents several methods to test mean neutrality and finds that the null

hypothesis of mean neutrality can be rejected for over one in four of hedge funds in his sample.

In addition, Patton (2009) offers a test to estimate a restricted type of dependence between the fund and the market, since risk-averse investors dislike only certain violations of mean neutrality. He calls this refinement of mean neutrality as mean neutrality on the downside. According to this new definition of mean neutrality, the relation between the fund and the market is to be negative only when the market return is negative and neutral otherwise. Patton finds that the downside mean neutrality is rejected for 20% of the funds. This implicates that a substantial amount of market neutral hedge funds display conditional mean dependence between their returns and the market return, and this is a relation risk-averse investors dislike.

The next three neutrality concepts offered by Patton are variance neutrality, value-at-risk (VaR) neutrality, and tail neutrality, which all concern the neutrality of the risk of the fund returns to market returns. The hypothesis is that the risk of a fund does not increase as the risk of the market index increases. Variance, VaR, and tail probabilities are all different measures of risk. Variance measures how far sample observations are from the sample mean. Patton finds that when risk is measured by variance, most of the funds in his sample are neutral to the market. As he presented a test on mean neutrality on the downside, a similar test can be carried out when testing variance neutrality: variance neutrality on the downside. Using the preferences of a risk-averse investor, Patton's hypothesis is that the sign of the first derivative of the variance function is positive when the market return is negative. Adjusting for the preferences of a risk-averse investor does not change Patton's results remarkably. He is not able to find violations of market neutrality, which means that the volatility of hedge fund returns is not impacted by the variance risk they are exposed to.

VaR is a measure of risk and its aim is to provide a single number to describe the total risk of a portfolio. It is a common risk measure used by fund managers as well as financial regulators. Two parameters, time horizon and confidence level, are needed to implicate the value of VaR. (Hull 2012: 471.) Hull reckons that the following statement should be able to be made after computation of VaR: "I am X

percent certain there will not be a loss of more than V dollars in the next N days." Here, the value of V represents the VaR of a portfolio, X the confidence level, and N the time horizon. Hull (2012: 474) presents an example how to compute the value of VaR with historical data: the aim is to calculate VaR using a confidence level of 99% and 501 days of data, since a one-day time horizon is used. Firstly, the market variables that affect the portfolio are identified, for example equity prices. For the most recent 501 days, the data on movements in the chosen market variables is chosen, providing 500 alternative scenarios for what can happen during one day, say today and tomorrow. The first day that data is obtained from is denoted as Day 0, the second day as Day 1, the third day as Day 2, and so on. The percentage change in the values of all market variables between Day 0 and Day 1 forms the Scenario 1. The percentage change in the values between Day 1 and Day 2 forms Scenario 2. In the end, 500 scenarios will be obtained. For each scenario, we calculate the dollar change in the value of the portfolio between today and tomorrow with following formula, where $v_i$ presents the value of a market variable on Day 1 and today is assumed to be day N:

$$Value\ under\ i^{th}\ scenario = v_n \frac{v_i}{v_{i-1}}. \tag{5}$$

Since gains can be considered as negative losses, a probability distribution for daily loss in the value of the portfolio is obtained. From the probability distribution, the fifth highest loss can be found from the left tail and interpreted as the 99$^{th}$ percentile of the distribution, where the estimate of VaR can be acquired when 501 observations are applied. As illustrated in equation 6, Patton (2009) argues a VaR-neutral portfolio has a value of VaR that is independent of the return of the market portfolio:

$$VaR\left(R_{i,t}\middle|R_{m,t}\right) = VaR\left(R_{i,t}\right). \tag{6}$$

Patton acknowledges that when it comes to VaR analysis, there must be a sufficient amount of data per fund, due to the data-intensive nature of VaR studies. This can be a challenging requirement, considering the loose disclosure requirements that hedge funds face. Additionally, data on hedge fund returns is available monthly, not daily.

Patton is able to conduct a conditional VaR neutrality test, based on equation 6, on restricted number of hedge funds in his sample, and finds no evidence against VaR neutrality. However, especially a situation where a fund's probability of exceeding its VaR is higher given that the market portfolio has exceeded its VaR, is something that a risk-averse investor would dislike. This hypothesis can be turned into a downside VaR neutrality test and Patton finds no evidence against this neutrality concept.

Tail neutrality, according to Patton (2009), is an extension of VaR neutrality but to the extreme tail. It is a neutrality concept applied to extreme events and a market neutral fund's probability of these extreme events should not be affected by market return. Patton takes the point of view of a risk-averse investor and claims that the only worthwhile test is the downside test of tail neutrality, which concerns only the left tail of the probability distribution. If an extremely right tail event was to happen, a risk-averse investor would not mind it having a positive effect on the returns of a hedge fund as well. If there is no lower tail dependence between fund returns and the market return, there is zero probability that the fund and the market will have an extremely low return at the same time. Similar downside test as for VaR-neutrality is performed for lower tail neutrality, and no evidence of violations of this neutrality concept is found in Patton's database.

Until this point market neutrality has been studied against the equity market. As it is possible to analyze market neutrality by conducting a simple linear regression on hedge fund returns against market index returns, for example the S&P 500, it is similarly feasible to regress the fund returns against a bond index fund. Muhtaseb and Colborn (2012) study the neutrality of equity market neutral strategy and one of their hypotheses is that the risk characteristics that equity market neutral hedge funds exhibit resemble more those of bonds, rather than equities. The bond index fund Muhtaseb and Colborn use is the Spartan US Bond Index Fund. Thus, a bond market beta for a hedge fund is obtained and the bond-like riskiness of funds is reflected in the significance and value of the beta estimate. A substantial difference between the study of Muhtaseb and Colborn and other studies presented in this thesis is that Muhtaseb and Colborn use hedge fund indexes, Greenwich Van Hedge Index (GVH) and DJ Credit Suisse (DJCS), to analyze neutrality to the stock market and to the

bond market, as most other studies have collected data of individual hedge funds from hedge fund databases. When measuring neutrality to the bond market, Muhtaseb and Colborn find inconsistent results between the two indexes, and for GVH index they were not able to obtain a significant bond market beta only but once during the 17-year research period. The bond market beta they present as a measure of bond market neutrality is perhaps not a considerable substitute for the traditional market beta when measuring market neutrality, but an interesting addition to analysis. Even though they are not able to provide a significant beta for the other index, they find that equity market neutral indexes have higher monthly excess returns compared to the Spartan US Bond Index Fund.

# 4 PERFORMANCE OF MARKET NEUTRAL HEDGE FUNDS

## 4.1 Issues When Measuring Performance of Hedge Funds

Fung and Hsieh (2000) take it as a given that data on hedge funds contains biases. This is primarily caused by the loose disclosure requirements that hedge funds face; they have a choice whether to report their returns to hedge fund databases. Hence it is impossible to create a market portfolio of hedge funds that would provide the aggregate investment experience in hedge funds, since not all hedge funds have chosen the option to disclose their returns. The market portfolio can be proxied by an equally weighted portfolio of hedge funds in a database, which is then called the observable portfolio. This portfolio is, however, not excluded from natural and spurious biases. Natural biases generate from hedge funds' birth, growth, and death processes, while spurious biases are created by statistical techniques to omit data shortcomings.

Survivorship bias is one of the natural biases of hedge funds, according to Fung and Hsieh (2000). A distinction between surviving and defunct funds should be made, to clarify the origin of survivorship bias. Hedge fund databases contain information only for funds that still operate, but hedge funds also have a choice whether to report to databases or not. The reporting hedge funds are called surviving funds. Defunct funds may have several reasons why they have stopped reporting information to databases including bankruptcies, liquidations, and voluntary stoppage of reporting. If the primary reason for becoming defunct is poor performance, it creates an upward bias in the historical performance of surviving funds in the database since the poor performance is omitted from the data. Fund and Hsieh show that a majority of hedge funds in the TASS database became defunct because of liquidation, and over one in four were removed because the manager stopped reporting information. The defunct funds performed worse than surviving funds, and the liquidated funds had substantially lower returns when compared to other defunct funds.

When it comes to hedge fund data obtained before 1994, Titman and Tiu (2011) find survivorship bias as an issue. Before 1994, databases simply disregarded the funds that stopped reporting information, but after 1994 a graveyard sample can be

obtained of the prior returns of defunct funds. The sample can be used to minimize the effect of survivorship bias, but also the performance of the month following the last reporting month has to be specified. Titman and Tiu use -100% as the following month's return in their reported test. In his study, Patton (2009) reports the results of neutrality tests separately for surviving and defunct funds and finds that defunct funds actually have lower proportion of non-neutral funds in their set than the surviving funds. However, this may be explained by the shorter historical data available of defunct funds.

Another bias concerning hedge fund databases is selection bias. As in the case of survivorship bias, databases are not able to offer a representative sample of hedge funds if they are affected by selection bias. Fung and Hsieh (2004) state that because hedge funds are prohibited from public solicitation, the only way of marketing themselves is through databases. Fung and Hsieh (2000) assume that only funds with good past performance have an incentive to include themselves in a database. However, conflicting incentives of hedge funds may offset each other decreasing the effect of selection bias. If a fund has closed early and managers are not interested in attracting more investors, they may not report to databases regardless of good past performance. Oppositely to survivorship bias, which can be observable in mutual fund databases as well, selection bias concerns only hedge funds since they have the option of reporting their performance.

In addition to survivorship bias and selection bias, Fung and Hsieh (2000) add that hedge fund databases are affected by instant history bias, which is more commonly known as backfilling bias. When hedge funds start reporting to a database, they are likely to backfill their instant histories at the same time. Fund is unlikely to start reporting to a database, if its historical performance has been bad. On the contrary, having a good tracking record is a good way to market themselves to potential investors via database. This creates an upward bias in the database. It is possible to mitigate the effect of backfilling bias, by deleting a selected amount of the first months' returns from the sample data. Fung and Hsieh estimate the appropriate amount using information on the incubation period, which is the lag between the founding date of a fund and the date when it enters the database. The median of the incubation period is 343 days, hence Fung and Hsieh suggest that monthly returns of

the first 12 months should be dropped from the sample data in order to minimize the effect of backfilling bias. They found that by dropping the first 12 months, the portfolio average returns decreased by 1.4 percentage points. Even higher amounts of months to be dropped have been suggested. Titman and Tiu (2011) drop the first 27 months from their sample. They find backfilling bias something to be particularly concerned about because of the upward bias it causes to the historical performance of a database. Titman and Tiu claim that backfilling causes problems especially when a manager is able to launch multiple funds and only report the performance of funds that are successful.

Many hedge funds hold illiquid exchange-traded securities and difficult-to-price over-the-counter securities in their portfolios, and Asness et al. (2001) argue that this causes stale or managed prices. It is hard to find publicly available traded prices for these securities near the end of every month, which makes the use of monthly returns of hedge funds problematic when analyzing market neutrality. Hedge funds are left with flexibility in how they value these securities and positions in their monthly reporting and managers, especially the ones of market neutral funds, have a strong incentive to show consistent and uncorrelated monthly returns with the market. This can artificially decrease estimated volatility and correlation of hedge funds with traditional indexes and create non-synchronous movements in returns. Asness et al. claim that betas of simple monthly regressions may be severely understated due to lagged relations between returns.

Dimson (1979) and Scholes and Williams (1977) (via Asness et al. 2001) present a model to correct the estimate of beta that is downward biased due to lagged prices. New regression equation of returns on both parallel and lagged market returns is of the following form:

$$R_{i,t} = \alpha_i + \beta_{0i}R_{m,t} + \beta_{1i}R_{m,t-1} + \beta_{2i}R_{m,t-2} + \beta_{3i}R_{m,t-3} + \cdots + \varepsilon_{i,t} \,. \quad (7)$$

It is possible to obtain a more accurate estimate of hedge fund's beta with the market by summing all betas, starting from $\beta_0$, together. Asness et al. studied how the summed or lagged betas would differ from betas obtained from the simple regression model for several different trading strategies of hedge funds. He found strong

increases in betas, when adjusting for stale or managed prices. However, Asness et al. were not able to reject the null hypothesis that the summed beta is zero for equity market neutral category, which supports the hypothesis of market neutral strategy as zero-beta strategy.

## 4.2 Empirical Evidence During Bull and Bear Markets

Investors expect market neutral hedge funds to deliver good returns regardless of market conditions (Patton 2009) and to maintain the returns constant over time (Fung & Hsieh 1999). Thus, one of the most essential ways to analyze market neutrality is to study the returns generated by these funds and the return persistence. Brown, Goetzmann and Park (2001) acknowledge that the data of hedge funds prior to year 1994 is nearly unusable because there is no reliable information of the number of non-survivors, and the data is severely affected by survivorship bias. Therefore it is not meaningful to conduct analysis on hedge fund performance and persistence on data that has been collected before 1994, even though the data is available. Consequently, Capocci et al. (2005) claim that too little studies have focused on performance under different market conditions, since the time window available for performance research has been composed of mainly bullish markets. They note that prior studies have attempted to capture the behavior on bear markets, but the study periods have not been optimal since the experienced downward-trends have been rare and discontinuous. Capocci et al. are able to analyze performance in bear markets that occurred after March 2000, when the stock indexes went down almost continuously for three years. Fortunately for researchers, the subprime mortgage crisis took place in 2008 driving the world economy into a financial crisis and depression, giving researchers another opportunity to analyze hedge fund performance and persistence in bearish markets.

In their study, Capocci et al. (2005) use hedge fund data from 1994-2002, of which the sub-period from January 1994 to March 2000 forms the bullish period, and the sub-period from April 2000 to December 2002 represents the bearish period. When analyzing the whole sample period, Capocci et al. find that the market neutral strategy generates significantly positive alpha and when compared to the other trading strategies, it has the highest Sharpe ratio. Sharpe ratio was first introduced by

Sharpe (1964) and is obtained by dividing the excess returns over a risk-free rate by standard deviation of the excess returns (Hull 2012: 813). Hence, the higher Sharpe ratio obtained indicates that market neutral strategy outperforms other trading strategies when adjusting for risk. When the performance is considered separately over bullish and bearish sub-periods, market neutral strategy stands out even more. While other trading strategies record outperformances primarily during the bullish sub-period, market neutral strategy continues to distinctly outperform the market during the bearish sub-period as well.

Even though Brown et al. (2001) criticize the use of hedge fund data prior to 1994, a study of Edwards and Caglayan (2001) analyze hedge fund performance between 1990 and 1998, and they report similar evidence as Capocci et al. (2005). Market neutral funds have the highest Sharpe ratio during the whole sample period as well as separately over bear and bull periods. They continue to deliver positive returns over the bearish sub-period along with the short-selling funds, while other strategies exhibit negative returns. In addition to high Sharpe ratio, Capocci et al. find that on average market neutral hedge funds exhibit lower variance and higher alphas, and thus show persistence in performance in both bull and bear markets. However, they claim that to provide positive abnormal return market neutral funds need to show a very targeted investment behavior, since persistence is observed only for the medium and top past performers. Nevertheless, the study of Capocci et al. provides encouraging evidence on performance of market neutral hedge funds and reinforces the alpha-generating dimension of market neutral investment strategy. However, the studies of Capocci et al. and Edwards and Caglayan do not take into consideration the lagged or summed betas, which according to Asness et al. (2001) can crate a down-ward bias in beta estimates and correlation between fund returns and the market return. It can also result in unreliable estimates of Sharpe ratio.

The performance of equity market neutral hedge funds is studied by Asness et al. (2001) during 1994-2000, and the results they report support the findings of both Capocci et al. (2005) and Edwards and Caglayan (2001). Asness et al. find that equity market neutral funds have the lowest standard deviation, which is the square root of variance, and the highest Sharpe ratio when compared to other hedge fund investment strategies. They compute Sharpe ratios for hedge fund returns using

summed betas to minimize the bias effect of stale or managed prices. Results provide strong evidence that supports the outperformance of market neutral hedge funds when adjusting for risk. During the sample period, equity market neutral funds were one of the few that were able to provide a positive Sharpe ratio and their Sharpe ratio was the highest.

The period of the recent financial crisis of 2008 is included in the study of Muhtaseb and Colborn (2012). Their analysis period includes data from January 1995 to January 2012. However, they use the returns of hedge fund indexes instead of the returns of individual hedge funds, which according to Capocci (2006) can create biases in study results. During the whole period, the GVH index outperforms both the stock and the bond market indexes, and the DJCS index is able to perform as well as the bond market. When it comes to the risk-adjusted returns, namely the Sharpe ratio, GVH again outperforms both markets and DJCS underperforms the bond market, but performs as well as the stock market. When monthly alphas are analyzed specifically during and after the financial crisis, Muhtaseb and Colborn find results that are against the findings of Capocci et al. (2005) according to which market neutral hedge funds are able to outperform the market in bear markets. According to Muhtaseb and Colborn, the previously significantly positive alphas decline almost to zero by January 2009 and for the other index, alpha became negative in January 2012. This provides evidence against the assumption that market neutral hedge funds are able to provide protection against declining markets.

From the obtained results, Muhtaseb and Colborn (2012) conclude that equity market neutral hedge fund indexes generate higher excess returns over the bond market index, the Spartan US Bond Index Fund. Muhtaseb and Colborn claim that equity market neutral strategy can provide returns that are higher or at least as high as the returns delivered by the stock market, and with a lower risk. They present that equity market neutral strategy faces risks that resemble more the risks of bonds, which are regarded to be lower than the risks of the stock market. Their evidence on the contrary during the bear markets of financial crisis may not be perfectly comparative to findings of Capocci et al (2005). Muhtaseb and Colborn analyze two hedge fund indexes, as opposed to Capocci et al. who employ data on individual hedge funds obtained from a hedge fund database, Managed Account Reports (MAR). Capocci et

al. also analyze market neutral strategy in general, and the study of Muhtaseb and Colborn focuses on a sub-strategy of market neutrality, the equity market neutral strategy.

Since not many comprehensive studies have been made on the performance of market neutral hedge funds during the financial crisis of 2007-2009, other ways have to be discovered in order to analyze market neutral funds over this period. During the financial crisis, liquidity declined and even dried up causing a liquidity shock (Cornett et al. 2011). The dimensions of liquidity are usually measured by the time and the costs associated when a given asset position is transformed into cash and vice versa (Brandon and Wang 2013), and for example bid-ask spreads are a practical measure of liquidity (Schaub & Schmid 2013). One of the characteristics of hedge funds is that they often hold illiquid exchange-traded securities (Asness et al. 2001); hence it is interesting to analyze the effect of liquidity risk on the performance of hedge funds.

This is the purpose of the study of Brandon and Wang (2013), who analyze data from January 1994 to December 2006. Even though Brandon and Wang's analysis period does not include the period of the financial crisis, their findings are noteworthy. The results of Brandon and Wang's (2013) study implicate that the managerial skills, measured by alpha, of most equity hedge funds are overestimated since the impact of liquidity risk is not incorporated into the performance evaluation framework. After accounting for liquidity risk, the previously observed outperformance disappears or declines substantially, except for equity market neutral and long-short equity hedge funds. Equity market neutral strategy is able to yield significant superior performance even after accounting for liquidity risk. Brandon and Wang suggest, that the residual alphas after accounting for liquidity risk of equity market neutral hedge funds are attributed to the rents earned from providing liquidity during periods when liquidity is scarce. Hence, these hedge funds are compensated for providing liquidity when it is most needed. According to Brandon and Wang's results, one may speculate that equity market neutral hedge funds ought to have outperformed other strategies during the financial crisis as well, when the liquidity was extremely scarce.

# 5 ARE MARKET NEUTRAL HEDGE FUNDS REALLY MARKET NEUTRAL?

In this chapter we present relevant research results of previous studies aimed at to determine whether so-called market neutral hedge funds have exposure to the equity market. Results are obtained by utilizing the theory behind market neutrality and the methods of analyzing it, which are presented in the second chapter. Market neutrality – or non-neutrality – is studied during periods that contain both bearish and bullish market periods, but also separately over bull and bear markets.

Capocci (2006) states the sole purpose of market neutral funds is to generate positive returns regardless of the market conditions. He studies whether market neutral hedge funds are actually market neutral, by analyzing various market neutral indexes as well as individual hedge fund returns during 1993–2002 and separately in bull and bear markets. One of the theories behind market neutrality is the assumption of a zero beta, and Capocci finds that the absolute beta is low but significantly positive. For the entire period, a relatively low value of $R^2_{adj}$ is found for market neutral funds, which is one of the criteria of market neutrality and indicates that market return does not explain the majority of returns of the index. The value of $R^2_{adj}$ is, however, too high for a strategy that is supposed to be neutral to the market. When alphas and average returns are compared for individual funds, the $R^2_{adj}$ values are significantly low and even close to zero. Thus, the alpha created by market neutral funds is not largely explained by the market factor. Capocci suggests the aggregation of funds behind the indexes is the main cause why indexes seem to have higher market exposure than individual funds. Hence, the importance of using individual funds in empirical analysis is high, in order to avoid biased results.

From the sub-period analysis of indexes, Capocci (2006) finds that in the bull period market neutral funds are able to outperform the market index and that the alpha created is independent from the market. Market factors, which are comparable to market betas, are not significantly different from zero and a very low $R^2_{adj}$ is reported, hence market factors do not explain the outperformance. During the bear market period, the average returns and standard deviations of indexes are lower than during the whole analysis period. Severe market exposure is observed since the

reported beta is significantly positive during this period and also the value of $R^2_{adj}$ is higher than the one obtained during the bull market. However, the alpha created is positive for the bear period as well tough it is lower than during the bull period. In conclusion, market exposure of market neutral funds seems to increase during bear periods based on the analysis of market neutral hedge fund indexes. Similar results are found when analyzing individual funds during the bull and bear markets. In the bull period, almost all market betas are not significantly different from zero and a low $R^2_{adj}$ confirms the result. During the bear period, market exposure increases but interestingly, funds are significantly and negatively exposed to the market, indicating that some funds short the falling market and generate returns by having negative exposure to the market.

A decile analysis is conducted by Capocci (2006) to determine whether market neutral hedge funds are able to show persistence in their returns, and how market neutrality varies between the best and worst performing funds. In decile analysis, funds are classified in deciles based on their average performance over the study period. Results indicate that the middle decile funds are market neutral, and that the most volatile returns are provided by the worst and best performing funds, although especially for them the alphas were significantly positive. The sub-period analysis indicate that during the bull period, indexes and deciles were not significantly exposed to the market and that the worst and best performing funds of the whole period were able to outperform the equity market in the bull period. During the bear markets, higher market exposure is reported in the form of negative exposure, but this did not impact returns of market neutral funds negatively.

Muhtaseb and Colborn (2012) analyze market neutrality of two equity market neutral hedge fund indexes, the DJSC index and the GVH index, over the period of January 1995 – January 2012. They focus on studying the neutrality of equity market neutral funds, which is one of the main sub-strategies of market neutral investment strategy. Neutrality is analyzed against both the stock market and the bond market, and Muhtaseb and Colborn conclude that over the long term equity market neutral funds are able to avoid exposure to the market until September 2008, when the economic recession began. The neutrality is maintained or the exposure is at least negligible during economic risk-free periods and this result is in line with the one of Capocci

(2006). Muhtaseb and Colborn conclude due to rolling beta analysis that during bear market periods market neutrality decreases and the alpha produced is positive, but falls down over their study period. From the two hedge fund indexes, the GVH exhibits higher market neutrality compared to the DJCS. The GVH provides lower stock and bond market betas, as well as higher and more significant alphas against stock and bond market indexes. Hence Muhtaseb and Colborn are able to find a market neutral hedge fund index, regardless of Capocci's assumption of the aggregation of funds increasing the observed market exposure.

The detailed study of Patton (2009) analyses the neutrality of market neutral hedge funds over the time period from April 1993 to April 2003, by combining a database of 1423 hedge funds from HFR and Lipper TASS hedge fund databases. We previously reported the main results on Patton's individual neutrality tests: mean neutrality, variance neutrality, VaR neutrality, and tail neutrality. Patton combines the results of these tests as well as a test of complete neutrality, and creates a joint test of market neutrality to draw an overall conclusion of the neutrality of hedge funds. The results of tail neutrality test are however excluded, due to biases that the small number of data available for the test might cause. Nearly a third of the hedge funds fail the joint test of market neutrality but the number decreases only to one in five, if the joint test is considered only against the alternatives that a risk-averse investors would dislike; the neutralities on the downside.

Patton (2009) conducts a neutrality test on the HFR Equity Market Neutral index to analyze, whether a hedge fund index shows more or less market neutrality compared to individual funds. The hypothesis of Capocci et al. (2005) is that indexes are more exposed to the market, but Muhtaseb and Colborn (2012) were able to find a market neutral index. The results of Patton's test conclude that the index was able to pass all of the five neutrality tests that Patton presents, which supports the results of Muhtaseb and Colborn but offers counter evidence against Capocci's assumption. In comparison, roughly 25 % of the individual funds failed the joint neutrality test, as in showed non-neutrality in at least one of the five tests of market neutrality. Patton suggests that market exposures of individual funds offset each other and by combining the individual self-proclaimed market neutral hedge funds one is able to create a truly market neutral fund of funds.

Based on the joint neutrality test on the downside, Patton (2009) creates two portfolios, neutral and non-neutral portfolio. The neutral portfolio includes the individual funds that passed the joint neutrality test, and the non-neutral portfolio correspondingly includes the funds that failed the test. A few remarks can be made from these portfolios. On average, non-neutral funds are 33% older than neutral funds and they have more funds under management. Patton suggests the higher age of non-neutral funds may result in a greater power to reject the null hypothesis of market neutrality or it can simply indicate the tendency of older funds losing market neutrality over time. He finds the neutral portfolio had a negative correlation with the market in months following a six-month period of below-average market returns, while the corresponding value for non-neutral portfolio was close to one. The correlation of neutral portfolio with the market decreases in bearish markets, but for the non-neutral portfolio the correlation increases. It is not a surprising result, considering that the joint test included only the neutrality test on the downside. However, it signals that some of the so-called market neutral funds can remarkably let down the expectations of a risk-averse investor at a time when especially a market neutral fund is expected to provide protection against the declining markets. This result is in line with the findings of Capocci (2006), who also found that market exposure of market neutral funds increases during bear markets.

# 6 DATA AND METHODOLOGY

## 6.1 Description of Data

The data used in this study is obtained from Lipper TASS database over the period from January 1994 to December 2012. TASS is a company specialized in hedge fund research and a widely used source of data when analyzing hedge fund performance. Monthly returns of both live and defunct funds are included in the data. The data of Lipper TASS database is composed of individual hedge funds instead of indices, which allows more detailed analysis for example in deciles. According to Fung and Hsieh (2000), this data can be viewed as the observable portfolio, since it is impossible to create a market portfolio of hedge funds due to loose regulatory requirements and the voluntary disclosure of returns to hedge fund databases.

Lipper TASS database includes 11 different main strategies: CTA, emerging markets, event driven, fund of funds, global macro, long/short, market neutral, multi-strategy, relative value, short bias, and others. Here, CTAs are seen as a sub-category of hedge funds rather than as its own investment vehicle. According to TASS classification methodology, event driven strategies aim to profit from mispricing of securities related to specific corporate or market events while taking positions in various assets classes. Global macro and long/short strategies are classified as directional strategies, where global macro strategy aims to exploit from price valuations of macro-economic drivers. Long/short strategy combines holding of both long and short sides while hedging and diversifying across sectors or regions. Multi-strategy hedge funds can run several different strategies, while no single strategy accounts for more than 75% of risk capital. Several sub-strategies can be referred to as a relative value strategy, including convertible arbitrage, fixed income arbitrage, and options arbitrage. Lastly, short bias strategy can be implemented by constantly having a net-short exposure to the market, by pursuing short sales of stocks, or sometimes by selling forward. Hedge funds included in the “others” bucket may apply a combination of several hedge fund strategies that are not applicable to be included in the multi-strategy category. (Thomson Reuters 2016).

The time series data of the 11 hedge fund strategies includes monthly net-of-fee returns of 18,891 funds, of which 690 funds report to follow the market neutral strategy. Hence, funds following market neutral strategy account for less than 4% of the total number of funds included in this study. The relative share is lower than expected. In the study of Capocci (2006), 28.3% of the global MAR/CISDM hedge funds in the database are market neutral funds, while the figure is 13.8% in the study of Patton (2009). This may be due to differences in classification of strategies between different hedge fund databases. Lipper TASS database separates market neutral and long/short strategies, while in some studies long/short strategy is referred to as an equity market neutral strategy and hence, as a sub-category of market neutral strategy. This study presents the data of long/short hedge funds as its own strategy and it is included as one of the benchmarks for market neutral strategy. Both returns and AUM are converted to USD and on average in year 2012, the total AUM is $670 billion. AUM is calculated as a yearly average due to some funds reporting AUM information only bi-yearly, rather than monthly or quarterly. In addition to the main strategy applied, monthly returns and AUM, the data provider collects useful information on certain fund characteristics such as fund name, currency, domicile, inception date, management fee, and incentive fee.

The monthly returns of the S&P 500 Net Total Return index are used to evaluate the neutrality of hedge funds against the market. The index is commonly used as a market proxy for performance benchmarking and for market neutrality assessment. For conservative reasons and in order to use the benchmark more accurately, monthly returns are included as a total return measure including dividend reinvestment. Dividends add significantly to the total return of the index and if dividend reinvestment was excluded, the performance of hedge funds would more easily appear superior to the S&P 500 index. As a proxy for risk-free return, we use generic one-month U.S government T-bill rate obtained from Bloomberg.

### 6.2 Summary Statistics

Table 1 presents the summary statistics of the monthly returns of the 11 hedge fund strategies. The statistics confirm that on average hedge funds performed well during the sample period from January 1994 to December 2012. Short bias strategy has the

lowest average monthly return, as well as the highest standard deviation after emerging markets hedge funds. Hedge funds applying the short bias strategy present a minor share of the sample, with only 54 funds in total during the sample period utilizing it as their primary strategy. Remarkably, the standard deviation of market neutral funds is the lowest, excluding CTA funds. Minimum and maximum monthly returns of market neutral hedge funds are also the top performing ones compared to other strategies. Long/short, emerging markets, and multi-strategy funds are able to generate the highest monthly returns on average.

**Table 1. Summary statistics of monthly hedge fund returns, number of funds and AUM.**

| | Hedge fund strategy | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTA | Emerging Markets | Event Driven | Fund of Funds | Global Macro | Long/ Short | Market Neutral | Multi-Strategy | Relative value | Short Bias | Others |
| Mean | 0.007 | 0.009 | 0.008 | 0.005 | 0.007 | 0.010 | 0.008 | 0.009 | 0.007 | 0.002 | 0.009 |
| Standard deviation | 0.007 | 0.042 | 0.017 | 0.022 | 0.020 | 0.028 | 0.015 | 0.025 | 0.018 | 0.041 | 0.015 |
| Skewness | 0.324 | -0.943 | -1.716 | -0.925 | 0.050 | -0.239 | -0.697 | -1.243 | -2.556 | 0.805 | -1.132 |
| Kurtosis | -0.080 | 3.679 | 6.096 | 3.936 | 1.515 | 1.748 | 7.572 | 6.361 | 17.919 | 3.716 | 6.699 |
| Min | -0.055 | -0.212 | -0.086 | -0.105 | -0.080 | -0.094 | -0.068 | -0.114 | -0.130 | -0.094 | -0.080 |
| Max | 0.083 | 0.138 | 0.051 | 0.073 | 0.067 | 0.109 | 0.083 | 0.098 | 0.072 | 0.224 | 0.060 |
| N | 1 164 | 1 058 | 801 | 6 371 | 978 | 4 005 | 690 | 2 364 | 833 | 54 | 573 |
| AUM | 50 940 | 31 298 | 26 086 | 179 058 | 84 647 | 75 133 | 8 557 | 114 561 | 67 884 | 54 | 31 836 |

This table presents the summary statistics on monthly hedge fund returns over the sample period from January 1994 to December 2012. The rows below hedge fund strategies present statistics of equal-weighted hedge fund portfolio returns for each strategy. The penultimate row presents the number of funds that have reported to follow each style category. The final row presents the total AUM in millions of USD for each strategy in year 2012, where individual fund's AUM is calculated as the monthly average AUM in year 2012.

Skewness measures the degree of asymmetry in the return distribution, i.e positive skewness indicates that relatively higher share of the monthly returns are positive and vice versa. From table 1 we can see that skewness is positive only for CTA, global macro, and short bias funds during the full sample period. Relative value and event driven funds experience the highest negative skewness in their monthly returns. Kurtosis is a measure of concentration of the returns, and generally a rational investor is expected to prefer an investment with low or negative kurtosis. This would indicate more predictable returns. Only CTA funds have negative kurtosis, while funds following the relative value strategy experience significantly high

kurtosis indicating unpredictable returns during the sample period. Both in terms of number of funds and total AUM in year 2012, the most common hedge fund strategies were fund of funds, long/short and multi-strategy.

Table 2 presents the yearly average AUM per each hedge fund strategy during the sample period. In year 2012, the total AUM is $670 billion for the eleven strategies and, on average during the whole sample period the total AUM is $453 billion. According to the sample data, the total AUM in 1994 is only $45 billion, which may indicate that during the sample period both reporting to the hedge fund database has become more common and interest towards hedge funds as an investment class has grown. The peak AUM is reported during years 2007-2008, when the yearly AUM broke the threshold of $1,000 billion in USD in this database. Total AUM decreased significantly in 2009, and continued to do so until the end of the sample period. This can be a consequence of poor performance during the financial crisis, leading hedge funds to stop reporting to a database or even being dissolved. For market neutral funds, AUM increase remarkably from 1994 until 2007, but decrease by half after year 2007. This can indicate presence of survivorship bias in the data, since defunct funds may have stopped reporting information to the database due to poor performance, bankruptcy, or liquidation causing an upward bias in the return data.

Table 3 includes annualized returns of each hedge fund strategy from year 1994 to 2012. We can observe volatile returns especially for funds following emerging markets, short bias, and fund of funds strategies. This is supported by table 1, where we see highest standard deviations for these strategies. Returns are mainly positive each year, excluding 2008 and 2011, during which majority of the strategies experience negative annual return on average. Finn (1998) addresses market neutral strategies also as absolute return strategies, and from table 3 we can observe that on average market neutral funds are able to generate a positive annual return each year of the sample period, excluding year 2008. Annual return is slightly positive in year 2011 as well, while most other strategies were not able to generate a positive annual return.

**Table 2. Yearly total AUM.**

| | Hedge fund strategy | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTA | Emerging Markets | Event Driven | Fund of Funds | Global Macro | Long/ Short | Market Neutral | Multi-Strategy | Relative value | Short Bias | Others |
| 1994 | 3 318 | 3 568 | 3 090 | 6 270 | 10 054 | 10 237 | 475 | 4 770 | 2 044 | 134 | 638 |
| 1995 | 3 534 | 3 999 | 3 727 | 7 836 | 10 669 | 12 419 | 484 | 5 481 | 2 341 | 158 | 782 |
| 1996 | 3 386 | 4 748 | 5 424 | 13 552 | 12 472 | 17 176 | 789 | 7 190 | 4 026 | 222 | 1 099 |
| 1997 | 3 338 | 9 541 | 9 243 | 17 623 | 18 109 | 24 305 | 1 788 | 9 155 | 8 306 | 341 | 1 796 |
| 1998 | 4 614 | 7 566 | 14 650 | 19 883 | 23 323 | 32 478 | 3 396 | 11 329 | 12 442 | 458 | 3 028 |
| 1999 | 5 605 | 5 429 | 15 038 | 21 300 | 14 594 | 50 520 | 5 304 | 10 564 | 11 263 | 570 | 3 046 |
| 2000 | 5 070 | 6 040 | 20 958 | 28 352 | 8 727 | 75 694 | 7 425 | 12 585 | 13 737 | 785 | 2 945 |
| 2001 | 6 361 | 5 367 | 28 251 | 42 734 | 3 667 | 80 180 | 12 005 | 14 866 | 24 245 | 917 | 2 245 |
| 2002 | 8 796 | 6 457 | 33 638 | 60 286 | 5 132 | 79 462 | 13 754 | 17 841 | 33 382 | 397 | 3 962 |
| 2003 | 17 077 | 9 584 | 43 280 | 87 758 | 10 723 | 82 710 | 15 601 | 22 693 | 44 441 | 318 | 6 970 |
| 2004 | 33 048 | 17 694 | 69 715 | 151 869 | 20 115 | 110 922 | 16 522 | 33 832 | 56 480 | 293 | 11 200 |
| 2005 | 38 608 | 30 285 | 94 972 | 183 706 | 26 711 | 138 444 | 19 454 | 40 139 | 56 032 | 277 | 15 801 |
| 2006 | 45 329 | 42 354 | 112 343 | 222 151 | 39 744 | 175 058 | 21 261 | 46 911 | 51 802 | 373 | 17 635 |
| 2007 | 55 240 | 61 820 | 131 623 | 304 625 | 49 870 | 225 886 | 30 100 | 81 255 | 67 167 | 420 | 25 397 |
| 2008 | 56 136 | 61 813 | 102 570 | 463 894 | 67 412 | 188 167 | 22 067 | 98 490 | 50 088 | 791 | 34 697 |
| 2009 | 55 889 | 35 132 | 56 674 | 269 476 | 54 512 | 108 271 | 11 002 | 68 692 | 85 925 | 396 | 26 583 |
| 2010 | 56 982 | 38 454 | 68 792 | 239 926 | 60 968 | 112 318 | 9 993 | 80 449 | 31 981 | 274 | 28 247 |
| 2011 | 64 541 | 35 848 | 30 895 | 231 684 | 84 322 | 98 585 | 12 063 | 112 753 | 64 565 | 74 | 31 182 |
| 2012 | 50 940 | 31 298 | 26 086 | 179 058 | 84 647 | 75 133 | 8 557 | 114 561 | 67 884 | 54 | 31 836 |

This table presents yearly AUM per hedge fund strategy. AUM is calculated by firstly considering the yearly average AUM for each individual fund, since some funds report AUM information only quarterly or bi-yearly. Hence, measuring the end-of-year AUM could create a downward bias in the value. Secondly, the AUM of individual funds are added together to obtain the total AUM for each strategy.

**Table 3. Annualized returns.**

| | Hedge fund strategy | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTA | Emerging Markets | Event Driven | Fund of Funds | Global Macro | Long/ Short | Market Neutral | Multi-Strategy | Relative value | Short Bias | Others |
| 1994 | 0.030 | 0.072 | 0.073 | -0.031 | -0.056 | 0.076 | 0.084 | -0.034 | 0.033 | 0.144 | 0.049 |
| 1995 | 0.152 | 0.040 | 0.215 | 0.120 | 0.188 | 0.399 | 0.277 | 0.158 | 0.202 | -0.012 | 0.251 |
| 1996 | 0.115 | 0.352 | 0.176 | 0.134 | 0.159 | 0.272 | 0.222 | 0.167 | 0.209 | 0.045 | 0.122 |
| 1997 | 0.127 | 0.254 | 0.236 | 0.126 | 0.147 | 0.247 | 0.161 | 0.176 | 0.123 | 0.133 | 0.198 |
| 1998 | 0.131 | -0.251 | 0.068 | 0.015 | 0.064 | 0.221 | 0.144 | 0.117 | 0.052 | -0.061 | 0.079 |
| 1999 | 0.007 | 0.883 | 0.229 | 0.235 | 0.145 | 0.850 | 0.104 | 0.281 | 0.158 | -0.150 | 0.207 |
| 2000 | 0.092 | -0.027 | 0.128 | 0.105 | 0.032 | 0.173 | 0.223 | 0.149 | 0.128 | 0.142 | 0.082 |
| 2001 | 0.030 | 0.171 | 0.107 | 0.046 | 0.110 | 0.168 | 0.067 | 0.094 | 0.117 | 0.095 | 0.102 |
| 2002 | 0.160 | 0.101 | 0.053 | 0.106 | 0.118 | 0.024 | 0.096 | 0.153 | 0.132 | 0.220 | 0.148 |
| 2003 | 0.213 | 0.469 | 0.294 | 0.228 | 0.328 | 0.305 | 0.173 | 0.284 | 0.170 | -0.157 | 0.463 |
| 2004 | 0.098 | 0.218 | 0.161 | 0.136 | 0.092 | 0.130 | 0.090 | 0.206 | 0.106 | -0.044 | 0.149 |
| 2005 | 0.045 | 0.280 | 0.098 | 0.031 | 0.086 | 0.108 | 0.030 | 0.147 | 0.053 | 0.028 | 0.071 |
| 2006 | 0.134 | 0.343 | 0.182 | 0.162 | 0.111 | 0.176 | 0.119 | 0.179 | 0.126 | -0.030 | 0.140 |
| 2007 | 0.159 | 0.346 | 0.107 | 0.146 | 0.594 | 0.146 | 0.112 | 0.212 | 0.087 | 0.107 | 0.123 |
| 2008 | 0.168 | -0.321 | -0.181 | -0.206 | 0.010 | -0.169 | -0.091 | -0.190 | 0.392 | 0.290 | -0.079 |
| 2009 | 0.005 | 0.365 | 0.258 | 0.110 | 0.220 | 0.243 | 0.138 | 0.372 | 0.293 | -0.131 | 0.301 |
| 2010 | 0.134 | 0.102 | 0.130 | 0.027 | 0.102 | 0.097 | 0.047 | 0.145 | 0.093 | 0.012 | 0.150 |
| 2011 | -0.045 | -0.126 | -0.014 | -0.067 | -0.042 | -0.063 | 0.007 | 0.043 | 0.007 | 0.025 | 0.010 |
| 2012 | -0.036 | 0.066 | 0.108 | 0.050 | 0.027 | 0.092 | 0.048 | 0.047 | 0.091 | -0.162 | 0.106 |

This table presents annualized monthly returns as equal-weighted for each hedge fund strategy during the sample period from January 1994 to December 2012.

Table 4 provides information on fund characteristics, such as average AUM of a fund during its lifespan, fund age, and management and incentive fees. While the mean hedge fund size over the life of a fund is $94.3 million, the median hedge fund size is only $23.6 million. According to Bali et al. (2012), this result reflects the true industry standard suggesting that there are few funds with very large assets under management. Another typical hedge fund characteristic is the short span of life and from table 4 we can see that the mean hedge fund age is 65 months, which is around 5.4 years. The use of HWM and payout schedules encourage hedge fund managers to dissolve quickly and found a new fund after a bad year, since they are not compensated before covering losses from prior years or exceeding the HWM. Bali et al. suggest this as the main factor behind the short span of life of hedge funds. The median management fee is 1.5% and the incentive fee 20.0%, which are the same as the fees on average in the study of Titman and Tiu (2011) and reflect the industry standard.

**Table 4. Fund characteristics.**

Fund Characteristics

| | N | Mean | Median | Standard deviation |
|---|---|---|---|---|
| Average AUM over the life of the fund (millions $) | 18 891 | 94.3 | 23.6 | 294.5 |
| Age of fund (number of months in existence) | 18 891 | 64.6 | 54.0 | 46.4 |
| Management fee | 18 711 | 1.4% | 1.5% | 0.01 |
| Incentive fee | 17 841 | 13.3% | 20.0% | 0.09 |

This table provides the fund characteristics over the sample period from January 1994 to December 2012 including all hedge fund strategies. AUM is calculated as the average over the life of the fund and age of fund represents the number of months each fund has reported to the database. The table also provides information on management and incentive fees.

## 6.3 Reshaping and Mitigating Biases

Primarily due to the loose regulatory environment hedge funds are able to operate in, hedge fund data contains several biases. According to Fung and Hsieh (2000), backfilling bias creates an upward bias in a database, since only well-performing hedge funds are likely to start reporting their returns and often these funds backfill their instant histories at the same time. The effect of backfilling bias can be mitigated by deleting a selected amount of the first month's returns from the sample. In this study, we drop the first 12 monthly returns of each fund as suggested by Fung and

Hsieh and hence, the actual first monthly data included in this study is obtained from January 1995. No actions are taken to mitigate the effect of selection bias from the sample data, as Fund and Hsieh (1997) propose that the bias is omitted from databases. They believe that poorly preforming funds do not publish their returns in the fear of bad publicity, and well performing funds have closed out quickly and do not need to advertise their good returns in order to attract more investors.

According to Titman and Tiu (2011), survivorship bias is caused by the voluntary nature of reporting to databases. TASS database does not include any defunct funds prior to 1994 and in order to mitigate survivorship bias, data series of this study starts earliest from January 1995 after accounting for backfilling bias. The effect of survivorship bias can be studied by testing neutrality separately for surviving and defunct funds, and Patton (2009) finds that defunct funds contained lower proportion of non-neutral funds in their set than the surviving funds. In this study, no separate data of defunct funds are tested for neutrality and the analyzed data includes both live and defunct funds. To minimize possible general errors in the data, returns greater than 400% and losses greater than 100% are set as missing. Additionally, the incentive fee of a single fund with an incentive fee of 200% is set as missing.

### 6.4 Research Methods

As an investment strategy, the market neutral strategy seems a very lucrative one due to its expected characteristic of providing protection against declining markets. The main objective of this study is to analyze the performance and neutrality of market neutral hedge funds against equity markets during the financial crisis. Main focus is on market neutral hedge funds, while it is interesting and meaningful to analyze the performance and neutrality of other hedge funds strategies as well in order to compare the final results. Performance analysis and neutrality tests are performed during both the financial crisis and comparison period, in order to capture how the performance of market neutral hedge funds differs from average during a bear market. In this study, the period of financial crisis starts in July 2007 and ends in December 2008, hence including 18 months and accounting for 8% of total sample period. The definition is similar to one used by Schaub and Schmid (2013), who study the impact of share restrictions on hedge fund performance during the crisis

and non-crisis periods. The comparison period used in this study starts from January 1995 and ends in December 2004. Period is set to be relatively long in order to capture bullish, bearish, and also average market conditions. Monthly returns of both live and defunct funds are included in this study.

Alpha is used as the main measure to study hedge fund performance, and the search for alpha is usually the original motive of investors for investing in a hedge fund. The model used in this study is a single index model, the CAPM, developed by Sharpe (1964) and Lintner (1965):

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_i(R_{m,t} - R_{f,t}) + \varepsilon_{i,t}, \quad (8)$$

where $R_{i,t}$ represents return on a hedge fund $i$, $R_{f,t}$ is the risk-free return and $R_{m,t}$ return on the market index on month $t$. Here $\alpha_i$ and $\beta_i$ are the intercept and slope of the regression, respectively, and $\varepsilon_{i,t}$ represents the error term on month $t$. As described in previous chapters, alpha is often used as a measure of out- and underperformance in relation to the applied market proxy. S&P 500 index is used as the market proxy in this study, which is in line with other studies presented in the literature review of the thesis. The exact index used is the S&P 500 Net Total Return index, which accounts for dividends being reinvested back into the index after tax effect. As a proxy for risk-free return, we use generic one-month U.S government T-bill rate. In addition to alpha, Sharpe ratio is used to analyze the performance of funds. Capocci (2006) highlights the importance of focusing on hedge fund's risk-return characteristics and uses Sharpe ratio also to analyze persistence in hedge fund returns. Sharpe ratio is a ratio of the average return on the standard deviation and intends to describe whether hedge funds are able to generate consistent returns over time. It is a widely used measure in studies focusing on hedge funds, regardless of its limitations and shortcuts it takes. In addition to use of Sharpe ratio, persistence in performance is determined by analysis of measures such as alpha, skewness, and kurtosis as well as their significance levels during the whole period.

Studying performance of market neutral hedge funds is crucial in order to determine true neutrality, since one of the definitions of market neutrality is to provide good and stable returns regardless of market conditions. In addition, we will measure the

level of neutrality during the financial crisis and the comparison period utilizing classic neutrality measures. We study the slope of equation (8), beta, which is a measure of security's exposure to market risk and one of the most commonly used measures in the neutrality analysis of hedge fund returns. To further analyze neutrality to the market movements, we present correlation coefficients of hedge fund returns against the market return, and expect correlation between hedge fund return and market return to be low or negative. According to Patton (2009), a risk-averse investor prefers zero correlation to positive correlation, but prefers negative correlation to zero correlation. In addition, neutrality is analyzed by computing $R^2$. Both measures are expected to be low in order to support the hypothesis of market neutrality. These are well known and widely used measures of neutrality in prior studies focusing on neutrality analysis.

While these measures can be easily computed and interpreted, their information value might be low due to the dynamic trading strategies used by hedge funds as well as due to stale or managed prices, which might cause lagged relations between returns. One suggestion to obtain a more accurate estimate of hedge fund's beta with the market is by summing all betas presented previously in equation (7). However, Asness et al. (2001) were not able to find significant evidence that summed or lagged betas would differ from betas obtained from the simple regression model. To further analyze neutrality, we test the concept of mean neutrality presented by Patton (2009) as described in previous chapters and in equation (4). Mean neutrality test is performed for the average strategy portfolio as well as for individual hedge funds during the financial crisis, to compute the percentage of individual hedge funds that are able to pass the test. In addition, former studies suggest that among self-claimed market neutral funds, one can find truly neutral as well as non-neutral funds. Later on we will present results of decile analysis, which is performed for market neutral hedge funds during the financial crisis.

# 7 EMPIRICAL RESULTS

## 7.1 Performance and persistence

### 7.1.1 Performance and persistence during the financial crisis

This section presents the performance of hedge funds during the financial crisis, with main emphasis on hedge funds utilizing the market neutral strategy. The performance of market neutral hedge funds is compared to the performance of funds utilizing other strategies, which are considered as benchmarks. Additionally, results are compared to the market return, proxied by S&P 500 index return. The period of financial crisis is set to start form July 2007 and end in December 2008. The effect of back-filling bias is mitigated from the following results by excluding first 12 monthly observations of each hedge fund.

**Table 5. Statistics of monthly hedge fund and market returns during the financial crisis.**

| | Hedge fund strategy and S&P 500 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTA | Emerging Markets | Event Driven | Fund of Funds | Global Macro | Long/ Short | Market Neutral | Multi-Strategy | Relative value | Short Bias | Others | S&P 500 |
| Mean | 0.012 | -0.021 | -0.014 | -0.010 | 0.003 | -0.011 | -0.005 | -0.009 | -0.011 | 0.018 | -0.009 | -0.026 |
| Standard deviation | 0.034 | 0.060 | 0.028 | 0.040 | 0.024 | 0.036 | 0.027 | 0.045 | 0.039 | 0.027 | 0.027 | 0.054 |
| Skewness | 0.237 | -0.955 | -1.118 | -0.860 | -0.001 | -0.693 | -1.122 | -0.942 | -2.170 | 0.005 | -1.735 | -1.002 |
| Kurtosis | -0.576 | 0.703 | 1.221 | 0.308 | -0.392 | 0.082 | 0.476 | 0.347 | 4.292 | -1.062 | 3.066 | 0.718 |
| Min | -0.042 | -0.176 | -0.090 | -0.105 | -0.047 | -0.097 | -0.069 | -0.109 | -0.137 | -0.030 | -0.091 | -0.169 |
| Max | 0.076 | 0.055 | 0.024 | 0.046 | 0.048 | 0.038 | 0.025 | 0.053 | 0.028 | 0.067 | 0.024 | 0.048 |
| N | 392 | 465 | 371 | 3 661 | 258 | 1 738 | 262 | 919 | 340 | 25 | 183 | - |

This table presents the summary statistics of monthly hedge fund returns and return on the market, proxied by S&P 500, over the financial crisis period from July 2007 to December 2008. The rows below hedge fund strategies present statistics of equal-weighted hedge fund portfolio returns for each strategy. The final row gives information on the number of funds that reported to TASS Lipper database during the full or part of the financial crisis period.

Table 5 reports the summary statistics of monthly hedge fund returns as well as return on the market during the financial crisis. Average monthly return of market neutral hedge funds is negative, while this is the case for most other strategies as well. Standard deviation during the period is among the lowest ones for market

neutral hedge funds, while they experience some low positive kurtosis as a sign of unpredictability in returns. Table 6 shows that the annual return for market neutral hedge funds is -2.9%, indicating that funds are not performing according to their definition of generating good and stable returns regardless of market conditions. However, market neutral hedge funds are able to outperform the market during the financial crisis period. Only funds following CTA, global macro, and short bias strategies are able to generate a positive annualized return during the financial crisis. Interestingly, all strategies report positive returns on year 2007, while the market return is already negative. This can be related to hedge funds holding illiquid exchange-traded securities and difficult-to-price over-the-counter securities, which can cause stale or managed prices (Asness et al. 2001). As a result, hedge funds may have flexibility in valuing these securities, since it is of the manager's interest to show consistent and uncorrelated monthly returns with the market. Overall, all strategies are able to outperform the market during the financial crisis. Findings are similar to ones made by Capocci et al. (2005), while they find that market neutral strategy positively stands out even more during bear markets.

**Table 6. Hedge fund and market return during the financial crisis.**

| | Hedge fund strategy and S&P 500 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTA | Emerging Markets | Event Driven | Fund of Funds | Global Macro | Long/ Short | Market Neutral | Multi-Strategy | Relative value | Short Bias | Others | S&P 500 |
| 2007 | 0.188 | 0.279 | 0.043 | 0.116 | 0.220 | 0.094 | 0.096 | 0.165 | 0.055 | 0.295 | 0.097 | -0.046 |
| 2008 | 0.155 | -0.363 | -0.186 | -0.202 | 0.069 | -0.171 | -0.075 | -0.197 | -0.174 | 0.324 | -0.131 | -0.385 |
| Annua-lized | 0.138 | -0.230 | -0.093 | -0.119 | 0.137 | -0.101 | -0.029 | -0.129 | -0.115 | 0.301 | -0.087 | -0.288 |

This table presents annualized monthly returns as equal-weighted for each hedge fund strategy and the S&P 500 index during the financial crisis period from July 2007 to December 2008. Annualized return is presented separately for each year and additionally, as annualized for the whole financial crisis period.

In table 7, we present alphas and Sharpe ratios of monthly returns for each hedge fund strategy utilizing the CAPM. We can see that on average most strategies persistently create positive alpha even during the financial crisis, however, none of the alphas are statistically significant. The annualized alpha of market neutral hedge funds is among the lowest. The concept of risk-return trade-off is based on the underlying assumption that potential return rises as the risk increases. Deviation in monthly returns of market neutral hedge funds is lower than for most other strategies,

while it generates lower alpha. CTA and multi-strategy funds report highest alphas, but also the highest standard deviations. The exception are global macro hedge funds, which are able to generate a higher alpha while having a lower standard deviation of monthly returns than market neutral funds. Sharpe ratio describes hedge fund's ability to show persistence in return generation and from table 7 we can see that most Sharpe ratios are negative, but deviate for different strategies. While emerging markets, long/short and relative value hedge funds generate higher alphas than market neutral hedge funds, their Sharpe ratios are significantly lower. Market neutral hedge funds are not able to show persistence in their returns during the financial period with a negative Sharpe ratio of -1.09. Additionally, returns for market neutral funds are negatively skewed and they show low but positive kurtosis as an indication of unpredictable returns. However, Sharpe ratios of other strategies, excluding CTA and short bias, are negative as well and the ratio for market neutral hedge funds is among the highest ones of those.

**Table 7. Hedge fund alpha and Sharpe ratio of monthly returns during the financial crisis.**

| | Hedge fund strategy | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTA | Emerging Markets | Event Driven | Fund of Funds | Global Macro | Long/ Short | Market Neutral | Multi-Strategy | Relative value | Short Bias | Others |
| Alpha | 0.104 | 0.018 | -0.053 | 0.015 | 0.074 | 0.017 | 0.014 | 0.063 | 0.024 | 0.030 | -0.006 |
| Alpha p-value | 0.394 | 0.889 | 0.291 | 0.884 | 0.321 | 0.827 | 0.847 | 0.574 | 0.779 | 0.616 | 0.919 |
| Sharpe ratio | 0.818 | -1.315 | -2.021 | -1.158 | -0.189 | -1.308 | -1.089 | -0.955 | -1.282 | 1.883 | -1.532 |

This table presents the annualized single-factor model alpha of hedge fund returns for each hedge fund strategy during the financial crisis from July 2007 to December 2008. It also presents the annualized Sharpe ratio of monthly returns.

### 7.1.2 Performance and persistence during the comparison period

The comparison period includes 10 years of monthly returns, starting from January 1995 and ending in December 2004. The number of funds that were active during a part of or full period is lower for each strategy when compared to the financial crisis period, which is a significantly shorter time span. This supports the assumption that both number of hedge funds and the popularity of reporting returns to the hedge fund database have increased over the years. After excluding for backfilling bias, on

average most hedge fund strategies perform well based on the average monthly return. Market neutral hedge funds experience relatively very low standard deviation during the period, and have significantly higher positive skewness when compared to other strategies. However, they also experience very high positive kurtosis, indicating unpredictability in returns.

**Table 8. Statistics of monthly hedge fund and market returns during the comparison period.**

| | Hedge fund strategy and S&P 500 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTA | Emerging Markets | Event Driven | Fund of Funds | Global Macro | Long/ Short | Market Neutral | Multi-Strategy | Relative value | Short Bias | Others | S&P 500 |
| Mean | 0.009 | 0.010 | 0.010 | 0.008 | 0.008 | 0.013 | 0.010 | 0.011 | 0.009 | 0.001 | 0.009 | 0.009 |
| Standard deviation | 0.028 | 0.046 | 0.014 | 0.017 | 0.020 | 0.028 | 0.012 | 0.014 | 0.010 | 0.055 | 0.012 | 0.045 |
| Skewness | 0.328 | -1.331 | -1.892 | 0.030 | 0.707 | -0.038 | 4.323 | -0.338 | -0.810 | 0.706 | -1.893 | -0.638 |
| Kurtosis | -0.048 | 5.389 | 9.101 | 1.293 | 1.164 | 1.519 | 33.243 | 0.943 | 1.999 | 2.185 | 8.475 | 0.423 |
| Min | -0.056 | -0.233 | -0.073 | -0.052 | -0.042 | -0.089 | -0.015 | -0.037 | -0.030 | -0.144 | -0.060 | -0.146 |
| Max | 0.085 | 0.134 | 0.038 | 0.061 | 0.081 | 0.104 | 0.109 | 0.050 | 0.031 | 0.239 | 0.038 | 0.097 |
| N | 283 | 187 | 329 | 2 000 | 164 | 1 271 | 211 | 346 | 320 | 23 | 101 | - |

This table presents the summary statistics on monthly hedge fund returns and return on the market, proxied by S&P 500, over the comparison period from January 1995 to December 2004. The rows below hedge fund strategies present statistics of equal-weighted hedge fund portfolio returns for each strategy. The final row gives information on the number of funds that reported to TASS Lipper database during the full or part of the comparison period.

During the period, market neutral hedge funds are able to create positive annualized returns each year. Market neutral hedge funds are able to slightly outperform the market in terms of annualized return during the whole period, while experiencing significantly lower deviation in returns when compared to market return. Market return was negative during years 2000-2002, but market neutral hedge funds were able to generate positive annual returns, even though returns decreased during that period from previous years. Recession of 2001 is generally considered to be more moderate than the financial crisis of 2008. For example, Schuermann (2004) states that banks entered the 2001 downturn with better profitability and more robust balance sheets when compared to the recession of 1990-1991 and were able to come through the recession reasonably well. Main reason for this was the relative mildness of the downturn period as well as banks' more effective risk management. While market neutral hedge funds are able to outperform the market, many other hedge

funds, such as ones utilizing multi-strategy or event driven strategies, on average outperform the market with higher annual returns. Hedge funds utilizing CTA or short bias strategies are not able to outperform the market, while these funds perform remarkably better than other strategies during the financial crisis.

**Table 9. Hedge fund and market return during the comparison period.**

| | Hedge fund strategy and S&P 500 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTA | Emerging Markets | Event Driven | Fund of Funds | Global Macro | Long/ Short | Market Neutral | Multi-Strategy | Relative value | Short Bias | Others | S&P 500 |
| 1995 | 0.543 | -0.018 | 0.252 | 0.103 | 0.227 | 0.284 | 0.174 | 0.195 | 0.213 | 0.016 | 0.164 | 0.341 |
| 1996 | 0.101 | 0.343 | 0.182 | 0.123 | 0.145 | 0.262 | 0.167 | 0.165 | 0.159 | 0.011 | 0.091 | 0.203 |
| 1997 | 0.151 | 0.132 | 0.199 | 0.118 | 0.142 | 0.238 | 0.182 | 0.152 | 0.122 | 0.328 | 0.138 | 0.310 |
| 1998 | 0.118 | -0.273 | 0.037 | 0.000 | 0.035 | 0.193 | 0.116 | 0.139 | 0.012 | -0.042 | -0.054 | 0.267 |
| 1999 | 0.009 | 1.293 | 0.263 | 0.232 | 0.765 | 0.782 | 0.186 | 0.239 | 0.119 | -0.174 | 0.188 | 0.195 |
| 2000 | 0.149 | -0.035 | 0.098 | 0.075 | 0.024 | 0.109 | 0.201 | 0.162 | 0.064 | 0.215 | 0.082 | -0.101 |
| 2001 | 0.024 | 0.170 | 0.091 | 0.042 | 0.103 | 0.189 | 0.058 | 0.123 | 0.115 | 0.092 | 0.067 | -0.130 |
| 2002 | 0.233 | 0.112 | 0.035 | 0.100 | 0.049 | -0.004 | 0.097 | 0.072 | 0.123 | 0.220 | 0.128 | -0.234 |
| 2003 | 0.211 | 0.468 | 0.245 | 0.221 | 0.376 | 0.292 | 0.108 | 0.254 | 0.177 | -0.145 | 0.635 | 0.264 |
| 2004 | 0.115 | 0.215 | 0.161 | 0.147 | 0.119 | 0.132 | 0.086 | 0.193 | 0.085 | -0.058 | 0.162 | 0.090 |
| Annua-lized | 0.078 | 0.115 | 0.149 | 0.147 | 0.107 | 0.133 | 0.103 | 0.201 | 0.107 | -0.005 | 0.159 | 0.102 |

This table presents annualized monthly returns as equal-weighted for each hedge fund strategy and the S&P 500 index during the comparison period from January 1995 to December 2004. Annualized return is presented separately for each year and additionally, as annualized for the whole comparison period.

Market neutral hedge funds generate a good, statistically significant annualized alpha of 6.0% during the comparison period, being outperformed only by long/short and multi-strategy hedge funds. Alpha is significantly higher than what is reported during the financial crisis, where alpha of market neutral hedge funds was among the lowest as well as statistically insignificant. During the comparison period they have a high Sharpe ratio of 1.42, indicating good risk-return trade-off as well as persistence in returns. Ratio is far from -1.09, which was reported during the financial crisis period. The results are in line with studies of Capocci et al. (2005) and Caglayan (2001), who conclude that market neutral strategy generates significantly positive alpha and high Sharpe ratio. Alpha being a measure of manager's realized skill and Sharpe ratio describing the excess return received for riskier asset's volatility, market neutral hedge perform well during the comparison period in terms of performance and persistence when compared to other strategies as well as when compared to results obtained during the financial crisis. While CTA, global macro, and short bias funds

generated the highest annualized returns during the financial crisis period, they are not able to create statistically significant alphas at 0.95 confidence level during the comparison period.

**Table 10. Hedge fund alpha and Sharpe ratio of monthly returns during the comparison period.**

| | Hedge fund strategy | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTA | Emerging Markets | Event Driven | Fund of Funds | Global Macro | Long/ Short | Market Neutral | Multi-Strategy | Relative value | Short Bias | Others |
| Alpha | 0.053 | 0.029 | 0.059 | 0.030 | 0.036 | 0.080 | 0.060 | 0.067 | 0.045 | 0.003 | 0.049 |
| Alpha p-value | 0.074 | 0.504 | 0.000 | 0.066 | 0.085 | 0.001 | 0.000 | 0.000 | 0.000 | 0.952 | 0.000 |
| Sharpe ratio | 0.463 | 0.291 | 1.406 | 0.665 | 0.618 | 1.030 | 1.422 | 1.556 | 1.472 | -0.311 | 1.235 |

This table presents the annualized single-factor model alpha of hedge fund returns for each hedge fund strategy during the comparison period from January 1995 to December 2004. It also presents the p-value for alpha and the annualized Sharpe ratio of monthly returns.

## 7.2 Neutrality

### 7.2.1 Neutrality during the financial crisis

This section focuses on analyzing the neutrality of market neutral hedge funds against the market during the financial crisis. Analysis will be based on classical measures of neutrality often used in other studies when studying neutrality of hedge fund returns. Table 11 presents these measures for each hedge fund strategy during the financial crisis period from July 2007 to December 2008. Correlation coefficient of market neutral return is 0.65 and statistically significant at 0.95 confidence level, which is remarkably higher than expected for a market neutral strategy. This indicates that market neutral strategy correlates with the market return during the bear market. Correlation analysis shows that this was, then again, the case for most other strategies as well with even higher correlation with the market return. For all strategies excluding CTA, there is a statistically significant relationship between hedge fund return and market return and for short bias strategy, a statistically significant negative correlation with the market return identified. Excluding CTA and global macro strategies, market neutral hedge funds are able to show lowest

correlation to the market during the financial crisis. Regardless of the global scope that the financial crisis of 2008 had, the nature of global macro strategy and the given market proxy can to some extent explain the lower correlation coefficient.

**Table 11. Neutrality measures during the financial crisis.**

| | Hedge fund strategy | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTA | Emerging Markets | Event Driven | Fund of Funds | Global Macro | Long/ Short | Market Neutral | Multi-Strategy | Relative value | Short Bias | Others |
| Beta | 0.004 | 0.864 | 0.443 | 0.494 | 0.233 | 0.523 | 0.324 | 0.580 | 0.567 | -0.382 | 0.399 |
| Beta p-value | 0.980 | 0.000 | 0.000 | 0.002 | 0.027 | 0.000 | 0.004 | 0.001 | 0.000 | 0.000 | 0.000 |
| Correlation | 0.006 | 0.779 | 0.852 | 0.672 | 0.520 | 0.776 | 0.647 | 0.702 | 0.781 | -0.764 | 0.801 |
| Correlation p-value | 0.980 | 0.000 | 0.000 | 0.002 | 0.027 | 0.000 | 0.004 | 0.001 | 0.000 | 0.000 | 0.000 |
| R-squared | 0.000 | 0.607 | 0.726 | 0.451 | 0.270 | 0.603 | 0.418 | 0.492 | 0.610 | 0.584 | 0.642 |

This table presents the beta, p-value of beta, correlation, p-value of correlation, and R-squared measures for each hedge fund strategy during the financial crisis period from July 2007 to December 2008. Measures are based on a single factor model, obtained utilizing the CAPM.

When analyzing values of beta, we can observe a statistically significant beta for market neutral strategy. However, the beta is among the lowest with value of 0.32. Global macro as well as CTA strategies result in lower beta coefficients, and short bias hedge funds are measured to have a negative beta. According to beta analysis, only CTA and short bias strategy are able to generate neutrality to the market that is expected from market neutral hedge funds according to their definition, since to achieve market neutrality, beta is expected to be zero or negative. Then again, after CTA and global macro strategy, market neutral strategy reports the lowest $R^2$ value during the financial crisis. To support the hypothesis of market neutrality, $R^2$ should be close to zero indicating that market factors are not behind the hedge fund return. Hedge funds are expected to have limited exposure to the market, and report low values of correlation, beta, and $R^2$. Hence we can conclude that in terms of these neutrality measures, on average only CTA hedge funds can be seen to be somewhat neutral to market movements during the financial crisis. Hedge funds applying the short bias strategy show neutrality against the market that is preferred by a risk-averse investor, as presented by Patton (2009).

**Table 12. Results of mean neutrality test including all funds during the financial crisis period.**

| | Hedge fund strategy | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTA | Emerging Markets | Event Driven | Fund of Funds | Global Macro | Long/ Short | Market Neutral | Multi-Strategy | Relative value | Short Bias | Others |
| P-value | 0.017 | 0.772 | 0.404 | 0.308 | 0.049 | 0.314 | 0.145 | 0.292 | 0.350 | 0.005 | 0.230 |
| N | 392 | 465 | 371 | 3 661 | 258 | 1 738 | 262 | 919 | 340 | 25 | 183 |

This table presents the results of mean neutrality test during the financial crisis period. All hedge funds that were active during a part or full financial crisis period are included in the test. Mean neutrality test is conducted between a hedge fund strategy's mean monthly return and monthly return on the S&P 500 index. The last row describes the number of funds that reported monthly returns during a part of or full financial crisis period.

Mean neutrality is a neutrality concept used by Patton (2009) and nests the standard correlation- or beta-based definition of neutrality. Table 12 presents the results of mean neutrality test conducted for the average monthly returns of each strategy during the financial crisis. The null hypothesis of mean dependence can be rejected only for CTA, global macro, and short bias strategies at 0.95 confidence level, which is in line with the results obtained from neutrality analysis above based on classic neutrality measures. Based on this mean neutrality analysis, on average market neutral hedge funds are non-neutral to the market during the financial crisis. Similar results are reported by Capocci (2006) as well as Muhtaseb and Colborn (2012), who conclude that market neutrality of market neutral hedge funds decreases during bear periods.

We find it interesting to study whether there are individual hedge funds that are neutral to the market during the same bear market. Similar mean neutrality test is done for each individual hedge fund, which reported monthly returns to the database during the full financial crisis period. Since the number of monthly returns to be tested in this analysis is already low due to the short time period, we want to maximize the number of observations to mitigate any biases in the results. Table 13 shows that 27.4% of individual market neutral hedge funds included in this test are neutral to the market. Results indicate that during the financial crisis, there are market neutral hedge funds that are able to provide protection against the market movements and create market neutral returns. The share of neutral funds is low, and indicates that a significant share of self-claimed market neutral hedge funds were not

able to fulfill their promise of providing neutrality against the market during the financial crisis.

**Table 13. Results of mean neutrality test including funds that were active during full financial crisis period.**

| | Hedge fund strategy | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTA | Emerging Markets | Event Driven | Fund of Funds | Global Macro | Long/ Short | Market Neutral | Multi-Strategy | Relative value | Short Bias | Others |
| Average p-value | 0.125 | 0.479 | 0.403 | 0.348 | 0.227 | 0.345 | 0.232 | 0.322 | 0.283 | 0.198 | 0.284 |
| Neutral funds | 54.9% | 6.8% | 12.8% | 5.2% | 38.3% | 16.4% | 27.4% | 9.9% | 23.1% | 61.5% | 27.1% |
| N | 306 | 293 | 250 | 2 658 | 180 | 1 225 | 168 | 535 | 212 | 13 | 118 |

This table presents the results of mean neutrality test during the financial crisis period. All hedge funds that were active during full financial crisis period are included in the test. Mean neutrality test is conducted for each individual fund's monthly return and monthly return on the S&P 500 index. First row presents the average p-value for each hedge fund strategy. The second row shows the share of funds in each strategy that pass the mean neutrality test. The last row describes the number of funds that reported monthly returns during the full financial crisis period.

### 7.2.2 Neutrality during the comparison period

In this section we present the results of neutrality analysis during the comparison period from January 1995 to December 2004. From table 12 can be observed that the correlation coefficient of market neutral strategy is relatively low with value of 0.16. At 0.95 confidence level there is no statistically significant relationship between the average market neutral fund return and the market return. Result differs remarkably from analysis during the financial crisis, where statistically significant correlation coefficient of 0.65 is reported. Correlation analysis yields in statistically significant results for other strategies during the comparison period, showing a significant relationship between hedge fund and market returns. Hedge funds belonging to the "others" bucket have rather low correlation, while short bias strategy showcases negative correlation to the market during the comparison period, similarly as during the financial crisis.

Beta analysis results in low and statistically insignificant beta coefficient of 0.04 for market neutral hedge funds, providing support to the hypothesis of market neutrality

and indicating low dependence of a fund's return to the market index. Additionally, market neutral strategy results in a $R^2$ measure of 0.02, which is very close to zero and living up to the definition of market neutrality. Hedge funds in the "others" bucket and utilizing CTA strategy also have low or negative values of beta and $R^2$. Overall, in terms of the classic neutrality measures, market neutral hedge funds are able to show neutrality to the market during the comparison period. The result is very different from the one obtained from analysis during the financial crisis, where market neutral hedge funds were not able to pass beta, correlation, or $R^2$ definitions of neutrality. Muhtaseb and Colborn (2012) report similar results when analyzing two equity market neutral indexes. During bear markets market neutrality decreases, since beta coefficient increases and previously significant positive alphas turn insignificant.

**Table 14. Neutrality measures during the comparison period.**

| | Hedge fund strategy | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTA | Emerging Markets | Event Driven | Fund of Funds | Global Macro | Long/ Short | Market Neutral | Multi-Strategy | Relative value | Short Bias | Others |
| Beta | -0.058 | 0.570 | 0.192 | 0.171 | 0.163 | 0.435 | 0.043 | 0.209 | 0.083 | -0.866 | 0.057 |
| Beta p-value | 0.320 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.088 | 0.000 | 0.000 | 0.000 | 0.020 |
| Correlation | -0.092 | 0.556 | 0.614 | 0.467 | 0.367 | 0.697 | 0.156 | 0.655 | 0.385 | -0.704 | 0.211 |
| Correlation p-value | 0.320 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.088 | 0.000 | 0.000 | 0.000 | 0.020 |
| R-squared | 0.008 | 0.309 | 0.377 | 0.218 | 0.135 | 0.486 | 0.024 | 0.429 | 0.148 | 0.495 | 0.045 |

This table presents the beta, p-value of beta, correlation, p-value of correlation, and R-squared measures for each hedge fund strategy during the comparison period from January 1995 to December 2004. Measures are based on a single factor model, obtained utilizing the CAPM.

Table 15 presents results of mean neutrality test during the comparison period, which includes all hedge funds and is conducted as a strategy average against the market return. The number of observations of monthly returns available for the mean neutrality test is substantially higher during the comparison period than the financial crisis period, since the period covers 10 years of monthly returns. The null hypothesis of mean dependence cannot be rejected for any of the hedge fund strategies, when hedge fund returns are compared as a strategy average against the market return. In this analysis, strategies are in practice treated as strategy indexes

and results support hypothesis of Capocci et al. (2005), who expect indexes to be more exposed to the market. Overall, based on analysis of classic neutrality measures we can draw a concerning conclusion that market neutral hedge funds seem to lose market neutrality when moving to a bear market.

**Table 15. Results of mean neutrality test including all funds during the comparison period.**

| | Hedge fund strategy | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTA | Emerging Markets | Event Driven | Fund of Funds | Global Macro | Long/ Short | Market Neutral | Multi-Strategy | Relative value | Short Bias | Others |
| P-value | 0.945 | 0.937 | 0.774 | 0.788 | 0.869 | 0.414 | 0.890 | 0.656 | 0.934 | 0.218 | 0.971 |
| N | 283 | 187 | 329 | 2 000 | 164 | 1 271 | 211 | 346 | 320 | 23 | 101 |

This table presents the results of mean neutrality test during the comparison period. All hedge funds that were active during a part of or full comparison period are included in the test. Mean neutrality test is conducted between a hedge fund strategy's mean monthly return and monthly return on the S&P 500 index. The last row describes the number of funds that reported monthly returns during a part of or full comparison period.

## 7.3 How neutral and non-neutral market neutral hedge funds differ

The mean neutrality test performed for individual market neutral hedge funds shows that there can be found both neutral and non-neutral funds during the financial crisis. Of hedge funds that were active during the full financial crisis period and report to follow market neutral strategy, 27.4% are able to pass the mean neutrality test. In the light of these results, it is interesting to perform performance and neutrality analysis for market neutral hedge funds in deciles in order to study how neutral and non-neutral hedge funds differ. A criterion to distribute funds into deciles is the beta of the fund's monthly returns during the financial crisis, since it is one of the most common and simple measures of neutrality. Decile 1 includes funds with the lowest and decile 10 includes funds with the highest beta coefficients.

Table 16 presents the results of performance analysis performed for each decile. The average monthly return is positive for the most neutral funds and negative for funds in deciles 6 to 10. We can also observe that standard deviation of monthly returns is high for both most neutral and non-neutral funds. Skewness is negative for all deciles, as a result of having higher share of negative monthly returns over positive monthly returns. Additionally, most neutral and non-neutral deciles are more

negatively skewed during the period. Same result applies for kurtosis; in this sample the most unpredictable returns are generated in the most neutral and non-neutral deciles. Market neutral hedge funds in deciles 2, 3, and 5 are able to generate positive annualized return during the financial crisis period. However, this is not the case in decile 1, where we also measure a statistically significant negative beta of -0.32. It is noteworthy to mention that none of the deciles generate statistically significant alpha during the financial crisis period. Additionally, no clear pattern can be drawn from the Sharpe ratios of each decile. However, a positive Sharpe ratio is obtained in decile 2, indicating outperformance of other less neutral deciles when adjusting for risk as well as persistence in returns.

**Table 16. Performance and persistence analysis of market neutral funds in deciles during the financial crisis period.**

| | Decile | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Mean | 0.003 | 0.005 | 0.001 | -0.003 | 0.002 | -0.004 | -0.003 | -0.008 | -0.007 | -0.023 |
| Standard deviation | 0.029 | 0.013 | 0.009 | 0.018 | 0.014 | 0.029 | 0.044 | 0.035 | 0.048 | 0.088 |
| Skewness | -1.924 | -0.517 | -0.233 | -0.779 | -0.549 | -1.059 | -0.558 | -0.636 | -1.171 | -2.085 |
| Kurtosis | 4.923 | 0.068 | -1.262 | 0.607 | -0.296 | 0.102 | 0.453 | -0.206 | 0.717 | 4.414 |
| Min | -0.094 | -0.023 | -0.012 | -0.050 | -0.031 | -0.070 | -0.106 | -0.087 | -0.120 | -0.308 |
| Max | 0.051 | 0.028 | 0.014 | 0.023 | 0.022 | 0.035 | 0.083 | 0.041 | 0.050 | 0.070 |
| Annualized return | -0.003 | 0.060 | 0.010 | -0.037 | 0.021 | -0.044 | -0.038 | -0.102 | -0.098 | -0.320 |
| Alpha | -0.110 | -0.019 | -0.032 | -0.056 | 0.030 | 0.012 | 0.083 | 0.053 | 0.105 | 0.119 |
| Alpha p-value | 0.165 | 0.630 | 0.286 | 0.354 | 0.481 | 0.895 | 0.536 | 0.449 | 0.377 | 0.570 |
| Sharpe ratio | -0.070 | 0.364 | -1.032 | -1.216 | -0.431 | -0.868 | -0.538 | -1.134 | -0.819 | -1.046 |

This table presents the results of performance and persistence analysis conducted for monthly returns of market neutral funds in deciles during the financial crisis period starting from July 2007 and ending in December 2008. Only funds that reported monthly returns during the full financial crisis period are included in the figures. Distribution of funds into deciles is based on individual fund's beta during the financial crisis, where funds with the lowest beta coefficients are included in decile 1 and funds with the highest beta coefficients in decile 10.

Table 17 presents the neutrality measures and as expected due to the criterion of distribution funds into deciles, the beta coefficient increases towards the higher deciles and is even negative in deciles 1 to 3. However, beta coefficients are

statistically insignificant only for deciles 2 to 4. In addition, for these deciles, we do not observe a statistically significant relationship between hedge fund return and return on the market when considering the correlation coefficient. We can detect a statistically significant negative correlation with the market return for decile 1. For other deciles, relationship between returns is statistically significant as well as positive, indicating non-neutrality to market movements during the financial crisis. Results are in line with the distribution into deciles and hence, the results of beta analysis. Additionally, $R^2$ measure is higher for both the most neutral and non-neutral deciles. Since the value of $R^2$ is between 0 and 1 and it measures how well the market return explains the hedge fund return, it is logical that $R^2$ is high in decile 1 as well given the statistically significant negative correlation coefficient as well as the due to the statistically significant negative beta. During the recession in 2001, Capocci (2006) as well finds that market exposure increases in bear markets, but funds take negative exposure to the market indicating shorting on the falling market. Capocci concludes that the negative exposure to the market does not impact hedge fund returns negatively. In contrast, based on results obtained in decile 1, the high negative exposure taken against the market does not enable these funds to generate a positive annualized return during the crisis.

**Table 17. Neutrality analysis of market neutral funds in deciles during the financial crisis period.**

| | Decile | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Beta | -0.316 | -0.101 | -0.001 | 0.055 | 0.139 | 0.275 | 0.429 | 0.536 | 0.642 | 1.214 |
| Beta p-value | 0.011 | 0.080 | 0.980 | 0.515 | 0.025 | 0.033 | 0.026 | 0.000 | 0.001 | 0.000 |
| Correlation | -0.584 | -0.424 | -0.006 | 0.164 | 0.525 | 0.504 | 0.523 | 0.823 | 0.727 | 0.750 |
| Correlation p-value | 0.011 | 0.080 | 0.980 | 0.515 | 0.025 | 0.033 | 0.026 | 0.000 | 0.001 | 0.000 |
| R-squared | 0.341 | 0.180 | 0.000 | 0.027 | 0.276 | 0.254 | 0.274 | 0.677 | 0.528 | 0.562 |

This table presents the results of neutrality analysis conducted for monthly returns of market neutral funds in deciles during the financial crisis period starting from July 2007 and ending in December 2008. Only funds that reported monthly returns during the full financial crisis period are included in the figures. Distribution of funds into deciles is based on individual fund's beta during the financial crisis, where funds with the lowest beta coefficients are included in decile 1 and funds with the highest beta coefficients in decile 10.

In table 18, we present the results obtained from the mean neutrality test performed for each decile. Mean neutrality test confirms that most neutral funds in terms of beta coefficient pass the mean neutrality test with a higher probability than market neutral hedge funds with higher beta coefficients. Over a half of the market neutral hedge funds in deciles 1 to 3 are able to pass the mean neutrality test during the financial crisis period, while none of the funds in deciles 8 to 10 are able to pass the test. Interesting results can be observed in decile 5, where the average beta coefficient is 0.14. Market neutral hedge funds in this decile are on average able to generate both positive annualized return as well as positive alpha during this bear market. Additionally, these funds have lower standard deviation in monthly returns than neighbor deciles and nearly half of the funds in this decile pass the mean neutrality test.

**Table 18. Results of mean neutrality test in deciles during the financial crisis period.**

| | Decile | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Average p-value | 0.117 | 0.064 | 0.072 | 0.152 | 0.114 | 0.245 | 0.209 | 0.317 | 0.356 | 0.668 |
| Neutral funds | 70.6% | 58.8% | 41.2% | 18.8% | 41.2% | 23.5% | 18.8% | 0.0% | 0.0% | 0.0% |
| N | 17 | 17 | 17 | 16 | 17 | 17 | 16 | 17 | 17 | 17 |

This table presents the results of mean neutrality test in deciles during the financial crisis period. All market neutral hedge funds that were active during the full financial crisis period are included in the test. Mean neutrality test is conducted between a hedge fund strategy's mean monthly return and monthly return on the S&P 500 index. The penultimate row describes the share of funds in the respective decile that were able to pass the mean neutrality test. The last row describes the number of funds that reported monthly returns during a part of or full financial crisis period.

## CONCLUSIONS

The attraction of market neutral strategy lies on the assumption that hedge funds applying the strategy are able to generate stable stream of returns and provide neutrality even during declining market conditions. Performance and neutrality of market neutral hedge funds have been widely studied during the recession of 2001, while the financial crisis of 2008 is regarded to have had more extensive effect on the financial industry. The objective of this thesis is to conclude whether market neutral hedge funds were able to live up to their definition by showing persistence in returns during the financial crisis and providing protection against truly bear markets.

Based on the performance analysis, we can conclude that while market neutral hedge funds are able to outperform the market, they are not able to generate positive return during the financial crisis period. Although the generated return was higher than for other strategies, alpha for market neutral hedge funds was among the lowest as well as statistically insignificant. Only hedge funds applying CTA or short bias strategies were able to report positive annualized return during the financial crisis period. Neutrality analysis concludes that market neutral hedge funds have low values of beta, correlation, and $R^2$ during the crisis period when compared to other strategies. Nevertheless, the measures are too high to support the hypothesis of neutrality. Results indicate that on average, market neutral hedge funds do not deliver on their definition of good profit generation and market neutrality during the financial crisis period. When performance and neutrality analysis is performed during the comparison period, results tell a different story. Market neutral strategy slightly outperforms the market and provides stable stream of returns. They have a high Sharpe ratio, indicating high risk-adjusted returns as well as persistence in returns. Additionally, market neutral hedge funds generate the highest alpha as a measure of manager's realized skill. They also show true market neutrality by having low values of both beta and $R^2$, and not having statistically significant correlation with the market during the comparison period.

Results obtained from the comparison period are well in line with previous studies, where market neutral strategy is concluded to be able to generate positive alpha and produce high risk-adjusted returns compared to other hedge fund strategies. In

addition, prior studies report low values of beta and $R^2$ for market neutral hedge funds during normal market conditions. Empirical evidence from bearish periods prior to the financial crisis of 2008 suggests that the strategy is able to outperform the market during these periods, which is confirmed by this study. As prior studies, we can conclude that performance and neutrality decreases when moving from bullish or average market conditions towards bear markets. The impact is particularly remarkable when moving to the financial crisis period of 2008. When analyzing mean neutrality during the crisis, only a quarter of market neutral hedge funds pass the mean neutrality test. Detailed results indicate that the funds, which maintain a moderate negative exposure to the market, are able to generate a positive return during the financial crisis. We are able to draw a concerning conclusion that most market neutral hedge funds are not able to provide protection against the declining market during the crisis period.

Brandon and Wang (2013) study the effect of liquidity risk on the performance of hedge funds between 1994 and 2006, and find that equity market neutral strategy is one of two strategies that are able to yield significant superior performance after accounting for liquidity risk. Liquidity risk was one of the main concerns during the financial crisis and hedge funds often hold illiquid securities. As a suggestion for future research, it would be interesting to analyze performance of market neutral hedge funds during the financial crisis after accounting for liquidity risk. We also detect that the AUM in market neutral hedge funds decrease remarkably in the Lipper TASS database after the years of financial crisis, while the AUM increases, for example, in multi-strategy hedge funds. Since market neutral hedge funds did not deliver on their definition during the financial crisis, has interest towards them decreased and is the trend shifting towards more flexible and generic strategies in the hedge fund industry?

**REFERENCES**


Asness, C., Krail, R. & Liew, J. (2001). Do hedge funds hedge? *Journal of Portfolio Management* 28(1), 6–19.

A. W. Jones (2018). The original hedge fund. Available at: http://www.awjones.com. Cited 9.5.2018.

Barclay Hedge (2015). Assets under management – Hedge Fund and CTA. Barclay Hedge. Available at: http://www.barclayhedge.com/research/money_under_management.html. Cited 9.5.2018.

Bessler, W., Drobetz, W. & Seidel, J. (2008). Ship funds as a new asset class: An empirical analysis of the relationship between spot and forward prices in freight markets. *Journal of Asset Management* 9(2), 102–120.

Bodellini, M. (2017). From systemic risk to financial scandals: The shortcomings of U.S. hedge fund regulation. *Brooklyn Journal of Corporate, Financial & Commercial Law* 11(2), 417-467.

Brandon, R. G. & Wang, S. (2013). Liquidity risk, return predictability, and hedge funds' performance: An empirical study. *Journal of Financial & Quantitative Analysis* 48(1), 219–244.

Brown, S. J., Goetzmann, W. N. & Park, J. (2001). Careers and survival: Competition and risk in the hedge fund and CTA industry. *Journal of Finance* 56(5), 1869–1886.

Caldwell, T. (1995). Introduction: The model for superior performance. *Lederman, J., Klein, R. A. (1995). Hedge Funds: Investment and Portfolio Strategies for the Institutional Investor.* Irwin Professional Publishing, 1–17.

Capocci, D. (2006). Neutrality of market neutral funds. *Global Finance Journal* 17(2), 309–333.

Capocci, D., Corhay, A. & Hübner, G. (2005). Hedge fund performance and persistence in bull and bear markets. *European Journal of Finance* 11(5), 361–392.

Cornett, M. M., McNutt, J. J., Strahan, P. E. & Tehranian, H. (2011). Liquidity risk management and credit supply in the financial crisis. *Journal of Financial Economics* 101(2), 297.

Dimson, E. (1979). Risk measurement when shares are subject to infrequent trading. *Journal of Financial Economics* 7.

Dubil, R. (2011). Hedge funds: Alpha, beta, and replication strategies. *Journal of Financial Planning* 24(10), 51–60.

Edwards, F. R. & Caglayan, M. O. (2001). Hedge fund and commodity fund investments in bull and bear markets. *Journal of Portfolio Management* 27(4), 97–108.

Finn, M. T. (1998). Market neutral investing. *Journal of Financial Planning* 11(4), 76–81.

French, K. R. (2008). Presidential address: The cost of active investing. *Journal of Finance* 63(4), 1537–1573.

Fung, W. & Hsieh, D. A. (1997). Empirical characteristics of dynamic trading strategies: The case of hedge funds. *Review of Financial Studies* 10(2), 275–302.

Fung, W. & Hsieh, D. A. (1999). A primer on hedge funds. *Journal of Empirical Finance* 6(3), 309–331.

Fung, W. & Hsieh, D. A. (2000). Performance characteristics of hedge funds and commodity funds: Natural vs. spurious biases. *Journal of Financial & Quantitative Analysis* 35(3), 291–307.

Fung, W. & Hsieh, D. A. (2004). Hedge fund benchmarks: A risk-based approach. *Financial Analysts Journal* 60(5), 65–80.

Goetzmann, W. N., Ingersoll, J. E.,Jr & Ross, S. A. (2003). High-water marks and hedge fund management contracts. *The Journal of Finance* 58(4), 1685–1717.

Hull, J. C. (ed.). (2012). *Options, futures and other derivatives* (8th edition). Pearson Education Limited.

Kaal, W. A. (2011). Hedge fund regulation via Basel III. *Vanderbilt Journal of Transnational Law* 44, 389-463.

Kung, E. & Pohlman, L. (2004). Portable alpha. *Journal of Portfolio Management* 30(3), 78–87.

Laurelli, P. (2014). Hedge funds see 2nd month of asset outflows, AUM still over $3 trillion. Evestment. Available at: https://www.evestment.com/resources/blog/corporate-blog/2014/11/20/hedge-funds-see-2nd-month-of-asset-outflows-aum-still-over-$3-trillion. Cited 15.1.2015.

Liang, B. (2009). On the performance of hedge funds. In: Lawton, P. & Jankowski, T. (eds.). CFA Institute Investment Perspectives Series. Hoboken, N.J.: Wiley, 481–499.

Lintner, J. (1965). The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets. *Review of Economics and Statistics* 47 (1), 13–37.

Muhtaseb, M. R. & Colborn, R. (2012). Neutrality of equity market neutral strategy to period and index. *Journal of Derivatives and Hedge Funds* 18(4), 301–332.

Patton, A. J. (2009). Are "market neutral" hedge funds really market neutral? *Review of Financial Studies* 22(7), 2495–2530.

Peltomäki, J. (2009). Investor sentiment and time-varying market risk in market-neutral hedge funds. *Journal of Behavioral Finance* 10(4), 226–233.

Schaub, N. & Schmid, M. (2013). Hedge fund liquidity and performance: Evidence from the financial crisis. *Journal of Banking & Finance* 37(3), 671.

Scholes, M. & Williams, J. T. (1977). Estimating betas from nonsynchronous data. *Journal of Financial Economics* 5.

Schuermann, T. (2004). Why were banks better off in the 2001 recession? *Current Issues in Economics & Finance* 10(1), 1-7.

Sharpe, W. F. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk. *The Journal of Finance* 19(3), 425-442.

Thomson Reuters (2016). Thomson Reuters Lipper Global Classification. Available at: https://financial.thomsonreuters.com/content/dam/openweb/documents/pdf/financial/lipper-global-fund-classification-methodology.pdf. Cited 10.5.2018.

Titman, S. & Tiu, C. (2011). Do the best hedge funds hedge? *Review of Financial Studies* 24(1), 123–168.

Vuoti, N. (2015) Performance and persistence of market neutral hedge funds: Are they really market neutral? *Oulu Business School*

Wooldridge, J. M. (2009). *Introductory econometrics: The modern approach.* (5th Edition edition) South Western, Cengage Learning.

Zhan, G. (2011). Manager fee contracts and managerial incentives. *Review of Derivatives Research* 14(2), 205–239.