



Hedge fund replication: A new approach

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Abstract: <p>The thesis aims to apply a new approach to hedge fund replication. The new approach introduces a data bias in the data selection to increase the returns of the replicator.</p> <p>The dataset consists of 189 managed futures hedge funds active during the time period between January 2004 and September 2012. The dataset is divided in two different sub samples, HP sample and All sample. The HP sample includes the top 50 % hedge funds based on 6 month Sharpe ration. The All sample includes the whole dataset. Also, the study is divided in pre-crisis and post-crisis periods. The aim of the thesis is addressed using a standard OLS multivariate regression. The results are thereafter utilized to create passive hedge fund replicators. In the end, replication quality and replicators performance is analyzed.</p> <p>The three main finding of the study is that (1) the replicator based on HP samples has higher risk-adjusted returns than the replicator based on All sample, (2) there exists differences in pre and post crisis replication quality, and (3) the HP sample based replicator is able to beat some benchmark indices pre-crisis. The result indicates that investors are better off by introducing the selection bias to their data, and that the financial crisis has a large impact on replication quality. Finally, the results show that the HP replicator is able to beat some benchmark indices pre-crisis, but due to the risk of financial crises, investors are better-off investing in other market indices.</p>	
Keywords: Hedge fund replication, OLS multivariate regression, replication, hedge fund studies, risk-exposure analysis	

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1 INTRODUCTION

In recent years, the interest towards hedge funds research has grown among investors and academics. The interest lays in their promise to deliver above average market-neutral returns. Hedge funds try to achieve this by active management that seeks to create abnormal returns by investing in a diverse range of markets, investments instruments and strategies. However, historical evidence shows that hedge funds have in many occasions failed to deliver on these promises.

This have caused frustration among investors and led to a growing interest towards hedge fund replication. Merrill Lynch and Goldman Sachs have been the first investment banks to announce the launch of hedge fund replication tools, the 'Merrill Lynch Factor Index' and the 'Goldman Sachs Absolute Return Tracker Index'. They argue, that the heuristic trading rules that aim to replicate hedge funds offers a more cost-efficient, transparent and liquid alternative to achieve risk-exposure towards hedge funds.

Hedge fund managers motivate their high-fee structure with their unique ability to earn market-neutral abnormal returns. Though, there are some counter-arguments for this. First, several studies (Fung & Hsieh, 2004; Roncalli & Jerome, 2007) show that hedge fund returns can be explained to a large extent by market exposure. Furthermore, hedge funds are only available for a selected group of individuals with high net worth. Hedge funds have also so called lock-up periods, which restrict withdrawal of invested capital, and lower their investment liquidity. These lock-up periods can range up to 2 years. Finally, hedge funds have limited reporting liability, i.e. they report on voluntary basis and therefore investors do not have knowledge on how their capital is invested, which lowers the monitoring of managers actions.

Several authors (Amenc, Martellini, & Meyfredi, *Passive Hedge Fund Replication - Beyond the Linear Case*, 2010; Hasanhodzic & Lo, 2007; Roncalli & Jerome, 2007) have noticed the need for more cost-efficient, liquid and transparent exposure for hedge funds. They argue that the answer is hedge fund replication. In hedge fund replication, first one analysis the hedge funds risk-exposures, i.e. the correlation between the hedge fund and the chosen asset, and then, instead of investing in actual hedge funds, they invest straight into these assets. Fung and Hsieh created in their articles (1997, 2004 & 2006) the foundation for hedge fund replication, and several others (Amenc, Gehin, Martellini, & Meyfredi, 2008; Kat & Palaro, 2012; Wallerstein,

Tuchschmid, & Zaker, 2011; Wei, 2010; Amenc, Martellini, & Meyfredi, Passive Hedge Fund Replication - Beyond the Linear Case, 2010) have followed. Hasanhodzic and Lo (2007) published the first attempt to replicate hedge funds by linear regression to analyse the risks hedge funds are exposed to. A more dynamic approach by Amenc, Martellini and Meyfredi (2010), was followed and since then several different replication methodologies have been introduced.

This thesis focuses foremost on the risk-exposure analysis and the performance comparison between replication products and actual hedge funds. The aim is to analyse if investors can realize higher risk-adjusted returns by investing in replication products instead of investing in actual hedge funds. The main contribution of this thesis is to improve the performance of the hedge fund replication product. Previous studies replicate the whole universe of hedge funds. Obviously, this leads to the replication of low-performance hedge funds as well. Therefore, this study focuses only on replication of the high-performance hedge funds, as these hedge funds offer returns more feasible for investors.

1.1. Purpose

The purpose of the study is to apply a new approach to hedge fund replication.

1.2. Delimitations

The time period for the study is between January 2002 and September 2012. The time period is chosen to analyse differences before pre-crisis and post-crisis results. Many hedge fund databases exist, and this study uses the Lipper TASS Hedge Fund database. Further, previous research (Placeholder1; Amenc, Gehin, Martellini, & Meyfredi, 2008; Kat & Palaro, 2012) show that other strategies are more replicable than other and therefore the study is limited to only the managed futures strategy.

1.3. Problem statement

In general, investors seek for investments that offer uncorrelated returns and high risk-return ratios. Hedge funds are argued to be a good alternative to the traditional asset classes. As mentioned in the introduction, hedge funds claim to offer returns that are less correlated to markets and therefore more attractive than traditional returns.

However, hedge funds tend to be costly, intransparent and illiquid. It is these issues Hedge fund replication attempts to improve.

There are two separate parts of hedge fund replication, the risk exposure analysis and the building of the replicator. Building the replicator is a straightforward process, but the risk exposure analysis is a more intriguing task. Figure 1 represents a methodological framework for hedge fund factor replication by Weisang (2011). He divides the risk exposure analysis task in three categories: model selection, factor selection and variable selection.

Figure 1 Framework on hedge fund replication

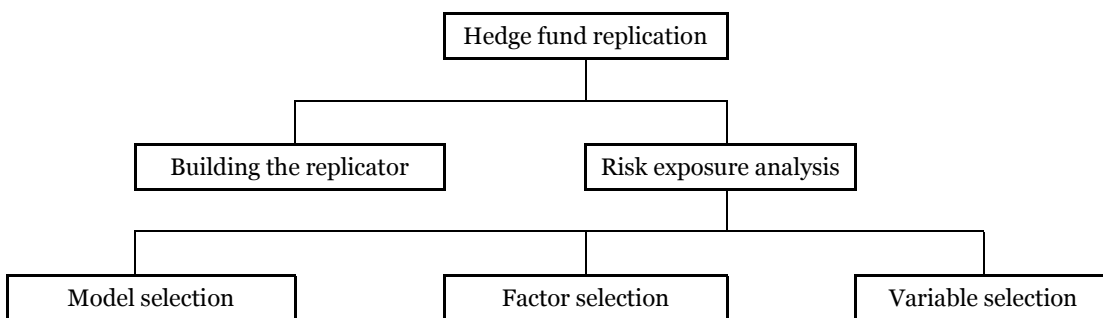


Figure 1 presents a framework for hedge fund replication. Source: (Weisang, 2011)

First main issue in hedge fund replication is the model choice. Hedge funds apply dynamical trading strategies, and therefore a model that takes the dynamical attributes of the return into account should be chosen. The dynamical nature for hedge funds comes from the fact that the funds aim for absolute returns and are less regulated, which allows them to apply sophisticated investment strategies and utilize complex financial instruments, such as derivatives.

The second main issue in hedge fund replication is the factor selection, which is the most important problem. The chosen factors should correspond to the risk exposures hedge fund returns are exposed. One should however avoid data snooping, i.e. arbitrarily choosing factors that maximizes the explanatory power of the model, as this leads to non-robust results.

The third main issue in hedge fund replication is the variable selection. At this point, it is important to differentiate between a variable and a factor. A variable is an economic parameter that is used to measure a specific factor. The variable that most accurately reflects the factor development should be chosen to give best actual explanatory power of the factor. I.e. a variable is a proxy for the factor. (Weisang; 2011) For instance, if one

analyse the impact of European interest rates on a repressor, one should choose which European interest rate (one month, three months or 12 months interest rate) is most suitable to apply in the model.

Besides the three main issues described in the Weisang (2011) framework, another import issue in hedge fund replication is the data reliability. For instance, hedge funds report performance on a voluntary basis and therefore many hedge funds do not report their performance. This leads to a so-called selection biased. A data bias might either have a positive or a negative impact on the aggregate hedge fund performance. An argument that selection bias leads to higher returns is that hedge funds with low return do not want to disclose their performance and therefore the aggregated hedge fund return is upward biased. On the other side, one could argue that hedge funds with the highest performance do not voluntary report their performance, as they want to protect their immaterial assets i.e. their unique investments strategies. It could be argued that if the investment strategy were made public, other investors would utilize the information, which would make the investment strategy unprofitable.

1.4. Contribution and approach

According to the purpose the aim of the thesis is to replicate hedge funds with a new approach. Previous research (Hasanhodzic & Lo, 2007; Wei, 2010; Amenc, Martellini, & Meyfredi, *Passive Hedge Fund Replication - Beyond the Linear Case*, 2010; Tuc10; Kat & Palaro, 2012) has focused on improving the replication process, but no previous research has tried to improve the replicators' performance through data selection. The hypothesis is that replicators' performance could be improved by including only high-performance hedge funds in the data set. Therefore, this thesis extends the methodological framework (figure 1) by including data selection.

Figure 2 Extended framework on hedge fund replication

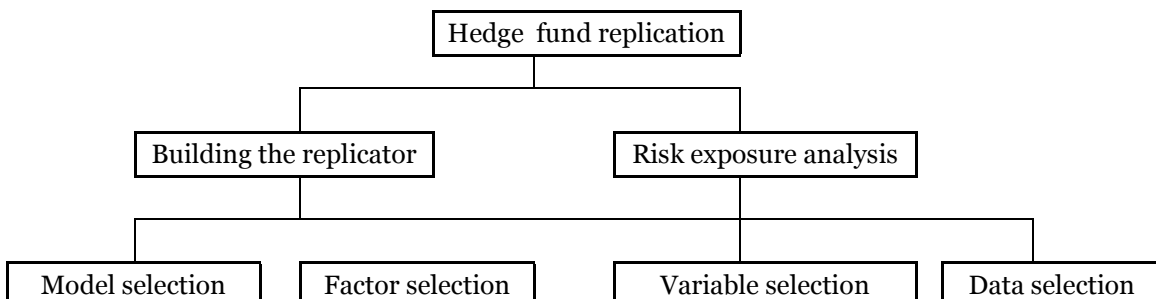


Figure 2 presents the extended framework applied in the thesis. Beyond the Weisangs (2011) framework with model selection, factor selection and variable selection, the new framework includes also data selection.

The new replication approach aims to improve the risk-adjusted returns obtained by the investors that invest in these replication products.

1.5. Structure of the study

The study continues by a *definition on hedge funds, their special characteristics, the different hedge fund strategies* and a look into *the future of hedge funds*, in section two. In section three, background theories are given, focusing on *alternative investments, the hedge fund replication techniques* and *the future of hedge funds*. In section four, four *previous studies* relevant to this thesis are explained. Section five presents the four-step methodology and analysis for the study, which is followed by a description of *data biases* and *descriptive data*, in section six. Section seven presents the results of the four-step methodology and analysis of the study. Finally, section eight discusses the results in *comparison to previous studies, the implications of the study, the critical discussion of the study* and presents *suggestion to further research*, after which section nine draws the *conclusions* of the study.

2 HEDGE FUNDS AS INVESTMENT TARGETS

Hedge funds are unique investment vehicles that have many special characteristics compared to traditional assets. Thus, the thesis begins with an introduction to hedge funds. The introduction first *defines hedge funds*, and thereafter discusses the *characteristics of hedge funds*. Then, because hedge funds apply several different strategies, the *different strategies* are explained. Finally, to give an overview on the development of the hedge fund industry, the section is summarized with a discussion on the *future of hedge funds*.

2.1. Defining hedge funds

Accordingly to Lhabitant (2010), traditionally, hedge funds were seen as funds with investments strategies that aimed to be uncorrelated to the direction of the market. They achieve this by investing in a mix of short and long market positions. Though, today, the description of hedge funds is not as self-evident as before, and an exact definition does not exist.

For instance, the interpretation of hedge funds varies on both sides of the Atlantic. In Europe, all offshore investment vehicles whose strategy goes beyond buying and holding stocks or bonds, and that have an absolute performance goal are considered to be hedge funds. In the U.S, a hedge fund is typically a domestic limited partnership that is not registered with the Security and Exchange Commission, can invest in a broad array of securities and investment strategies, and where the manager is rewarded with an incentive fee. (Kirschner, Mayer, & Kessler, 2006)

2.2. Hedge fund characteristics

Hedge funds have a range of special characteristics that differs from traditional mutual funds. The most important characteristic, considering the aim of this thesis, are their special cost-structure, illiquidity, limited clientele, lack of transparency, the possibility to exploit leverage, the active approach to portfolio management and the possibility to invest in a large scope of securities. These differences stem mainly from lenient regulation and abroad registration.

2.2.1. Cost-structure

Hedge funds have a special cost-structure. Foremost, the funds have incentive fees. Hedge fund incentive fee have been discussed a lot because they are asymmetric and uses high water marks. In comparison to the mutual fund industry, hedge fund incentives can be compared with a call option where the expected return for managers increases with an increased portfolio risk. Even though the incentive structure better aligns manager and investors interest, it also increases managers' appetite for risk. (Lhabitant, 2006)

The cost structure of hedge funds can roughly be divided in to three separate parts; the management fee, the incentive fee and the redemption fee. The management fee is a recompense of the cost incurred to the hedge fund itself due to brokerage commissions, reporting costs, client interaction and administrative costs and average around 2 % as a percentage of the fund's net asset value, while the incentive fee is compensation on above average performance and is typically 20 % of the funds profits during the period. Finally, the redemption fee is a charge required if an investor withdraws money before a set time period. (Schwarz, 2007)

The special cost structure is a key issue in hedge fund replication. Hedge funds state that they possess unique investments strategies, which able them to earn abnormal returns. If it is possible to re-engineer these investment strategies, hedge funds high fee structure is irrational. If investors are able to evade paying high fees for hedge fund-like returns, investors can maximize their portfolio value by extracting information of the hedge funds investment strategies and constructing the portfolio by themselves.

2.2.2. Liquidity

Hedge funds are less liquid than mutual funds. In traditional mutual funds, investors can enter and exit their positions whenever they want. Hedge funds apply trading strategies that often require speculative long-term positions in assets, and therefore they restrict investors from liquidating their investments. The liquidation is restricted in three manners, terms of subscription, lock-up period and terms of redemption. (Lhabitant, 2006)

The terms of subscription tells at which dates investors can enter a hedge fund. This limits the possibility for investors to include feasible hedge funds in their portfolio. A lock-up period is a pre-defined time period that states when the investor can redeem

his investment. Usually, the lock-up period is one year, but some hedge funds extend up to ten years. The lock-up period enables more freedom and space for the hedge fund manager to apply his investment strategy, because the expected return for some investments in illiquid assets might take a long time to realize. (Kahrea, Tolonen, & Joenväärä, 2011) The terms of redemption specify when the investors can redeem their shares. These terms often require an advance notice share redemption notice and are typically between 30 to 90 days before actual redemption. (Lhabitant, 2006)

The liquidity restrictions restrain investors' ability to actively manage their funds and this can create problems to investors for instance in turbulent markets. Hedge fund replicators are created with investments in liquid assets and are therefore not subject for similar liquidity constraints. However, replication products are exposed to other distinctive liquidity issues. Currently, only monthly hedge fund return data is available, and therefore risk exposure between variables and hedge fund returns can only be updated once a month. This has a negative impact on the replication quality, as it is challenging to capture the dynamical asset allocation of hedge funds.

2.2.3. *Clientele*

Hedge funds are open mostly to wealthy investors. The clientele is restricted by minimum investment requirement that can range from 10 000€ to more than 1 000 000 € (Frush, 2007). The introduction of funds of hedge funds has lowered barriers to enter for investor and nowadays, to some extent, also individual investors, with less wealth, are able to invest in hedge funds. Though, the variety of hedge fund strategies private investors can invest in is limited. (Kirschner, Mayer, & Kessler, 2006)

Hedge fund replicators are constructed by investment in different liquid assets. The replicator product is thereafter sold to investors. The replication products are listed on the markets as the corresponding ETF products and the transparency of the replicators' investments makes it easy for investors to evaluate the price for the replication products. Though, it's important for individual investor to acknowledge, that hedge fund replication is still in its infancy and that many issues need to be solved before replication quality can be compared with the quality of other synthetic products, such as the mentioned ETFs.

2.2.4. Transparency

Hedge funds have less transparency than mutual funds. The transparency is measured by how good information investors have about their investment, i.e. what are the underlying assets hedge funds have invested the capital. Hedge funds are often registered offshore, and therefore are not required to issue reports, such as performance information, detailed asset allocation or earnings. The hedge funds do not want to disclose performance, because their investment strategies are vulnerable to information leakage, which might lead to overcrowding. However, many hedge funds report their monthly returns, as they are not allowed to market their products, and therefore performance disclosure is a tool to attract new investors. (Frush, 2007)

Lack of transparency obviously causes issues for hedge fund replication. Without accurate data, the hedge fund positions cannot be obtained nor replicated. This is a considerable issue in this study. However, many hedge funds voluntarily report their monthly returns, whereas lack of information does not hinder hedge fund replication.

2.2.5. Leverage

Hedge funds apply more leverage than mutual funds. Leverage is often used to achieve higher returns, exploit market inefficiencies, modify the portfolios risk profile and expand the market exposure during feasible time periods. (Kahrea, Tolonen, & Joenväärä, 2011). In extreme cases, as in Long Term Capital Management, the hedge fund leverage amounted to over 50 times more than their net capital. Today, the regulatory environment for hedge funds is stricter and hedge fund leverage ratios are on more healthy levels. (Jorion, 2000)

The most visible effect of hedge fund leverage is the lower correlation hedge funds have towards other assets. With leverage, hedge funds are able to exploit investment strategies that are less dependent on the market movement and more dependent on the vision of the hedge fund manager. Thus, as discussed in the introduction, these uncorrelated hedge fund returns create an attractive investment object for investors, but also makes it more difficult to analyse the hedge fund risk exposures.

2.2.6. Active management

Hedge funds have an active approach to portfolio management. Hedge fund managers' doesn't believe in traditional investment paradigms, such as efficient market

hypothesis¹ or modern portfolio theory² and therefore apply specific trading strategies to exploit market mispricing. (Lhabitant, 2006). They take speculative positions and try to achieve abnormal returns, through which hedge funds motivate their high fee structure.

Active management imposes a problem to hedge fund replication. The active management causes the hedge funds to have a dynamical nature and therefore more difficult to analyse. Also, as managers actively change their positions, the monthly data published by hedge funds is not perfectly reflecting the hedge funds' investments during the month.

2.2.7. *Investment opportunities*

Hedge funds have a less restricted universe to invest in. Due to more lenient regulation, hedge funds are able to invest in securities that traditional funds are not permitted to invest in. For instance, hedge funds can combine short and long positions, concentrate their investments, leverage their portfolio, trade derivatives and hold unlisted securities. Though, this also exposes hedge fund for greater manager specific risk, which emphasizes the importance of thorough analysis when investing in hedge funds. It is however important to remember that hedge fund necessary do not employ all the available opportunities, only the ones needed. (Lhabitant, 2006)

Hedge funds are able to take more precise positions to future market scenarios and utilize leverage and derivative products to take stance on the development of different financial securities. The risk factor analysis shares light on the perspective hedge funds have at the moment of different securities and markets. Though, a large investment scope allows hedge fund to invest in alternative assets with alternative risk-exposures. It is questionable if basic assets are able to capture the risk-exposures for returns obtained from these alternative assets.

¹ Accordingly to the efficient market hypothesis all security prices fully reflect all publicly available data (Fama, 1970)

² Modern portfolio theory believes that markets are perfect and that investors should only invest in efficient portfolios (Markowitz, 1952)

2.3. Hedge fund strategies

Hedge fund typically focuses on specific asset classes or trading strategies. For example, some strategies are driven by macro-economic factors, while others invest only in distressed³ securities. Therefore, to analyse hedge fund one need to separate them into standardized investment styles. Currently, there is no accepted norm for the separation and several classifications exist. In this thesis hedge funds are classed with the Lipper TASS Hedge Fund Database classification standard. Appendix 1 presents 13 classes that Lipper TASS divides the investment strategies in.

As mentioned in the delimitations of the study, the analysis only focuses on managed futures strategy, which is included in *the directional strategies main* class. Therefore directional strategies are presented in more detail.

2.3.1. Directional strategies

A directional strategy is any trading or investment strategy that entails taking a net long or short position in a market, i.e. the investor is betting on the market movement. The directional strategies are divided in six sub-categorize: dedicated short bias, emerging market, global macro, long bias, long-short equity and managed futures.

The dedicated short bias is any hedge fund strategy that consistently has a short exposure to the market. A short position is created, for example by shorting financial instruments or investing in put-derivative products. The emerging market strategy invests either in equity or debt securities of companies in emerging markets. The investor may use any kind of instrument to create his position, and may invest in all emerging countries, or focus on a specific market. Global macro strategy tries to identify extreme market movements in stock markets, interest rate, foreign exchange rates or commodities. The managers use a top-down approach, analyzing how different macro-events may affect individual financial instruments.

³ Distressed securities are securities of companies or government entities that are in "default, under bankruptcy protection, or in distress and heading towards such a condition". (Morningstar, 2005)

The long bias strategy is similar to traditional long-only strategies, with the exception of a larger variety of investable instruments. The long-short strategy tries to combine long holdings in equity with short positions in derivatives of stock or stock index. The strategy uses a lot of derivatives to achieve more concentrated positions than traditional equity funds. The managed future strategy tries to identify market trends and gain exposure to these trends through futures forwards and options. The strategy includes usually a high level of leverage to increase position.

As mentioned, this study focuses on managed futures strategy. The managed futures strategy is chosen because it is one of the most replicable strategies with good expected returns for investors. Hence it is an attractive investment class for investors. Table 5 share some light on the replication quality of the strategy.

Table 1 Correlation, adjusted R^2 and RMSE comparison of different hedge fund strategies (Amenc, Martellini, & Meyfredi, 2010)

	Correlation	Adj. R^2	Annualized RMSE	Annualized geometric excess return (AER)	Annualized Sharpe
Convertible arbitrage	0.10	-0.12	0.05	-0.06	0.37
<i>Managed futures</i>	<i>0.42</i>	<i>0.37</i>	<i>0.12</i>	<i>-0.03</i>	<i>0.02</i>
Distressed securities	0.41	0.20	0.05	-0.07	0.69
Emerging markets	0.51	0.39	0.11	-0.11	0
Equity Markets neutral	0.37	-0.38	0.03	-0.05	0.59
Event Driven	0.47	0.31	0.04	-0.05	0.85
Fixed income Arbitrage	0.22	0.10	0.03	-0.03	0.28
Global macro	0.00	-0.28	0.08	-0.09	-0.04
Long-short equity	0.47	0.49	0.09	-0.05	0.41
Risk arbitrage	0.15	0.23	0.04	-0.01	1.03
Dedicated short bias	0.68	0.63	0.12	-0.04	-0.11
Fund of funds	0.40	0.40	0.06	-0.05	0.33

Table 1 presents the strategy analysis from a replication quality perspective and a replication performance perspective. The replication quality is measured with the correlation, adjusted R^2 and annualized root-mean squared error. The replication performance is measured with Average excess return and Annualized Sharpe. The Annualized geometric excess return (AER) measures if the deviation between the clone and the index leads to under- or over performance of the clone relative to the index. The results are from January 1999 through December 2006. Source: (Amenc, Martellini, & Meyfredi, 2010)

The managed futures strategy is not the best strategy to replicate in any respect. The Risk arbitrage has the highest annualized Sharpe. However, risk arbitrage has a low replication quality, as the Adj. R^2 is 0.23. Event driven strategy is another strategy with high Sharpe ratio. However, this strategy has a lower Adj. R^2 compared to Managed futures. Further, event driven strategies carry lot of illiquidity risk and are therefore not preferable strategy to replicate. The assumption is that the managed future might be most accurately replicated as the strategy relies on trend-following, i.e. holding long-term asset positions and analyzing changes in the trend. From a replication perspective, the managed futures strategy follows usually a trend and does not have as volatile returns as other strategies, and therefore be more replicable. Therefore, the managed futures strategy is chosen as the other strategies either have lower replication quality or lower replicator performance.

2.4. The future of hedge funds

Merton and Bodie (1995) argue that the evolution of financial systems is an innovation spiral, in which different markets and intermediaries compete against each other with existing products and complement each other with new products. Historically, it is shown, that products that is offered by intermediaries ultimately move to be offered as instruments on markets. An example on this is the mutual fund industry. Traditionally, mutual funds offered diversification benefits to individual investors by pooling their resources and investing them in several different assets. Today, ETFs offer the same diversification mechanism, however with a lower cost.

Research has shown that hedge fund alpha is uncommon. For instance Fung and Hsieh (2007) showed that in 2004-2005 only about 5 % of funds of hedge funds delivered alpha. Further, several other studies (Jaeger & Wagner, 2005; Kosowski, Naik & Teo, 2007) argue that the average hedge fund alpha is in recent years continuously declining. The decline can be explained with two causes: maturation and crowding. *Maturation*, caused by the enormous growth in the hedge funds, led to evaporation of previously profitable strategies. Hence, in the long run, any profitable alpha-generating strategy will converge to a beta-driven strategy. This is also in line with Merton and Bodies (1995) innovation spiral – theory. Crowding is caused because the hedge fund industry offers a high compensation and has low barriers to entry, which have attracted many new hedge fund managers to the market. This has also led to diminishing alphas. (Kosowski, Naik & Teo, 2007)

The present state of the hedge fund industry can be compared with that of the mutual fund industry 15 years ago. In the late 1990, as the mutual fund industry matured, the number of market indices and passively managed funds grew tremendously. (Bowler, Ebens, Davi & Amanti, 2006) Today, hedge fund replication products are changing the hedge fund industry by converting the active hedge fund strategies to replicator products.

3 THEORETICAL FRAMEWORK

This section provides a theoretical framework for hedge fund replication. The chapter is divided in two main parts: a discussion on *alternative investments* and a discussion on *hedge fund replication techniques*. Hedge fund replication is based on beta replication and therefore the concept of *alternative beta* is introduced. Thereafter, the focus is on the hedge fund replication, and especially *the different replication techniques* and the *limits of hedge fund replication*. To end the chapter, a brief overview of *the existing hedge fund replicators* is given.

3.1. Alternative investments

An alternative investment is an investment in other than traditional assets, such as stocks, bonds, mutual funds or cash. In some circumstances, even exotic geographical regions, such as emerging markets, are labelled as alternative assets. (Skidmore, 2009) Figure 3 presents the main difference between traditional assets and alternative asset, which is their correlation with the market portfolio.

Figure 3 The R^2 when hedge funds and mutual funds regressed on typical asset classes

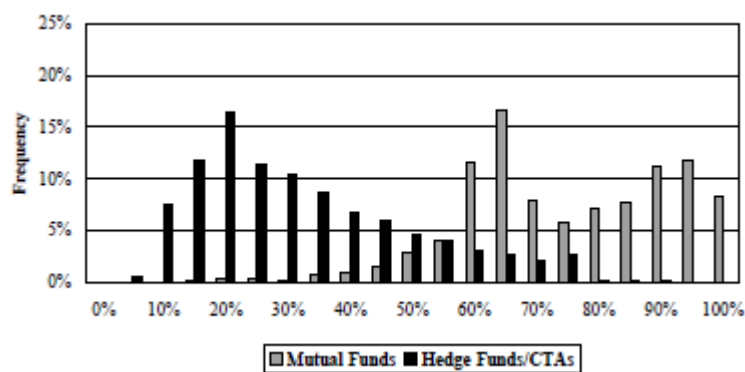


Figure 3 represents the distribution of R^2 of regression of hedge fund returns and mutual fund return on eight different asset classes (US equities, non-US equities, emerging market equities, US government bonds, non-US government bonds, one-month Eurodollar deposit rate, gold, trade-weighted value of the Dollar). The lower correlation for hedge funds towards traditional assets explicit in the figure is due to the use of derivatives instrument, leverage and investing in alternative assets. Source: (Fung & Hsieh, 1997)

Table 2 elaborates further on the findings from figure 3. It decomposes the hedge funds to different hedge fund strategies, and shows that overall, the correlation between different hedge funds strategies tend to be low correlation, in addition to the stock market, even to the bond market⁴.

Table 2 Correlation between hedge fund strategies and traditional assets

	S&P500	Barcleys US
Convertible Arbitrage	0.31	0.18
Distressed Securities	0.37	0.01
Emerging Markets	0.57	0.03
Equity Hedge	0.63	0.12
Market Neutral	0.12	0.23
Equity non-Hedge	0.77	0.13
Event Driven	0.59	0.10
Fixed Income Arbitrage	0.42	0.13
Macro	0.42	0.37
Relative Value	0.34	0.04
Short Selling	-0.69	-0.07
Market Timing	0.68	0.19

Table 2 presents the correlation between different hedge fund strategies, the S&P500, and the Barclays bond index. Except the equity non-hedge, strategies show correlations ranging between 0.69 for market timing to -0.69 for short selling for S&P500 and correlations ranging between 0.37 for macro to -0.07 for short selling. Source: (Amenc, Martellini & Vaissié, 2003)

To summarize, the results hint that alternative investments are able to offer better diversification benefits than traditional assets. The risk-exposures that traditional assets cannot explain are analysed with alternative betas.

3.1.1. Alternative Beta

Alternative beta is a modification of the traditional beta. Next, the parameter is introduced through the *Sharp's (1992) capital asset pricing model*. This model states, that in equilibrium, all assets and portfolios will have the same return after adjustment

⁴ Stock-markets are represented by S&P500 and Bond markets is represented by Barclays US bond index

for risk that is represented by capital asset pricing model. Alternative beta can be seen as an extension to this model. Equation 1 presents the Capital asset pricing model.

$$E(r_i) = r_f + \beta_i [E(r_m) - r_f] \quad (1)$$

Alpha, In a CAPM world, is the excess return that cannot be explained by risks, market return or assets individual risks, and can be represented formally as,

$$\alpha_i = E(r_i) - \beta_i [E(r_m) - r_f] - r_f \quad (2)$$

where β_i presents the risk of asset_i, which is measured as

$$\beta_i = \frac{Cov(r_i, r_m)}{Var(r_m)} \quad (3)$$

Hence, α_i may be undetected risk inherent from alternative β_i , and therefore adding new alternative β_i may explain more $E(r_i)$, and therefore decreases the α_i .

Hedge funds are exposed to specific risk factors due to the use of eccentric instrument, such as short selling, leverage and the use of derivatives. These risk exposures can be extracted using alternative betas and to analyse the alternative betas, academics (Fung & Hsieh, 1997; Amenc, Martellini & Meyfredi, 2010; Bollen & Fisher, 2012) use eccentric instruments as risk factors.

Tancar and Viebig (2008) classify alternative risk factors in four groups: Illiquidity risk, risk transfer, spreads and optionality and volatility. They state that an illiquidity premium is often connected to high transaction costs and long holding periods, and arise on asymmetric markets, where there is imbalance between buyers and sellers. The risk transfer premiums are similar to insurance premiums as one takes on risk that others fear. The spread premiums arise from mispricing of similar securities, and the most common spreads are credit spreads, value-growth spreads, and small-large-cap spreads. Finally, the optionality premiums are often found in volatile markets.

The illiquidity is especially interesting when risk-adjusted performance comparison is conducted. Illiquid assets tend to have low volatility due to ineffective markets. Therefore, the realized volatility does not mimic the actual risk for the instrument. Hence, a lower volatility leads to higher risk-adjusted returns than actually obtained. It is therefore important to analyse the illiquidity of the return series to be able to confirm the robustness of the results.

3.2. Hedge fund replication

Hedge fund replication attempts to extract information on the strategies applied by hedge funds to achieve similar returns with lower costs. There exists several different approaches into how extract the information. Therefore, this section gives an overview of the different hedge fund replication techniques. However, there exists many limitations to the hedge fund replication process, and therefore these are presented.

3.2.1. Hedge fund replication techniques

There exist empirically inductive and economically deductive replication techniques. The economically deductive approach analyses the economic as a whole and makes assumption based on the observable. In contrary, the empirically inductive approach analyses the return performance of hedge funds to replicate the funds.

Figure 4 presents the three main approaches to hedge fund replication: the factor approach, the rule based approach and the distribution based approach.

Figure 4 Hedge fund replication techniques

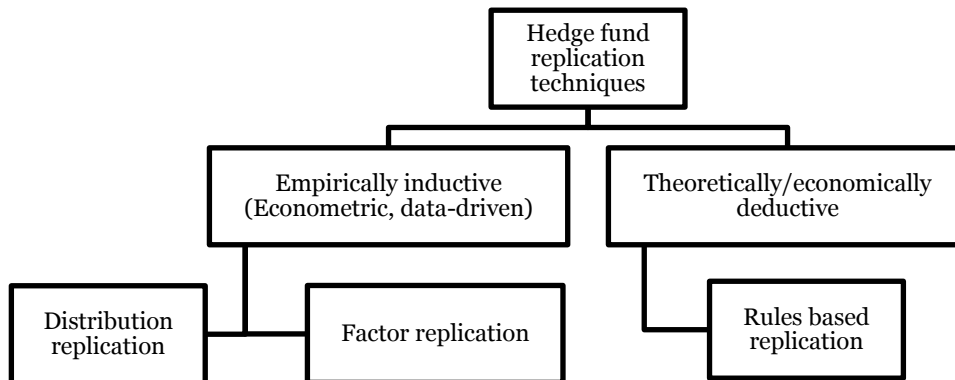


Figure 4 presents the different hedge fund replication techniques. The techniques are divided in two different categories. Factor and distribution replication techniques are driven by historical data, whereas the rules based replication is driven by theoretical analysis. The two former are based on replicating the statistical properties of the hedge fund returns, while the rules based technique attempts to replicate the investment strategies hedge funds apply. This thesis applies factor replication technique. Source: (Tancar & Viebig, 2008)

The thesis applies the factor replication approach, as it is more intuitive and non-complex to its nature. Many investment banks apply the same approach as well, as it is shown to be the most efficient (Wallerstein, Tuchschnid, & Zaker, 2011).

Basically, the factor replication process can be divided in two steps: risk exposure analysis and portfolio construction. Hedge fund risk exposure is analysed with multiple regression analysis, presented in equation 4.

$$r_t^{HF} = \sum_{k=1}^K \hat{\beta}_{ik} F_{kt} + \hat{\varepsilon}_{it} \quad (4)$$

Where $\hat{\beta}_{ik}$ is the factor exposures, F_{kt} is the factor returns and $\hat{\varepsilon}_{it}$ is the error terms.

The factor exposures are applied as portfolio weights and a passive portfolio is created to obtain out-of-sample⁵ returns. The replication quality is analysed by comparing return characteristics for the replicator returns against return characteristics of underlying hedge funds. (Amenc, Gehin, Martellini, & Meyfredi, 2008). Equation 5 presents the second step.

$$r_t^{replicator} = \sum_{k=1}^K \hat{\beta}_{ik} F_{kt} \quad (5)$$

I.e. the replicator return is obtained by summarizing the beta exposures multiplied with the factor returns.

Amenc, Martellini and Meyfredi (2010) divided the model selection in two approaches: conditional and unconditional models. To capture the dynamical nature of hedge funds, authors introduce conditional models, such as Markow-regime switching model and Karman filters. However, even if the conditional models are able to improve the risk-analysis of hedge funds, the replication quality has not been improved. The main reason is that the models are not able to convert the better risk-analysis to better out-of-sample replication quality. Therefore this thesis focuses on unconditional models.

The quality of the replication process is determinate by the factors used in the model. The factor selection is a statistical process, in which one tries to identify the factors most correlated with the hedge fund returns. In hedge fund replication, usually a benchmark set of factors, based on previous research, is compared to a new set of factors. Then, a range of different statistical parameters is analyzed to see if the given factors increase the model precision. This thesis uses both findings from previous studies and includes some new factors.

⁵ Out-of-sample refers to the models performance on data that was not in the sample used to calibrate it

3.2.2. *Limits of hedge fund replication*

Hedge fund replication has theoretical and practical limitations. There is no defined hedge fund database that is used in hedge fund replication studies, and therefore it is difficult to compare results from different studies. Hedge funds have voluntary reporting and hedge funds typically report only to two hedge fund databases. Therefore the different hedge fund databases constitute different hedge funds. (Lhabitant, 2006). The reporting issue and its effects are discussed in detail in the data chapter.

More importantly with respect to this thesis, hedge fund replication quality is exposed to other issues, such as time lags, data availability and differences in hedge fund strategies. Hedge funds report performance only once a month and therefore the performance is observed with a time lag. The observed returns in the end of the month does not necessarily correspond to the investments that hedge funds at the moment actually holds.

Further, hedge fund industry has not existed for a long period of time, and for instance CS/Tremont Hedge Fund Composite index only have 167 data points. This implies that there might be issues with the time series length. If the sample does not include hedge funds with enough monthly return data, one is unable to make the replication analysis. The time series length are therefore analysed in the data chapter.

Finally, as already noted in this study, hedge funds replication quality is dependent on the analysed hedge fund strategy. (Mitev, 2007) Different strategies have different attributes. Therefore, this thesis analyses only one specific hedge fund strategy.

3.3. Existing hedge fund replicators

As mentioned in the introduction, Merrill Lynch and Goldman Sachs were the first to introduce their replication products and a numerous of investment banks⁶ have followed. The general consensus seem to be that hedge fund replication products will lead to better liquidity and lower fees for hedge fund like returns. Though, the function of hedge fund replicators causes dispute. Some consider hedge fund replicators as complementary products to existing hedge fund portfolio, where others predict that

⁶ Société Générale, Barclays, Credit Suisse, Fulcrum Asset Management, JP Morgan, State Street Global Advisors, Blue White Alternative Investments, Concept Fund Solutions, IceCapital Fund Management, Innocap Investment Management, Deutsche Bank, Index IQ, Rydex SGI, Desjardins Global Asset Management

they will be a valuable alternative for hedge fund investments. (Wallerstein, Tuchsmid & Zaker, 2011)

Wallerstein, Tuchsmid and Zaker (2011) investigates the products in the hedge fund replication universe. First, he investigates the applied techniques and finds that from the sample replicators, 13 are based on factor approach, four are based on rule based approach, two are based on a combination of factor and rule based approach and two are based on the distribution approach. From the 21 replicators, only two confirmed that they use Kalman filters or other conditional models to enhance the ability to capture dynamical characteristics of hedge funds.

Secondly, the author analyses the replicators' performance. How have existing replicators managed the real world? Appendix 2 elaborates on the main findings. To summarize, all products beat their US and international benchmark indices, S&P 500 and MSCI EAFE respectively. Further, more than 13 replication products outperform all the aggregated hedge fund indices, even though many times with higher volatility.

To conclude, replication products exist on the market and perform relative well. Their correlation with the benchmark indices is high and they often outperform their benchmark.

4 PREVIOUS RESEARCH

This section gives an overview on hedge fund replication research. It begins with an overview on hedge fund research, after which the sections presents four relevant articles.

The three first articles share light on the development in hedge fund replication research, developing from a simple idea (Fung & Hsieh, 2004) to actual solution (Hasanhodzic & Lo, 2007) and further to a more complex dynamical approach (Amenc, Martellini, & Meyfredi, 2010). Finally, the forth article discuss the performance of hedge fund replicators introduced on the market to increase the credibility of the research.

4.1. An overview on hedge fund research

Basically, hedge fund research can be classified in four different main categories. Table 3 summarizes the categories. The first category studies the performance of hedge funds: i.e. comparison of hedge fund performance with classical markets (Ackermann, McEnally, & Ravenscraft, 1999; Agarwal & Naik, 2004; Liang, 2001), comparison with mutual funds (Ackermann, McEnally, & Ravenscraft, 1999) and performance persistence evaluation (Liang, 2001). In the second category, hedge fund investment styles are analysed. These studies focus on Sharpe style analysis (Fung & Hsieh, 1997; Goetzmann, & Park, 2001), rolling regression (McGuire, Remolona, & Tsatsaronis, 2005) and dynamic models (Swinkels & Van der Sluis, 2001). The third category analyses market exposure of hedge funds, by looking at the correlation (Fung & Hsieh, 1997) and diversification power (Amenc & Martellini, 2002) of hedge funds. These studies aim to explain the diversification benefits for hedge funds by focusing in differences in tail-risk and correlation between hedge fund and other investments. The final category includes all other hedge fund studies that cannot be fitted in the three categories presented; for instance hedge fund risk (Jorion, 2000), data bias analysis (Fung & Hsieh, 2001), hedge fund indices (Amenc & Martellini, 2002) and CTAs (Gregoriou & Rouah, 2003).

Table 3 Summary on hedge fund research categories

Performance of hedge funds	Performance comparison with classical markets	Ackermann, et al., 1999 Agarwal and Naik, 2004 Liang, 2001
	Performance comparison with mutual funds	Ackermann, et al., 1999
	Performance persistence evaluation	Liang, 2001
Hedge fund investment styles	Sharpe style analysis	Fung and Hsieh, 1997 S.J., et al., 2001
	Rolling regression	McGuire, et al., 2005
	Dynamic models	Swinkels and Van der Sluis, 2001
Market exposure of hedge funds	Hedge fund correlation	Fung and Hsieh, 1997
	Hedge fund diversification power	Amenc and Martellini, 2002
Other hedge fund studies	Hedge fund risk	Jorion, 2000
	Data bias analysis	Fung and Hsieh, 2001
	Hedge fund indices	Amenc and Martellini, 2002
	CTAs	Gregoriou and Rouah, 2003

Table 3 presents the main categories of hedge fund research. Hedge fund replication research contributes to the hedge fund performance studies and other hedge fund study categories.

Although one could argue this thesis to cover all categorises discussed above, the main contribution is within the category of hedge fund performance studies and other hedge fund studies. This thesis has two purposes: first, it replicates hedge funds returns. This part of the study contributes to the fourth category: Other hedge fund studies. Secondly, it analyses if return based data selection can impact the return of hedge fund replicators. The performance of the replicators is also compared to market returns. This part of the study contributes to the first category of hedge fund research, i.e. hedge fund performance comparison.

4.2. Fung and Hsieh (2004)

In their article “Hedge fund Benchmarks: A Risk-Based Approach” published in *Financial Analyst Journal*. The authors’ main argument is that hedge fund returns are less correlated to traditional asset classes and therefore the traditional model (Sharpe, 1992) is less applicable to analyse hedge fund return. Hence the authors introduces a

new seven asset-based style factor model that explains up to 80 per cent of monthly return variation in hedge funds. This high explanatory power of the model laid the foundation for hedge fund replication.

To proxy typical hedge fund portfolios, the authors exploit the monthly returns for the HFR Fund of Fund Index. They then regress the returns of the index on seven different factors from February 1995 to September 1998 and from April 2000 to December 2002. The seven factors consist of two stock-factors, two interest-rate factors and three option factors. The two stock factors are the return on S&P 500 (S&P) and the difference between returns on Wilshire 1750 Small Cap and Wilshire 750 Large Cap (SC-LC). Interest rate factors consist of the change in the 10-year U.S treasury bonds (10Y), and the difference between Moody's Baa bonds and U.S. Treasury bond (CredSpr). The option factors consist of lookback options on bonds (BdOpt), currencies (FXOpt) and commodities (ComOpt). Lookback option is an option where the buyer of the option can buy the underlying asset to the lowest price during the duration of the option and the seller of the option has the possibility to sell the option to the highest price during the duration of the option. The author combines these lookback attribute with buy and sell options to create straddles which favours the investor if the price of the underlying asset rises over or falls under the exercise price. Equation 6 presents the model.

$$r_t = \alpha + \beta_1 S\&P_t + \beta_2 SC - LC_t + \beta_3 10Y_t + \beta_4 CredSpr_t + \beta_5 BdOpt_t + \beta_6 FXOpt_t + \beta_7 ComOpt_t + \beta_8 \varepsilon_t \quad (6)$$

Source: Fung and Hsieh (2004)

Table 4 further elaborates on the authors' main findings.

Table 4 Fung and Hsieh (2004) results

February 1995 to September 1998	HFRFOF	April 2000 to December 2002	HFRFOF
Intercept	0.00488	Intercept	0.00210
<i>Standard error</i>	0.00211*	<i>Standard error</i>	0.00190
S&P	0.02228	S&P	0.04245
<i>Standard error</i>	0.05097	<i>Standard error</i>	0.04188
SC-LC	0.16584	SC-LC	0.17205

(Continued on next page)

February 1995 to September 1998	HFRFOF	April 2000 to December 2002	HFRFOF
<i>Standard error</i>	0.07555*	<i>Standard error</i>	0.05179**
10Y	-2.175	10Y	-2.201
<i>Standard error</i>	1.29118	<i>Standard error</i>	0.90190**
CredSpr	-8.844	CredSpr	-1.828
<i>Standard error</i>	2.63717**	<i>Standard error</i>	1.39932
<i>Standard error</i>	0.01672	<i>Standard error</i>	0.00857
FXOpt	0.00560	FXOpt	0.00167
<i>Standard error</i>	0.00836	<i>Standard error</i>	0.00986
ComOpt	0.00769	ComOpt	0.02361
<i>Standard error</i>	0.01610	<i>Standard error</i>	0.01824
R2	0.405	R2	0.540

Table 4 summaries the regression results in Fung and Hsieh (2004). HFRFOF is the HFR fund of funds index. S&P is the return for S&P 500 and the SC-LC is the difference between returns on Wilshire 1750 Small Cap and Wilshire 750 Large Cap. 10Y is the interest rate factors consisting of the change in the 10 year U.S Treasury bond. CredSpr is the difference between Moody's Baa bonds and U.S. Treasury bond. The option factors consist of lookback options on bonds (BdOpt), currencies (FXOpt) and commodities (ComOpt). The analysis is conducted from February 1995 to September 1998, and from April 2000 to December 2002. *, ** indicates significance at the 5% and 1% levels.

The authors find evidence also on time-varying beta loadings and conduct a research on the time-variation for beta loadings. The findings indicate that the beta loadings are dependent on the state of the market and for instance that hedge funds only generate positive alphas during bullish markets. In light of hedge fund replication, time-varying beta exposure can be considerate by time-varying model. Two methods on replication methods are introduced, rolling window factor method and fixed weight method. The author shows that the rolling window model is more suitable for replication than the fixed weight model.

4.3. Hasanhodzic and Lo (2007)

Hasanhodzic and Lo's article "Can Hedge-Fund Returns be Replicated? The linear Case", which was published in the *Journal of Investment Management*, was the first study to attempt to create a hedge fund replication product. The research was based on previous findings from Fung and Hsieh (2004), Kat and Palaro (2005, 2006a) and Bersimas, Kogan, and Lo (2001).

In the factor model, the authors perform a six factor linear regression for all the hedge funds in the TASS Hedge Fund Live database between February 1986 and September 2005. The study is conducted in two phases; first, hedge fund returns are regressed on six risk-factors to obtain the common risk factors for hedge fund returns and secondly, these risk-factors are utilized as portfolio weight to create a replication product.

The model includes the following six factors; the U.S. Dollar Index return (USD), the return of the Lehman Corporate AA Intermediate Bond Index (BOND), the spread between the Lehman BAA Corporate Bond Index and the Lehman Treasury Index (CREDIT), the S&P 500 total return (SP500), the Goldman Sachs Commodity Index total return (CMDTY), and the first-difference of the end-of-month value of the CBOE Volatility Index (VIX).

$$R_{it} = \alpha_i + \beta_{i1}USD_{1t} + \beta_{i2}BOND_{1t} + \beta_{i3}CREDIT_{1t} + \beta_{i4}SP500_{1t} + \beta_{i5}CMDTY_{1t} + \beta_{i6}DVIX_{1t} + \epsilon_{it} \quad (7)$$

These factors are chosen to represent a mix of the key risk exposures for a hedge fund and to make replication through liquid instrument achievable in practice.

To compare methods, the authors create both a fixed-weight and a rolling window replicator. In the model, the intercept is omitted and beta coefficients constrained to equal one. Then, the beta factors from the factor model are used as portfolio weights in building the replicators. However, the authors implement an additional renormalization so that the new portfolio return has the same volatility as the original funds return series.

The results are intriguing. First, they do not find significant differences in the rolling-window and fixed-weight methodological approaches – the fixed weight have a higher return, but it is mainly due to the differences in returns for different underlying sampling periods. Secondly, and most interestingly, for several categories, the average mean return of the comparison index is only slightly better, and for some strategies, the replicators' outperformance the comparison index. The five fixed weight replicators that have higher average mean return than their comparison index are Dedicated Short Bias, 6.70 % compared to 5.98 %; Equity Market Neutral, 10.00 % compared to 8.09 %; Global Macro, 15.54 % compared to 11.38 %; Managed Futures, 27.97 % compared to 13.64 %; and Fund of Funds, 9.29% compared to 8.25%. Even if these differences are not necessary statistically significant, the results suggest that the performance of fixed-weight replicators may be comparable to their corresponding funds.

4.4. Amenc, Martellini and Meyfredi (2010)

In the article “Passive Hedge Fund Replication – Beyond the Linear Case”, which was published in *European Financial Management* the authors extend the work of Hasanodzic and Lo (2007) by introducing new dynamical methods to construct the replicator. Additionally, the authors study if factor selections impact the out-of-the sample returns.

The paper uses the same database as Hasanodzic and Lo (2007), TASS Hedge Fund Live database. The paper applies the same factor based replication approach as Hasanodzic and Lo (2007), but extends it with the introduction of an unconditional option-based factor model, a conditional markov regime-switching (MRS) model and a conditional Kalman filter model. The motivation for the new models are that hedge funds apply dynamical trading strategies and the three new models introduce more complex method to capture this dynamic characteristic and non-linearity of hedge funds. More specifically, the authors use a 24 months estimation window for the unconditional models, i.e. linear model and option-based model, and add new information as it arrives in the calibration window for the conditional models, i.e. MRS and Kalman filter. The authors finally obtain 96 monthly out-of-sample returns for the different replicators from January 1999 through December 2006.

Furthermore, the paper introduces a new set of risk factors, the so-called *economic factor model*. The author analyses the different hedge fund strategies and determinate the most suitable factors for each model. In addition to the factors introduced by Hasanodzic and Lo (2007) (Equation 10), the authors introduce the following factors: Small/Large spread; proxied by the return spread between the S&P 600 Small Cap index and the S&P 500 Composite index, IFC Emerging Markets index, Merrill Lynch 300 Global Convertible Bond index, Default spread; proxied by the return spread between Lehman US Aggregate Intermediate Credit BAA and the Lehman US Aggregate Intermediate AAA indices, Mortgage spread; modelled by the excess return of the GNMA index over the Lehman US Treasury Bill index.

The results are presented for the in-sample⁷ quality estimation of the replication product and the out-of-sample⁸ quality estimation of the replication product. The main

⁷ In-sample defines the results given from the regression performed on an arbitrarily chosen time series.

⁸ Out-of sample define the results that are not impacted by the underlying sample.

finding for the in-sample estimation is that introducing dynamical risk factors significantly increases the explanatory power of the replication product, and especially the Kalman filter approach strives. However, in the out-of-sample context the authors find little differences in the explanatory power of the conditional models. In contrary to the study of Hasanodzic and Lo (2007), all but one of the replication products displays lower annual excess returns and lower Sharpe ratios in comparison to the comparison index. Though, the annual excess return for the five strategies that beat their comparison index in Hasanodzic and Lo (2007) paper show negative AER ranging from 9 % (Global Macro) to 3 % (Managed futures). To conclude, the authors show that the dynamical models do not improve the replication process.

4.5. Tuchschnid, Wallerstein and Zaker (2010)

In the article “Hedge Fund Clones still to count on”, Tuchschnid, Wallerstein and Zaker analyses the existing hedge fund replicators by comparing replication returns to benchmark returns. Further, they analyse the alphas of existing replication products using the extended Fung and Hsieh (2004) 8-factor model (Equation 8).

The sample consists of hedge fund replication products launched before August 2009 and consist of 22 hedge fund replication products. The authors divide the study in two time periods: one between April 2008 and October 2010, and another between August 2009 and October 2010. To make comparison possible, the replicated returns are benchmarked against the HFRI fund of fund index.

The replication products show annualized mean return that range between -7.1 % and 12.4 %. This however gives a wrong impression, as 86 % of the products fit the range of 2.4 % to 12.4 %. More than 50% of the replicators outperform their benchmark on a raw return basis. However, replication products tend to have higher annualized standard deviation, ranging between 2.9% to 11.1 % compared with the benchmark ranging between 4.4 % and 6.0 %. Thus, only 9 % of replication products succeed to beat their benchmark based on risk-adjusted returns.

Finally, authors focus on the alpha of the replication products by analysing the returns with the 8-factor model. They find that the adjusted R^2 of the model is around 80 % for more than 67 % of the replication products, thus verifying a high model fit. The annual alpha for replication products range between -13.2% and 10.4 %. Furthermore, more than 53 % of the replication products have higher alpha than their benchmark.

4.6. Summary of previous studies

The chapter presents four previous studies. The three first articles describes the concept of hedge fund replication, developing from an underlying risk analysis theory to a more advanced dynamic replication model, whereas the last discusses the existing replicators. Table 5 summarizes the previous studies.

Fung and Hisieh (2004) laid the foundation to hedge fund replication in their article that discussed risk-analysis for hedge funds. This was the first article that brought the idea of hedge fund replication into public. Based on Fung and Hsieh (2004) article, Hasanhodiz and Lo (2007) published their article which is the first attempt to replicate hedge funds. The author regress six factors, which have liquid proxy instruments towards a set of hedge fund return for the period February 1986 to September 2005. Thereafter, Amenc, Martellini and Meyfredi (2010) introduce a dynamical model to capture the dynamic nature of hedge funds. However, these conditional models do not significantly improve the replication performance. Finally, Tuchschnid, Wallerstein and Zaker (2010) analyze the existing replicators and show that the replicators in fact offer relatively attractive returns for investors.

In comparison to previous studies, this thesis follows the same methodology as Hasanhodiz and Lo (2007) and extends it to also consider data selection. Also, it combines variables from both Hasanhodiz and Lo (2007) and Amenc, Martellini and Meyfredi (2010). To summarize, the thesis attempts to apply data selection to the same methodologies used in previous studies to achieve a higher return for investors.

Table 5 Summary of previous studies

Study	Year	Purpose	Data	Method	Results
Fung and Hsieh	2004	Analyze hedge fund risk-exposure	Monthly returns for the HFR Fund of Fund index between January 1994 and December 2002	OLS regression analysis; $R_{it} = \alpha_i + \beta_1 S\&P_t + \beta_2 SC - LC_t + \beta_3 10Y_t + \beta_4 CredSpr_t + \beta_5 BdOpt_t + \beta_6 FXOpt_t + \beta_7 ComOpt_t + \beta_8 \epsilon_t$	The adjusted R^2 for the model is 0.405 between February 1995 to September 1998, and 0.540 between April 2000 and December 2002. The significant variables for first time period are the intercept and SC-LC on 5% significance level and CredSpr on a 1% significance level. For the second time period the SC-LC and 10Y is both statistical significance on a 1% level. The model has an adjusted R^2 of 80% to hedge fund returns.
Hasanhodzic and Lo	2007	Replicate hedge fund returns	Monthly returns for 1610 hedge funds from TASS Hedge Fund Live database between February 1986 and September 2005	OLS regression analysis; $R_{it} = \alpha_i + \beta_{i1} USD_{1t} + \beta_{i2} BOND_{1t} + \beta_{i3} CREDIT_{1t} + \beta_{i4} SP500_{1t} + \beta_{i5} CMDTY_{1t} + \beta_{i6} DVIX_{1t} + \epsilon_{it}$	No statistical significant parameters. However, the returns for the passive hedge fund indices for five replicators higher than their comparison index; Dedicated Short Bias, 6.70 % compared to 5.98 %; Equity Market Neutral, 10.00 % compared to 8.09 %; Global Macro, 15.54 % compared to 11.38 %; Managed Futures, 27.97 % compared to 13.64 %; and Fund of Funds, 9.29% compared to 8.25%
Amenc, Martellini, and Meyfredi	2010	Improve the hedge fund replication technique	Monthly returns for 1610 hedge funds from TASS Hedge Fund Live database between January 1999 and December 2006	OLS regression analysis; conditional linear and option models, and unconditional Kalman filter and markov-regime switching models	Hedge fund replication needs to be further developed, and the conditional models (Kalman filters and markow regime switching models) do not improve replication quality
Tuchschnid, Wallerstein, Zaker	2010	Analyze the performance of existing hedge fund replicators	Monthly hedge fund replicators return for replicators launched before August 2009; 22 hedge fund replicators	OLS regression; Fung and Hsieh eight factor model	Compared to the HFRI fund of funds index more than 50 % of the replication products outperform their benchmark on a raw return basis and one third of replicator outperform index on Sharpe basis.

Table 5 summarizes the results from four relevant hedge fund studies as it describes the authors, the publication year, the sample data, the method and the results for the studies. The Fung and Hsieh (2004) model includes the return for S&P 500 (S&P) and the difference between returns on Wilshire 1750 Small Cap and Wilshire 750 Large Cap (SC-LC). The interest rate factors consisting of the change in the 10 year U.S Treasury bond (10Y). The difference between Moody's Baa bonds and U.S. treasury bond (CredSpr). The option factors consist of lookback options on bonds (BdOpt), currencies (FXOpt) and commodities (ComOpt). The Hasanhodzic and Lo (2007) model includes the following six factors; the U.S. Dollar Index return (USD), the return on the Lehman Corporate AA Intermediate Bond Index (BOND), the spread between the Lehman BAA Corporate Bond Index and the Lehman Treasury Index (CREDIT), the S&P 500 total return (SP500), the Goldman Sachs Commodity Index total return (CMDTY), and the first-difference of the end-of-month value of the CBOE Volatility Index (VIX).

5 METHOD

The method is divided in four different parts to give a clear structure for the section. The first chapter discusses the *classification of hedge funds*, which introduces the new data selection methodology in more detail. Then, the model for the *risk-exposure analysis* is introduced, where also the variable description is included. Thereafter, the method for *building the replicators* is introduced. The chapter concludes with the review on the *analysis of replicators*, which is divided to performance analysis and to replication quality analysis.

5.1. Classification of hedge funds

The main contribution of this thesis is the proposed data selection conducted before the replication process. As discussed previously, hedge funds tend to have short-term performance persistence (Agarwal & Naik, 2000). Therefore one should be able to buy-and-hold well-performing hedge funds and make a short-term abnormal profit.

The individual hedge funds are divided in two categories based on their historical returns. As mentioned, previous research (Agarwal & Naik, 2000; Edwards & Caglayan, 2001; Harri & Brorsen, 2004; Ammann, Huber, & Schmid, 2010) have shown that short-term performance persistence in hedge funds exists. Amman, Huber and Schmid (2010) find performance persistence for time periods to up to 36 months, and that performance persistence is most detectable in shorter time period. In practice, first, individual hedge funds are sorted by their six-month average risk-adjusted return. Then, hedge funds that have the highest six-month average risk-adjusted return are chosen to high-performance sample (HP sample). Finally, the re-classification is made every 6 months, and hence the sample changes every six months.

The risk- adjusted return is calculated with Sharpe ration. Equation 8 presents the equation for the Sharpe ration,

$$\text{sharpe ratio} = \frac{r_i - r_{\text{benchmark}}}{\sigma} \quad (8)$$

where r_i is the average six month return for the individual hedge fund, $r_{\text{benchmark}}$ is the return for the US treasury 6 month interest rate and σ is the six month standard deviation for $r_i - r_{\text{benchmark}}$.

Some hedge funds have been launched in the middle of the six month time periods. For a hedge fund to have sufficient data it is required that for each six month time period the hedge fund reports at least four monthly observations. If there are less than four return observations for a six month time period, the hedge fund is deleted from that period.

5.2. Hedge fund risk exposure analysis

The key step in hedge fund replication is the risk exposure analysis where one tries to measure how much of hedge funds expected return is due to risk exposure to identifiable factors.

As previous studies discuss, there are two possible methodologies for factor risk exposure analysis; the rolling-window multiple regression or the fixed weight multiple regression. They both come with their limitations. The largest issue in fixed weight approach is the look-ahead bias. The entire history of fund and factor returns is used to construct the replicators' portfolio weights. In contrary, the rolling window approach only uses returns for a specified period. However, the rolling-window approach has also its limitations. There exist much larger rebalancing needs in contrast to fixed-weight approach. The purpose of the study is to replicate hedge funds, and only the rolling-window approach yields truly out-of-sample returns. Further, the rolling-window approach captures better the dynamical characteristics of hedge funds, and therefore this approach is chosen.

This thesis uses the original model by Hasanhodzic and Lo (2007) and adds Mortgage and SMB variables introduced by Amenc, Martellini, Meyfredi and Ziemann (2008). The model is

$$r_i = \beta_{1i}USD_t + \beta_{2i}BOND_t + \beta_{3i}SP500_t + \beta_{4i}CREDIT_t + \beta_{5i}MORTAGE_t + \beta_{6i}COMMODITY + \beta_{7i}SMB_t \quad (9)$$

I.e. the multiple regression consists of seven factors; (1) *USD*: the U.S. Dollar index return; (2) *BOND*: the return on the Barclays intermediate corporate Bond (AA) index; (3) *SP500*: The SP500 total return, (4) *CREDIT*: The spread between Barclays intermediate corporate Bond (BAA) index and the Barclays U.S. 5 year treasury index; (5) *MORTAGE*: The spread between GNME mortgage index and the Barclays U.S. 5 year

treasury index; (6) COMMODITY; the return of SP GCSI Commodity index; and (7) SMB; The spread between small and large company spreads (Fama-French factor). These seven factors are chosen to respond to a broad-range of risk-exposures to the hedge funds, i.e. stocks, bonds, currencies, commodities, default-spreads. Further, they all are liquid assets.

As mentioned in the previous section, there are two different samples; the All sample and HP sample. The thesis performs OLS rolling-regression, dependent on the time period in focus, to between 64 to 189 individual funds in All sample and also to between 32 to 94 individual funds in the HP sample. Every fund is regressed 106 times⁹ and every regression has a 24 month-long window. I.e. a 24-month rolling window is used, from month $t-24$ to $t-0$, to estimate the regression¹⁰. The regression is thereafter “rolled” one month further; hence the second window is from month $t-23$ to $t+1$. The coefficients are indexed by both i and t because we repeat the process each month for every fund i .

The analysis period is also divided into two sub-samples; the pre-crisis period and the post-crisis period. Pre-crisis period elapses through January 2004 to August 2008, whereas the post-crisis period elapses through September 2008 to September 2012.

5.3. Building the replicator

Building the replicator is a straightforward process. The parameter estimates are used to construct replication products returns (r_{it}^*):

$$r_{it}^* = \beta_{ti1}^* USD_t + \beta_{ti2}^* BOND_t + \beta_{ti3}^* SP500_t + \beta_{ti4}^* CREDIT_t + \beta_{ti5}^* MORTAGE_t + \beta_{ti6}^* COMMODITY + \beta_{ti7}^* SMB_t \quad (10)$$

$$\text{Subject to } 1 = \beta_{i1} + \dots + \beta_{i7}$$

Using the parameter estimates (r_{it}^*) for the individual hedge funds in our sample, we can now reformulate the question of whether or not a hedge-fund strategy can be cloned to a question about how much of a hedge fund’s expected return is due to risk premium from identifiable factors. Hence, the regressions are first performed to each

⁹ The number of six month time periods

¹⁰ The hedge funds monthly return is regressed on historical returns for the variables.

individual hedge fund and then the regression parameters are averaged across the whole sample.

The method is the same as proposed by Sharpe (1992) for “style analysis”. However, the motivation is quite different as the intercept is dropped to create the best estimate of a weighted average of the factors that best replicate the fund returns. As we drop the constant term, the least-square algorithm forces the factor means to fit the means of the fund. Further, the betas are constrained to sum to one to yield a portfolio interpretation for the weights. The method used in this thesis differs from Sharpe’s (1992) original method, also in the respect that it allows negative betas. Negative betas enable occasionally short selling each of the instruments to achieve risk exposures usual to hedge funds.

The monthly beta coefficients are multiplied with monthly returns for the variables to achieve monthly replicator returns. Next, the next section introduces the tools for analysis.

5.4. Analysis of replicators

In the last step of the methodology, the HP and All replicators’ performance and replication quality are analyzed in respect to each other, hedge fund indices and other benchmark indices. The replicators are analysed with respect to the *replication quality* and with respect to the *replicator performance*.

5.4.1. Analysis of replicator performance

The performance of replicators is analyzed with the *return component*, *volatility*, *risk-adjusted return* and *liquidity* for the replicator. These parameters are then compared with benchmark indices. Liquidity issues are discussed in more detail in the next chapter.

Return is analyzed with the annualized average return and the volatility is analyzed with the annualized standard volatility. The risk-adjusted return is measured with the annualized Sharpe ratio, which is a risk-adjusted performance measurement and is widely used as a comparison measurement. The ratio takes into account both the return and the risk. Equation 12 presents the annualized Sharpe ratio.

$$\text{sharpe ratio} = \frac{r_{i \text{ annual}} - r_{\text{benchmark}}}{\sigma_{\text{annual}}} \quad (11)$$

The measurement compares the annualized abnormal return¹¹ against the annualized standard deviation that is a proxy for risk. The annualized mean return for the replicators is subtracted with the US treasury 1-month interest rate and is thereafter divided by the annualized standard deviation for the replicators.

The first-order autocorrelation is used as proxy for liquidity. The first-order autocorrelation ρ_1 is the correlation between a time-series current return and the time-series previous month return. Multiple researchers (Lo, 2011; Getmansky, Lo, Makarov (2004) observe that a positive value for ρ_1 is a sign for illiquidity risk. Equation 14 presents first-order autocorrelation.

$$\rho_{\varepsilon_t, \varepsilon_{t-1}} = \frac{\sum \varepsilon_t \varepsilon_{t-1}}{\sqrt{\sum \varepsilon_t^2} \sqrt{\sum \varepsilon_{t-1}^2}} \quad (12)$$

A positive autocorrelation indicates that returns for a replicator do not vary as much as they should between months. A positive autocorrelation decreases the volatility of the returns and hence increases the Sharpe ration, which decreases the robustness of the results.

5.4.2. Analysis of replicators' replication quality

The replication quality is measured with correlation, adjusted R^2 , and root-mean squared error (RMSE). These parameters are then compared with benchmark indices. HFRI index is chosen to compare the replicators to a broad sample of hedge funds. The DJ CS managed futures index is chosen to compare the replicators to a set of hedge funds with the same strategy.

The correlation is a natural measurement for estimating replication quality. However, the correlation only relies on second-order co-movement, and is unable to measure first-order movement. Hence the correlation can be high, even though the replicator constantly yields lower returns. Secondly, the correlation coefficient is unable to consider the magnitude of the movement.

¹¹ Return excess to the benchmark index.

The adjusted R^2 measures the explanatory power of the replicator to the benchmark. The test is performed to analyze how much the replicator follows the benchmark. The replicator is the independent variable and the benchmark is the dependent variable. Equation 14 presents the OLS regression.

$$r_{\text{benchmark},it} = r_{\text{replicator},it} + \varepsilon_{it} \quad (13)$$

The parameter is analyzed with a standard OLS regression. Equation 15 presents the formula for the adjusted R^2

$$\text{Adjusted } R^2 = 1 - \frac{(1 - R^2)(N - 1)}{N - p - 1} \quad (14)$$

The R^2 is the sample R-square, p is number of parameters and N is total sample size. Hence, the adjusted R^2 penalizes the amount of parameters. A high adjusted R^2 show that the independent variable explains a large part of the variation in the dependent variable.

The RMSE is a frequently used measure of the difference between values predicted by a model or an estimator and the observed values. Equation 16 presents the formula for RMSE.

$$\text{RMSE} = \sqrt{\frac{1}{T} \sum_{t=1}^T (\hat{r}_t - r_t)^2} \quad (15)$$

The measurement observes the residuals and aggregates them into a single measure of predictive power. The RMSE can also be interpreted as the tracking error between the replicator and its benchmark and a low RMSE indicated good replication quality.

6 DATA

In hedge fund studies multiple different data biases exists, which needs to be considerate to confirm robust results. Therefore, this section begins with a discussion of the major *data biases* in hedge fund research. Thereafter, the section presents the *descriptive statistics* for the time-series length, individual hedge funds and the variable returns.

6.1. Data bias

Hedge fund replication is subject to several different data biases, such as *survivorship bias*, *selection bias*, *illiquid returns*, and *instant history bias*. The biases arise mostly due to voluntary reporting, hedge funds special characteristics and the lack of regulation.

6.1.1. *Survivorship bias*

The survivorship bias refers to the tendency that only successful hedge funds are able to survive in the database, as the unsuccessful hedge funds are excluded from the databases. The database includes therefore more successful hedge funds than what the whole hedge fund universe consists of, which skew the returns of the sample higher. (Brown, Goetzmann, Ibbotson, & Ross, 1992)

Previous studies (Fung & Hsieh, 1997; Malkiel, 1995; Liang, 2001; Brown, Goetzmann, Ibbotson, & Ross, 1992) show that survivorship bias in hedge fund studies range annually from 1.5 % to 3.0%. In hedge fund replication, survivorship bias is not an issue as no absolute performance comparison is made. For instance, the replication quality measures how well the replicator follows the underlying data. It is therefore assumed, that all survivorship bias existing in the underlying data, also exists in the replicated data, and hence survivorship bias does not need to be adjusted.

In this study, only “Active”- hedge funds from Lipper TASS Hedge fund Database are included, which introduces a survivorship bias as sample includes only successful hedge funds. The survivorship bias is assumed to have a somewhat positive impact on the overall results. Assuming that all data is equally replicable, the survivorship bias skews the return of the data higher, and therefore also skews the return higher for the replicator.

6.1.2. Selection bias

Selection bias can arise if the sample of hedge funds is not representative of the hedge fund universe. In hedge funds, there exist two different selection biases, the voluntary reporting and different hedge fund databases. (Heckman, 1979)

As discussed previously in the study, unlike mutual funds, hedge funds report on voluntary basis. As hedge funds are not allowed to market their products, the voluntary report is one way for them to spread information about a fund. Therefore, assumable, only hedge funds with high performance choose to report, which skews the sample performance higher compared to the whole hedge fund universe. Another selection bias is caused by the different hedge fund databases. The Lipper TASS hedge fund database, Hedge Fund Research Database, and Barclays Hedge Fund database are the largest hedge fund databases, and many others exist. If a hedge fund chooses to report performance, it can choose to which database or databases it reports, and therefore the different databases consist of data from different hedge fund.

The aim of this thesis is to introduce a selection bias to the data, and through this selection bias skew the return of the replicator. Therefore, an additional selection bias arising from the voluntary performance reporting does not have significant impact to the results. However, it is important to acknowledge this bias. Also, the selection bias due to different databases does not need to be adjusted, as no comparison analysis between hedge fund returns is done. However, both biases need to be taken into consideration in the discussion.

6.1.3. Illiquid returns

Illiquid returns are defined as returns that do not have normal variation in their price due to low trading volumes or inefficient pricing. (Fung & Hsieh, 2004)

Illiquid returns can affect hedge fund replication in several aspects. First, as hedge funds often follow special strategies, some of these may be subjected to illiquid returns. For instance, many Event driven-strategies carry liquidity risk, as no one else is willing to invest in the illiquid investment. This leads to a low variation in hedge fund returns and therefore the fund will have a high correlation with each own previous returns. It is difficult to measure liquidity risk and therefore it's difficult to analyse the actual risk-exposure of the investment.

In this study, illiquid returns are an issue as one could assume that the managed futures strategy carry some liquidity risk. The illiquidity is an issue that cannot be adjusted for, but it is important to consider it when forming conclusion. To test for this, first-order autocorrelation measures the liquidity for the replicators return time-series.

6.1.4. *Instant history bias*

Instant history bias occurs when a new hedge fund is included in the database, and all of its past performance is included in the database. As hedge funds report voluntary, hedge fund manager may start many funds, some successful and other less successful, and chose to include only the successful to databases. Therefore, only successful past historic performance is included. This skews the returns of the data sample higher. (Fung & Hsieh, 2004)

As for the selection bias, and the survivorship bias, also instant history bias skews the sample return higher. However, as discussed earlier, in hedge fund replication the absolute performance of hedge funds is not compared with other assets, and therefore the positive skew is not an issue. As the instant history has the same effect as survivorship bias and selection bias, the data is not adjusted.

6.2. Descriptive statistics

Hedge fund data is gathered from Lipper TASS Hedge fund database, which divides the data in an “active”-category¹² and a “Graveyard”-category¹³. The “Active”- category consist of 1610 individual hedge funds and the period between January 2004 and September 2012 is chosen. This period is chosen so that one can analyse pre-crisis and post-crisis differences. Finally, the thesis focuses on only hedge funds following the managed futures strategy.

Other data restrictions include companies, which do not report net of fee returns, that report in other currencies than US dollar, that report less frequently than monthly, or that have fewer than 24 observations. This leads to a total sample size of 189 hedge funds.

¹²Includes only of active hedge funds

¹³Includes only closed hedge funds

To analyze the effect of these restrictions and to test data sufficiency, the next section analyzes the time series length for individual hedge funds.

6.2.1. Time series length for individual hedge funds

The life cycle of a hedge fund is shorter than for traditional mutual funds. Further, previous studies have shown (Baquero, Horst, & Verbeek, 2005) that there exists a problem with the time series length. The required length for the time series is 24-months.

Table 6 present the median, average, minimum and maximum monthly observations for individual hedge funds. It can be concluded that no problem with short time series exists in the data.

Table 6 Time series length for individual hedge funds

	Managed
Median	101
Averagee	94
Minimum	24
Maximum	129
All funds	189
Above 36 observations	182
Above 54 observations	157
Above 72 observations	143
Above 90 observations	127

Table 6 presents descriptive statistics for number of observations and number of individual. The table above presents number of observations and the table below presents the number of funds.

6.2.2. Descriptive statistic for individual hedge funds

Table 7 presents monthly descriptive statistics for individual hedge funds. Descriptive statistic for individual hedge funds

Table 7 Descriptive statistics on individual hedge funds.

		Average return (%)				Median return (%)			
		Average	Median	Max	Min	Average	Median	Max	Min
		0.667	0.624	2.902	-0.678	0.535	0.456	5.12	-1.028
p.a.		7.472	6.84	30.02	-7.767	6.574	6.866	36.332	-13.032
		Extreme values (%)				Standard deviation (%)			
		Max	Min			Average	Median	Max	Min
		61.29	-61.628			4.710	4.112	15.676	0.514
p.a.		149.379	-65.779			14.656	12.514	51.506	0.666
		Skewness				Kurtosis			
		Average	Median	Max	Min	Average	Median	Max	Min
		-0.616	-0.577	3.357	-11.094	3.761	1.980	125.015	-1.245
		Normality				Autocorrelation			
		Normality %				AR (1) %			
		48 %				21 %			

Table 7 present descriptive statistics for the individual managed futures hedge funds returns between January 2004 and September 2012. Normality % indicates the proportion of hedge funds that have normal distribution according to the Jarque-Bera test. Autocorrelation % indicates the proportion of hedge funds that exhibit statistic significant AR (1) coefficient. The significance level is 5%.

The returns for individual hedge funds tend to be positive as the average and median values are all positive. The financial crisis can be seen in the extreme values as the monthly maximum returns for individual hedge funds is above 60% and minimum returns for individual hedge funds is below 60% and both occurred during 2008 September-October period as the markets panicked due to the Lehman Brothers bankruptcy.

Hedge funds tend to have high risk-appetite, which is shown from the high average standard deviation (4.71%) for the funds. Hedge funds make risky investments and some of these investments succeed, resulting in high return, whereas some of these investments fail, resulting in low returns.

Hedge funds do not usually follow normal distribution (Agarwal & Naik, Risk and Portfolio Decisions Involving Hedge Funds, 2004). The managed futures strategy seems to differ from the overall hedge funds as 48 % of individual hedge funds have returns that follow the normal distribution on a 5 % significance level. This is a surprising finding, as one could expect a non-normal distribution due to tail-events during the financial crisis.

Autocorrelation is not an issue for the individual hedge funds, but should be pointed out that 21% of them show signs of autocorrelation on a 5 % significance level. Managed futures invest mostly in derivatives products with high volatility and therefore the autocorrelation is expected to be lower for this category compared to other hedge fund categories. This must be taken into consideration when making concluding remarks of the results.

6.2.3. Descriptive statistic for variables returns

Table 8 presents monthly descriptive statistics for the factors; average return, median return, minimum return, maximum return and standard deviation. Also the kurtosis, skewness, normality and autocorrelation are presented. The data is graphically represented in figure 5.

The average annualized return for the S&P 500 is 7.1 % between January 2002 and September 2012. The financial downturn in late 2008 is seen in the low returns of -38.4% for the S&P 500. Also, the data shows the USD devaluation during last decade, as the average return for USD is - 3.1. %. The hypothesis that small companies earn premium returns compared to larger companies is also suggested by the data, as the SMB annual return is 3.7%.

One can also observe a high kurtosis in credit spread due the Lehman Brothers bankruptcy. In October 2008, the return for BAA companies was -14.3%, while the return for AA companies was “only” - 5.1 %. Further, the commodity price index have explicit three large bull-markets and these are both observable from figure 5.

Many of the variables follow normal distribution. The Bond, SP500, Credit and Mortgage variables all follow normal distribution on a 5 % significance level. Commodity follows normal distribution on a 10 % significance level. The USD and SMB variables are non-normal. On the other hand, neither autocorrelation nor multicollinearity (Appendix 4) exists in the variables. Heteroskedasticity exists in Bond and SP500 with a 5 % significance level and in Mortgage with a 10 % significance level. The OLS regression uses heteroscedasticity consistent standard errors to improve the OLS estimates. Overall, the descriptive statistics for the variables are as expected.

Table 8 Descriptive statistics for factor returns

	USD	BOND	SP500	CREDIT	MORTGAGE	COMMODITY	SMB
Average return (%)	-0.260	0.039	0.462	-0.086	0.213	0.731	0.335
p.a.	-3.101	0.482	7.161	-0.889	2.539	7.203	3.946
Median (%)	-0.234	0.186	1.370	-0.174	0.135	1.989	0.050
p.a.	-6.261	-0.636	11.760	-0.691	3.696	12.550	3.695
Max (%)	7.385	5.090	12.816	9.190	4.330	17.183	5.840
p.a.	10.140	10.315	28.426	14.481	13.283	27.493	22.082
Min (%)	-6.089	-5.136	-23.745	-4.373	-4.136	-21.539	-5.150
p.a.	-14.971	-3.695	-38.462	-14.677	-3.701	-44.507	-0.445
Standard dev. (%)	2.510	1.304	4.715	1.389	1.164	6.881	2.435
p.a	7.225	3.985	18.540	6.673	4.370	20.012	8.107
Skewness	0.240	-0.289	-1.254	2.095	0.407	-0.639	0.184
Kurtosis	0.499	3.395	4.481	15.354	2.888	0.642	-0.489
Normality	4.888	23.356**	18.068**	41.358**	27.076**	6.423*	3.179
AR(1)	0.416	0.969	0.854	0.847	0.767	0.254	0.384
Heteros.	1.103	2.772**	2.732**	0.952	3.469*	1.355	3.106
Observations	129	129	129	129	129	129	129

Table 8 present descriptive statistics for (1) *USD*: the U.S. Dollar index return; (2) *BOND*: the return on the Barclays intermediate corporate Bond (AA) index; (3) *SP500*: The SP500 total return, (4) *CREDIT*: The spread between Barclays intermediate corporate Bond (BAA) index and the Barclays U.S. 5 year treasury index; (5) *MORTGAGE*: The spread between GNME mortgage index and the Barclays U.S. 5 year treasury index; (6) *COMMODITY*; the return of SP GCSI Commodity index; and (7) *SMB*; The spread between small and large company spreads (Fama-French factor) during the time period between January 2002 and September 2012. AR (1) proxies autocorrelation for the individual variables and Hetero. indicates heteroskedasticity. *, **, *** indicates significances at the 10%, 5 % and 1% levels.

7 RESULTS

This section presents the results. The section follows the same structure as the methodology section. First, it discusses the *classification of hedge funds*. This is followed by the results from *hedge fund risk-exposure analysis*. Thereafter the results from *building the replicators* are given. The section ends with *analysis of replicators' performance* and *analysis of replicators' replication quality*.

7.1. Classification of hedge funds

The hedge funds are classified in two categories based on their six month average Sharpe ration. As mentioned in the method section, the *All* sample includes all hedge funds and the *HP sample* includes 50% of sample hedge funds with highest Sharpe-ration. Table 9 presents the number of observations, the returns and the Sharpe ratios for both categories.

Four monthly observations are required per period, and some funds do not meet the restriction. These funds monthly returns are deleted and Appendix 3 elaborates on this. The risk-adjusted returns for the HP sample are tremendously higher than those for All sample. This is expected as the portfolios are sorted by their respective risk-adjusted performance. However, it is interesting to notice that the difference is so large. The average difference between the All sample and the HP sample is 3.04 Sharpe ration.

Also, the standard deviation for the All category is lower on average. The average standard deviation for the whole time period for HP is 9.69% as it is 11.63% for the All category. Hence, the HP sample hedge funds have been able to create higher return with lower risk. As a result, the average Sharpe ratios is 2.72 and -0.13, respectively. This is in line with the findings that hedge fund returns show short-term performance persistence.

It is also worth mentioning, that the initial analysis indicates that Sharpe ration for All sample is relatively low. In more than 50% of time periods, the funds in the All sample generate negative risk-adjusted returns. This is in line with the criticism towards hedge funds capability to create abnormal returns. On the other side, the All sample performs well compared to other assets during the market downturn in 2008. This indicates that the hedge funds offer hedging-like properties and good diversification benefits during downturn.

Table 9 Hedge fund classification in HP sample and All sample

	All						HP					
	Observations	Return			Sharpe		Observations	Return			Sharpe	
		Average	Median	SD	Median	SD		Average	Median	SD	Median	SD
1.1.2002-31.6.2002	67	0.051	0.059	0.090	-0.915	-0.978	34	0.120	0.113	0.047	1.979	1.011
1.7.2002-31.12.2002	68	0.132	0.116	0.128	1.221	1.139	34	0.223	0.187	0.107	2.997	40.956
1.1.2003-31.6.2003	78	0.100	0.087	0.102	0.147	0.072	39	0.174	0.144	0.085	3.205	15.826
1.7.2003-31.12.2003	84	0.094	0.059	0.231	0.276	0.048	42	0.199	0.119	0.281	3.314	19.565
1.1.2004-31.6.2004	91	-0.018	-0.019	0.077	-1.905	-1.982	46	0.041	0.026	0.051	0.630	3.224
1.7.2004-31.12.2004	103	0.081	0.061	0.090	0.916	0.753	52	0.146	0.129	0.078	4.332	48.914
1.1.2005-31.6.2005	112	0.006	0.011	0.091	-1.424	-1.479	56	0.078	0.067	0.052	2.117	16.554
1.7.2005-31.12.2005	122	0.063	0.040	0.101	-0.044	-0.096	61	0.128	0.100	0.100	3.612	20.190
1.1.2006-31.6.2006	128	0.064	0.053	0.095	-0.491	-0.551	64	0.129	0.107	0.082	2.662	2.110
1.7.2006-31.12.2006	134	0.042	0.035	0.115	-0.756	-0.830	67	0.114	0.078	0.116	3.658	3.171
1.1.2007-31.6.2007	139	0.059	0.063	0.079	-0.123	-0.264	70	0.113	0.101	0.045	3.413	14.428
1.7.2007-31.12.2007	142	0.077	0.056	0.140	0.662	0.552	71	0.179	0.133	0.117	3.699	13.668
1.1.2008-31.6.2008	148	0.164	0.141	0.161	2.336	2.289	74	0.280	0.223	0.147	5.038	13.213
1.7.2008-31.12.2008	157	0.056	0.058	0.191	-0.273	-0.357	79	0.192	0.165	0.114	2.864	17.214
1.1.2009-31.6.2009	165	-0.035	-0.036	0.115	-2.417	-2.484	83	0.048	0.027	0.081	1.165	10.510
1.7.2009-31.12.2009	173	0.009	0.010	0.101	-0.746	-0.840	87	0.079	0.057	0.070	2.647	13.353
1.1.2010-31.6.2010	181	0.008	0.017	0.085	-0.890	-0.961	91	0.070	0.051	0.054	1.952	12.619
1.7.2010-31.12.2010	188	0.133	0.100	0.162	2.148	2.074	94	0.233	0.172	0.172	5.146	23.340
1.1.2011-31.6.2011	189	-0.029	-0.031	0.084	0.039	0.039	94	0.027	0.015	0.058	0.204	11.460
1.7.2011-31.12.2011	189	-0.013	-0.008	0.118	0.041	0.041	94	0.059	0.036	0.110	1.343	14.291
1.1.2012-31.9.2012	189	0.009	0.008	0.087	-0.612	-0.719	94	0.070	0.045	0.069	1.327	19.394

Table 9 presents the number of observations, the average return, the median return, the standard deviation and the Sharpe ratios for individual hedge funds. The sorting is done every six month and therefore the sample is divided into 21 six month time periods. Hedge funds are sorted according to their Sharpe ration. HP sample includes the top 50% hedge funds based on that periods Sharpe ratios and All sample includes all hedge funds in sample.

7.2. Hedge funds risk exposure analysis

This section describes the results from the risk-exposure analysis. The model is described in the methodology section. The section summarizes the beta-coefficients and p-values from the 16 651 OLS rolling-regression performed to 189 individual funds during 106 different 24 month-long time periods between January 2004 and September 2012.

7.2.1. *Summary risk exposure for HP sample*

Table 10 present the beta-coefficients and p-values for the HP sample. There exists only one significant variable in the HP sample, which is the SP500 variable. The commodity beta is highly significant during the pre-crisis bull market, but loses its significance after the crisis, turning the variable insignificant on average. The significance for the other variables varies are overall low, between 0,191 for USD to 0,468 for SMB.

As expected, the explanatory power of the model is low. The adjusted R^2 for HP sample is only 0.092 i.e. the model explains only 9.2% of the returns for the underlying hedge funds. The F-test shows that on average 14 % of the regressions model for individual funds are statistical significant on a 5 % significance level. The adjusted R^2 and the model significance test, the F-test, both decreases immediately after the crisis. The reason is unclear, but expected to be due to inefficient and irrational markets.

A low explanatory power of the model can be explain through the approach the model is chosen. In contrary to the traditional approach, the model is chosen based on previous research. The adjusted R^2 is easily increased by dropping insignificant variables, such as the SMB variable, as the adjusted R^2 lowers the explanatory power for each additional insignificant variable. However, one introduces a sample bias, if the data is fitted with an optimal model, and therefore the approach based on previous research is preferred.

Also, as expected, the p-values are insignificant. As the model restricts the beta to equal one, the low significance levels are not surprising. The insignificant p-values exist also in previous studies. The insignificant p-values are a big issue in hedge fund replication, as it leads to unreliable beta coefficients, or so called over-fitting. In over-fitting, the beta coefficients do not represent actual causality between the dependent and

independent variable. Hence the estimated beta coefficients differ from the actual beta coefficients. (Fung & Hsieh, 2004)

7.2.2. Risk exposure comparison between HP sample and All sample

This section compares the risk exposures between HP sample and All sample. Table 11 present the comparable beta-coefficients and p-values for the All sample.

Similarly to the HP sample, the beta coefficients for All sample range between an average -0.044 for USD to an average 0.339 for Mortgage. The high beta for mortgage is mostly due to the mortgage crisis in US between 2007 and the end of 2008. There exist two statistical significant variables on 10% statistical level, SP500 and Commodity. The statistical significance is low also for the All sample. The other variables have statistical significances that range from an average 0.189 to an average 0.436.

The adjusted R^2 is higher for the All sample compared to the HP sample. The All sample adjusted R^2 is 14.2%, compared with HP samples adjusted R^2 of 9.2%. The higher adjusted R^2 for All sample can be explained with a larger sample size. As the number for fund increases the average returns are more stable and therefore more identifiable for with factors.

Also, the F-test shows that more significant models in the All sample than in the HP sample. On average, 16% of regression models of the 106 regressions conducted per fund have been statistically significant on a 5 % significance level for the All sample, whereas only 14 % of the regression models for HP sample have been statistical significant on a 5 % significance level.

Overall, the All sample implies to have better replication quality than the HP sample as the adjusted R^2 and the F-test are more significant. However, there seems to be small differences in the average betas for the two samples. To get a better picture of the risk-exposure variation between factors, the next chapter will present the rolling-beta values for the whole time period.

Table 10 Summary table for HP samples beta-coefficient

Statistics	Intercept					β – USD					β – Bond					
	Average	Mean	Min	Max	SD	Average	Mean	Min	Max	SD	Average	Mean	Min	Max	SD	
β	0.013	0.013	-0.016	0.029	0.009	-0.050	-0.057	-0.813	0.712	0.712	0.172	0.058	-0.853	1.647	0.588	
p-value	0.015	0.016	0.000	0.032	0.007	0.191	0.202	0.046	0.301	0.060	0.326	0.327	0.238	0.385	0.029	
Statistics	β - SP500					β – Credit					β – Mortgage					
	Average	Mean	Min	Max	SD	Average	Mean	Min	Max	SD	Average	Mean	Min	Max	SD	
β	0.176	0.127	-0.364	0.726	0.239	0.372	0.787	-2.743	2.419	1.206	0.211	0.191	-2.163	2.428	1.012	
p-value	0.081	0.062	0.017	0.217	0.054	0.223	0.218	0.105	0.323	0.055	0.420	0.427	0.271	0.461	0.036	
Statistics	β - Commodity					β – SMB					Significance (%)					
	Average	Mean	Min	Max	SD	Average	Mean	Min	Max	SD	Average	Mean	Min	Max	SD	
β	0.118	0.065	-0.243	0.637	0.161	-0.016	-0.082	-0.749	0.583	0.367	Adj. R^2	0.092	0.095	-0.084	0.313	0.072
p-value	0.122	0.118	0.043	0.253	0.048	0.468	0.469	0.454	0.480	0.006	F-test (%)	14%	17%	6%	27%	18%

Table 10 present the aggregated results from the rolling-regression performed to 94 individual funds and 106 individual 24 month-long between January 2004 and September 2012. The beta-coefficients are restricted to summarize to 1 in each regression. The p-values indicate the significance of the Betas. The regressions variables are (1) *USD*: the U.S. Dollar index return; (2) *BOND*: the return on the Barclays intermediate corporate Bond (AA) index; (3) *SP500*: The SP500 total return, (4) *CREDIT*: The spread between Barclays intermediate corporate Bond (BAA) index and the Barclays U.S. 5 year treasury index; (5) *MORTGAGE*: The spread between GNME mortgage index and the Barclays U.S. 5 year treasury index; (6) *COMMODITY*; the return of SP GCSI Commodity index; and (7) *SMB*; The spread between small and large company spreads (Fama-French factor). The adjusted R^2 indicates the explanatory power in the individual regressions. F-test states the proportion of significant regressions in the individual regressions

Table 11 Summary table for All samples beta-coefficient

Statistics	Intercept					β – USD					β – Bond					
	Average	Mean	Min	Max	SD	Average	Mean	Min	Max	SD	Average	Mean	Min	Max	SD	
β	-0.002	0.000	-0.053	0.018	0.013	-0.044	-0.026	-0.696	0.432	0.432	0.199	0.080	-0.690	1.218	0.457	
p-value	0.012	0.010	0.000	0.037	0.008	0.178	0.189	0.054	0.278	0.060	0.323	0.324	0.239	0.377	0.033	
Statistics	β - SP500					β - Credit					β - Mortgage					
	Average	Mean	Min	Max	SD	Average	Mean	Min	Max	SD	Average	Mean	Min	Max	SD	
β	0.156	0.127	-0.266	0.616	0.186	0.237	0.603	-1.934	1.812	0.856	0.339	0.264	-1.460	2.082	0.701	
p-value	0.080	0.058	0.026	0.186	0.048	0.210	0.219	0.079	0.299	0.051	0.427	0.436	0.301	0.468	0.036	
Statistics	β - Commodity					β - SMB					Significance (%)					
	Average	Mean	Min	Max	SD	Average	Mean	Min	Max	SD	Average	Mean	Min	Max	SD	
β	0.106	0.066	-0.109	0.562	0.133	-0.006	-0.129	-0.530	0.523	0.302	Adj. R^2	0.142	0.114	-0.046	0.345	0.085
p-value	0.106	0.099	0.033	0.217	0.042	0.482	0.482	0.469	0.488	0.004	F-test (%)	16%	18%	5%	30%	20%

Table 11 present the aggregated results from the rolling-regression performed to 189 individual funds and 106 individual 24 month-long time periods between January 2004 and September 2012. The beta-coefficients are restricted to summarize to 1 in each regression. The regressions variables are (1) *USD*: the U.S. Dollar index return; (2) *BOND*: the return on the Barclays intermediate corporate Bond (AA) index; (3) *SP500*: The SP500 total return, (4) *CREDIT*: The spread between Barclays intermediate corporate Bond (BAA) index and the Barclays U.S. 5 year treasury index; (5) *MORTAGE*: The spread between GNME mortgage index and the Barclays U.S. 5 year treasury index; (6) *COMMODITY*; the return of SP GCSI Commodity index; and (7) *SMB*; The spread between small and large company spreads (Fama-French factor). The adjusted R^2 indicates the explanatory power in the individual regressions. F-test states the proportion of significant regressions in the individual regressions. .

7.3. Building the replicator

Next, this section analyses beta coefficients and p-values for the USD, Bond, SP500, Credit, Mortgage, Commodity and SMB variables. The beta coefficients and p-values are given beginning from January 2004. The index values are indexed to January 2002 and the values are given there from. The section is concluded with a description of the building process.

Figure 6 presents the beta value, p-value and index value for the USD. The regression model appears to capture the unfavourable development for USD between January 2004 and December 2005, as it indicates a negative beta value throughout the time period. Further, the regression model seems to capture the appreciation of the USD during the financial crisis, as investors looked, under uncertainty, for safe heaven investments. Also, a negative trend exists in the significance of the coefficient. It is significant until the financial crisis, after which it becomes insignificant.

Figure 6 USD beta, p-value and index value

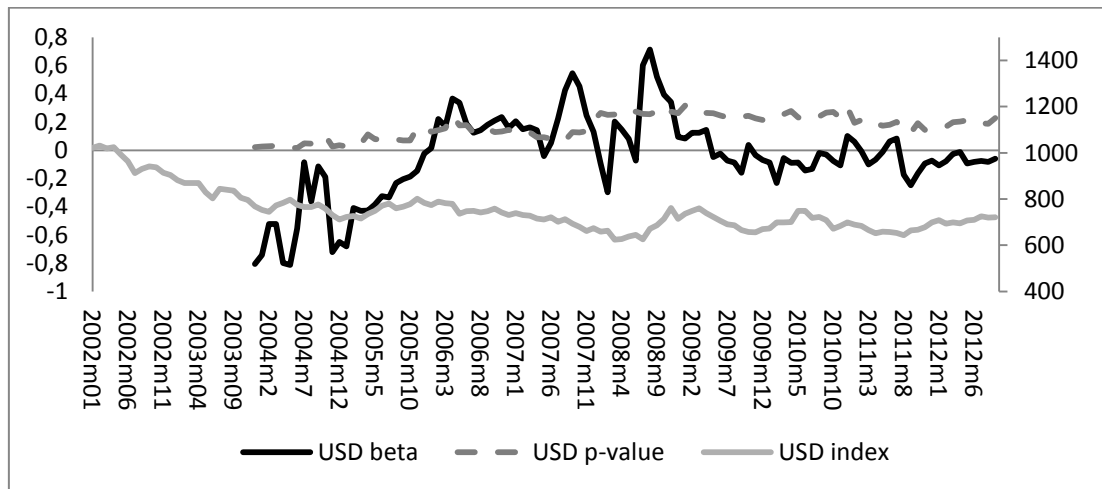


Figure 7 presents the beta value, p-value and index value for the Bond variable. First, the regression model is unable to signal the depreciation for the bond market between January 2004 and January 2006, as the beta coefficient is positive throughout the period. This has a negative impact on replicators return. Also, the model seems to lag the bull trend for bonds, immediately after the bond market downturn, ending in late 2007. Further, the negative beta coefficient during 2011 and during large part of 2012, have a negative impact on replicators return. The bond variable is insignificant throughout the whole time period.

Figure 7 Bond beta, p-value and index value

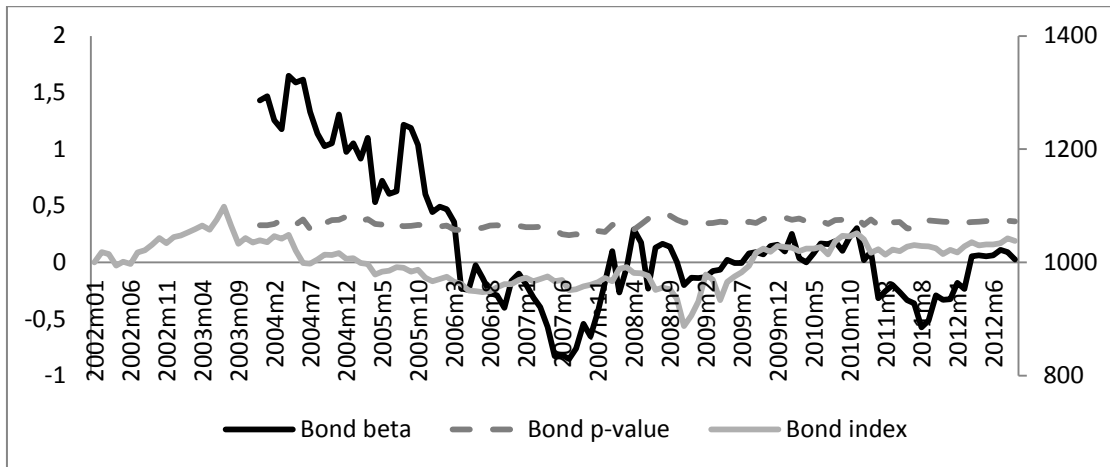


Figure 8 presents the beta value, p-value and index value for the SP500 variable. The predictability of the regression model is good. The beta coefficient is positive during the bull markets between January 2004 and January 2008. Also, even though with a lag, the regression model is able to adjust to the bear market in 2008. However, the model is unable to signal the financial crisis, as the beta coefficients are still positive always as the markets crash. The model is either able to signal the recovery between March 2009 and September 2009, as the beta coefficient stays negative during the time period. Hence, the model shows evidence from trend signalling, but is not able to signal actual returns.

The significance for the beta value is good. The beta value is significant throughout the time period, except between June 2005 and May 2007.

Figure 8 SP500 beta, p-value and index value

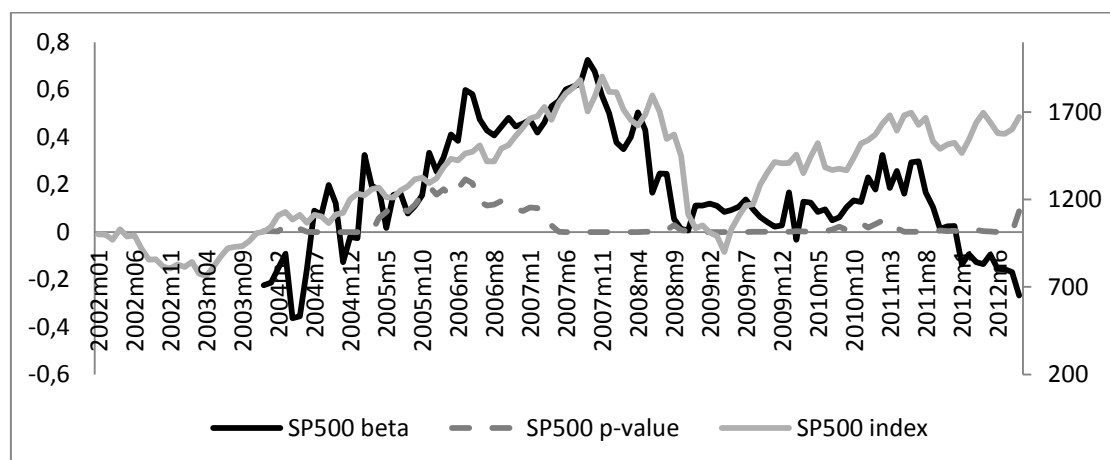


Figure 9 presents the beta value, p-value and index value for the Credit variable. The variance is high for the Credit beta coefficient. The variable is stable, which can explain the instability of the beta coefficient. The beta coefficient is highly positive in advance to the credit bubble in September 2008. However, the coefficients decrease in advance to the positive market movement. Further, the model is unable to signal the downturn in credit markets in the June 2009, which is evident from the positive beta value during that time period. Overall, the p-value is insignificant for Credit variable.

Figure 9 Credit beta, p-value and index value

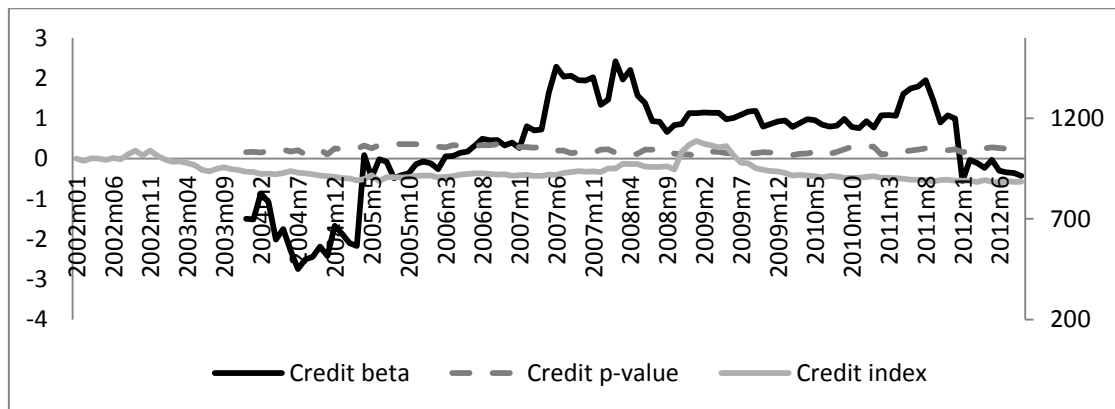


Figure 10 presents the beta value, p-value and index value for the Mortgage variable. The regression model signals well the development of the Mortgage value. As an example, it signals the housing bubble between August 2007 and January 2009, and have negative beta throughout the period. Also, the model increases its exposure to the Mortgage variable in advance to the positive trend seen in the beginning of 2012. However, the p-value is highly insignificant throughout the analysed period.

Figure 10 Mortgage beta, p-value and index value

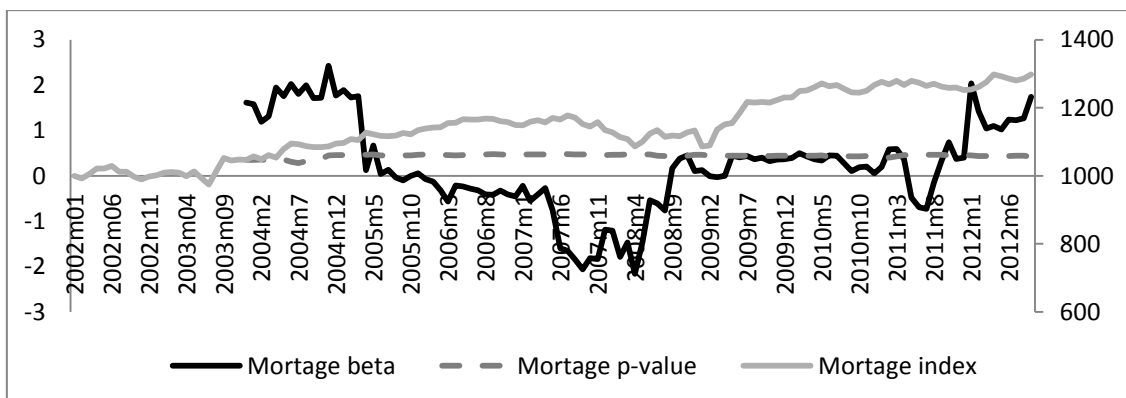


Figure 11 presents the beta value, p-value and index value for the Commodity variable. Except the negative beta during January 2011 and May 2011, the model signals well the fluctuations in commodity prices. The model is, as for the SP500, also able to signal trends for the commodity variable. However, the exposure to the commodity bull market is averaging around 0.2. Therefore, the model is unable to capture all return potential. The p-value is highly significant between January 2005 and June 2010. However, as for the USD, the commodity beta coefficient is affected by the financial crisis.

Figure 11 Commodity beta, p-value and index value

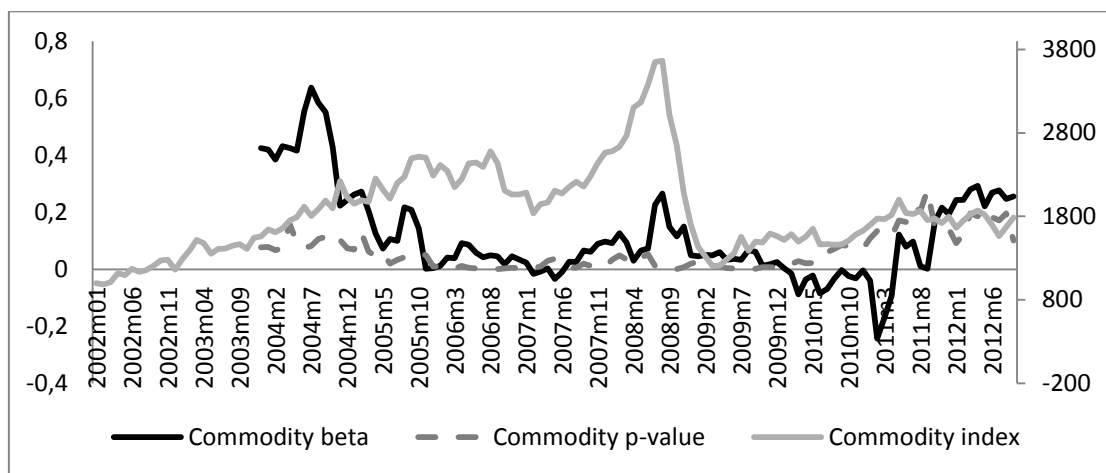
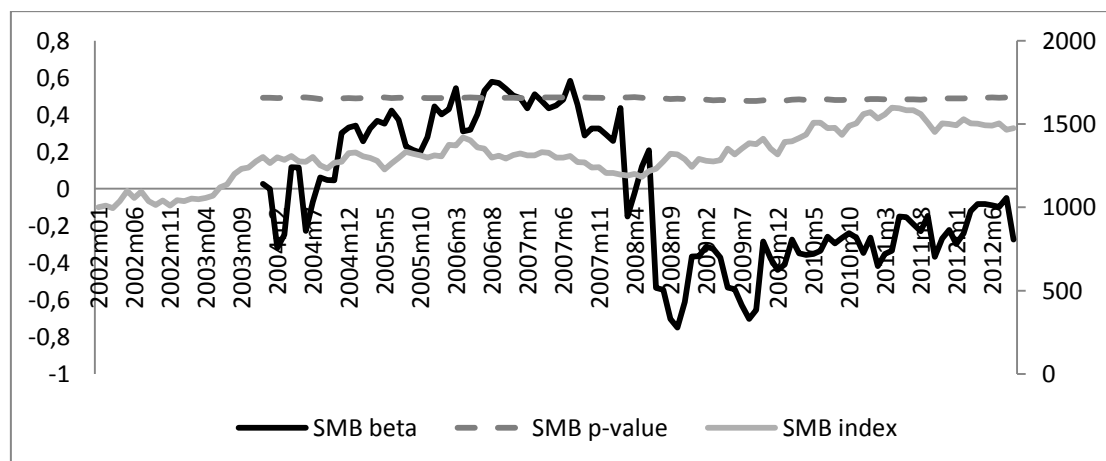


Figure 12 presents the beta value, p-value and index value for the SMB variable. The regression model is unable to signal the movement for SMB. The variable is highly insignificant throughout the whole period. The main finding is that deleting the SMB variable would make the model more significant.

Figure 12 SMB beta, p-value and index value



The risk exposures are transformed to portfolio weights to build the replicators. The portfolio weights are thereafter multiplied with the monthly returns for the variables to get monthly replicator returns. Appendix 5 presents the monthly return decomposition for the HP replicator and appendix 6 presents the monthly return decomposition for the All replicator.

To summarize, there is indicators that the financial crisis affects multiple beta coefficients. Overall, the significant level for the coefficients is lower post-crisis, which indicates that the model is not working as adequately during post-crisis. The main reason may be that the economies work differently during the financial crisis and therefore the regression model is unable to calibrate accordingly.

7.4. Analysis of replicators performance

This section discusses the performance for the hedge fund replicator and compares their performance to each other and also other benchmark indices. The aim is to analyse if the new approach improves the replicator returns.

7.4.1. Descriptive statistics on replicators performance

Figure 13 and table 12 summarizes the performance for the HP replicator, All replicator, HFRI index, DJ CS managed futures index and the SP500.

Figure 13 Graphical representation of returns for HP replicator, All replicator, HFRI index, DJ CS managed futures Index and the SP500

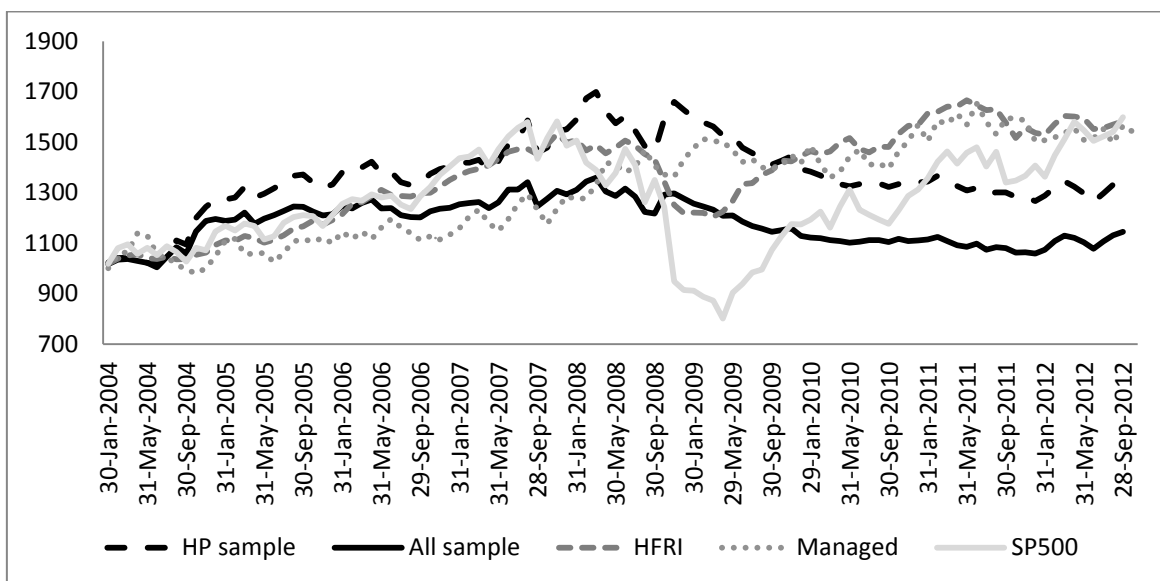


Table 12 Performance comparison between replicators and benchmark indices

Panel A: January 2004 to September 2012 (Whole period)

Sample	Annual mean return (%)		Annual SD (%)		Annual Sharpe		ACF	
	Mean	SD	Mean	SD	Mean	SD	P1	P-value
HP	4.99	12.79	7.42	3.60	0.02	1.61	0.146	0.2
All	2.49	9.67	6.14	2.85	-0.28	1.55	0.03	0.75
HFRI	6.00	10.89	5.59	1.51	1.11	1.53	0.33	0.041
Managed	5.06	5.38	10.73	2.19	0.30	0.50	0.12	0.17
SP500	7.18	17.42	14.24	5.76	0.65	0.86	0.05	0.6943

Panel B: January 2004 to August 2008 (Pre-crisis)

Sample	Annual mean return (%)		Annual SD (%)		Annual Sharpe		ACF	
	Mean	SD	Mean	SD	Mean	SD	P1	P-value
HP	11.17	8.90	13.93	2.16	0.62	1.35	0.11	0.15
All	6.54	7.35	9.55	1.95	0.01	1.33	0.4	0.032
HFRI	7.92	4.67	5.90	0.35	0.97	1.48	0.34	0.039
Managed	7.14	10.63	4.07	2.42	0.59	0.90	0.16	0.09
SP500	7.39	11.25	7.56	2.77	0.14	1.27	0.08	0.25

Panel C: September 2008 to September 2012 (Post-crisis)

Sample	Annual mean return (%)		Annual SD (%)		Annual Sharpe		ACF	
	Mean	SD	Mean	SD	Mean	SD	P1	P-value
HP	-2.05	7.66	5.56	2.63	-0.59	1.62	0.27	0.052
All	-2.07	6.39	4.52	2.07	-0.85	1.59	0.15	0.18
HFRI	2.76	12.43	5.75	0.67	-0.08	3.10	0.32	0.052
Managed	0.99	0.72	9.49	2.18	0.14	0.10	0.11	0.51
SP500	5.18	32.73	15.59	4.26	0.28	1.63	0.10	0.52

Table 12 presents the annual mean return, annual standard deviation, annual Sharpe and first-order autocorrelation for the HP sample, All sample, HFRI index, DJ CS managed futures Index (Managed) and SP500. The table presents both the mean and standard deviation for the parameters. Panel A presents findings for time period between January 2004 and September 2012, Panel B presents findings for time period between January 2004 and August 2008 and Panel C presents findings for time period between September 2008 and September 2012.

Panel A presents the findings for the whole time period. The average mean returns for the five indexes are 4.99%, 2.49%, 6.00%, 5.06% and 7.18% respectively. This suggests that the HP replicator annual mean return is higher than the return for All replicator, hence gives first indicator that data selection improves replicators' returns. However, also the standard deviation is higher for the HP replicator than the All replicator. The standard deviation is in line with the risk-reward assumption, only HFRI index is able to earn high returns with a low standard deviation of 5.59%, assumable due to illiquidity.

The annual Sharpe is minimum -0.28 for the All replicator and maximum 1.11 for the HFRI index. A high Sharpe for the HFRI is expected as hedge fund investments attempt to be more risk-neutral. The average Sharpe ration of the HP replicator is 0.02. This is low, as there exist multiple other assets on the markets that offer higher Sharpe ratios for the time period. Compared to the All replicator, HP replicators Sharpe ratio is 0.30 higher than the Sharpe ratio for the All replicator. However, it is considerably lower than HFRI index 1.09 and SP500 0.63, respectively. There are signs that the first-order autocorrelation for HFRI index is statistically significant. This tells us that the constituent index funds invest probably in illiquid assets or in assets with less efficient pricing. The illiquidity, as mentioned, impacts the Sharpe ration, as it smoothens the volatility parameter and therefore increases the Sharpe ration, which may explain some degree of HFRI higher Sharpe ration.

Panel B presents findings for the pre-crisis period. The annual returns for the five indices for this time period is 11.17 %, 6.54 %, 7.92%, 7.14%, and 7.39% respectively. Surprisingly, HP replicator is able to substantially beat all the other indices measured with annual return. The annual standard deviations for the five indices are 13.93%, 9.55%, 5.90%, 4.07% and 7.59% respectively. After the risk is taken into consideration, the HP replicator is still able to beat the Managed futures index and SP500 index measured with Sharpe. Also, most interestingly to the purpose of this thesis, the HP replicator clearly beats the All replicator in Sharpe ration comparison. Hence, there is indication that the data selection actually creates value at least during the pre-crisis period.

Panel C presents finding for the post-crisis period. The annual returns for the five indices are -2.05%, -2.07%, 2.76%, 0.99%, and 5.18% respectively. The higher return for SP500 index is mainly due to lower starting point compared to the other indices in September 2008, as the other indices had not been affected by the financial downturn

as hard as the SP500 in September 2008. As expected, the standard deviation is highest for the SP500 mainly due to the volatile market during the financial turmoil. Surprisingly, the volatility for the replicator products is low, 5.56 and 4.52, respectively. This might be explained that the model seems to work poorly after the financial crisis and the return distribution has high kurtosis.

Also, the replicators performance measured in Sharpe is low in the post-crisis period, -0.59% and -0.85%, respectively. However, interestingly, the HP replicator again has higher Sharpe than the All replicator, validating the hypothesis that replicators' performance is improved with data selection.

To conclude, during the whole time period, the replicators perform worse than the benchmarks indices measured with Sharpe ration and therefore investors earn higher risk-adjusted returns investing in other assets. However, there are significant differences between pre-crisis and post-crisis returns. Also, the findings validate the hypothesis that performance can be improved with data selection as the HP replicator dominates the All replicator completely through the whole observation period measured with annual Sharpe. Finally, results indicate that HP replicator is able to earn higher Sharpe than many benchmark indices during the pre-crisis period.

7.4.1. *Decomposition of replicators returns*

Next, the replicator returns are decomposed to analyze the average percentage contribution of each individual factor to total return. Results are shown in table 13.

Note, that average percentage contributions add up to 100% when summed across all seven factors and constant. This is because the decomposition sums to 100% for each fund, and when the decomposition is averaged across all funds, the sum is still the same. The constant should be zero, as the dropped in the model. However, it takes a value due to rounding errors when regressions results are summarized.

Table 13 The average of percentage contribution of factor to total expected return

Panel A: January 2004 to September 2012 (Whole period)

	Sample size	Avg. monthly return	Average of percentage contribution of factors to total expected return (%)							
			USD	Bond	SP500	Credit	Mortgage	Commodity	SMB	Constant
HP	94	0.39%	10.13	-26.59	20.56	23.75	69.95	26.51	-29.48	5.17
All	189	0.19%	-4.67	-31.14	-12.15	22.60	105.14	62.26	-39.55	-2.50

Panel B: January 2004 to August 2008 (Pre-crisis)

	Sample size	Avg. monthly return	Average of percentage contribution of factors to total expected return (%)							
			USD	Bond	SP500	Credit	Mortgage	Commodity	SMB	Constant
HP	76	0.92 %	-9.85	-18.55	13.83	36.48	36.87	44.83	-6.90	3.28
All	150	0.54 %	-15.73	-21.67	4.65	37.46	39.60	61.85	-4.34	-1.83

Panel C: September 2008 to September 2012 (Post-crisis)

	Sample size	Avg. monthly return	Average of percentage contribution of factors to total expected return (%)							
			USD	Bond	SP500	Credit	Mortgage	Commodity	SMB	Constant
HP	94	-0.16 %	-85.82	12.03	-11.74	84.92	-88.95	114.51	78.98	-3.94
All	189	-0.17 %	-30.83	-2.89	30.80	55.02	-72.00	50.89	52.80	-0.44

Table 13 presents the decomposition of total average mean return of 94 funds in the HP sample and 189 funds in the All sample according to percentage contribution from seven factors and error term. Panel A presents findings for time period between January 2004 and September 2012, Panel B presents findings for time period between January 2004 and August 2008 and Panel C presents findings for time period between September 2008 and September 2012.

Panel A presents the findings for the whole time period. Surprisingly, the Mortgage variable contributes most to both HP replicator and All replicators' returns, explaining, in average, 69.95% and 105.14% respectively of the returns of the replicators. This confirms the findings from the previous section, which indicated that the regression model is able to give some signal for the development of the Mortgage variable. However, the robustness of the findings is low, as the Mortgage variable is highly insignificant.

Other factors that contributes to HP replicator returns, is the USD 10.13%, SP500 20.56%, Credit 23.75%, and Commodity 26.51% variables. For the All replicator, the positive contributors are the Credit 22.60%, and Commodity 62.26% variables. The bond and SMB variables contribute negative returns for both replicators, -26.59% and -31.14% for bond and -29.48% and -39.55% for SMB, respectively. It is shown that the Bond and SMB beta coefficients are negative in bull markets and positive in bear markets. Hence, the model is unable to signal development in these variables and therefore have unwanted exposure to the variables.

HP replicators annual return is almost twice as high as that for the All replicator. The main differences between the HP replicator and All replicator appears to be, during the whole time period, differences in exposure to three variables: SP500; 20.56% and -12.15% respectively, Mortgage; 69.95% and 105.14% respectively, and Commodity; 26.51% and 62.26% respectively. The significant p-values for SP500 and Commodity indicates that the HP replicator is able to estimate the bull market in SP500 and the fluctuation in commodity index better than the average hedge funds.

Panel B presents the finding for the time period between January 2004 and August 2008. The HP replicators return is again almost twice as high as the All replicators. The main factor, which contributed positively to HP replicator returns is Commodity 44.83%, Mortgage 36.87% and Credit 36.48%. For the All replicator the main positive contributors the same as for the HP replicator. Both replicators average returns are impacted by the USD and Bond factor. The main difference between the HP replicator and the All replicator is their exposure to SP500, 13.83% and 4.65% respectively. Hence, one could conclude that the HP hedge funds were able to take more market risk as the markets rose prior to the financial crisis, which lead to a higher total average return for constituent hedge funds. Overall, the contributions percentages pre-crisis between the two replicators do not vary enormously.

Panel C presents the finding for the time period between September 2008 and September 2012. In contrary to the two previous periods, the annual mean returns are almost equal for the two replicators. Main factors, which contributed positively to the HP replicators is the Mortgage -88.95%¹⁴, USD -85.82% and SP500 -11.74%. For the All replicator, the positive contributors are Mortgage -72.00%, USD -30.83% and Bond -2.89%. All replicators negative average return is mostly explained with Commodity exposure, 111.51% and the All replicators negative average monthly return is mostly explained with exposure to credit risk 55.02 %, small stocks 52.80%, and commodities 50.89%. Hence, the exposure for the two groups varies significantly.

To conclude, the contributions to the two replicators vary more post-crisis than pre-crisis. The reason is unclear. However, the constituents of the HP sample seem to be better market timers, explaining a large part of pre-crisis differences between the replicators.

7.5. Analysis of replicators replication quality

The last section analyses the replication quality of the hedge fund replicators. The replicators returns are compared to HFRI index and the DJ CS managed futures Index. The parameters analyzed are the adjustedR², root-mean-squared errors (RMSE) and correlation coefficients. All parameters measure the replicators' out-of-sample replication quality. Table 14 summarizes the results.

Table 14 Replication quality between replicator and hedge fund indices measured with the adjusted R², RMSE and correlation

Panel A: January 2004 to September 2012 (Whole period)						
	Correlation		R ²		RMSE	
	HFRI Index	Managed Futures	HFRI Index	Managed Futures	HFRI Index	Managed Futures
HP	0.03	0.18	0.14	0.10	0.22	0.27
All	0.15	0.18	0.16	0.12	0.19	0.27

(Continued on next page)

¹⁴ As the monthly mean return is negative, positive contribution impacts negatively in monthly mean returns, and negative contributions impacts positively in the monthly mean returns.

Panel B: January 2004 to August 2008 (Pre-crisis)

	Correlation		R ²		RMSE	
	HFRI Index	Managed Futures	HFRI Index	Managed Futures	HFRI Index	Managed Futures
HP	0.31	0.26	0.17	0.16	0.15	0.18
All	0.36	0.25	0.18	0.14	0.16	0.16

Panel C: September 2008 to September 2012 (Post-crisis)

	Correlation		R ²		RMSE	
	HFRI Index	Managed Futures	HFRI Index	Managed Futures	HFRI Index	Managed Futures
HP	-0.28	0.02	0.08	0.06	0.49	0.56
All	-0.06	0.02	0.09	0.07	0.45	0.51

Table 14 presents replication quality of the HP replicator and All replicator by comparing the average correlation, average adjusted R^2 , and average RMSE between these and the HFRI index and DJ CS managed futures Index. Panel A presents findings for time period between January 2004 and September 2012, Panel B presents findings for time period between January 2004 and August 2008 and Panel C presents findings for time period between September 2008 and September 2012.

The discussion follows same pattern as before. Panel A presents the main findings for the whole time period. The correlation between replicators and benchmark indices are low. For instance, the correlation for HP replicator and HFRI index is only 0.03 and All replicator and HFRI index 0.15. As expected, the correlation between the replicators and the DJ CS Managed futures index is higher than the correlation between the replicators and the HFRI index.

Also, the results suggest that the adjusted R^2 is low for both HP replicator and All replicator. Compared to the HFRI index, the HP replicators adjusted R^2 is 14% and All replicators adjusted R^2 is 16 %. Surprisingly, for both replicators, the average adjusted R^2 is higher for the HFRI index then that for the DJ CS Managed futures index, As it is expected that the DJ CS Managed futures index has a higher adjusted R^2 than HFRI index, because the HFRI index includes multiple different strategies others than managed futures.

Finally, also the root-mean squared error show low overall replication quality. Again, surprisingly, the error term is larger between the replicators and the DJ CS Managed

futures index and then that between the replicators and the HFRI index. Also, the All replicator show slightly lower error term than the HP replicator. An assumption is that the difference is due to All replicators larger sample size.

Panel B presents the finding for the time period between January 2004 and August 2008 and Panel C presents the finding for the time period between September 2008 and September 2012. The two time periods show interesting finds of the replication quality, as it is significantly better in the pre-crisis period compared to the post-crisis period for both HFRI index and Managed futures index. The correlation differences compared to the HFRI index between the two sup-samples are 0.59, and 0.42 respectively. Also, the average adjusted R^2 is significantly higher for the pre-crisis period, a difference of 0.09 and 0.11, respectively for HFRI index and 0.10 and 0.07, respectively, for the managed futures index. Finally, the same pattern of improved replication quality pre-crisis continues for the RMSE. The difference in RMSE is 0.34 and 0.31, respectively for HFRI index and 0.38 and 0.45 respectively for managed futures index. Hence, the replication quality is significantly better according to all parameters pre-crisis compared to the post-crisis.

To conclude, the average replicator quality is low. One reason behind the low replication quality might be an imprecise model with too many variables, as many variables are insignificant throughout the observed period. Another interesting finding is that the replication quality is clearly better pre-crisis compared to post-crisis. This indicates that that hedge fund replication works less well after the financial crisis. Finally, the results show no significant differences between replication quality for HP replicator and All replicator.

8 DISCUSSION

The last section discusses the results and reflects them to previous studies. The discussion focuses on *replicators' performance* and *replicators' replication quality*. Also a brief discussion on *implications, criticism* and *suggestions for further research* is presented.

8.1. Comparison with previous studies

The comparison to previous studies discusses the results in two dimensions; the replication quality and replication performance. These dimensions are chosen as it creates a valid framework to answer the purpose of the thesis.

8.1.1. *Replication performance*

The first section analyses the replication performance. It analyzes the results from five different perspectives; (1) the performance differences between the HP replicator and the All replicator, (2) replicators performance compared to benchmarks, (3) the performance pre- and post the financial crisis, (4) the decomposition of factor contribution, and finally (5) the liquidity of the return series. Finally, it compares the thesis results to results from two previous studies; Hasanhodzic and Lo (2007) and Amenc, Martellini, and Meyfredi (2010)

First, the most central question for the purpose of this thesis is discussed, i.e. can the replicators' risk-adjusted returns be improved by data selection? The results show that the return for the HP replicator is consistent higher than that for the All replicator. The return for the HP replicator compared to the All replicator is 100% higher pre-crisis and even higher post-crisis. Even though the standard deviation for the HP replicator is constantly higher, also, the Sharpe ratio is clearly higher, 0.02 and -0.28 respectively for the whole time period. The largest differences can be seen pre-crisis, as the HP replicators average annual Sharpe is 0.61 higher than that of All replicator. This finding indicates that it is possible to improve risk-adjusted returns through data selection pre-crisis. It is ambiguous to state that HP replicators beat All replicators post-crisis, as the replication quality for both is low. Previous studies do not analyze data selection issues, and therefore no comparable results exist.

Secondly, the replicators' returns are compared with the benchmarks to answer of investors can achieve higher returns by investing in HP replicators? The HP replicator has higher Sharpe ration than Managed futures index and SP500 index, but slightly lower than HFRI index pre-crisis. However, the HP replicator is unable to consistently beat the benchmark indices, as the performance is inferior to benchmarks post-crisis.

Amenc, Martellini and Meyfredi (2010) show a Sharpe ration of 0.02 for managed futures between January 1999 and December 2006. These findings are in line with the All replicator, but lower than for the HP replicator. Hasanhodzic and Lo (2006), show a Sharpe ration of 0.66 for managed futures strategy. However, these results are not comparable as the time period for their study is February 1986 to September 2005. To conclude, it is interesting to observe, that the risk-adjusted return for the All replicator is similar as that for the first study, and that the HP replicator is able to earn higher Sharpe than previous studies. The difference in time period impacts the results, but one could say that the risk-adjusted return shown in previous research is overall comparable with the study.

Thirdly, the section analyses replicators performance pre- and post-crisis, i.e. does the financial crisis impact the replicators performance? Sharpe ratio for the HP replicator is on average 0.62 pre-crisis. However, it diminishes to a low of -0.59 post-crisis. Overall, the result indicates that investors are able to earn high returns without having to pay the high cost-structure to hedge fund managers pre-crisis. It is however important to remember that trading costs are not considerate in these calculations. However, both replicators perform less well in the post-crisis period. The Sharpe rations for both replicators are clearly lower than the benchmark indices, which indicate that investors are better of investing their capital in other instruments. It is unclear what causes this inferior performance, but one assumption is that the market ceased to work based on basic economic fundamentals and become thoroughly manipulated by many authorities¹⁵. The model is based on proper financial economics, not on erratic, and thus economically unpredictable, movements caused by market manipulation, irrational exuberance on the panic and fear side.

Wallerstein, Tuchschnid, and Zaker (2011) investigate the returns for hedge fund during turbulent markets. The results differ from the results from this thesis. The

¹⁵ FED, European Commision, other regulators and politicians

authors show that hedge fund replicators actually perform well during crises as they carry less liquidity risk. However, according to authors, on a long-term perspective, the return differences are equalized and the replicators perform in par with the benchmarks indices.

Fourth, the factor percentage contributions to replicators' total return are analyzed. As discussed in the preceding chapter, during the whole time period, the HP replicator earns 69.95% of total return from the Mortgage variable. In contrary, it earns negative return from the SMB and Bond variables of -29.48% and -26.59% respectively. The main differences between the HP replicator and All replicator appears to be, during the whole time period, differences in exposure to three variables: SP500; 20.56% and -12.15% respectively, Mortgage; 69.95% and 105.14% respectively, and Commodity; 26.51% and 62.26% respectively.

Hasanhodzic and Lo (2006) show that the largest contributor of risk premium is the Bond and Commodity variable. This finding differs from the results from the thesis results. Overall, the previous studies are able to create a model that better captures the bull markets.

Finally, the liquidity is analyzed. As previous studies have shown, it is important to look at the return series liquidity to be sure of the robustness of the risk-adjusted returns. As mentioned earlier, the liquidity of a time-series is measured with the first-order autocorrelation of the time-series. As with other studies, the HP replicator and All replicator do not show any signs of illiquidity. The managed futures are a strategy that focuses mostly on liquid investments, and the results are in line with expectations. Hasanhodzic and Lo (2007) show that the replication products have low average autocorrelation. This thesis shows similar results. The conclusion is that investors carry less liquidity risk when investing in hedge fund replicators.

8.1.2. Replication quality

The second section analyses the replication quality. It analyzes the results from four perspectives: (1) the out-of-sample correlation (2) the out-of-sample RMSE, (3) out-of sample adjusted R^2 , and finally (4) the impact of the financial crisis.

The correlation between the replicators and benchmark indices are low overall. There is a huge difference between pre and post crisis correlation, as the correlation for some

pairs turns negative post-crisis. The correlation is higher for the managed futures post crisis and higher to HFRI index pre-crisis. It is worthwhile to mention that the post-crisis correlation between HP replicator and the HFRI index is -0.28, i.e. highly negative correlated. Clear evidence, that the replicator does not work properly post-crisis.

Amenc, Martellini and Meyfredi show a 0.42 correlation between managed futures and their replicator. The pre-crisis replicators are able to achieve half of the correlation shown from previous research. Hence, it is argued that the replication quality as correlation is better for previous studies compared to this thesis.

The out-of-sample replication quality is also low. Amenc, Martellini and Meyfredi (2010) shows correlation and RMSE coefficient of 0.42 and 0.12 respectively. The correlation and RMSE between the HP replicator and the benchmark is 0.03 and 0.22 respectively. Also, for the All replicator the correlation and RMSE to the benchmark is as low as 0.15 and 0.19 respectively. Overall, the replicators are not able to show good replication quality measured with correlation and RMSE.

Also, the out-of-the sample adjusted R^2 is lower for the HP replicator compared to previous studies, a staggering 10 % compared to 37 %. Overall, the low adjusted R^2 is a sign of difficulty in identifying the right factors, as well as difficulty replicating the state and time dependent exposures of hedge funds. Hence, as expected, the model is unable to capture the dynamic hedge fund strategies. Also, as previous studies also shown, the risk premium associated with common risk factors do not account for a high level of hedge fund risk exposures, and instead, a lot of the risk premium is alternative risk premium.

Finally, as discussed, the financial crisis has a clear impact to the model. As an example, the correlation between the replicators and other hedge fund indices is negative. Wallerstein et al. (2011) show that one-third of replication products have high replication quality compared to HFRI composite index during the time period between April 2008 and October 2010. A large portion of the excess return is due to lower liquidity risk replicator products carry. These findings are strikingly different than the findings in this thesis. The results indicate that hedge funds replication is not possible in turbulent markets, and that the model is unable to capture the risk-exposures during market turmoil. It is important to notice, that the replication quality is comparable with previous research pre-crisis, but the model is unable to accurately capture the

dynamical and time-varying risk exposures of the underlying hedge funds during financial crises.

8.1.3. *The thesis compared to other hedge fund research*

The thesis is based upon the same models and theories than previous studies. It also implements the same replication techniques as previous studies and confirms their findings. Hence it is able to introduce an interesting alternative approach to improved risk-adjusted returns. There is evidence that data selection can improve the replicators' risk-adjusted returns.

Finally, it indicates that financial crises impact the model stability. Previous studies argue that the financial crisis do not impact the replication quality or replication performance. However, the thesis indicates that there actually is large deviation between pre and post-crisis replication performance and replication quality.

8.1.4. *Summary of result discussion*

The performance analysis indicates that results have some similarities and some differences compared to previous studies. Before the financial crisis, the thesis is explicating comparable results with previous studies. Also, the thesis shows same low in-sample replication quality as previous studies. However, the out-of-sample replication quality is lower in the thesis than in previous studies. Previous studies have not used data selection, and therefore it cannot be compared. Hence, the study shows that there exist clear differences between HP replicator performance and All replicator performance.

The replication quality analysis shows that the replicators presented in this thesis has lower replication quality than in previous research measured with correlation, RMSE and out-of sample adjusted R^2 . The differences are clearest post-crisis as the model seems to not work properly.

However, the assumption is that the biggest reason there exists differences between both the replicators' performance and replication quality between this study and previous studies are differences in the time period and differences in the models.

8.2. Implications of results

The main finding for the thesis is that the risk-adjusted returns for the HP replicator are larger than the risk-adjusted returns for the All replicator. This confirms, as discussed and expected, that (1); the performance of hedge fund replicator is affected by the underlying data, (2); the model is able to capture a fraction of the higher performance. Also, it is shown that the financial crisis has an impact on replication performance and replication quality.

These findings have contributed to the performance analysis of hedge funds and also the other hedge fund research category. These finding should be taken into consideration when hedge fund replicators are constructed. It can be argued, that a more stable and significant model, which is created with better resources, can better capture the superior performance in underlying data. However, investors should not be misled that the replicator products are as accurate as the comparable equity index replicator. Also, according to the findings from the thesis, it can be noted that the replicator products underperform during financial crises.

8.3. Critical discussion of the thesis

This section discusses issues impacting the robustness of the results. The main issues for the thesis is the model selection, and the weak out-of-sample adjusted R^2

First, the model choice can be criticized. In the thesis, the model is chosen based on previous research. However, as the results show, some of the variables are insignificant. The insignificant variables affect the overall explanatory power of the model and therefore the explanatory power of the model can be increased with fewer variables. For instance, the SMB variable has no contribution and the model would be more stable without it. Further, more comparable results can be obtained using the Fung and Hsieh eight-factor model.

Finally, the adjusted R^2 of the regression models are weak and therefore a significant part of hedge fund returns is not captured in the returns of the replicator. This might be due to the inclusion of insignificant variables such as SMB and Mortgage variables. The adjusted R^2 could be much higher if these were excluded.

8.4. Suggestion for further research

This thesis analyses a new approach to hedge fund replication and to the knowledge of the author is the first of its kind. The analysis is thorough; however there is always a possibility to improve the study with more depth and other aspects.

It would be interesting to include other variables that capture the dynamics of hedge funds. The VIX index is a variable that has been discussed by many studies. The index is starting to mature and there exists already sufficient data to include it into the regression model. Further, and more importantly, the trading volumes for the VIX index have risen. The index can soon be described as a liquid instrument.

Also, other alternative risk exposures could be tested. As mentioned, hedge fund strategies often invest in alternative beta, and to capture the alternative risk-exposure one needs alternative variables. An example on an alternative variable is an art index.

Also, the study includes data only until September 2012. The financial markets are constantly developing and therefore new data can yield different results and other findings. Therefore, new data could be included and the development post-crisis could be analyzed in more detail to answer if the model works.

Finally, the study only focuses on managed futures hedge funds. Even if managed futures are one of the most replicable hedge fund strategies, other strategies could be analyzed to increase the robustness of the study. A large variation exists between different strategies, and the chosen variables can explain one strategy better than another.

9 CONCLUSION

This thesis has contributed to the on-going discussion as it has shown that it is possible to increase the risk-adjusted returns with screening the data. However, the thesis is not able to support that these replicators earn consistent higher risk-adjusted returns than other assets. However, there is indication that HP replicator is able pre-crisis to beat some of its benchmark indices.

The thesis is divided in four different parts. The first part analyses and classifies hedge funds into two groups based on their performance. The results show that there exists difference between high-performance funds and the aggregated hedge funds measured with risk-adjusted returns.

These groups are thereafter analyzed with a seven-factor risk model to obtain the risk-exposures for the individual hedge funds. The model includes the following factors: (1) *USD*: the U.S. Dollar index return; (2) *BOND*: the return on the Barclays intermediate corporate Bond (AA) index; (3) *SP500*: The SP500 total return, (4) *CREDIT*: The spread between Barclays intermediate corporate Bond (BAA) index and the Barclays U.S. 5 year treasury index; (5) *MORTGAGE*: The spread between GNME mortgage index and the Barclays U.S. 5 year treasury index; (6) *COMMODITY*; the return of SP GCSI Commodity index; and (7) *SMB*; The spread between small and large company spreads (Fama-French factor). It shown that hedge fund risk-exposure can be analyzed, but that most variables and models are insignificant. However, it is shown that SP500 and the Commodity variable show significant results.

The third part of the thesis creates a replicator product based on the obtained risk-exposures. The replicator products obtain monthly returns for the whole time period between January 2004 and September 2012, which is further divided in a pre-crisis (January 2004 to August 2008) and post-crisis (September 2008 to September 2012) time periods. It is shown that there exists variation in the risk exposures between these two groups and between these two different time periods.

The final part of the thesis compares the performance and replication quality for the replicators to benchmark return. The performance is shown to be higher for HP replicators compared with the All replicator, and the differences are even greater in the sub-periods. Also, the HP replicator is able to beat some of the benchmark indices pre-crisis risk-adjusted returns. However, the HP replicator is unable to consistently beat

the benchmark indices, due to low post-crisis performance. Overall, the replicators' replication quality was comparable, however somewhat lower than that of previous studies. Also, there exists a large difference between the replication quality between pre and post-crisis. The thesis shows pre-crisis replication quality consistent with previous research, but low post-crisis replication quality. The assumption is that low post-crisis replication quality is because the financial markets work differently during unusual time periods.

As discussed, hedge funds aim to produce risk that differs from traditional risk, such as tail risk, liquidity risk, and credit risk. Investors are well off for bearing part of this risk, as this able them to diversify their investment and therefore maximize their return to risk ration. This thesis is able to produce a replicator product that maximizes the return earned through replicators.

To conclude, the thesis is unable to produce a replicator product that beats the markets consistently. The implication of this study is that replication performance can be enhanced by data selection and that there exists differences between post and pre-crisis periods. This indicates that the hedge fund replicators should include more hedge funds with high return to the sample when they create their replicator index and that hedge fund replication is not feasible during financial crises.

10 SVENSKA SAMMANFATTNING

10.1. Introduktion

Intresset för att undersöka hedgefonder har ökat bland investerare och forskare under de senaste åren. Intresset mot fonderna härstammar från deras löfte om att erbjuda marknadsneutrala abnorma avkastningar för investerare genom investeringar i skiftande marknader, instrument och strategier. Historiska hedgefondavkastningar visar dock att de inte har klarat av att erbjuda marknadsneutrala abnorma avkastningar.

Detta har orsakat frustration bland investerare och lett till ett ökat intresse för hedgefondreplikation. Merrill Lynch och Goldman Sachs var de första investeringsbankerna att lansera hedgefondreplikatorer. Företagen ger några argument för att deras produkter erbjuder ett mer kostnadseffektivt, transparent och likvid alternativ för investerare att få exponering för avkastningar på samma nivå som hedgefonderas avkastningar. För det första motiverar hedgefondförvaltarna sina höga kostnadsstrukturer med sin unika förmåga att skapa abnorma marknadsneutrala avkastningar. Flera studier har dock bevisat det motsatta. Flera studier (Fung & Hsieh, 2004; Roncalli & Jerome, 2007) visar även att hedgefondavkastningarna härstammar till stor grad från marknadsexponering. Dessutom är hedgefonderna tillgängliga endast till förmögna investerare och deras investeringar är därtill bundna till hedgefonderna under längre tidsperioder, vilka kan vara upp till två år. Slutligen rapporterar hedgefonder avkastningar endast på frivillig basis, och därmed har investerarna ingen kännedom om hur deras kapital förvaltas, vilket minskar investerarens möjligheter att följa med förvaltarnas ageranden.

Flera forskare (Amenc, Martellini, & Meyfredi, 2010; Hasanhodzic & Lo, 2007; Roncalli & Jerome, 2007) har insett att det finns ett behov av kostnadseffektiva, likvida och transparenta produkter som erbjuder marknadsneutral exponering. Tidigare nämnda forskare argumenterar att hedgefondreplikation är lösningen. I hedgefondreplikation analyserar man hedgefondernas riskexponering och därefter investerar man i likvida variabler i enlighet med hedgefondavkastningarnas riskexponering för dessa likvida variabler.

Fung och Hsieh skapar i sina artiklar (1997, 2004 & 2006) basen för hedgefondreplikation och flera studier (Amenc, Gehin, Martellini, & Meyfredi, 2008; Kat & Palaro, 2012; Wallerstein, Tuchschnid, & Zaker, 2011; Wei, 2010; Amenc, Martellini, & Meyfredi, 2010) vidareutvecklar forskningen om hedgefondreplikation. Hasanhodzic & Lo (2007) är de första att replikera hedgefonder, och dessa följs av Amenc, Martellini och Meyfredis (2010) studie som introducerar en mer dynamisk modell. Flera andra tekniker och metodologier har även introducerats därefter.

Denna avhandling analyserar hedgefondavkastningarnas riskexponering och analyserar hur valet av data inverkar på hur replikatorerna presterar. Målet är att analysera om investerare kan realisera högre riskjusterade avkastningar genom att investera i replikatorer istället för att investera i hedgefonder. Avhandlingen strävar efter att bidra till forskningen om hedgefonder genom att förbättra replikatorernas avkastning. Tidigare undersökningar replikerar alla hedgefonder, vilket leder till att även hedgefonder med sämre prestation replikeras. Till skillnad från dessa fokuserar denna studie på att replikera endast hedgefonder med god prestation för att dessa erbjuder mer attraktiva avkastningar för investerare.

10.1.1. Syfte

Avhandlingens syfte är att introducera ett nytt angreppssätt för att replikera hedgefonder.

10.1.2. Avgränsningar

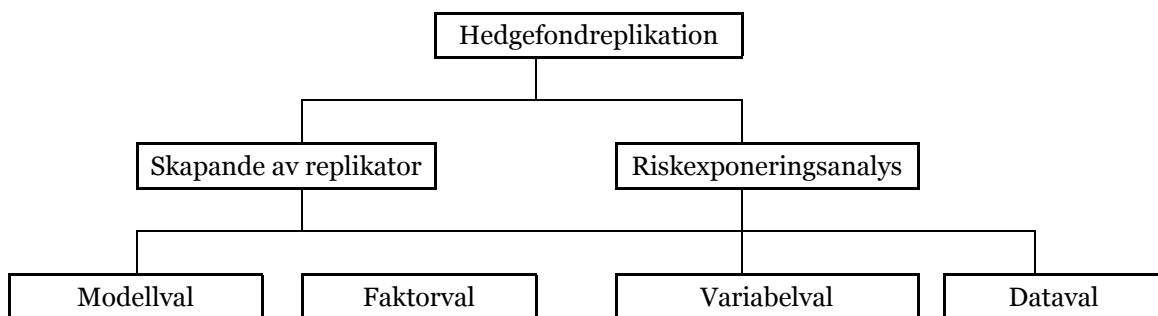
Studiens datasampel är från tidsperioden mellan 2002 och 2012, vilket möjliggör en analys av tidsperioden före och tidsperioden efter finanskrisen. Det finns flera hedgefonddatabaser och i denna studie används databasen TASS Lipper Hedge Fund. Tidigare studier (Amenc, Gehin, Martellini, & Meyfredi, 2008; Kat & Palaro, 2012) har visat att det finns skillnader bland strategiernas replikationskvalitet och därmed fokuserar studien endast på en strategi: managed futures-strategin.

10.1.3. Kontribution

Enligt syftet introducerar avhandlingen ett nytt angreppssätt för att replikera hedgefonder. Tidigare studier fokuserar på att förbättra replikationskvaliteten, medan inga tidigare studier fokuserar på att förbättra prestationen av replikatorerna.

Avhandlingens hypotes är att replikatorernas prestation kan förbättras genom att inkludera endast hedgefonder med hög historisk prestanda till datasamplet. Därmed utvidgar studien Weisangs (2011) struktur för hedgefondreplikation genom att inkludera val av data.

Table 15 Utsträckta strukturen för avhandlingen



Tabell 15 presenterar strukturen för avhandlingen. Utöver modellval, faktorval och variabelval som Weisang (2011) introducerar, omfattar avhandlingen även dataval.

10.2. Hedgefonder som investeringsmål

10.2.1. Definition av en hedgefond

Enligt Lhabitant (2010) definieras en hedgefond som en fond med investeringsstrategier som strävar efter att uppnå marknadsneutrala avkastningar. Dock existerar det inte en entydig definition på hedgefonder idag. Till exempel definieras hedgefonder olika i Europa och USA. I Europa definieras en hedgefond som en offshore-investeringsentitet, som även investerar i mera exotiska instrument och har ett absolut prestationsmål.

10.2.2. Hedgefondernas särdrag

Hedgefonder har flera särdrag som skiljer dem från traditionella fonder. Med hänsyn till syftet för avhandlingen är de mest betydande särdragen hedgefondernas speciella kostnadsstruktur, deras låga likviditet, deras begränsade klientel, deras icke-transparens, deras möjlighet att utnyttja hävstång, deras aktiva förvaltning samt de flera investeringsmöjligheter de kan investera i.

Hedgefonder har en speciell kostnadsstruktur. Kostnadsstrukturen kan indelas i tre skilda delar: förvaltningsavgift, prestationsavgift samt inlösensavgift. Förvaltningsavgiften inkluderar bl.a. kostnader för fondadministration och är i medeltal 2 % av fondens nettovärde. Prestationsavgiften är en kompensation för

prestation som överskrider den normala avkastningen och denna prestationsavgift är i medeltal 20 % av fondens avkastning för tidsperioden. Det inkluderas även en inlösningsavgift ifall investeraren löser in sin investering före en utsatt tid. **Error! Reference source not found.** Om man kan passivt replikera hedgefondavkastningar är denna höga kostnadsstruktur inte motiverad och investerare maximerar i så fall sin avkastning med att investera i replikatorerna istället för att investera i hedgefonderna.

Hedgefonderna är mindre likvida än vanliga fonder. Hedgefonder gör spekulativa långsiktiga investeringar vilket också är orsaken till att inlösen av hedgefonderna begränsas. Det finns tre restriktioner som är inköpstidpunkt, lösenperiod samt inlösenstidpunkt. Inköpstidpunkt fastställer tidpunkten för nya investeringar, lösenperiod är en förutbestämd tid när investerare kan sälja sina aktier och inlösenstidpunkt fastställer när investeraren bör meddela sin vilja att inlösa investeringarna. (Lhabitant, 2006). Replikatorerna skapas med likvida instrument och därmed kan investerare agera utan likviditetsrestriktioner.

Hedgefonder erbjuder sina tjänster främst för förmögna investerare. Det finns ett minsta investeringsbelopp som sträcker sig från 10 000 € till mer än 1 000 000 € (Frush, 2007). De nya fonder av hedgefonder, som introducerats på marknaden, har minskat hindren att investera i diverse hedgefonder, men dessa erbjuder endast en begränsad exponering för olika hedgefondstrategier. Replikationsprodukter skapas med investeringar i likvida medel och säljs efter replikatorkonstruktion på en börs, liksom ETF produkter. Därmed är de minsta investeringsbeloppen för hedgefonderna lägre än för replikatorerna och flera investerare kan investera i dessa replikatorprodukter.

Hedgefonder är även mindre transparenta än fonder. Hedgefonderna är ofta registrerade utomlands, och tvingas därför inte att rapportera t.ex. prestationsinformation, investeringsallokering eller lönsamhet. Utan denna information kan investerare inte övervaka vad förvaltarna gör och de känner inte heller till i vilka instrument deras pengar är investerade (Frush, 2007). Den begränsade rapporteringen är en viktig fråga i replikation för att det är mycket svårt att replikera en prestation ifall man inte har information om hedgefondernas avkastning. Tidigare undersökningar (Amenc, Martellini, & Meyfredi, 2010; Hasanhodzic & Lo, 2007) har visat att tillräckligt många hedgefonder ändå rapporterar prestationsinformation till databaser och därmed begränsar inte datarestriktionerna replikationen.

Hedgefonder utnyttjar mera hävstång än vanliga fonder. Målet med att utnyttja hävstång är att realisera högre avkastningar, utnyttja marknadsineffektivitet, modifiera portföljens riskprofil och öka hedgefondernas marknadsexponering under gynnsamma tidsperioder. I historien finns det extrema fall som t.ex. företaget Long Term Capital Management, som utnyttjade en hävstång som var 50 gånger större än dess nettokapital. Nuförtiden är regleringen för hedgefonder striktare och hävstångstalen är på mer hälsosamma nivåer (Jorion, 2000). Hedgefondernas avkastningar är mindre korrelerade med marknadsavkastningarna delvis på grund av en större hävstång och delvis på grund av att fonder kan utnyttja strategier som är mindre beroende av marknadsutveckling och mer beroende av förvaltarens vision. Dessa mindre marknadskorrelerade avkastningar erbjuder diversifieringsnytta för investerarna, men gör även analys om hedgefondernas riskexponering svårare.

Hedgefonder har ett aktivt angreppssätt till portföljförvaltning. Förvaltarna tar spekulativa positioner för att uppnå abnorma avkastningar och motivera höga kostnadsstrukturer. Det aktiva angreppssättet mot portföljförvaltning leder till att hedgefondavkastningar följer ett mer dynamiskt mönster och är svårare att analysera **Error! Reference source not found..** Förvaltaren kan snabbt omstrukturera sin portfölj och det är svårt att observera omstruktureringen snabbt då endast månatliga hedgefondavkastningar är tillgängliga.

Hedgefonder kan investera i flera olika instrument än vanliga fonder. Regleringen av hedgefonder är mindre strikt än regleringen av fonder. Därmed kan hedgefonderna investera i mera exotiska instrument, som t.ex. kombinera korta och långa positioner, använda hävstång i investeringen och investera i derivatprodukter (Lhabitant, 2006). Bredare investeringsmöjligheter för hedgefonderna leder till att fonderna är exponerade för bl.a. alternativa riskexponeringar. Därför kan man ifrågasätta om man är kapabel att fånga dessa alternativa riskexponeringar med replikatorer som skapas genom investeringar i traditionella likvida instrument.

10.2.3. Strategier för hedgefonder

Hedgefonder fokuserar vanligen i specifika tillgångsklasser eller handelsstrategier. Vissa hedgefondstrategier följer makroekonomiska faktorer medan andra investerar t.ex. i trängda instrument. Således indelas hedgefondstrategierna i standardiserade investeringsstrategier. Ingen accepterad norm för klassificeringen existerar, men avhandlingen klassificerar strategierna på basis av klassifikationsstandarderna som

används i Lipper TASS hedgefondsdatabas. Klassifikationsstandarden presenterar 13 olika strategikategorier. Tabell 16 presenterar de olika strategierna samt deras replikationskvalitet samt replikationsprestation. Enligt avgränsningarna fokuserar denna avhandling endast på managed futures-strategin.

Table 16 Tabell över olika hedgefondstrategier

	Korrelation	Adj. R^2	Annualiserad RMSE	Annualiserad geometrisk abnorm avkastning (AER)	Annualiserad Sharpe
Convertible arbitrage	0.10	-0.12	0.05	-0.06	0.37
<i>Managed futures</i>	0.42	0.37	0.12	-0.03	0.02
Distressed securities	0.41	0.20	0.05	-0.07	0.69
Emerging markets	0.51	0.39	0.11	-0.11	0
Equity Markets neutral	0.37	-0.38	0.03	-0.05	0.59
Event Driven	0.47	0.31	0.04	-0.05	0.85
Fixed income Arbitrage	0.22	0.10	0.03	-0.03	0.28
Global macro	0.00	-0.28	0.08	-0.09	-0.04
Long-short equity	0.47	0.49	0.09	-0.05	0.41
Risk arbitrage	0.15	0.23	0.04	-0.01	1.03
Dedicated short bias	0.68	0.63	0.12	-0.04	-0.11
Fund of funds	0.40	0.40	0.06	-0.05	0.33

Managed futures-strategin strävar efter att identifiera marknadstrender och skapa exponering för trenden med att använda hög hävstång och investera i futurer och optioner. Avhandlingen fokuserar på denna strategi för att den är bland de mest replikerbara strategierna och erbjuder hög förväntad avkastning för investerare. Enligt Amenc, Martellini och Meyfredi (2010) har managed futures-replikatorer en korrelation på 0,42, justerad R^2 0,37 och annualiserad root-mean-square error på 0,12 i jämförelse med de underliggande hedgefonderna, och en annualiserad geometrisk abnorm avkastning på -0,03 och ett annualiserat Sharpetal på 0,02.

10.2.4. Hedgefondindustrins framtid

Managed futures-strategin strävar efter att identifiera marknadstrender och skapa exponering för trenden med att använda hög hävstång och investera i futurer och optioner. Avhandlingen fokuserar på denna strategi för att den är bland de mest replikerbara strategierna och erbjuder hög förväntad avkastning för investerare. Enligt Amenc, Martellini och Meyfredi (2010) har managed futures-replikatorer en korrelation på 0,42, justerad R^2 0,37 och annualiserad root-mean-square error på 0,12 i jämförelse med de underliggande hedgefonderna, och en annualiserad geometrisk abnorm avkastning på -0,03 och ett annualiserat Sharpetal på 0,02.

10.3. Teoretisk referensram

10.3.1. Alternativa investeringar

En alternativ investering är en investering i ett icke-traditionellt instrument som aktie, obligation, fond eller likvida medel. Det hävdas också att exotiska geografiska områden kan definieras som alternativa investeringar (Skidmore, 2009). Största skillnaden mellan alternativa investeringar och traditionella investeringar är deras riskexponering för aktie- och obligationsmarknader (Fung & Hsieh, 1997).

Hedgefonder exponeras för alternativa riskfaktorer via investeringar i speciella instrument och speciella metoder som sälja kort, hävstång och derivatprodukter. Riskexponering för alternativa riskfaktorer kan analyseras med hjälp av alternativa betan. Tidigare forskning (Fung & Hsieh, 1997; Amenc, Martellini & Meyfredi, 2010; Bollen & Fisher, 2012) inkluderar därför alternativa faktorer i sina modeller för att analysera alternativa riskexponeringar.

Tancar och Viebig (2008) klassificerar alternativa riskfaktorer i fyra olika grupper: illikviditetsrisk, riskförflyttning, spridning och optionalitet samt volatilitet. Illikviditetsrisk härstammar från illikvida produkter med höga transaktionskostnader. Riskförflyttning är ett premium för att bära risk som ingen annan är villig att bära. Spridningspremium skapas från felprissättning av liknande produkter och volatilitet härstammar från risk av volatila marknader.

10.3.2. Hedgefond replikation

Det existerar flera hedgefondreplikationsmetodologier. Huvudgrupperna är distributionsreplikation, faktorreplikation och så kallad rules-based-replikation. Avhandlingen följer faktorreplikationsmetodiken för att denna har bevisats vara intuitiv, okomplicerad och tillämpas av de flesta investeringsbankerna. (Wallerstein, Tuchschnid, & Zaker, 2011)

Faktorreplikation har dock sina begränsningar. För det första existerar det flera hedgefonddatabaser som leder till att olika studier analyserar olika databaser. För det andra rapporterar hedgefonder endast månatlig avkastning vilket gör det svårt att identifiera riskexponering. För det tredje har hedgefondindustrin inte existerat under en lång tidsperiod och därmed kan det finnas brister i hedgefondtidsseriernas längd vilket leder till att man inte kan analysera riskexponering. För det fjärde existerar det skillnader mellan olika strategier vilket kräver att olika strategier analyseras med olika modeller.

10.3.3. Existerande hedgefondreplikatorer

Merrill Lynch och Goldman Sachs var de första att lansera replikatorer, vilket nämndes även i introduktionen, och därefter har flera andra investeringsbanker¹⁶ lanserat sina replikatorer.

I sin artikel analyserar Wallerstein, Tuchschnid och Zaker (2011) existerande replikatorer. För det första upptäcker författarna att 13 replikatorer skapas med faktorreplikationsmetoden, fyra skapas med rules-based-metoden, två skapas med att kombinera rules-based- och faktorreplikationsmetoden och två skapas med distributionsreplikationsmetoden. För det andra analyserar författarna replikatorernas prestation. Alla replikatorer slår deras internationella och amerikanska jämförelseindex. Mer än 13 replikatorer slår dessutom de jämförbara hedgefondindexen, men oftast med en högre volatilitet.

¹⁶ Société Générale, Barclays, Credit Suisse, Fulcrum Asset Management, JP Morgan, State Street Global Advisors, Blue White Alternative Investments, Concept Fund Solutions, IceCapital Fund Management, Innocap Investment Management, Deutsche Bank, Index IQ, Rydex SGI, Desjardins Global Asset Management

10.4. Sammanfattning av tidigare forskning

Tabell 17 sammanfattar tidigare forskning. Avhandlingen presenterar fyra tidigare forskningar inom hedgefondreplikation. De tre första artiklarna presenterar hur hedgefondreplikation har utvecklats från en enkel riskanalysmodell till en mer komplicerad dynamisk replikationsmetod. Fung och Hsieh (2004) skapade grunden för hedgefondreplikation i sin artikel som analyserar hedgefondernas riskexponering. Baserad på denna undersökning publicerade Hasanhodzic & Lo (2007) det första försöket att replikera hedgefonder. Författarna regresserar sex likvida faktorer mot hedgefondavkastningar för tidsperioden mellan februari 1986 och september 2005 och finner bevis som stöder möjligheten att replikera hedgefonder. Därefter introducerar Amenc, Martellini och Meyfredi (2010) ett dynamiskt angreppssätt för att replikera hedgefonder. Deras artikel visar också att dynamiska modeller inte signifikant förbättrar replikationskvalitén. I den fjärde artikeln diskuterar Tuchschnid, Wallerstein och Zaker (2010) de existerande replikatorerna och visar att dessa de facto erbjuder attraktiva avkastningar för investerare.

Med hänsyn till tidigare forskning följer avhandlingen samma metod som Hasanhodzic och Lo (2007) och utsträcker metoden att även inkludera val av data för att förbättra prestationen av replikatorer och därmed skapa attraktiva avkastningar för investerare. Därtill kombinerar avhandlingen variabler som används i både Hasanhodzic och Lo (2007) och Amenc, Martellini och Meyfredi (2010).

10.5. Metod och data

10.5.1. Metod

För att studera om hedgefondavkastningar kan replikeras används en metod med fyra olika delmoment. I det första momentet klassificerar avhandlingen hedgefonder enligt deras sex månaders riskjusterade avkastningar till två grupper: en ”högprestationsgrupp” (HP) och en grupp med alla hedgefonder (All). Grupperna uppdateras varje sex månader. Motivationen bakom valet är att tidigare studier (Agarwal & Naik, 2000; Edwards & Caglayan, 2001; Harri & Brorsen, 2004; Ammann, Huber, & Schmid, 2010) visar att hedgefonder erbjuder kortsiktigt bestående abnorma avkastningar och därmed strävar avhandlingen efter att fånga dessa abnorma avkastningar via klassificeringen. Avhandlingen beräknar riskjusterade avkastningar med Sharpe-talen.

I det andra momentet analyserar avhandlingen hedgefondernas riskexponering med hjälp av en modell med sju faktorer baserad på Hasanhodzic och Lo (2007) modell. Modellen tillämpar en rullande OLS-regression med 24-månaders tidsfönster. Modellen inkluderar avkastningen för U.S. Dollar index (USD), avkastningen för Barclays intermediate corporate Bond index (AA) index (Bond), totalavkastningen för SP500 (SP500), kreditskillnaden mellan avkastningen för Barclays intermediate corporate Bond (BAA) index och avkastningen för Barclays U.S. 5-åriga statsobligation (CREDIT), skillnaden mellan avkastningen för GNME mortgage index och avkastningen för Barclays U.S. 5-åriga statsobligation (MORTAGE), avkastningen för SP GCSI Commodity index (COMMODITY) och skillnaden mellan avkastningen för små och stora bolag (SMB).

I det tredje momentet skapas avkastningar för replikatorerna med att förvandla de månatliga aggregerade justerade R^2 till portföljvikter. Därtill restriktas summan av $\beta_{i1} + \dots + \beta_{i7}$ att summera till ett. Genom att multiplicera betavärden med månatliga avkastningar för underliggande variabler skapas månatliga avkastningar för både HP-samplet och All-samplet.

Till sist analyseras både prestationen för replikatorerna samt replikationskvalitet för replikatorerna. Prestationen för replikatorerna analyseras med annualiserad medeltalsavkastning samt annualiserade Sharpe-tal. Prestationen jämförs därefter mot avkastningar för SP500, HFRI-index samt DJ CS managed futures Index. Därtill analyseras avkastningarnas autokorrelation för att se om det finns illikviditetsproblem. Replikatorernas replikationskvalitet analyseras därefter med korrelation, adjusterad R^2 och root-mean squared error (RMSE) mellan replikatoravkastningar samt avkastningar för HFRI index och DJ CS managed futures Index.

Table 17 Sammanfattning av tidigare forskning.

Studie	År	Syfte	Data	Metod	Resultat
Fung and Hsieh	2004	Analysera hedgefondernas riskexponering	Månatlig avkastning från HFR Fund of Fund index för tidsperioden mellan januari 1994 och december 2002	OLS regressionsanalys; $R_{it} = \alpha_i + \beta_1 S\&P_t + \beta_2 SC - LC_t + \beta_3 10Y_t + \beta_4 CredSpr_t + \beta_5 BdOpt_t + \beta_6 FXOpt_t + \beta_7 ComOpt_t + \beta_8 \epsilon_t$	Modellens justerade R^2 är 0,405 under tidsperioden mellan februari 1995 och september 1998, och 0,540 under tidsperioden mellan april 2000 och december 2002. Signifikanta variabler under första tidsperioden är interceptet och SC-LC på en 5 % signifikansnivå och CredSpr på en 1 % signifikansnivå. För den andra tidsperioden är variabeln SC-LC och 10Y båda signifikanta på en 1 % signifikansnivå.
Hasanhodzic and Lo	2007	Replikation av hedgefondavkastningar	Månatliga avkastningar för 1610 hedgefonder från Lipper TASS Hedge Fund Live databas under tidsperioden mellan februari 1986 och september 2005	OLS regressionsanalys; $R_{it} = \alpha_i + \beta_{i1} USD_{1t} + \beta_{i2} BOND_{1t} + \beta_{i3} CREDIT_{1t} + \beta_{i4} SP500_{1t} + \beta_{i5} CMDTY_{1t} + \beta_{i6} DVIX_{1t} + \epsilon_{it}$	Studien visar inga statistiskt signifikanta variabler. Avkastningen för fem passiva replikationsprodukter är ändå högre än avkastningen för jämförelseindex; Dedicated Short Bias, 6,70 % jämfört med 5,98 %; Equity Market Neutral, 10,00 % jämfört med 8,09 %; Global Macro, 15,54 % jämfört med 11,38 %; Managed Futures, 27,97 % jämfört med 13,64 %; och Fund of Funds, 9,29 % jämfört med 8,25 %
Amenc, Martellini, and Meyfredi	2010	Förbättra angreppssätt för hedgefondreplikation	Månatliga avkastningar för 1610 hedgefonder från Lipper TASS Hedge Fund Live databas under tidsperioden mellan januari 1999 och december 2006	OLS-regressionanalys; konditional linjär och konditional optionsmodell, samt icke-konditional Kalman filter och markow-regime switching modeller	Hedgefondreplikationsmodeller bör vidare utvecklas och konditionala modeller förbättrar inte signifikant replikationskvalitén.
Tuchschnid, Wallerstein, and Zaker	2010	Analysera prestationen för existerande hedgefond-replikatorer.	Månatliga avkastningar för hedgefondreplikatorer lanserade före augusti 2009; totalt 22 hedgefond replikatorer.	OLS regressionsanalys; Fung and Hsieh åtta-faktormodell	Jämfört med HFRI fund of funds-index presterar mer än 50 % av replikatorerna bättre än deras jämförelseindex beräknat med avkastning och en tredjedel presterar bättre än jämförelseindexet beräknat med riskjusterade Sharpe-tal.

Table 17 sammanfattar resultatet från fyra tidigare hedgefondreplikationsstudier. Tabellen presenterar information om författaren, publikationsår, syfte, data, metod och resultat från studien. Fung and Hsieh (2004) modell inkluderar sex variabler: avkastningen för S&P500 (S&P) och skillnaden mellan avkastningarna för Wilshire 1750 Small Cap och Wilshire 750 Large Cap (SC-LC), förändringen i 10 åriga U. S statsobligation (10Y), skillnad mellan Moody's Baa obligationer and U.S. statsobligation (CredSpr), "lookback" optioner för obligationer (BdOpt), valutor (FXOpt) och råvaror (ComOpt). Hasanhodzic och Lo (2007) modell inkluderar följande sex faktorer; U.S. Dollar Index avkastning (USD), avkastning för Lehman Corporate AA Intermediate obligations Index (BOND), skillnaden mellan avkastning för Lehman BAA Corporate Bond Index och Lehman Treasury Index (CREDIT), total avkastning för S&P 500 (SP500), totalavkastning för Goldman Sachs Commodity Index (CMDTY), och första differensen mellan månatliga värden på CBOE Volatility Index (VIX). (BOND), skillnaden mellan avkastning för Lehman BAA Corporate Bond Index och Lehman Treasury Index (CREDIT), total avkastning för S&P 500 (SP500), totalavkastning för Goldman Sachs Commodity Index (CMDTY), och första differensen mellan värdet på CBOE Volatility Index (VIX) i slutet av månaden.

10.5.2. Data

Avhandlingen använder data från Lipper TASS Hedge fund-databas och fokuserar på endast aktiva fonder för tidsperioden mellan januari 2004 och september 2012. Denna avgränsning leder till att datasamplet består av avkastningar för 1610 fonder. Därefter inkluderas endast hedgefonder som följer managed futures-strategin varefter datasamplet inkluderar avkastningar för 189 fonder.

I teorikapitlet nämndes att det kan existera problem med tidsseriernas längd. Tidsseriernas längd för individuella fonder analyseras vilket verifierar att det inte existerar problem.

Hedgefondreplikation utsätts för flera olika snedvridningar i data och dess diskuteras till följande. Överlevnadsbias innebär att då endast avkastningar för fonder som är aktiva i slutet av tidsperioden beaktas i studien har flera fonder upplösts före denna tidpunkt, och avkastningen för dessa upplösta fonder beaktas inte i resultaten vilket snedvrider avkastningarna mot högre avkastningar. Urvalsbias innebär att alla hedgefonder inte rapporterar sina avkastningar och därmed representerar inte avkastningarna i databaserna hela hedgefondindustrins avkastningar. Stela priser innebär att hedgefonderna har mindre likvida avkastningar då de investerar i alternativa investeringar vilket leder till att avkastningarna inte är lika pålitliga. Omedelbar historiskavkastning innebär att då hedgefonder inkluderas till databaser så inkluderas all deras historiska avkastning till databasen. Hedgefonder strävar efter att först skapa hög avkastning och först därefter inkluderas i databasen vilket snedvrider avkastningarna mot högre avkastningar. Avhandlingen analyserar illikviditetsproblem i resultatdiskussionen samt beaktar de andra snedvridningarna. Överlag orsakar snedvridningarna inga större problem då avhandlingen inte utför någon relativ prestationsjämförelse mellan replikatorer och fonder utan strävar efter att uppnå en hög avkastning för replikatorer.

10.6. Analys och resultat

10.6.1. Hedgefondreplikation

I avhandlingen utförs 16 651 OLS-regressioner för att analysera riskexponering för hedgefonder för hela tidsperioden. I avhandlingen klassificeras hedgefonder på basis av deras riskjusterade avkastningar som mätts med Sharpe-talen. Riskjusterade

avkastningar för HP-samplet är, mätt med Sharpe-talen, i medeltal 3,04 högre än för All-samplet. Skillnaden är förväntad, men skillnaden är överraskande stor. Överlag tenderar HP-samplet även att ha en lägre volatilitet än All-samplet.

Justerad R^2 är låg för båda modellerna konstant genom hela tidsperioden. Även F-testet visar en mycket låg grad av signifikanta resultat. Därtill sjunker både förklaringsgraden för adjusted R^2 samt signifikansen för F-testet direkt efter finanskrisen. Även p-värden för variablerna är insignifikanta, vilket beror på att betan begränsas att summera till ett. Låg förklaringsgrad i modellen orsakar att egentlig kausalitet mellan beroende och oberoende variabler inte kan bevisas (Fung & Hsieh, 2004). All-replikatorn bevisar aningen bättre signifikans för variablerna samt modellerna i jämförelse med HP-samplet, men skillnaderna är marginella.

En djupare analys om förändringar i beta-variablerna för de olika tidsperioderna bevisar att finanskrisen har en effekt på flera beta-värden. Alla beta-värden är mindre signifikanta efter finanskrisen. En huvudsaklig orsak till detta kan vara att ekonomin fungerar annorlunda under finanskrisen och därmed är regressionsmodellen inte kapabel att kalibrera sig i linje med förändringarna.

10.6.2. Analys av replikatorerna

I avhandlingen undersöks replikatorernas prestation för hela tidsperioden, för tidsperioden före finanskrisen samt för tidsperioden efter finanskrisen. Under hela tidsperioden visar analysen flera intressanta observationer. För det första visar resultaten att prestationen för både HP-replikatorn och All-replikatorn inte slår konsistent jämförelseindexen. Avkastningen för HP-replikatorn är 4,99 % och standardavvikelsen 7,42 % medan avkastningen för All-replikatorn är 2,49 % och standardavvikelsen 6,14 %. Som jämförelse erbjuder SP500 en avkastning på 7,18 % med en standardavvikelse på 14,24 % för samma tidsperiod.

För det andra existerar det klara skillnader mellan resultaten före och efter finanskrisen. Före finanskrisen erbjuder HP-replikatorn bättre riskjusterade avkastningar än DJ CS Managed futures-index och SP500-index. Därtill är avkastningen för HP-replikatorn konstant högre än för All-replikatorn, vilket indikerar att dataval skapar mervärde före finanskrisen.

För de tredje är volatiliteten, men även Sharpe-talen, låga för replikatorerna efter finanskrisen. Sharpe-tal för HP-replikatorn är 0,59 % och Sharpe-tal för All-replikatorn

är -0,85 %. Intressant är att HP-replikatorn igen slår All-replikatorn mätt med Sharpe-tal vilket indikerar att dataval i hedgefondreplikation skapar mervärde.

Till följande analyseras replikatorernas replikationskvalitet som är låg igenom hela tidsperioden mätt med korrelation, justerad R^2 eller RMSE. För hela tidsperioden är korrelationen 0,03, justerade R^2 0,14 och RMSE 0,22 mellan HP-replikator och HFRI-index. För All-replikatorn och HFRI-indexet är dessa 0,15, 0,16 och 0,19. Då vi jämför HP-replikatorn mot managed futures-indexet är korrelationen 0,18, justerade R^2 0,10 och RMSE 0,27. Dessa mått mellan All-replikator och managed futures-indexet är 0,18, 0,16 och 0,27.

Avhandlingen finner klara skillnader i replikationskvalitén före och efter finanskrisen. Replikationskvalitén för båda replikatorerna jämfört med både HFRI-index och managed futures är högre före finanskrisen än vad de är efter finanskrisen. T.ex. korrelationen är negativ mellan båda replikatorerna och HFRI-index efter finanskrisen. Detta är ett tecken på att replikationen inte är exakt efter finanskrisen.

10.6.3. Implikationer av resultatet

Avhandlingen visar två implikationer till hedgefondreplikation. För det första indikerar resultaten att prestationen för replikationerna de facto är beroende av underliggande data som bevisas genom att HP-replikatorn har konstant en högre riskjusterad avkastning än All-replikatorn. Dessa resultat bekräftar hypotesen för studien att dataval har en inverkan på replikatorernas prestanda.

För det andra visar avhandlingen att replikationskvalitén är högre före finanskrisen än vad den är efter finanskrisen. Resultaten indikerar att detta är främst beroende på att modellen inte kalibrerar sig till det nya marknadsläget. Dessa implikationer bidrar till prestationsanalys av hedgefonder och torde också beaktas vid skapande av replikatorer.

10.7. Sammanfattning

Studiens resultat är synnerligen intressanta. Avhandlingen analyserar replikatorerna från två synvinklar: prestationen för dem samt deras replikationskvalité. Avhandlingens resultat är i stor grad i linje med tidigare forskning (Hasanhodzic & Lo, 2007; Amenc, Martellini & Meyfredi, 2010), men drar två slutsatser som skiljer sig från dessa tidigare studier.

För det första visar avhandlingen tecken på att datavalen förbättrar avkastningen för replikatorerna då HP-replikatorn har en högre riskjusterad avkastning än All-replikatorn genom hela tidsperioden. Det finns därmed ett argument för att välja data på basis av hedgefondernas historiska avkastningar då val av data kan leda till en högre riskjusterad avkastning för investerare. Resultaten kan dock ifrågasättas då replikationskvaliteten för replikatorerna endast är tillfredställande. Den låga replikationskvaliteten är långt beroende av att modellen inte är kapabel att beakta hedgefondernas dynamiska natur och därigenom kan den inte fånga all variation i avkastningarna.

För det andra existerar det en klar skillnad mellan replikatorprestation samt replikationskvaliteten för replikatorerna före och efter finanskrisen. Replikatorerna har klart högre avkastning och replikationskvalité före finanskrisen. Antagandet är att ekonomin fungerar annorlunda under finanskrisen och därmed är modellen inte kapabel att exakt och konstant replikera hedgefondernas avkastningar under dessa turbulenta marknader.

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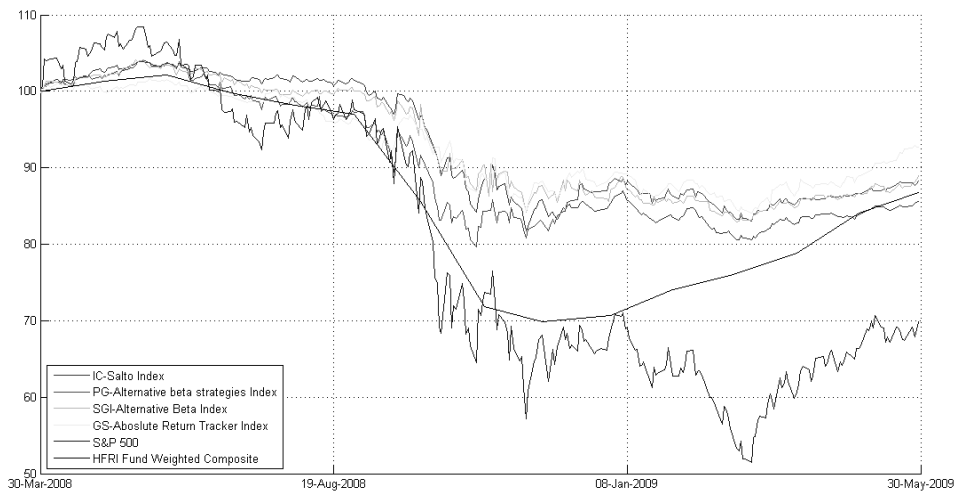
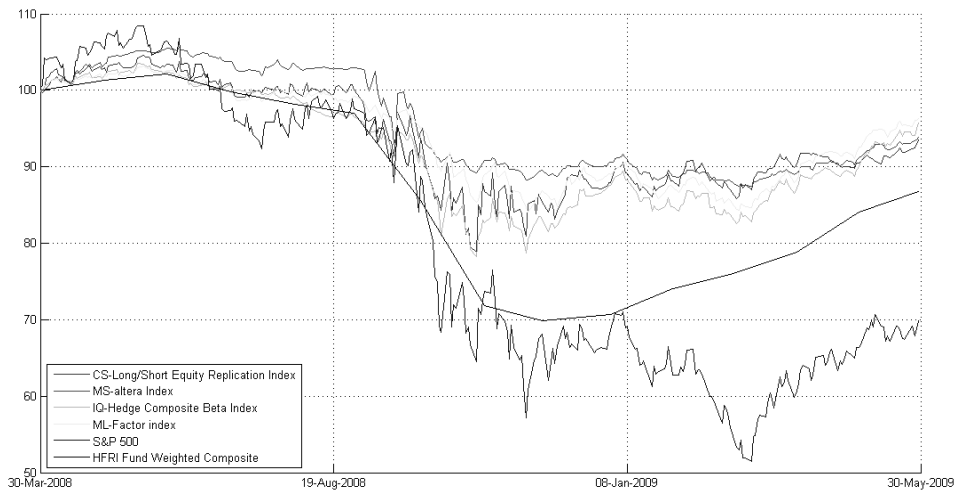
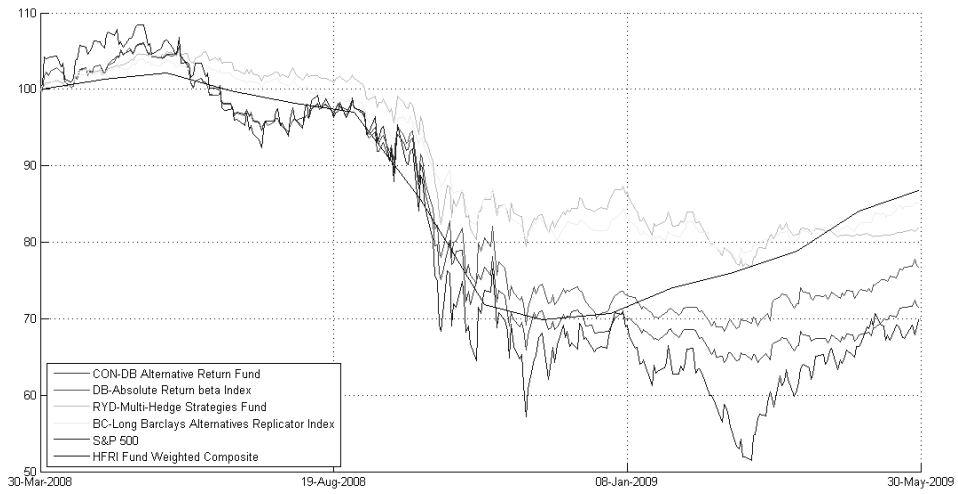
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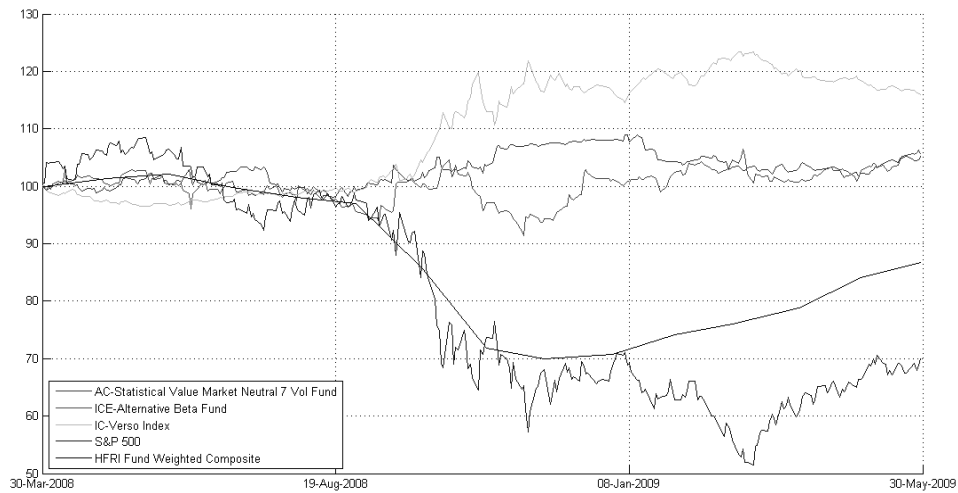
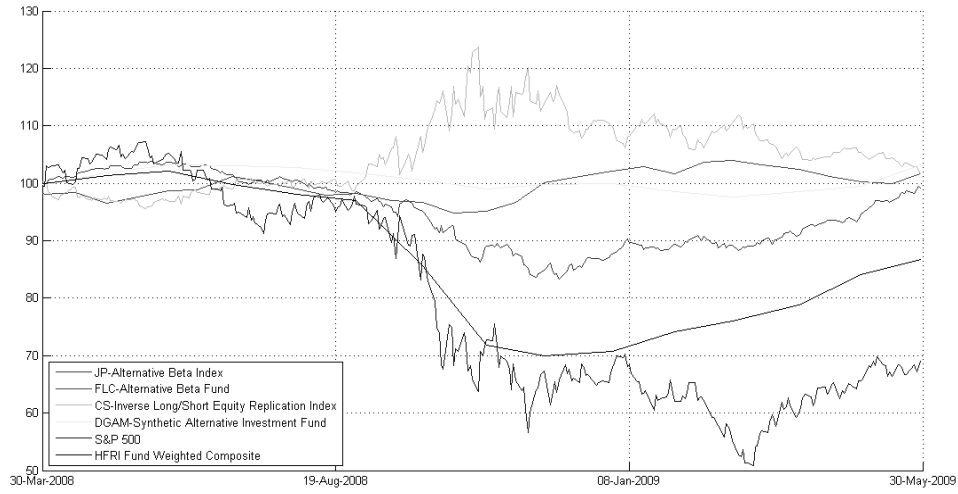
APPENDIX 1 LIPPER TASS HEDGE FUND STRATEGIES

Strategy type	LGC category	Sub strategies
Relative Value strategies	Convertible arbitrage	
	Equity Market Neutral	Statistical arbitrage Fundamental arbitrage
	Fixed income arbitrage	Swap-spread arbitrage Yield curve arbitrage Volatility arbitrage Capital structure arbitrage
	Options arbitrage	
Directional strategies	Dedicated short bias	
	Emerging markets	
	Global macro	
	Long bias	
	Long/short equity	
	Managed futures/ CTA	Systematic trend-following Discretionary
Event driven strategies	Event driven	Distressed securities Merger arbitrage Multi-strategy
Credit	Credit focus	Asset- and mortgage backed Structured securities High yield Long/ short credit Long bias Credit arbitrage Distressed credit Private placement Asset-based lending Credit multi-strategy
Mixed and other strategies	Multi-strategies	
	Other hedge	

Appendix 1 represents the main categories of the Lipper TASS Hedge fund Database. Source: (TASS, 2008)

APPENDIX 2 CUMULATIVE RETURNS FOR EXISTING REPLICATORS





Appendix 2 presents the cumulative returns for five replicator products and cumulative returns for the US equities and HFRI index over the period April 2008 to May 2009. As the figure shows, all the replicator products perform better than US equities. The replicators perform comparably against the HFRI index.

APPENDIX 3 DELETED HEDGE FUNDS DUE TO LACK OF DATA

Time period	Number of monthly hedge fund returns
1.1.2002-31.6.2002	1
1.7.2002-31.12.2002	4
1.1.2003-31.6.2003	4
1.7.2003-31.12.2003	4
1.1.2004-31.6.2004	6
1.7.2004-31.12.2004	6
1.1.2005-31.6.2005	7
1.7.2005-31.12.2005	3
1.1.2006-31.6.2006	4
1.7.2006-31.12.2006	2
1.1.2007-31.6.2007	2
1.7.2007-31.12.2007	2
1.1.2008-31.6.2008	4
1.7.2008-31.12.2008	2
1.1.2009-31.6.2009	5
1.7.2009-31.12.2009	3
1.1.2010-31.6.2010	2
1.7.2010-31.12.2010	1
1.1.2011-31.6.2011	0
1.7.2011-31.12.2011	0
1.1.2012-31.9.2012	0

Appendix 3 present the number of deleted hedge fund monthly returns for each time period. It is required that the individual hedge funds included in the time period reports at least 4 out of 6 monthly observations. The hedge funds that do not meet the requirements are deleted from the sample.

APPENDIX 4 MULTIKOLLINARITY IN VARIABLES

	USD	Bond	S&P500	Credit	Mortgage	Commodity	SMB
USD	1.000	-0.246	-0.358	0.225	0.246	-0.364	-0.013
Bond	-0.246	1.000	0.223	-0.361	-0.542	-0.032	0.044
S&P500	-0.358	0.223	1.000	-0.369	0.202	0.346	0.261
Credit	0.225	-0.361	-0.369	1.000	0.031	-0.183	-0.232
Mortgage	0.246	-0.542	0.202	0.031	1.000	0.182	-0.018
Commodity	-0.364	-0.032	0.346	-0.183	0.182	1.000	-0.057
SMB	-0.013	0.044	0.261	-0.232	-0.018	-0.057	1.000

Appendix 4 presents the multicollinearity between the variables in the model. The multicollinearity is calculated between January 2002 and September 2012. No multicollinearity exists.

APPENDIX 5 MONTHLY RETURN DECOMPOSITION FOR HP REPLICATOR

	Return component								Total return
	USD	Bond	SP500	Credit	Mortgage	Commodity	SMB	Constant	
2004m1	1.50 %	1.59 %	-0.39 %	1.66 %	-1.16 %	-0.84 %	0.00 %	0.00 %	2.36 %
2004m2	0.60 %	-0.58 %	-0.95 %	-0.14 %	1.33 %	1.06 %	0.37 %	0.02 %	1.72 %
2004m3	-1.99 %	0.78 %	-0.13 %	0.20 %	-0.92 %	2.58 %	-0.46 %	0.01 %	0.08 %
2004m4	-1.09 %	-4.39 %	1.26 %	-1.35 %	4.67 %	0.92 %	-0.30 %	0.00 %	-0.28 %
2004m5	-1.42 %	-3.36 %	-0.82 %	-1.57 %	2.66 %	2.91 %	-0.02 %	0.01 %	-1.60 %
2004m6	1.49 %	-0.20 %	0.43 %	1.79 %	-0.33 %	-3.19 %	-0.52 %	0.00 %	-0.54 %
2004m7	0.12 %	0.95 %	0.31 %	0.79 %	-0.94 %	2.79 %	0.27 %	-0.02 %	4.28 %
2004m8	0.00 %	0.98 %	-0.15 %	1.31 %	-0.54 %	3.23 %	-0.10 %	-0.03 %	4.70 %
2004m9	-0.17 %	-0.05 %	-0.72 %	1.88 %	0.03 %	-2.53 %	0.14 %	-0.03 %	-1.44 %
2004m10	0.43 %	0.32 %	0.65 %	0.54 %	0.28 %	7.35 %	0.02 %	-0.02 %	9.57 %
2004m11	2.65 %	-1.29 %	0.12 %	1.14 %	1.84 %	-1.91 %	1.24 %	-0.01 %	3.77 %
2004m12	1.76 %	0.13 %	-0.15 %	1.11 %	0.34 %	-0.97 %	0.06 %	-0.01 %	2.28 %
2005m1	-1.09 %	-0.94 %	-0.05 %	0.19 %	1.95 %	0.56 %	-0.57 %	-0.02 %	0.03 %
2005m2	-0.28 %	-0.12 %	-0.53 %	2.45 %	-0.39 %	-0.27 %	-0.19 %	-0.03 %	0.63 %
2005m3	0.70 %	-2.06 %	0.45 %	-1.76 %	3.43 %	2.91 %	-0.44 %	-0.02 %	3.20 %
2005m4	-1.19 %	0.26 %	-0.16 %	0.17 %	-0.06 %	-0.75 %	-1.47 %	0.03 %	-3.15 %
2005m5	-0.72 %	0.15 %	-0.08 %	1.45 %	-0.26 %	-0.37 %	1.05 %	0.03 %	1.26 %
2005m6	-0.97 %	0.37 %	0.18 %	-0.04 %	0.00 %	0.99 %	1.08 %	0.04 %	1.65 %
2005m7	-0.42 %	-0.06 %	0.78 %	0.00 %	0.02 %	0.32 %	1.04 %	0.04 %	1.71 %
2005m8	0.63 %	-0.83 %	0.15 %	0.11 %	-0.03 %	2.12 %	-0.21 %	0.04 %	1.98 %
2005m9	-0.18 %	0.40 %	0.07 %	-0.05 %	0.03 %	0.18 %	-0.14 %	0.04 %	0.34 %
2005m10	-0.29 %	-1.50 %	-0.05 %	-0.31 %	0.00 %	-0.06 %	-0.20 %	0.05 %	-2.37 %
2005m11	-0.42 %	-0.37 %	-1.08 %	-0.01 %	0.02 %	-0.01 %	0.29 %	0.07 %	-1.51 %
2005m12	0.05 %	0.17 %	0.96 %	-0.01 %	-0.02 %	0.02 %	-0.23 %	0.06 %	1.01 %
2006m1	-0.02 %	0.21 %	1.13 %	0.14 %	-0.01 %	-0.03 %	2.13 %	0.06 %	3.61 %
2006m2	0.46 %	-0.43 %	0.59 %	-0.11 %	-0.35 %	-0.35 %	-0.14 %	0.04 %	-0.29 %
2006m3	-0.16 %	-0.13 %	-0.16 %	0.02 %	-0.04 %	0.18 %	1.93 %	0.04 %	1.70 %
2006m4	-0.09 %	0.28 %	1.19 %	0.05 %	-0.19 %	0.76 %	-0.38 %	0.04 %	1.67 %
2006m5	-1.88 %	0.04 %	-0.56 %	0.04 %	0.01 %	0.04 %	-0.97 %	0.04 %	-3.23 %
2006m6	0.28 %	0.00 %	0.28 %	0.05 %	0.00 %	-0.13 %	-0.20 %	0.07 %	0.34 %
2006m7	0.03 %	-0.02 %	-1.19 %	0.01 %	-0.07 %	0.33 %	-2.10 %	0.06 %	-2.95 %
2006m8	-0.15 %	-0.20 %	-0.60 %	-0.15 %	0.02 %	-0.26 %	0.45 %	0.06 %	-0.84 %
2006m9	0.16 %	-0.16 %	1.85 %	-0.13 %	0.24 %	-0.62 %	-0.70 %	0.05 %	0.69 %
2006m10	0.29 %	-0.01 %	1.37 %	0.05 %	0.08 %	-0.04 %	0.88 %	0.05 %	2.68 %
2006m11	-0.49 %	-0.13 %	1.60 %	-0.29 %	0.28 %	0.00 %	0.37 %	0.05 %	1.41 %
2006m12	-0.24 %	-0.04 %	1.12 %	0.15 %	0.05 %	0.04 %	-0.45 %	0.06 %	0.69 %
2007m1	0.22 %	0.13 %	1.11 %	0.03 %	-0.20 %	-0.27 %	0.03 %	0.06 %	1.11 %
2007m2	-0.15 %	-0.13 %	0.16 %	-0.38 %	-0.22 %	-0.10 %	0.71 %	0.06 %	-0.06 %
2007m3	-0.08 %	-0.18 %	0.93 %	-0.01 %	0.23 %	-0.01 %	-0.14 %	0.05 %	0.79 %
2007m4	-0.25 %	0.47 %	-2.25 %	0.50 %	-0.29 %	0.02 %	-0.92 %	0.05 %	-2.68 %
2007m5	0.02 %	-0.19 %	2.46 %	-0.18 %	0.26 %	0.05 %	-0.01 %	0.04 %	2.45 %
2007m6	0.07 %	1.53 %	2.09 %	2.31 %	-1.66 %	-0.04 %	0.34 %	0.05 %	4.68 %
2007m7	-0.60 %	-0.12 %	1.41 %	1.08 %	0.90 %	0.07 %	-1.60 %	0.05 %	1.19 %
2007m8	0.70 %	-0.42 %	0.87 %	0.96 %	3.00 %	-0.07 %	-0.07 %	0.05 %	5.02 %
2007m9	-1.50 %	-0.16 %	-6.69 %	-0.74 %	1.30 %	0.39 %	-0.71 %	0.05 %	-8.06 %
2007m10	-0.90 %	-0.30 %	3.85 %	0.34 %	-2.09 %	0.25 %	0.06 %	0.05 %	1.42 %
2007m11	-0.64 %	-0.34 %	2.57 %	-0.60 %	3.82 %	0.47 %	-0.91 %	0.05 %	4.41 %
2007m12	0.23 %	0.11 %	-3.06 %	2.42 %	0.65 %	0.06 %	0.01 %	0.05 %	0.47 %

(Continued on next page)

	Return component								Total return
	USD	Bond	SP500	Credit	Mortgage	Commodity	SMB	Constant	
2008m1	0.21 %	0.23 %	0.50 %	0.06 %	1.52 %	0.19 %	-0.21 %	0.04 %	2.53 %
2008m2	-0.17 %	-0.08 %	-2.02 %	6.15 %	0.91 %	0.64 %	-0.24 %	0.03 %	5.22 %
2008m3	-1.19 %	0.05 %	-0.82 %	-0.49 %	2.94 %	1.15 %	-0.13 %	0.02 %	1.52 %
2008m4	0.07 %	-0.02 %	-2.21 %	0.27 %	-2.87 %	0.06 %	0.03 %	0.01 %	-4.64 %
2008m5	0.15 %	-0.08 %	1.60 %	-2.13 %	-3.12 %	0.43 %	0.36 %	0.03 %	-2.76 %
2008m6	-0.08 %	0.59 %	1.13 %	-0.31 %	-0.48 %	0.59 %	0.23 %	0.05 %	1.71 %
2008m7	-1.84 %	0.06 %	-1.06 %	0.04 %	1.04 %	0.09 %	-1.91 %	0.05 %	-3.54 %
2008m8	5.26 %	-0.06 %	-2.57 %	0.33 %	-0.24 %	-4.67 %	-2.02 %	0.04 %	-3.93 %
2008m9	1.17 %	-0.24 %	0.39 %	-1.10 %	-0.02 %	-1.82 %	0.21 %	0.05 %	-1.38 %
2008m10	1.57 %	-0.02 %	-0.11 %	7.62 %	0.39 %	-2.48 %	1.69 %	0.04 %	8.69 %
2008m11	2.23 %	-0.41 %	-0.15 %	2.87 %	0.20 %	-2.74 %	2.21 %	0.02 %	4.23 %
2008m12	-0.57 %	-0.38 %	-0.39 %	2.13 %	-0.43 %	-0.77 %	-1.45 %	0.01 %	-1.84 %
2009m1	0.25 %	-0.70 %	-0.03 %	-1.53 %	0.03 %	-0.35 %	0.36 %	0.01 %	-1.96 %
2009m2	0.23 %	0.12 %	-0.31 %	-0.83 %	-0.02 %	-0.45 %	0.10 %	0.01 %	-1.15 %
2009m3	0.17 %	0.29 %	-0.19 %	-1.03 %	-0.04 %	0.03 %	-0.23 %	0.01 %	-1.00 %
2009m4	-0.39 %	-0.22 %	-0.70 %	0.65 %	0.00 %	0.36 %	-1.99 %	0.01 %	-2.27 %
2009m5	0.11 %	0.02 %	1.19 %	-4.27 %	1.14 %	0.19 %	1.41 %	0.01 %	-0.21 %
2009m6	0.05 %	0.00 %	0.41 %	-3.65 %	1.12 %	0.54 %	-1.44 %	0.01 %	-2.96 %
2009m7	0.16 %	-0.01 %	0.66 %	-0.33 %	-0.05 %	-0.36 %	-1.56 %	0.01 %	-1.47 %
2009m8	0.06 %	0.18 %	0.11 %	-2.76 %	0.07 %	0.52 %	0.37 %	0.01 %	-1.45 %
2009m9	0.47 %	0.06 %	0.49 %	-1.01 %	-0.07 %	-0.05 %	-1.61 %	0.01 %	-1.70 %
2009m10	-0.05 %	-0.04 %	0.21 %	-0.57 %	0.20 %	0.09 %	1.20 %	0.01 %	1.04 %
2009m11	0.01 %	0.14 %	0.10 %	-0.15 %	0.21 %	-0.03 %	1.00 %	0.01 %	1.28 %
2009m12	-0.15 %	-0.03 %	0.00 %	-0.78 %	0.01 %	-0.07 %	-2.53 %	0.01 %	-3.54 %
2010m1	-0.04 %	-0.01 %	1.78 %	-1.28 %	0.60 %	0.02 %	-0.08 %	0.01 %	1.01 %
2010m2	-0.90 %	-0.16 %	-0.09 %	0.30 %	0.07 %	0.08 %	-0.39 %	0.01 %	-1.09 %
2010m3	0.01 %	0.02 %	-0.66 %	-0.40 %	0.32 %	-0.32 %	-0.55 %	0.01 %	-1.59 %
2010m4	-0.03 %	0.00 %	0.89 %	-0.19 %	0.35 %	-0.22 %	-1.76 %	0.01 %	-0.94 %
2010m5	-0.60 %	0.02 %	0.46 %	-0.66 %	-0.24 %	0.25 %	0.03 %	0.01 %	-0.73 %
2010m6	0.02 %	-0.21 %	-0.59 %	0.65 %	0.15 %	-0.02 %	0.71 %	0.00 %	0.71 %
2010m7	0.53 %	0.36 %	-0.08 %	-0.21 %	-0.39 %	0.04 %	-0.03 %	0.00 %	0.21 %
2010m8	-0.01 %	0.18 %	-0.09 %	-0.68 %	-0.24 %	-0.01 %	0.85 %	0.00 %	0.01 %
2010m9	0.06 %	-0.01 %	-0.15 %	0.10 %	0.00 %	-0.01 %	-1.02 %	0.00 %	-1.02 %
2010m10	0.42 %	0.11 %	0.59 %	-0.03 %	0.08 %	-0.12 %	-0.25 %	0.00 %	0.82 %
2010m11	-0.20 %	-0.32 %	0.59 %	0.44 %	0.28 %	-0.09 %	-0.96 %	0.00 %	-0.26 %
2010m12	0.22 %	-0.05 %	0.46 %	0.34 %	0.04 %	-0.02 %	-0.26 %	0.01 %	0.75 %
2011m1	-0.08 %	0.06 %	0.60 %	-0.70 %	-0.11 %	-0.18 %	0.65 %	0.00 %	0.24 %
2011m2	0.01 %	0.29 %	1.57 %	-0.06 %	0.49 %	0.14 %	-0.69 %	0.01 %	1.75 %
2011m3	0.28 %	-0.22 %	0.53 %	-0.19 %	-0.57 %	-0.50 %	-0.91 %	0.01 %	-1.58 %
2011m4	0.14 %	0.06 %	-0.85 %	-0.25 %	0.35 %	-0.95 %	0.10 %	0.01 %	-1.40 %
2011m5	-0.02 %	-0.20 %	0.50 %	-0.93 %	0.19 %	-0.98 %	0.10 %	0.00 %	-1.34 %
2011m6	-0.01 %	-0.10 %	0.45 %	-0.08 %	0.52 %	-0.06 %	0.01 %	0.00 %	0.74 %
2011m7	-0.05 %	0.05 %	-1.55 %	-0.20 %	-0.35 %	0.22 %	0.28 %	0.00 %	-1.60 %
2011m8	0.28 %	0.04 %	0.69 %	-1.57 %	0.09 %	-0.06 %	0.75 %	0.00 %	0.23 %
2011m9	-0.80 %	0.17 %	-0.87 %	1.15 %	-0.12 %	0.00 %	0.55 %	0.00 %	0.08 %
2011m10	-0.07 %	0.30 %	0.01 %	0.11 %	0.08 %	-0.50 %	-1.31 %	0.00 %	-1.38 %
2011m11	-0.17 %	-0.24 %	0.03 %	-0.56 %	-0.23 %	0.94 %	0.07 %	0.00 %	-0.15 %
2011m12	-0.22 %	0.14 %	0.07 %	0.07 %	0.08 %	-1.43 %	0.12 %	0.00 %	-1.16 %
2012m1	-0.16 %	-0.19 %	0.43 %	0.02 %	1.10 %	1.25 %	-0.75 %	0.00 %	1.69 %
2012m2	0.17 %	-0.17 %	-0.58 %	0.02 %	1.64 %	1.07 %	0.39 %	0.00 %	2.54 %
2012m3	-0.02 %	-0.03 %	-0.56 %	-0.12 %	1.85 %	0.67 %	0.03 %	0.00 %	1.81 %
2012m4	0.01 %	0.01 %	-0.62 %	0.20 %	-0.45 %	-0.77 %	0.05 %	0.00 %	-1.57 %

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	Return component								Total return
	USD	Bond	SP500	Credit	Mortgage	Commodity	SMB	Constant	
2012m5	-0.16 %	0.00 %	0.21 %	0.02 %	-0.56 %	-1.50 %	0.01 %	0.00 %	-1.98 %
2012m6	-0.04 %	0.01 %	0.42 %	-0.25 %	-0.56 %	-2.10 %	-0.07 %	0.00 %	-2.58 %
2012m7	-0.16 %	0.09 %	-0.18 %	0.17 %	0.56 %	1.92 %	0.25 %	0.00 %	2.66 %
2012m8	0.06 %	-0.04 %	-0.20 %	-0.07 %	1.26 %	1.67 %	-0.04 %	0.00 %	2.64 %
2012m9	0.28 %	0.00 %	-1.03 %	0.03 %	0.87 %	1.23 %	-0.12 %	0.00 %	1.26 %

Appendix 5 presents the return decomposition for HP replicator between January 2004 and September 2012. The variables are (1) *USD*: the U.S. Dollar index return; (2) *BOND*: the return on the Barclays intermediate corporate Bond (AA) index; (3) *SP500*: The SP500 total return, (4) *CREDIT*: The spread between Barclays intermediate corporate Bond (BAA) index and the Barclays U.S. 5 year treasury index; (5) *MORTGAGE*: The spread between GNME mortgage index and the Barclays U.S. 5 year treasury index; (6) *COMMODITY*: the return of SP GCSI Commodity index; and (7) *SMB*: The spread between small and large company spreads (Fama-French factor). Each beta coefficient is multiplied with the monthly return for the variable. The monthly return for the variable is each time periods last month's variable return. There is a total of 106 different time periods. The return for the hedge fund is regressed against the last 24 months for the variable.

APPENDIX 6 MONTHLY RETURN DECOMPOSITION FOR ALL REPLICATOR

	Return component								Total return
	USD	Bond	SP500	Credit	Mortgage	Commodity	SMB	Constant	
2004m1	1.16 %	1.30 %	-0.24 %	1.13 %	-0.84 %	-0.75 %	-0.01 %	-0.01 %	1.73 %
2004m2	0.56 %	-0.56 %	-0.78 %	-0.17 %	1.41 %	1.04 %	0.19 %	0.00 %	1.68 %
2004m3	-1.87 %	0.72 %	-0.14 %	0.18 %	-0.80 %	2.40 %	-0.19 %	0.00 %	0.30 %
2004m4	-0.86 %	-3.00 %	0.68 %	-0.54 %	2.42 %	0.83 %	-0.28 %	0.00 %	-0.76 %
2004m5	-1.21 %	-2.40 %	-0.41 %	-0.49 %	1.26 %	2.55 %	-0.01 %	0.00 %	-0.71 %
2004m6	1.32 %	-0.14 %	-0.02 %	0.60 %	-0.14 %	-2.80 %	-0.53 %	-0.01 %	-1.72 %
2004m7	0.25 %	0.64 %	0.62 %	0.37 %	-0.45 %	2.47 %	0.22 %	-0.02 %	4.08 %
2004m8	0.00 %	0.76 %	-0.23 %	0.83 %	-0.39 %	2.86 %	-0.11 %	-0.04 %	3.68 %
2004m9	-0.31 %	-0.04 %	-0.99 %	1.30 %	0.02 %	-2.58 %	0.31 %	-0.04 %	-2.32 %
2004m10	0.48 %	0.27 %	0.68 %	0.37 %	0.21 %	6.21 %	0.02 %	-0.03 %	8.20 %
2004m11	2.55 %	-1.16 %	0.12 %	0.91 %	1.58 %	-1.55 %	1.27 %	-0.03 %	3.67 %
2004m12	1.71 %	0.14 %	-1.86 %	0.98 %	0.35 %	-0.65 %	0.06 %	-0.11 %	0.62 %
2005m1	-1.07 %	-0.89 %	-0.24 %	0.14 %	1.74 %	0.41 %	-0.60 %	-0.15 %	-0.65 %
2005m2	-0.23 %	-0.11 %	-0.37 %	2.08 %	-0.36 %	-0.24 %	-0.14 %	-0.15 %	0.47 %
2005m3	0.60 %	-1.92 %	0.15 %	-1.42 %	3.03 %	2.43 %	-0.39 %	-0.14 %	2.35 %
2005m4	-1.05 %	0.34 %	-0.07 %	-0.67 %	-0.24 %	-0.70 %	-1.15 %	-0.08 %	-3.63 %
2005m5	-0.64 %	0.17 %	0.17 %	2.12 %	-0.38 %	-0.37 %	0.67 %	-0.06 %	1.68 %
2005m6	-0.78 %	0.40 %	0.16 %	-0.38 %	-0.01 %	1.10 %	0.77 %	-0.04 %	1.21 %
2005m7	-0.32 %	-0.06 %	0.56 %	-0.01 %	0.04 %	0.36 %	0.81 %	-0.05 %	1.33 %
2005m8	0.63 %	-0.45 %	0.24 %	0.05 %	0.19 %	1.07 %	-0.25 %	-0.06 %	1.43 %
2005m9	-0.18 %	0.23 %	0.09 %	-0.03 %	-0.08 %	0.09 %	-0.18 %	-0.04 %	-0.10 %
2005m10	-0.30 %	-0.97 %	-0.04 %	-0.19 %	0.30 %	-0.04 %	-0.25 %	-0.05 %	-1.54 %
2005m11	-0.29 %	-0.36 %	-0.47 %	-0.01 %	0.09 %	-0.42 %	0.29 %	-0.02 %	-1.21 %
2005m12	0.05 %	0.17 %	0.24 %	-0.01 %	0.03 %	0.20 %	-0.24 %	-0.03 %	0.41 %
2006m1	-0.02 %	0.21 %	0.44 %	0.15 %	0.00 %	-0.11 %	2.09 %	0.00 %	2.78 %
2006m2	0.17 %	-0.41 %	0.18 %	-0.02 %	-0.17 %	-0.43 %	-0.16 %	-0.01 %	-0.85 %
2006m3	-0.10 %	-0.16 %	-0.04 %	-0.02 %	-0.01 %	0.27 %	1.86 %	0.00 %	1.79 %
2006m4	-0.07 %	0.04 %	0.69 %	-0.15 %	0.16 %	0.73 %	-0.30 %	-0.01 %	1.09 %
2006m5	-1.72 %	0.01 %	-0.33 %	-0.05 %	-0.01 %	0.04 %	-0.75 %	0.00 %	-2.81 %
2006m6	0.25 %	-0.01 %	0.18 %	-0.01 %	0.00 %	-0.12 %	-0.17 %	0.00 %	0.12 %
2006m7	0.03 %	-0.03 %	-0.73 %	0.00 %	0.03 %	0.34 %	-1.95 %	-0.02 %	-2.31 %
2006m8	-0.14 %	-0.15 %	-0.38 %	-0.03 %	-0.01 %	-0.25 %	0.39 %	-0.01 %	-0.59 %
2006m9	0.14 %	-0.12 %	1.17 %	-0.03 %	-0.07 %	-0.62 %	-0.61 %	0.01 %	-0.14 %
2006m10	0.30 %	-0.01 %	1.00 %	0.02 %	-0.05 %	-0.01 %	0.74 %	0.00 %	2.00 %
2006m11	-0.44 %	-0.05 %	1.10 %	-0.04 %	-0.02 %	0.00 %	0.31 %	0.06 %	0.92 %
2006m12	-0.25 %	-0.01 %	0.76 %	0.02 %	0.00 %	0.03 %	-0.39 %	0.07 %	0.22 %
2007m1	0.26 %	0.09 %	0.77 %	-0.02 %	0.27 %	-0.32 %	0.02 %	0.09 %	1.17 %
2007m2	-0.25 %	-0.10 %	0.13 %	-0.02 %	0.10 %	0.01 %	0.48 %	0.09 %	0.43 %
2007m3	-0.13 %	-0.14 %	0.70 %	0.00 %	-0.18 %	0.01 %	-0.10 %	0.09 %	0.25 %
2007m4	-0.49 %	0.32 %	-1.73 %	0.00 %	0.42 %	0.07 %	-0.58 %	0.09 %	-1.89 %
2007m5	-0.05 %	-0.14 %	2.02 %	-0.10 %	0.04 %	0.04 %	-0.01 %	0.04 %	1.84 %
2007m6	0.22 %	1.19 %	1.72 %	1.36 %	-0.72 %	-0.04 %	0.22 %	0.05 %	4.00 %
2007m7	-0.86 %	-0.10 %	1.12 %	0.51 %	0.30 %	0.07 %	-1.12 %	0.07 %	0.01 %
2007m8	0.55 %	-0.39 %	0.72 %	0.46 %	0.94 %	-0.04 %	-0.06 %	0.06 %	2.23 %
2007m9	-1.19 %	-0.14 %	-5.69 %	-0.34 %	0.51 %	0.34 %	-0.62 %	0.04 %	-7.07 %
2007m10	-0.82 %	-0.22 %	3.42 %	0.13 %	-0.71 %	0.43 %	0.04 %	0.04 %	2.32 %
2007m11	-0.65 %	-0.20 %	2.29 %	-0.26 %	1.47 %	0.49 %	-0.66 %	0.03 %	2.52 %

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	Return component								Total return
	USD	Bond	SP500	Credit	Mortgage	Commodity	SMB	Constant	
2007m12	0.37 %	0.09 %	-3.03 %	1.14 %	0.28 %	0.06 %	0.01 %	0.02 %	-1.06 %
2008m1	-0.03 %	0.36 %	0.48 %	0.02 %	0.55 %	0.22 %	-0.21 %	0.00 %	1.37 %
2008m2	-0.03 %	-0.04 %	-2.18 %	3.82 %	0.56 %	0.52 %	-0.16 %	-0.01 %	2.48 %
2008m3	-0.94 %	0.04 %	-0.86 %	-0.32 %	2.13 %	1.05 %	0.11 %	-0.01 %	1.18 %
2008m4	0.06 %	-0.01 %	-2.08 %	0.18 %	-1.94 %	0.10 %	-0.29 %	-0.03 %	-4.01 %
2008m5	-0.17 %	-0.03 %	1.52 %	-1.68 %	-1.91 %	0.24 %	0.72 %	-0.05 %	-1.35 %
2008m6	-0.21 %	0.63 %	1.66 %	-0.25 %	-0.27 %	0.39 %	0.36 %	-0.06 %	2.25 %
2008m7	-1.00 %	0.01 %	-1.34 %	0.04 %	0.65 %	0.06 %	-0.84 %	0.00 %	-2.42 %
2008m8	2.13 %	-0.01 %	-3.14 %	0.29 %	-0.10 %	-2.97 %	-0.96 %	0.01 %	-4.74 %
2008m9	0.44 %	-0.06 %	1.11 %	-0.95 %	-0.04 %	-1.19 %	0.11 %	0.02 %	-0.57 %
2008m10	0.42 %	0.36 %	-0.93 %	6.50 %	0.47 %	-1.56 %	0.90 %	0.00 %	6.16 %
2008m11	1.08 %	-0.35 %	-2.19 %	2.32 %	0.23 %	-2.12 %	1.47 %	0.00 %	0.45 %
2008m12	0.17 %	-0.33 %	-0.61 %	1.71 %	-1.04 %	-0.59 %	-0.92 %	0.00 %	-1.61 %
2009m1	-0.09 %	-0.32 %	-0.05 %	-1.16 %	0.07 %	-0.27 %	0.25 %	0.00 %	-1.56 %
2009m2	0.06 %	0.07 %	-0.46 %	-0.65 %	0.54 %	-0.53 %	0.07 %	0.00 %	-0.89 %
2009m3	0.05 %	0.09 %	-0.32 %	-0.82 %	0.10 %	0.04 %	-0.18 %	0.00 %	-1.02 %
2009m4	-0.21 %	0.04 %	-0.96 %	0.51 %	0.04 %	0.47 %	-1.83 %	0.00 %	-1.94 %
2009m5	-0.02 %	0.05 %	1.38 %	-3.58 %	0.84 %	0.37 %	1.02 %	0.00 %	0.07 %
2009m6	-0.05 %	0.04 %	0.45 %	-3.09 %	0.79 %	0.95 %	-1.08 %	0.00 %	-1.99 %
2009m7	0.05 %	0.05 %	0.77 %	-0.29 %	-0.03 %	-0.71 %	-1.31 %	0.00 %	-1.48 %
2009m8	-0.03 %	0.25 %	0.13 %	-2.18 %	0.04 %	0.68 %	0.25 %	0.00 %	-0.86 %
2009m9	-0.12 %	0.07 %	0.64 %	-0.71 %	-0.04 %	-0.06 %	-0.91 %	0.00 %	-1.13 %
2009m10	-0.12 %	-0.09 %	0.00 %	-0.49 %	0.10 %	0.43 %	0.68 %	0.00 %	0.52 %
2009m11	-0.01 %	0.22 %	-0.01 %	-0.12 %	0.10 %	-0.12 %	0.61 %	0.00 %	0.67 %
2009m12	0.04 %	-0.04 %	0.00 %	-0.63 %	0.01 %	-0.17 %	-1.85 %	0.00 %	-2.65 %
2010m1	0.00 %	-0.02 %	0.03 %	-1.04 %	0.38 %	0.19 %	-0.06 %	0.00 %	-0.51 %
2010m2	-0.34 %	-0.11 %	0.05 %	0.23 %	0.07 %	0.13 %	-0.29 %	0.00 %	-0.26 %
2010m3	0.01 %	0.05 %	-0.31 %	-0.28 %	0.37 %	-0.12 %	-0.33 %	0.00 %	-0.63 %
2010m4	-0.01 %	0.00 %	0.67 %	-0.13 %	0.43 %	-0.13 %	-1.18 %	0.00 %	-0.35 %
2010m5	-0.52 %	0.03 %	0.41 %	-0.48 %	-0.33 %	0.31 %	0.02 %	0.00 %	-0.56 %
2010m6	0.02 %	-0.21 %	-0.60 %	0.48 %	0.19 %	-0.02 %	0.54 %	0.00 %	0.38 %
2010m7	0.62 %	0.52 %	-0.04 %	-0.16 %	-0.47 %	0.03 %	-0.02 %	0.00 %	0.48 %
2010m8	-0.05 %	0.31 %	-0.02 %	-0.55 %	-0.33 %	-0.01 %	0.74 %	0.00 %	0.10 %
2010m9	0.21 %	-0.03 %	-0.05 %	0.08 %	-0.01 %	0.06 %	-0.97 %	0.00 %	-0.70 %
2010m10	0.82 %	0.17 %	0.15 %	-0.02 %	0.13 %	0.12 %	-0.26 %	0.00 %	1.11 %
2010m11	-0.30 %	-0.40 %	0.21 %	0.42 %	0.41 %	0.00 %	-1.16 %	0.00 %	-0.82 %
2010m12	0.05 %	-0.32 %	0.28 %	0.32 %	0.14 %	0.07 %	-0.29 %	0.00 %	0.24 %
2011m1	-0.01 %	0.11 %	0.36 %	-0.69 %	-0.14 %	-0.01 %	0.78 %	0.00 %	0.40 %
2011m2	0.02 %	0.01 %	0.90 %	-0.04 %	0.49 %	0.06 %	-0.60 %	0.00 %	0.84 %
2011m3	0.18 %	-0.06 %	0.39 %	-0.13 %	-0.66 %	-0.28 %	-0.89 %	0.00 %	-1.43 %
2011m4	0.00 %	-0.01 %	-0.93 %	-0.20 %	0.17 %	-0.60 %	0.09 %	0.00 %	-1.47 %
2011m5	0.04 %	-0.02 %	0.66 %	-0.73 %	0.18 %	-0.80 %	0.10 %	0.00 %	-0.56 %
2011m6	-0.03 %	-0.04 %	0.56 %	-0.08 %	0.76 %	-0.04 %	0.02 %	0.00 %	1.16 %
2011m7	-0.09 %	0.02 %	-1.98 %	-0.21 %	-0.48 %	0.12 %	0.33 %	0.00 %	-2.28 %
2011m8	0.07 %	0.02 %	1.17 %	-1.46 %	0.33 %	0.01 %	0.83 %	0.00 %	0.97 %
2011m9	-0.48 %	0.08 %	-1.73 %	1.11 %	0.02 %	-0.01 %	0.69 %	0.00 %	-0.33 %
2011m10	-0.03 %	0.03 %	0.08 %	0.11 %	0.04 %	-0.44 %	-1.46 %	0.00 %	-1.66 %
2011m11	-0.10 %	-0.09 %	0.18 %	-0.53 %	-0.11 %	0.69 %	0.08 %	0.00 %	0.12 %
2011m12	-0.10 %	0.05 %	0.38 %	0.07 %	0.04 %	-1.00 %	0.15 %	0.00 %	-0.41 %
2012m1	-0.09 %	0.06 %	0.19 %	0.03 %	1.10 %	0.99 %	-0.91 %	0.00 %	1.37 %

(Continued on next page)

	Return component								Total return
	USD	Bond	SP500	Credit	Mortgage	Commodity	SMB	Constant	
2012m2	0.07 %	0.02 %	0.09 %	0.15 %	1.52 %	0.84 %	0.50 %	0.00 %	3.20 %
2012m3	-0.01 %	-0.10 %	-0.13 %	-0.18 %	1.83 %	0.53 %	0.05 %	0.00 %	1.99 %
2012m4	0.01 %	0.03 %	-0.20 %	0.18 %	-0.45 %	-0.58 %	0.15 %	0.00 %	-0.86 %
2012m5	-0.06 %	0.01 %	0.07 %	0.12 %	-0.61 %	-1.08 %	0.02 %	0.00 %	-1.52 %
2012m6	-0.02 %	0.05 %	0.18 %	-0.28 %	-0.57 %	-1.47 %	-0.20 %	0.00 %	-2.30 %
2012m7	-0.09 %	0.20 %	-0.08 %	0.17 %	0.57 %	1.31 %	0.62 %	0.00 %	2.70 %
2012m8	0.06 %	-0.05 %	-0.11 %	-0.06 %	1.38 %	1.07 %	-0.11 %	0.00 %	2.18 %
2012m9	0.32 %	0.01 %	-0.63 %	0.02 %	0.86 %	0.78 %	-0.14 %	0.00 %	1.23 %

Appendix 6 presents the return decomposition for All replicator between January 2004 and September 2012. The variables are (1) *USD*: the U.S. Dollar index return; (2) *BOND*: the return on the Barclays intermediate corporate Bond (AA) index; (3) *SP500*: The SP500 total return, (4) *CREDIT*: The spread between Barclays intermediate corporate Bond (BAA) index and the Barclays U.S. 5 year treasury index; (5) *MORTGAGE*: The spread between GNME mortgage index and the Barclays U.S. 5 year treasury index; (6) *COMMODITY*: the return of SP GCSI Commodity index; and (7) *SMB*: The spread between small and large company spreads (Fama-French factor). Each beta coefficient is multiplied with the monthly return for the variable. The monthly return for the variable is each time periods last month's variable return. There is a total of 106 different time periods. The return for the hedge fund is regressed against the last 24 months for the variable.