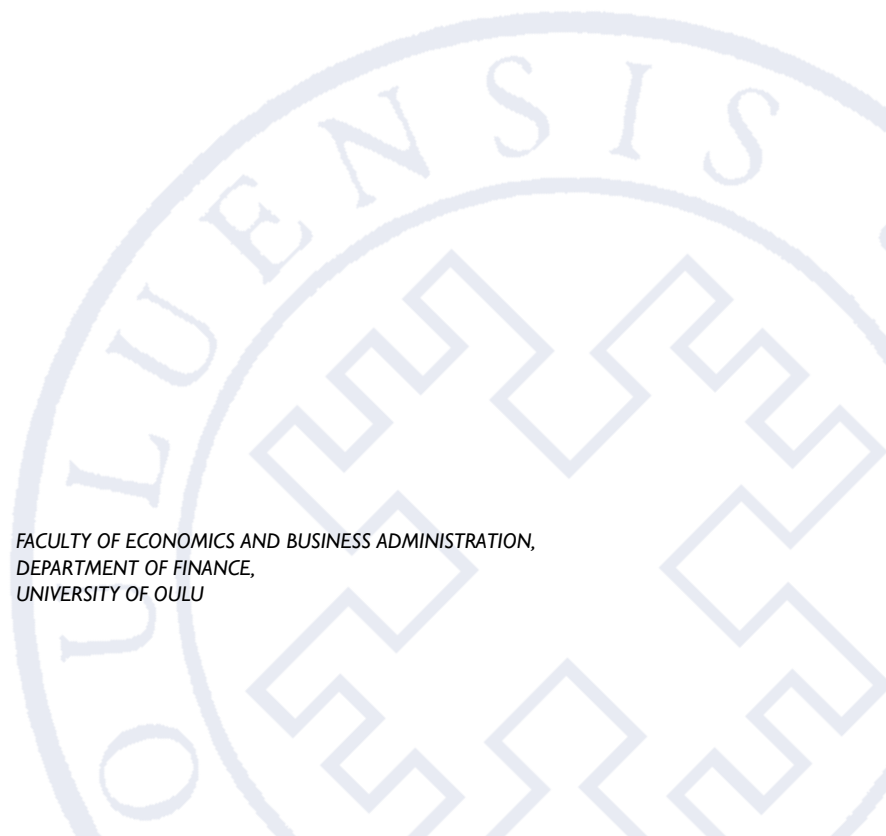


*Juha Joenväärä*

ESSAYS ON HEDGE FUND  
PERFORMANCE AND RISK

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OECONOMICA

FACULTY OF ECONOMICS AND BUSINESS ADMINISTRATION,  
DEPARTMENT OF FINANCE,  
UNIVERSITY OF OULU





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*JUHA JOENVÄÄRÄ*

**ESSAYS ON HEDGE FUND  
PERFORMANCE AND RISK**

Academic dissertation to be presented with the assent of the Faculty of Economics and Business Administration of the University of Oulu for public defence in Arina-sali (Auditorium TA105), Linnanmaa, on 25 September 2010, at 12 noon

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*Abstract*

This doctoral thesis aims to contribute to the literature on hedge fund performance and risk by conducting four interrelated essays. The first two essays measure and predict hedge fund performance using novel methodologies based on recent development in portfolio choice techniques. This new way to evaluate fund performance relies on economic theory and robust econometric principles. The first essay exploits hedge fund characteristics in order to pick right funds into a portfolio, whereas the second essay predicts hedge fund performance using conditional information that is contained in macroeconomic variables. The empirical analysis shows that the proposed conditional real-time portfolio strategies deliver significant outperformance over the unconditional benchmark strategy which does not utilize conditional information.

The third essay investigates whether a particular hedge fund with specific fund characteristics contributes to systemic risk and how hedge funds with a high systemic risk contribution perform during the times of financial distress. The findings suggest that the fund's capital structure is related to its systemic risk contribution, and, furthermore, that hedge funds with a high systemic risk contribution tend to deliver extremely poor performance during the times of financial distress.

The fourth essay examines the impact of share restrictions on hedge fund performance and risk-taking. The essay finds that hedge funds with a lockup period tend to take excess risk that is not compensated when performance is measured as a unit of risk taken by the hedge fund. In addition, the length of notice periods increases along with the illiquidity level of fund investments. Finally, hedge funds with a long notice period seem to be able to earn an illiquidity premium.

*Keywords:* active portfolio management, hedge fund performance, hedge fund risk-taking, systemic risk



## List of original essays

Essay one was co-authored with Professor Hannu Kahra. Both authors were involved in planning, designing and executing the study. Joenväärä's main responsibility was to perform the statistical analysis and to write the manuscript. Kahra focused in solving the optimization problem. Essay four was co-authored with Pekka Tolonen. The contribution of both authors was substantial. Specifically, both authors participated in planning, designing and executing the statistical analyses as well as writing the manuscript. Joenväärä's main responsibility was the part of the essay that is related to performance evaluation, while Tolonen concentrated on the part that examines the determinants of the share restrictions and hedge fund risk-taking.

- I Joenväärä J & Kahra H (2010) Investing in hedge funds when the fund's characteristics are exploitable. Manuscript.
- II Joenväärä J (2010) Predicting hedge fund performance using optimal portfolio weights. Manuscript.
- III Joenväärä J (2010) Hedge fund systemic risk contribution, capital structure and performance. Manuscript.
- IV Joenväärä J & Tolonen P (2010) Share Restrictions, Risk Taking and Hedge Fund Performance. Manuscript.





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Oulu, September 2010

Juha Joenväärä

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# 1 Introduction

## 1.1 Background

There is no generally accepted institutional definition for hedge funds or the investment strategies that they follow. Currently, hedge funds are a lightly regulated group of alternative investment vehicles that share common characteristics.<sup>3</sup> These commonalities arise from their performance-based compensation structure and the share restrictions that they tend to impose on capital withdrawals. Academic research (e.g., Agarwal *et al.* (2009) and Aragon (2007)) shows that variables related to hedge funds' compensation and share restrictions explain cross-sectional variation in risk-adjusted hedge fund returns.

The compensation of a typical hedge fund manager consists of assets under a management-based management fee and a performance-based incentive fee. The incentive fee is typically the subject to a high-water mark provision. Depending from the high water provision, each investor only pays an incentive fee when the value of their investment is greater than its previous maximum. Hence, hedge funds have an attractive compensation structure compared to mutual funds that usually earn only a small management fee.

Hedge funds can impose share restrictions such as lockup, redemption and advance notice periods. Share restrictions limit significantly hedge fund investors' liquidity making, hedge funds illiquid investments. Specifically, hedge funds can impose a lockup provision that specifies the period during which the investor is unable to withdraw her capital. At the end of the lockup period, it is possible to redeem the capital by giving an advantage notice signifying that the investor is willing to pull over her capital. However, the investor will receive the capital when the pre-specified redemption interval is at hand.

Hedge fund trading strategies differ significantly from each other. Some of the hedge funds employ dynamic trading strategies using a wide range of securities, while others rely on the concentrated long-term bets that are boosted by active corporate governance. The leverage and the way how it is implemented also varies significantly across hedge funds and their investment strategies.

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<sup>3</sup> Policymakers are moving towards a more tight regulation regime.

All of the hedge funds seem to have a common goal; they are seeking to generate superior performance in the form of alpha for their clients and owners. The alpha is commonly defined as a return that cannot be explained by the hedge fund's exposure to the systematic risk factors.<sup>4</sup> The pioneering work of Fung & Hsieh (2004) documents that hedge fund time-series returns are exposed to several systematic risk factors based on conventional asset classes and option-based strategies. However, it is not a trivial task to identify and forecast the hedge fund's alpha. Specifically, a large cross-section of hedge funds suggest that some of the top hedge funds outperform solely due to luck, not skill. In addition, the nature of hedge fund strategies implies that it is extremely difficult to model and estimate the joint distribution of hedge fund and benchmark returns.<sup>5</sup> This implies that hedge fund performance or alpha is often measured and predicted imprecisely with a large estimation error.

Empirical evidence suggests that historically it has been difficult to find funds that consistently beat the market on a risk adjusted basis. However, some hedge funds seem to outperform the market. Specifically, recent evidence (e.g., Fama & French (2010) and Barras *et al.* (2009)) suggests that mutual funds do not deliver consistently significant alpha, but, on the contrary, Fung *et al.* (2008), Jagannathan *et al.* (2010) and Kosowski *et al.* (2007) provide clear evidence that some of the hedge funds deliver superior performance that persists. One potential explanation is that the lucrative compensation contracts and the flexibility arising from share restrictions to employ innovative active portfolio management strategies imply that hedge fund industry should attract the most skilled fund managers. Still, several unexamined issues related to cross-sectional variation in hedge fund performance and risk demand rigorous further investigation.

## 1.2 Aim of the thesis

This doctoral thesis aims to contribute to the understanding of the determinants that explain and forecast cross-sectional variation in hedge fund performance and risk. For the purposes, the thesis conducts four essays that are related with each other.

The first two essays evaluate hedge fund performance using novel methodologies based on recent development in portfolio choice techniques. Specifically, the recent literature (e.g., At-Sahalia & Brandt (2001), Brandt (1999), Brandt *et al.* (2009) and

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<sup>4</sup>Ferson (2009) provides excellent keynote address on the problems of the definition of the alpha.

<sup>5</sup>The problems arise from the fact that it is difficult to identify common risk factors. In addition, typical hedge return time-series are short with non-linearities and autocorrelation.

Brandt & Santa-Clara (2006)) focuses directly on optimal portfolio weights by estimating them from the data. This implies that the error prone task to model and to estimate the conditional return distribution can be skipped. Doing so, the conditional portfolio weights are estimated more accurately than using the conventional two-step approach based on the estimated expected returns and covariance matrix of returns.

The new portfolio choice techniques should be even more relevant in measuring and predicting hedge fund performance than in solving portfolio choice problems. This is due to fact that the difficulties are emphasized when the conditional hedge fund return distributions have to be modeled and estimated. Indeed, there is an inherent short-sample problem in hedge fund returns, and hedge fund return means, volatilities and correlations tend to be highly time-varying. Hence, new ways to measure and predict hedge fund performance that can handle these problems relying on economic theory and robust econometric principles are of the first order importance both to the academic researchers and the practitioners.

The aim of the first two essays is to examine the issue by focusing on the following questions: What is an economically well-motivated and an econometrically robust approach to measure and predict hedge fund performance? Can hedge fund characteristics be exploited to pick superior hedge funds? Can macroeconomic information be utilized to identify outperforming hedge funds? Do these conditional strategies based on fund characteristics and macroeconomic variables outperform the unconditional strategy relying solely on historical performance?

The third essay aims to add to the understanding of the role of hedge funds in creating systemic risk in the financial system. While Brown *et al.* (2009) suggest that there is very little evidence that hedge funds create systemic risk in the financial system, hedge funds, however, have been associated with the systemic risk during the collapse of LTCM in the fall of 1998 and the recent financial crisis in 2007-2009. Importantly, Boyson *et al.* (2010) show that hedge funds at the aggregate level deliver extreme poor performance when an aggregate liquidity shock occurs. However, the cross-sectional differences in the performance of individual hedge funds during the times of financial distress are still an unexamined issue. Hence, the essay seeks an answer for two specific questions that are of great relevance especially among academic researches and regulators: Does a group of hedge funds with similar characteristics contribute to systemic risk in the financial system? If so, how do these systemically important hedge funds perform when a systemic event occurs?

The fourth essay investigates the impact of share restrictions on hedge fund performance and risk-taking. While it is clear from Aragon (2007) and Agarwal *et al.* (2009) that hedge funds' share restrictions, in general, explain variation in cross-sectional risk-adjusted returns, the importance and the roles of different share restrictions is still an unanswered question. Essay four aims to contribute to the understanding of the determinants that drive hedge fund managerial performance and risk-taking by shedding new light on the following questions: Why do hedge funds impose different share restrictions? Do different share restrictions have a similar impact on hedge fund risk-taking and performance?

The rest of the introductory chapter is organized as follows. Section 2 links the thesis to the economic theory. Section 3 discusses the contributions of the thesis and provides implications for investors and policymakers.



## 2 Theoretical motivation of the thesis

### 2.1 Theoretical motivation of essay one

The first essay proposes a new way in measuring and forecasting hedge fund performance based on the Brandt *et al.* (2009) approach.<sup>6</sup> The approach relies heavily on recent developments in portfolio choice approaches in which the conditional portfolio weights are estimated directly from the data. In this essay, the portfolio weights are parameterized as functions of fund characteristics, and then the parameters that maximize the expected utility are solved. Technically speaking, using this approach, the optimal portfolio weights can be obtained for each individual hedge fund. However, in practice, the portfolio weights can serve as a rank of a specific hedge fund when investors are selecting funds into their portfolios. Hence, the aim of the approach is to provide an optimal way to predict fund performance using the information contained in hedge fund characteristics.

The approach has important economic and econometric advantages that are particularly well-suited for hedge fund performance evaluation. The fact that the portfolio weights are optimized using power utility implies that hedge fund performance is measured under so called “manipulation-proof conditions”.<sup>7</sup> Specifically, Goetzmann *et al.* (2007) show that a performance measure that satisfies these conditions is difficult to game by employing informationless trading strategies that do not require managerial skills.<sup>8</sup> In addition, the approach is econometrically robust for model misspecification and estimation error, since the hedge fund portfolio weights are solved directly from the data without modeling and estimating the conditional return distribution. Indeed, the hedge funds’ optimal portfolio weights can be obtained by estimating only common parameters representing the hedge fund characteristics instead of a large number of parameters related to hedge funds’ expected returns, variances and covariances.

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<sup>6</sup>The essay differs significantly from Brandt *et al.* (2009), since they optimize a large portfolio of equities by exploiting the well-known value, momentum and size effects.

<sup>7</sup>According to the Goetzmann *et al.* (2007) manipulation-proof conditions, the performance measure must be, (i) increasing in returns to recognize arbitrage opportunities, (ii) concave to avoid increasing the performance measure via simple leverage or adding unpriced risk, (iii) time separable to prevent dynamic manipulation of the estimated measure, and (iv) have a power form to be consistent with an economic equilibrium.

<sup>8</sup>According to Weisman (2002), hedge funds follow commonly these informationless strategies in order to generate a “fake” alpha that does not pose any true investment skills.

The proposed approach utilizes information on hedge funds' managerial incentives, share restrictions and capacity constraints. Specifically, the portfolio weights are modeled as a function of the manager's option delta, notice period, and fund size.<sup>9</sup> Of course, the choice of fund characteristics is always somewhat arbitrary. The clear advantage of the used quantities is that their relation to the cross-sectional fund return distribution is based on economic theory and robust empirical evidence. Therefore, the relation should not be an artifact in the data, and the problems related to the data snooping bias are not the concern.

Specifically, agency and liquidity-based asset pricing theories and capacity constraints associated with the profitability of the fund's strategies help to understand why some hedge funds deliver higher expected returns than their peers. Based on the prediction of agency theory, Agarwal *et al.* (2009) find that hedge funds with higher managerial incentives measured using the fund's option delta deliver superior performance compared to their peers. Aragon (2007) shows that hedge funds with strict share restrictions in a form of long lockup, notice and redemption periods are able to earn an illiquidity premium.<sup>10</sup> As the Berk & Green (2004) equilibrium suggests, Teo (2009) documents robust evidence that smaller hedge funds tend to deliver higher future performance than their larger peers.<sup>11</sup> Hence, it is interesting to examine whether combining optimally information contained on these specific fund characteristics is a robust way to measure and forecast hedge fund performance.

The estimated parameters representing hedge fund characteristics suggest consistently with economic theory that it would be better to invest in a small fund with high managerial incentives and a long notice period than in a big fund with low managerial incentives and a short notice period. Importantly, the results show that the characteristics-based strategy adds value for investors. Specifically, we find an annual Fung and Hsieh (2004) alpha spread between the top and bottom quintiles ranging from 2.7 to 4.0 percent. In addition, we find that the characteristics-based strategy contains information over the naïve strategies that are based on the single sorts on the  $t$ -statistics of the Fung and Hsieh (2004) alpha, or the fund's characteristics that are used in forming the characteristics-based strategy. Finally, we find that the results are robust even for a

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<sup>9</sup>The manager's option delta is defined as the sensitivity of the manager's compensation to one percent increase in the fund's net asset value.

<sup>10</sup>According to Amihud *et al.* (2006), liquidity-based asset pricing predicts that both the level of liquidity and the liquidity risk should be priced.

<sup>11</sup>Berk & Green (2004) equilibrium suggests that fund performance suffers once the funds grow beyond a certain optimal size.

portfolio strategy that takes into account each fund's share restrictions, the lockup and notice periods as well as the redemption and subscription frequencies, in such a way that investors are able to apply the proposed strategy in a real time.

## 2.2 Theoretical motivation of essay two

Essay two evaluates and predicts hedge fund performance adapting from the recent developments in portfolio choice techniques based on the Britten-Jones (1999) and the Brandt & Santa-Clara (2006) approaches. The main proposition of the essay is that hedge fund performance can be measured and predicted using the  $t$ -statistic of the hedge fund's portfolio weight. Throughout the essay, the  $t$ -statistic of the hedge fund's portfolio weight is obtained by adding on a one by one basis a hedge fund to the portfolio of stocks, bonds and trend-following strategies derived from the Fung & Hsieh (2004) benchmark model. Instead of using fund-specific characteristics, the essay utilizes common macroeconomic variables in order to predict hedge fund performance.

This new way to measure and predict hedge fund performance has several methodological advantages. First, the approach is tightly linked to the standard way to measure fund performance using the fund's alpha, since the unconditional  $t$ -statistic of the fund's portfolio weight and that of alpha are equal with exactly the same magnitude. Hence, the standard approach to measure fund performance using the  $t$ -statistic of the fund's alpha is a special case of the proposed way to measure fund performance using the optimal portfolio weights.<sup>12</sup>

Second, extending the Britten-Jones (1999) approach hypothesises about the weights of the mean-variance portfolio can be tested.<sup>13</sup> Specifically, it is possible to examine which individual hedge funds or hedge fund strategies are the significant determinants of the portfolio policy, or which macroeconomic variables provide information that can be used in adjusting the hedge fund portfolio weights.

Third, hedge fund performance is predicted using the conditional  $t$ -statistic of the fund's portfolio weight. The conditional information is based on the macroeconomic variables that are incorporated in an economically meaningful way. Following the Brandt & Santa-Clara (2006) approach, the asset space is augmented with mechanically

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<sup>12</sup>Recent papers (e.g., Barras *et al.* (2009), Fama & French (2010) and Kosowski *et al.* (2006)) suggest that the fund's performance should be measured using the  $t$ -statistic of alpha obtained from the benchmark model.

<sup>13</sup>In principle, hypotheses can be tested using more flexible utility functions that capture also different preferences than the quadratic utility over the investors wealth.

managed portfolios that are constructed along the lines of Hansen & Richard (1987).<sup>14</sup> In other words, I model the portfolio weights directly as functions of the state variables, and I then solve the coefficients of these functions that maximize the investor's utility. This also implies that the approach is econometrically robust, since the extremely difficult task to estimate the conditional return distribution can be skipped.<sup>15</sup>

Finally, the Britten-Jones (1999) approach leads itself naturally to testing whether a particular hedge fund is a closet index fund. Economically, a closet index fund more or less tracks a benchmark index, and earns high fees without adding true value to investors. The test procedure is based on a well-known statistical metric called the variance inflation factor (VIF). This test is particularly well-suited for hedge funds, because it only needs as inputs returns on a specific hedge fund and benchmark assets. This is a clear advantage, since hedge fund holdings are not generally available for investors and researchers.

The overall empirical results show that hedge funds are significant determinants of the portfolio policy and that the portfolio weights vary significantly across hedge fund investment strategies. In addition, the hedge fund portfolio weights can be predicted using macroeconomic variables such as volatility, fund aggregate flow and default spread. Specifically, the portfolio weights in the emerging markets, the event driven and the fixed income arbitrage strategies show significant portfolio weight predictability. On the contrary, the portfolio weights in the strategies that employ directional trades, especially managed futures, is hard to predict using a current set of macroeconomic variables. Finally, I find that only an insignificant proportion of hedge funds seem to be closet index funds.

Finally, the results suggest that the information contained on macroeconomic variables can be utilized in picking the right hedge funds into a portfolio. Specifically, conditional strategies that are formed based on the conditional  $t$ -statistic of the fund's optimal portfolio weight outperform marginally the unconditional benchmark strategy relying solely on historical performance. However, the combination strategy that incorporates the portfolio weight predictability based on a set of macroeconomic variables outperforms all of the conditional strategies based on a single state variable as well as the unconditional strategy. One potential explanation is that the estimation

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<sup>14</sup>Technically speaking, the mechanically managed portfolios are formed by multiplying hedge fund returns by a lagged state variables that contains information on macroeconomic conditions.

<sup>15</sup>Avramov *et al.* (2010) provide clear evidence that it is extremely difficult to forecast hedge fund returns and alphas due to the estimation error and model instability.

error and the risk of model misspecification can be reduced by using a combination of predictors, and each macroeconomic variable may contain unique information.

## 2.3 Theoretical motivation of essay three

The essay aims to contribute to the understanding of the role of hedge funds in generating systemic risk in the financial system. Specifically, the essay focuses on two issues by investigating whether a group of hedge funds that share similar characteristics creates systemic risk in the financial system, and how individual systemically important hedge funds' perform especially when a systemic risk event occurs.

Both academics and regulators propose that a new financial regulation regime should be based on macro-prudential regulation that takes into account systemic risk, *i.e.*, the risk that the stability of the financial system as a whole is threatened. Current financial regulation is based on micro-prudential regulation that concentrates to limit each institution's risk in isolation. The shortcoming of the current financial regulation is the fact that it is based on risk measures like value-at-risk that do not capture risk spillovers across financial institutions.

In this essay, hedge funds' systemic risk is measured using an approach related to the Acharya *et al.* (2010) and Adrian & Brunnermeier (2009) approaches.<sup>16</sup> The definition of a systemic risk measure follows closely Adrian & Brunnermeier (2009), since the measure is estimated using their simple quantile regression approach. Specifically, hedge funds' systemic risk is measured using a co-expected shortfall (*CoES*), which is defined as a hedge fund's expected shortfall conditional on the whole financial system being in distress. In addition, the hedge fund's marginal systemic risk contribution is obtained as a difference of the conditional and unconditional expected shortfall (*ES*) of the whole financial system. Importantly, a hedge fund with a high estimated systemic risk contribution is classified to be systemically important.

The economic motivation of the used systemic risk measure is based on the theoretical work of Acharya *et al.* (2010). The main assumption of their model is that the externality that is imposed by a financial institution depends on the aggregate capital shortfall in the financial industry. The model predicts that the level of systemic risk should vary cross-sectionally on the financial institution's expected equity return conditional on a systemic event, and on the financial institution's leverage. Unfortunately, based on two

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<sup>16</sup>This essay differs significantly from both papers, since they focus on other financial institutions like banks, not on hedge funds as this essay does.

reasons these predictions about the role of leverage are difficult to verify empirically in case of hedge funds. A typical hedge fund's capital structure is not similar to other financial institutions like banks. Liu & Mello (2009) show using a theoretical model that hedge funds' capital structure is fragile mainly due to the facts that the equity can be redeemed at investors' discretion and prime brokers may impose strict limits on leverage and reduce the availability of credit. In addition, it is extremely difficult to measure hedge funds' leverage due to limited data and the complexity of hedge fund leveraging strategies. Therefore, the cross-sectional variation of the hedge fund's systemic contribution is explained using several variables that are related to the fund's capital structure instead of using only the level of the hedge fund's leverage.

The overall empirical results suggest that hedge funds' systemic risk contribution varies significantly based on fund characteristics related to the capital structure such as the fund's size, asset liquidity and leveraging instrument. In addition, the determinants of the hedge fund's systemic risk contribution and financial risk exposure measured using the value-at-risk approach differ significantly from each other. Hence, hedge funds that contribute to systemic risk are not necessarily exposed to high financial risk. This implies that a particular hedge fund's capital adequacy based on the traditional risk measure such as value-at-risk may be very different compared to a case when it is determined by taking systemic risk contribution into account using the macro-prudential risk measure.

Finally, the essay documents that a hedge fund lagged systemic risk contribution is an important determinant in the cross-section of hedge fund returns. Specifically, the essay finds that systemically important hedge funds deliver significantly lower risk-adjusted returns than their peers especially during the times of financial distress. Importantly, the results suggest that the systemically important hedge funds delivered extremely low returns during the LTCM episode and the financial meltdown in the fall of 2008, but not in the summer of 2007 when the Quant crisis took place.

## **2.4 Theoretical motivation of essay four**

Essay four investigates the impact of hedge funds' share restrictions on the risk-taking and the performance of hedge funds. Contrary to mutual funds that provide daily liquidity for their investors, hedge funds tend to impose share restrictions in a form of lockup, redemption and notice periods in order to limit investors' liquidity. Share restrictions are imposed at the inception of the fund and those are not usually changed

during the life of the fund suggesting that there are no endogeneity problems.<sup>17</sup> Hence, the hedge fund industry provides a fertile laboratory to study empirically theories related to the limits of arbitrage and liquidity-based asset pricing.

Specifically, hedge funds may impose a lockup period suggesting that during that time investors are not allowed to redeem their shares. In order to withdraw their capital, investors have to give an advance notice that they are willing to redeem. Thereafter, investors have to wait until the pre-specified redemption interval is at hand. A typical hedge fund imposes a one-year lockup period, a one-month notice period and provides quarterly redemptions.

The limits of arbitrage arguments proposed by Shleifer & Vishny (1997) and liquidity-based asset pricing may explain why hedge funds impose share restrictions. The security prices might diverge from economic value longer than a hedge fund can stay solvent due to funding risk. Therefore, hedge funds with strict share restrictions may exploit this mispricing, since their funding risk is not so severe arising from the fact that investors cannot redeem their capital at first glance. Indeed, Stein (2005) shows that, in theory, investment funds with a daily liquidity may make both fund managers and investors worse off. However, due to agency problems, in practice, funds cannot credibly communicate to investor by choosing to offer contracts that give themselves less favorable terms in the form of share restrictions such as a lockup provision. Finally, the liquidity-based asset pricing theory predicts that both the level of liquidity and the liquidity risk should be priced. Therefore, hedge funds with strict share restrictions may pursue illiquid strategies earning a premium, in the form of a higher expected return. Finally, the empirical evidence suggests that share restrictions, in general, explain hedge fund cross-sectional returns. Specifically, Aragon (2007) and Agarwal *et al.* (2009) document that hedge funds with severe share restrictions deliver, on average, higher returns than their peers.

In this essay, we argue that share restrictions differ fundamentally from each other. Therefore, we hypothesize that they should have a different impact on hedge fund risk-taking and performance. Specifically, a notice period is the only restriction that gives specific information about investors' aims to withdraw their investment. Therefore, we expect that hedge funds with a long notice period should manage illiquid assets more efficiently than their peers with a short notice period. On the contrary, a long lockup

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<sup>17</sup>Aragon (2007) and Agarwal *et al.* (2009) make this assumption and test it. However, anecdotal evidence suggests that the assumption is questionable, since hedge funds have changed their share restrictions during the financial crisis of 2007-2009.

period provides hedge funds flexibility to pursue a wide range of arbitrage strategies or simply take more risk. Hence, it is interesting to examine the risk-taking and the performance of hedge funds that impose a lockup period.

The overall results suggest that the impact of hedge funds' share restriction on hedge funds' risk-taking and performance differs significantly across share restrictions. We find that hedge funds with a long notice period tend to pursue illiquid strategies, while hedge funds that choose a high risk level also impose long lockup periods. Hence, our results suggest that the notice period is associated with illiquidity, whereas the lockup period is related to risk-taking. In addition, we find that hedge funds with a lockup take more risk, which is not compensated especially when their performance is measured as a unit of risk taken by the hedge fund.



## 3 Contributions and implications of the thesis

### 3.1 Contributions

The first two essays contribute to the investment performance literature by measuring and predicting hedge fund performance using novel methodologies based on recent developments in portfolio choice techniques. The empirical applications of both essays suggest that the proposed approaches provide an economically well-motivated and econometrically robust way to utilize conditional information based on either fund-specific characteristics or common macroeconomic variables.

The first two essays make several methodological contributions by showing that recent developments in portfolio choice techniques are particularly relevant to hedge fund performance evaluation. Specifically, the first essay extends the Brandt *et al.* (2009) approach to hedge fund performance evaluation. The proposed approach provides an optimal way to exploit information that is contained in hedge fund characteristics. Specifically, investors can combine optimally the information contains of economically motivated fund characteristics. They are more like to end up to selecting into their portfolios small hedge funds with high managerial incentives, and a long notice period. In addition, the proposed performance measure satisfies the Goetzmann *et al.* (2007) “manipulation-proof conditions”. Hence, the essay takes the first attempt to predict hedge fund performance using a measure that is difficult to game using the informationless strategies, and that utilizes optimally conditional information based on fund-specific characteristics.

The second essay extends the Britten-Jones (1999) and the Brandt & Santa-Clara (2006) portfolio choice techniques to hedge fund performance evaluation. First, it is important to note that the proposed approach is tightly linked to the standard way to measure fund performance using the fund’s alpha, since it can be shown that the unconditional  $t$ -statistics of the fund’s portfolio weight and alpha are equal with exactly the same magnitude. Therefore, the standard approach to measure fund performance using the  $t$ -statistic of the fund’s alpha is a special case of the proposed way to measure fund performance using the optimal portfolio weights.

Second, the Britten-Jones (1999) approach is extended to economically well-motivated hypotheses about the optimal portfolio weights of hedge funds and benchmark

assets. Indeed, it is used to test hypotheses between two extremes; whether the individual hedge fund's portfolio weight differs significantly from zero, or whether portfolio weights for benchmark assets (Fung and Hsieh (2004) factors) are jointly zero. The former extreme test indicates that the investor is able to make a discrete decision whether she should invest in a particular fund, while the latter extreme test indicates implicitly whether the investor should place all of her wealth on a particular hedge fund.

Third, the existing literature is extended by a return-based closed index test. Specifically, the Britten-Jones (1999) approach lends itself to multicollinearity test, which can be used in identifying closed index funds that track benchmark indices. It is worth noting that Cremers & Petäjistö (2009) examine closed indexing in the mutual fund industry using a measure that is based on fund holdings. However, their approach cannot be applied to hedge funds, since hedge funds' holdings are not generally available.

Finally, the essay adds to the existing literature by proposing that hedge fund performance can be predicted using the conditional  $t$ -statistic of the hedge fund's portfolio weight. The conditional information is incorporated in an economically meaningful way by following the Brandt & Santa-Clara (2006) approach that is based on the use of mechanically managed portfolios that are formed along the lines of Hansen & Richard (1987). The empirical results suggest that a portfolio strategy based on the conditional  $t$ -statistic of the hedge fund's portfolio weight delivers significant outperformance over an unconditional benchmark strategy. Hence, the proposed approach provides a robust way to predict hedge fund performance using macroeconomic variables.

The third essay contributes to the understanding of the role of hedge funds in generating systemic risk in the financial system. The first main empirical finding suggests that hedge funds' systemic risk contribution varies significantly based on fund characteristics such as investment strategy, leveraging instruments and the level of asset liquidity. While recent literature (e.g., Boyson *et al.* (2010)) provides clear evidence on hedge fund contagion that is magnified during the liquidity shocks, they, however, explain hedge fund contagion using only aggregate variables related to funding and asset liquidity based on the Brunnermeier & Pedersen (2009) model's predictions. This essay differs significantly from the previous literature since it uses fund characteristics such as investment strategy, leveraging and the level of asset liquidity based on the theoretical work of Xiong (2001), Liu & Mello (2009) and Dai & Sundaresan (2009) to explain cross-sectional differences in the hedge fund systemic risk contribution. Hence, the essay sheds light on a more specific issue whether a group of hedge funds sharing

similar characteristics contribute to systemic risk compared to the case when the hedge funds' relation to the systemic risk is examined using aggregate level data, only.

The results concerning the role of different hedge fund characteristics are tightly linked to the theoretical work of several papers. The theoretical analyses of Xiong (2001) and Fung & Hsieh (2001) may provide an explanation why the systemic risk contribution is the highest for fixed income arbitrage funds and the lowest for managed futures funds. According to Xiong's (2001) model, spread-traders reduce asset price volatility and provide liquidity by taking risky positions against noise traders. However, when an unfavorable shock, like systemic event, occurs, spreads may not converge, thereby spread-traders may suffer capital losses and even amplify the original shock. On the other hand, Fung & Hsieh (2001) show theoretically that trend-followers can exploit these widening spreads using lookback straddle option strategies, which capture the spread between the different asset prices providing high profits when spreads are wide. Finally, it is important to note that the essay fails to provide any empirical evidence supporting the prediction of the Acharya *et al.* (2010) model concerning the role of the hedge funds' leverage. The findings show clearly that the funds' average and maximum leverage levels are not related to the fund's contribution to systemic risk. The theoretical work of Liu & Mello (2009) may explain these results, since they show that it is not optimal for hedge funds to take excess leverage. The alternative explanation is the quality of the data, since the time-varying levels of leverage are not available for researchers.

The second empirical main finding suggests that hedge funds' systemic risk contribution is not tightly linked to the hedge funds' financial risk that is measured using the traditional risk measure such as value-at-risk. The finding adds to recent literature (e.g. Gupta & Liang (2005)) suggesting that the majority of hedge funds fulfill the proposed capital requirements. However, these new findings suggest that a particular hedge fund's capital adequacy based on the traditional value-at-risk approach may be very different compared to a case when it is determined using a measure that takes systemic risk into account. Hence, this essay sheds some light on hedge funds' proposed capital requirements. Since when the capital requirements are imposed to protect the financial system, not to protect investors, they should be based on a macro-prudential systemic risk measure that internalizes externalities.

The third empirical main finding shows that there is a significant cross-sectional relation between the systemic risk contribution and the hedge fund returns. Importantly, this relationship is magnified during the times of financial distress. These findings add

to the existing literature on hedge fund liquidity, correlation and extreme risks. It is clear from recent papers (e.g., Sadka (2009), Buraschi *et al.* (2009), and Bali *et al.* (2007) ) that hedge funds are exposed to liquidity, correlation and extreme risks. This essay differs from those by showing that the fund's lagged systemic risk contribution explains the cross-section variation in the hedge fund returns, and that the relationship is magnified during the times of financial distress. Importantly, the results provide clear support for the theoretical work of Acharya *et al.* (2010) suggesting that the hedge funds' systemic risk contribution should vary cross-sectionally on the fund's expected equity return conditional on a systemic event.

The forth essay contributes to the understanding of the role of share restrictions in managerial performance and risk-taking. The hedge fund industry provides an ideal test setting, because, in contrast to mutual funds, hedge funds are organized in various different ways that may be associated with managerial performance and risk-taking. Specifically, the role of asymmetric information between managers and investors is emphasized in the hedge fund industry because of the lucrative nature of hedge fund manager compensation, the high degree of share restrictions and the secretive nature of hedge fund strategies and positions.

While Agarwal *et al.* (2009) and Aragon (2007) show that hedge funds with strict share restrictions deliver superior performance compared to their peers, it not clear how different hedge funds' share restrictions impact on managerial risk-taking and performance. The essay adds to the existing literature by documenting several findings related to this issue. The results suggest that hedge funds tend to impose lockup periods when they take excess risk, but when they invest in illiquid assets they tend to impose longer advance notice periods. Since a notice period is a rolling restriction, it may help the hedge funds to manage illiquid investments more efficiently. This implies that hedge funds with a long notice period are able to earn an illiquidity premium, i.e., a higher return than its peer with a short notice period. On the other hand, a lockup period only determines the period during which the investor's initial investment cannot be withdrawn, but does not give any specific information to managers about the timing when the investors intend to withdrawn their investment. Hence, it may not help hedge funds to manage illiquid assets more efficiently.

Finally, some of the results concerning the role of lockup provision are contrary to the studies of Agarwal *et al.* (2009) and Aragon (2007). However, a large set of robustness checks suggest that the results should not be an artifact in data. Unfortunately,

the essay uses only the HFR database in the study suggesting that the representativeness of the data set is a major concern.

Taken together, the thesis contributes significantly to the understanding of the determinants that drive and forecast cross-sectional differences in hedge fund performance, risk-taking and systemic risk contribution. Specifically, the two first essays add to the existing literature by showing that the recent developments in portfolio choice techniques are particularly well-suited for measuring and predicting hedge fund performance. The third essay contributes by documenting that fund characteristics related to capital structure are significant determinants of the funds' systemic risk contribution. In addition, the lagged fund's systemic risk contributions forecast cross-sectional differences in hedge fund performance. Finally, the fourth essay finds significant differences in the roles of hedge funds' share restrictions in explaining hedge fund performance and risk-taking.

### **3.2 Implications for investors**

According to the Deutsche Bank 2010 Alternative Investment Survey, hedge fund investment performance and risk management process are the two most important factors driving investors' decisions to invest in a hedge fund. Given that all the four essays focus on hedge fund performance and risk, the thesis provides important implications for hedge fund investors like pension funds and high-net-wealth individuals. The empirical results suggest that the proposed methodologies are particularly well-suited for investors as part of their quantitative due diligence process.<sup>18</sup> Specifically, the thesis provides a set of quantitative tools that help investors to predict hedge funds' future performance and to assess hedge funds' risks properly.

To evaluate and measure hedge fund performance and risk, it is important to take realistically into account database biases and hedge funds' special properties that have an impact on the decisions to invest in hedge funds. Since hedge funds report voluntarily to the databases, they can potentially suffer from several biases. These database biases such as survivorship bias, backfilling bias, self-selection bias, and stale price bias, can have a significant impact on hedge funds' performance and risk measures.<sup>19</sup> Furthermore, it is important to emphasize that hedge fund investing differs significantly from investing in many conventional asset classes like equities. For example, a typical fund of hedge

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<sup>18</sup>As, e.g., Brown *et al.* (2008a) and Brown *et al.* (2008b) point out, the proper performance due diligence process is an important source of alpha for hedge fund investors.

<sup>19</sup>Agarwal & Naik (2005) and Fung & Hsieh (2006) provide comprehensive surveys about hedge fund database biases.

funds portfolio includes 10-50 hedge funds, while a well-diversified equity portfolio may contain thousands of stocks.<sup>20</sup> Importantly, hedge funds tend to impose share restrictions that have a significant impact on the possibilities to rebalance a portfolio and to trade hedge funds dynamically. In addition, there is not usually any possibility to sale short hedge funds. Finally, hedge fund database biases and special properties are addressed in throughout the essays by conducting an empirical analysis under so realistic a setting as possible.

The first two essays propose and show that new methodologies based on recent developments in portfolio choice approaches are particularly useful for hedge fund investors in measuring and predicting hedge fund performance. Using yearly rebalanced buy-and-hold strategies, the essays show that the real-time investors can utilize conditional information based on hedge fund-specific characteristics and macroeconomic variables. Specifically, the results suggest that the real-time investors can select the most attractive hedge funds into the portfolio and make hedge fund style allocation decisions based on macroeconomic information. It is worth noting that the proposed approaches can be easily extended investor-specific so that they are particularly well-suited for the investor's purposes. For example, the investor could use other hedge fund characteristics, which are in their first order of importance, to help in making the investment decision. On the other hand, the current set of macroeconomic variables could be extended with variables that are linked more tightly with investors' preferences.

The third essay provides a diagnostic tool that could be used as part of hedge fund investors' risk management process. Specifically, the results show that hedge funds with a high systemic risk contribution tend to deliver extremely low risk-adjusted returns during the times of financial distress. Since hedge fund systemic risk contribution is highly persistent and related to a certain type of hedge fund characteristics, it would be optimal to reduce allocation to these kind of hedge funds when the probability of a systemic event is high. Unfortunately, dynamic trading strategies based on this signal may be hard to implement, since the funds with a high systemic risk contribution tend to impose tight share restrictions to redemptions.

The forth essay documents that a certain type of hedge funds' share restrictions has a significant impact on hedge fund performance and risk-taking. Perhaps, due to increased flexibility, hedge funds with a lockup provision tend to take excess risk, which is not compensated as a superior performance. On the other hand, hedge funds with a long

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<sup>20</sup>The Deutsche Bank 2010 Alternative Investment Survey documents that a typical hedge fund portfolio contains 10-50 funds.

notice period seem to invest in illiquid assets. Probably, due to the fact that the notice period is a rolling restriction, it allows hedge funds to manage illiquid investments more efficiently and earn an illiquidity premium. Therefore, investors should pay attention that hedge funds' share restrictions are placed to match their liabilities and the level of asset liquidity. Specifically, strict share restrictions may help a hedge fund with illiquid assets to ride over a market turbulence. On the other hand, agency problems are highlighted when hedge funds impose tight share restrictions. Therefore, investors should not accept the fact that hedge funds do not allow redeem for their capital on demand.

Finally, it is important to emphasize that quantitative due diligence process may also have significant shortcomings, since it may not detect frauds that are common in the hedge fund industry.<sup>21</sup> Therefore, before investing in hedge funds that show an attractive historical performance, the investors should also perform a careful qualitative due diligence process verifying that the hedge fund's investment process is based on meaningful economic principles and that the hedge fund is not a fraud.<sup>22</sup>

### **3.3 Implications for regulators**

The essay aims to provide insight to regulators which hedge funds are likely to be systematically important.<sup>23</sup> This kind of information is particularly relevant for regulators, since the regulation regime is going towards macroprudential regulation focusing on the financial institutions' systemic risk. The overall results in essay three suggest that market-based systemic risk measure provides information that regulators could use as part of their process in identifying systemically important hedge funds.

Alternative investment vehicles such as hedge funds will also face tighter regulation.<sup>24</sup> Specifically, both regulators in the US and Europe are planning to impose new rules in protecting the financial system in hedge fund activities and in preventing hedge fund frauds. According to the rules, hedge funds over a certain asset under management

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<sup>21</sup>The most famous fraud is the Ponzi scheme organized by Bernard Madoff, who was the non-executive chairman of the NASDAQ stock market.

<sup>22</sup>Of course, quantitative tools could be used to detect a fraud. Specifically, Bollen & Pool (2010) develops a set of performance flags, based on suspicious patterns in returns, as indicators of a heightened risk of fraud.

<sup>23</sup>Hedge funds are classified to be systemically important when their estimated systemic risk contribution is high.

<sup>24</sup>Specifically, US Senate is passing the Restoring American Financial Stability Act of 2010 and the European Parliament is finalizing the new Alternative Investment Fund Managers (AIFM) Directive. Both US Act and European Directive should obtain the status of law during the 2010.

threshold have to register with SEC in the US and with local regulators in Europe.<sup>25</sup> It looks like that hedge funds have to release information on several variables such as the amount of asset under management, the use of leverage, and counterparty risk credit risk exposure. The information contents of these variables are used to assess a particular hedge fund's systemic risk. In addition, regulators in Europe focuses on hedge funds' capital adequacy implying that a hedge fund has to demonstrate that it has the required minimum level of capital.<sup>26</sup>

While this extensive set of variables related to hedge fund activities helps regulators to identify systemically important hedge funds, essay three suggests that the market-based systemic risk measure provides information that may also be useful for regulators. Specifically, the results show that hedge funds with a high systemic risk contribution deliver lower returns and Fung & Hsieh (2004) alphas. In addition, hedge fund's systemic risk contribution is highly persistent and related to specific fund characteristics. This suggests that regulators could use this kind of measure in identifying systemically important hedge funds. A clear advantage of a continuous market-based measure is the fact that it is hard to game such a market-based measure. Instead, when the rules are based solely on the information that hedge funds have to release, they have an incentive to undertake regulatory arbitrage in order to obtain a lighter regulation regime.

Finally, the essay finds that hedge funds with a high systemic risk are not necessarily risky in isolation. Therefore, it is likely the proposed capital requirements relying solely on the value-at-risk approach do not capture hedge funds that contribute significantly to systemic risk. Since the regulators aim to focus on limiting systemic risk, they should also take into consideration hedge funds' systemic risk contribution.

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<sup>25</sup>In US the threshold is 100 million dollars asset under management, while it is 100 (500) million euros asset under management in Europe for (un)leveraged hedge funds.

<sup>26</sup>The required capital is 125,000 euros plus 0.02 percent for assets above 250,000 euros.



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