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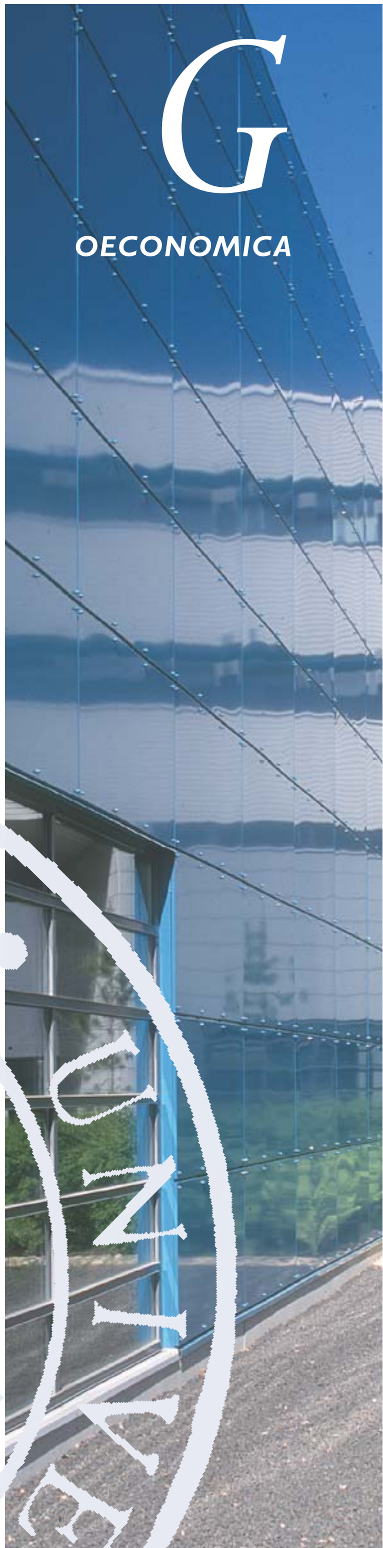

Pekka Tolonen

THREE ESSAYS ON HEDGE FUND PERFORMANCE

*UNIVERSITY OF OULU GRADUATE SCHOOL;
UNIVERSITY OF OULU, OULU BUSINESS SCHOOL,
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PEKKA TOLONEN

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Abstract

This doctoral thesis aims to contribute to the literature on hedge fund performance in three interrelated essays. The first essay uses a novel database aggregation and a comprehensive analysis of differences between the main commercial databases exploring the effects of different databases on previously documented stylized facts, including the (1) average risk-adjusted performance; (2) the persistence of that performance; (3) and the cross-sectional relation between fund-characteristics and risk-adjusted returns. The main finding is that several previously documented stylized facts about hedge fund performance are sensitive to database selection and associated biases. Differences in conclusions stem from database differences in defunct coverage, survivorship and backfill biases, and the completeness of assets under management information.

The second essay examines the effect of frictions on the returns that investors can earn from investing in hedge funds. The study focuses on size and redemption restrictions that are key investment constraints in practice. The size–performance relationship is positive (negative) when past (future) performance is used. The negative size–performance relationship is consistent with theories suggesting a decreasing returns-to-scale in the active management industry. Differences in attrition rates and risk taking as well as the relative importance of management fees and capacity constraints between small and large funds are consistent with an equilibrium in which investors and hedge funds optimally respond to incentives subject to constraints. Performance persistence decreases along with the fund size but concentrated hypothetical Fund-of-Fund portfolios outperform.

The third essay examines hedge funds' ability to enhance their performance through leverage. The essay explicitly shows that leverage enhances risk-adjusted performance and risk of investment programs. The main finding is that the average high-leverage fund class underperforms its low-leverage counterpart of the same investment program after their returns are appropriately adjusted to the same level. The finding is consistent with the predictions of leverage aversion theories suggesting that leverage constraints and costs of leverage have a negative impact on risk-adjusted returns.

Keywords: active portfolio management, hedge funds, investment constraints, leverage, performance persistence, risk taking, risk-adjusted performance measurement

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Tiivistelmä

Tämä väitöskirja sisältää kolme artikkelia, joissa tutkitaan hedge-rahastojen menestystä. Ensimmäisessä artikkelissa rakennetaan yhdistelmäaineisto päätietokannoista ja tutkitaan tietokantojen eroavaisuuksien vaikutuksia keskeisiin kirjallisuudessa esitettyihin tutkimustuloksiin hedge-rahastojen riskikorjatun tuoton tasosta ja tuoton pysyvyydestä sekä rahastokohtaisten ominaispiirteiden ja riskikorjatun tuoton välisestä relaatiosta. Tutkimuksessa havaitaan että tutkimusaineiston valinta vaikuttaa merkittävästi aikaisemmassa kirjallisuudessa esitettyihin tutkimustuloksiin. Merkittävimmät erot tutkimustuloksissa eri tietokantojen välillä selittyvät tietokantojen eroavaisuuksissa toimintansa lopettaneiden rahastojen kattavuudessa ja näin ollen eloonjäämis- ja backfilling-harhan tasossa sekä rahastojen markkina-arvoa kuvaavan aineiston määrässä ja laadussa.

Toinen artikkeli tarkastelee rajoitteita, joita sijoittajat kohtaavat sijoittaessaan hedge-rahastoihin. Päähuomio on koko- ja lunastusrajoitteissa, jotka ovat käytännössä merkittävimmät rajoitteet hedge-rahastosijoittajalle. Rahastojen markkina-arvon ja riskikorjatun tuoton välillä on negatiivinen (positiivinen) relaatio kun tarkastellaan rahastojen tulevaa (historiallista) menestystä. Tulokset tukevat teoreettisia esityksiä, joiden mukaan rahastojen kasvu heijastuu menestykseen negatiivisesti. Markkina-arvoltaan pienissä rahastoissa on huomattavasti enemmän riskiä kuin markkina-arvoltaan suurissa rahastoissa. Korkeampi riski pienissä rahastoissa lisää tuottoperusteisten palkkioiden merkitystä palkkiorakenteissa kun taas suurilla rahastoilla on kannustimet maksimoida markkina-arvon mukaan määriteltyjä hallinnointipalkkioita. Tulokset tukevat talousteoriaa, jonka mukaan riski ja tuoton taso pienevät rahastojen markkina-arvojen kasvaessa. Tuoton pysyvyys pienenee rahaston markkina-arvon kasvaessa. Kuitenkin hypoteettiset rahastot, jotka on hajautettu aikaisempiin menestyjiin keskeiset sijoittajien rajoitteet huomioiden, menestyvät riskikorjatusti.

Kolmannessa artikkelissa tutkitaan hedge-rahastojen kykyä lisätä riskikorjatun tuoton tasoa velkavivun avulla. Velkavivun käyttö kasvattaa sijoitusstrategian tuoton ja riskin tasoa alhaisemman velkatason osuuslajeihin verrattuna. Päätuloksena havaitaan, että tyypillinen sijoitusstrategian korkean velkatason osuuslajin tuoton taso on merkittävästi alhaisempi matalan velkatason osuuslajiin nähden kun molempien osuuslajien tuottoaikasarjat ovat asetettu samalle tasolle. Talousteoriaa ennustaa, että sijoittajien rajoitteet käyttää velkavipua ja velkavivun käyttöön liittyvät kustannukset heijastuvat salkun tuoton tasoon negatiivisesti.

Asiasanat: aktiivinen salkunhoito, hedge-rahastot, investointirajoitteet, riskikorjatun tuoton estimointi, riskin ottaminen, tuoton pysyvyys, velkavipu

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Oulu, June 2014 Pekka Tolonen

List of original essays

The thesis is comprised of an introductory chapter and the following three essays:

I Joenväärä J, Kosowski R & Tolonen P (2014) Hedge fund performance: What do we know? Manuscript.

II Joenväärä J, Kosowski R & Tolonen P (2014) The effect of investment constraints on hedge fund investor returns. Manuscript.

III Tolonen P (2014) Hedge fund leverage and performance: New evidence from multiple leveraged share classes. Manuscript.

Contents

1 Introduction

There is increasing interest from investors, researchers, and regulators in the multi-trillion dollar hedge fund industry, which currently manages over $2 trillion of assets under management (AuM). There is no clear definition of hedge funds. The term "hedge fund" is a marketing term, not a regulatory form.[1] Hedge funds are sophisticated financial intermediaries with great trading flexibility. Hedge funds' primary function is to deliver positive risk-adjusted returns or alpha for an invested wealth, which is defined as the average return accrued over and above compensation for exposure to different sources of systematic risk (Fung *et al.* 2008). A Jensen (1968) alpha is a direct application of the theoretical results of the CAPM measured as a model where returns of a mutual fund are regressed on its market benchmark, and where the alpha is the intercept of the model. The Jensen's alpha represents the average incremental rate of return on the portfolio, which is due solely to the manager's ability to forecast future security prices. In hedge fund performance analysis, returns are typically benchmarked on a number of asset-based risk factors including buy-and-hold strategies of traditional asset classes (e.g., equities, bonds) and passive option-based strategies.[2] The literature of hedge funds suggests that a large proportion of the variation in hedge fund returns can be explained by market-related factors (e.g., Fung & Hsieh 2004, Fung & Hsieh 1997, Agarwal & Naik 2004). Patton (2009) shows that market neutral hedge funds exhibit significant exposure to market risk, but less than the proportion of significant exposures for other styles. Fung & Hsieh (2004) have proposed the multi-factor analogue of the Jensen alpha, which has become the standard measure of the value added in hedge fund performance analysis.

The main fundamental research questions for hedge fund investors are: (1) has the average active hedge fund manager delivered positive risk-adjusted returns?; (2) are the top managers skillful or lucky?; and (3) does their performance persist? The popularity of these investment vehicles can be explained by their impressive historical track records. Both theoretical (Glode & Green 2011) and empirical studies suggest that hedge funds generate significant alpha, with estimates ranging from 3–5%

[1] Hedge funds have existed for a long time. It is generally believed that Alfred W. Jones started the first hedge fund in 1949, whose strategy was to invest in under-valued securities and hedge systematic risk using the proceeds from the short-sales of related securities (Stulz 2007). The aim was to create a "market neutral" strategy. Today, hedge fund industry covers a multitude of different strategies.

[2] Passive option-based strategies are used to control for hedge funds' non-linear risk exposures that arise as a consequence of the use of dynamic trading strategies and leverage (e.g., Fung & Hsieh 2001, Agarwal & Naik 2004).

annually (e.g., Fung *et al.* 2008, Ibbotson *et al.* 2011, Kosowski *et al.* 2007), and that past alphas predict future alphas (e.g., Jagannathan *et al.* 2010).

As private entities hedge funds have not historically been required to report their performance to any regulatory agency.[3] Some hedge funds self-report performance data to commercial databases in order to attract potential investors. Today, multiple providers offer their products for researchers and investors. Databases consisting of self-reporting funds form a cornerstone in academic research.

Quantitative research that exploits commercial hedge fund databases is challenging for several reasons. First, a database of a single data provider may not be representative of the unobservable population of hedge funds (Fung & Hsieh 2000). Second, there is no standard reporting practices across commercial databases. Third, much of the information is duplicated in databases; multiple vendors cover the same fund, and each database contains multiple share classes for the same fund investment program. The same investment program can be listed multiple times as a result of different leverage levels, different reporting currencies, different domicile or legal structures, or variation in management and incentive compensation or share restrictions. Fourth, there is no standard methodology described in literature that could be used to (1) clean databases from duplicated share classes; or to (2) consolidate single databases. Fifth, historical returns are routinely revised in publicly available databases (Patton *et al.* 2013). They find that funds that revise their track records significantly and predictably underperform those funds that never revised, suggesting that unreliable disclosures constitute a valuable source of information for researchers and investors.

Commercial databases can differ with respect to their coverage of defunct funds, AuM data or fund characteristics. This raises an important question, which we examine in Essay 1: How does the choice of the database affect the stylized facts of hedge fund performance? As regards mutual funds, Elton *et al.* (2001) find systematic differences between the popular Morningstar and CRSP mutual fund databases and show that they can alter conclusions regarding investment strategies that incorporate individual funds or a group of such funds. Harris *et al.* (2013) conclude that the database selection affects the level of average performance in private equity funds.

In the first part of Essay 1, we provide detailed steps to construct a consolidated database using a cross-section of five major databases, namely, Lipper TASS, Hedge

[3] The regulatory landscape in the U.S. evolved with the passage of the Dodd-Frank Act in 2010, which set forth new registration and other requirements for hedge fund managers. In the EU, the Alternative Investment Fund Managers Directive (AIFMD) has increased reporting requirements of the managers of alternative investment funds ("AIFs").

Fund Research, BarclayHedge, EurekaHedge, and Morningstar consisting of over 60,000 share classes for the time period of 1994–2012. However, this number does not reflect the true number of unique investment programs. After executing our quantitative methodology described in Essay 1, this number drops to 31,493. We find that 74% of all share classes are covered by only one of the databases, with proportions of one commercial database ranging from 13.4% (Morningstar) to 17.2% (TASS). Therefore, each of the commercial databases covers share classes that are not included in the other databases. This suggests that database selection may have a significant impact on the inferred stylized facts about hedge funds.

In the second part of Essay 1, we perform a comprehensive analysis of differences between the main commercial databases to explore the effects of different databases on previously documented facts of (1) the average risk-adjusted performance of hedge funds; (2) persistence in risk-adjusted returns; and (3) fund attributes that explain hedge funds' alphas in the cross-section.

The main finding of Essay 1 is that stylized facts based on the consolidated database are qualitatively different from those based on the individual databases. Differences in conclusions about an average performance and return persistence stem from database differences in the survivorship and backfill bias as well as the completeness of the AuM data. After database selection biases are accounted for, we find, in contrast to earlier studies, that fund share restrictions (e.g., lockup and notice periods) are not associated positively with alphas (as suggested by Aragon (2007)) across databases. Consistent with Agarwal *et al.* (2009) and Ackermann *et al.* (1999), we find that hedge funds with greater managerial incentives outperform. In the consolidated database, consistent with recent studies in performance analysis, a typical hedge fund delivers alpha with a short-term persistence in returns. The consolidated database also suggests a decreasing trend in average alphas at the end of the sample. Essay 1 recommends that researchers aggregate multiple databases in order to get reliable inferences of hedge fund performance and cross-sectional determinants of alphas.

The fact that skilled managers with return persistence exist, raises a question of great interest for institutional investors: is this superior performance exploitable in practice?

In Essay 2, our research question is how frictions and real-world investment constraints affect the returns that investors can earn from investing in hedge funds. The empirical and theoretical asset pricing literature has studied the effect of frictions on asset prices (e.g., Luttmer 1996), but little research has addressed the effect of investment constraints on the opportunity set of hedge fund investors. We contribute to the literature by accounting for share restrictions, minimum diversification requirements and fund size restrictions – all of which are commonly faced by institutional investors.

Since institutional investors are likely to focus on large funds, we examine the effects of the size on hedge funds' average performance and persistence. Using economically motivated size limits, we show that Mega funds (funds that manage over $1 billion of AuM) do not deliver statistically significant risk-adjusted performance after fees. Mega funds have had impressive historical track records in the past, but they underperform smaller funds in the future. The negative size–performance relationship is consistent with Berk & Green (2004) suggesting a decreasing returns-to-scale in returns from active management. We show that the higher capital allocation to larger funds could be the result of an equilibrium (Goetzmann *et al.* 2003), in which investors avoid the 'headline' risk of smaller funds, since we find that larger funds have lower total risk and attrition rates. Using gross returns of hedge funds, we show that the relative contribution of incentive fees to total fees decreases with the fund size, whereas the relative contribution of management fees increases with the fund size. Theoretical models of Berk & Green (2004) and Goetzmann *et al.* (2003) attribute this result to decreasing returns to scale. The optimal leverage model of Lan *et al.* (2013) implies that as a hedge fund grows larger, its management may decide to reduce both leverage and risk in order to secure management fees.

In essay 2, we show that fund size and redemption restrictions are important determinants of hedge fund performance persistence. We demonstrate that performance persistence decreases along with the fund size suggesting that risk-adjusted returns of the smallest funds persists more than the largest funds. In addition, we show that hedge funds with the highest historical risk-adjusted performance and strict share restrictions deliver statistically and economically significant risk-adjusted returns. After incorporating fund size and redemption restrictions realistically into rebancing rules of hypothetical investor portfolios, we show that concentrated investor portfolios consisting of top 20 funds outperform.

In Lan *et al.* (2013), the level of optimal leverage depends on the distance between the fund's AuM and the high-water mark. Alpha-generating strategies motivate the use of leverage, which increases the volatility and the value of incentive contracts. The use of leverage also increases the probability of poor performance and investors' redemptions. Consequently, the risk-neutral manager often behaves risk-aversely and chooses prudent leverage because a downside liquidation risk is costly. Theoretical models of hedge funds' fragile capital structure imply that hedge funds' short positions to funding options and redemption options restrict the use of leverage. (e.g., Dai & Sundaresan 2010, Liu & Mello 2011).

Theoretical studies cited above motivate the research question of Essay 3: are hedge funds able to lever up their portfolios' exposures to the level as suggested by their strategies and enhance risk-adjusted returns through leverage? We build on Frazzini & Pedersen (2012), who show that embedded leverage is associated with low risk-adjusted returns in portfolios of equity/index options and levered ETFs. We provide a unique perspective by examining financial intermediaries with highly active mandates and construct a sample of investment programs that offer multiple leverage classes for investors. We contribute to the theory of leverage aversion (e.g., Frazzini & Pedersen 2013, Black 1972), which implies that leverage-constrained investors put overweight to high-risk assets, and as a consequence, high-beta assets deliver lower risk-adjusted returns than low-beta assets.

Using a hand-collected data for levered share classes constructed from the union of five major commercial databases, we show that management companies establish high-leverage classes of their investment programs that exhibit higher levels of total returns and volatility. The average high-leverage class of the investment program underperforms its low-leverage counterpart after returns (and risk) of the both classes are adjusted to the same level. Our findings are in line with the theory of leverage aversion and suggest that costs of leverage as well as leverage constraints of investors have a negative impact on returns. The high-leverage classes generate an economically and statistically significant alpha but not to the extent that could be expected based on their level of leverage.

The remainder of this introductory chapter is organized as follows. In section 2, we provide a literature survey of theoretical and empirical facts that are related to this thesis. Section 3 concludes the main empirical findings of this thesis.

2 Relevant theory and empirical facts

Three essays in this dissertation test empirically the questions stated in section 1. These questions are mainly related to four specific areas in theoretical literature: (1) the theory of delegated portfolio management; (2) models that rationalize hedge funds' value added and persistence; (3) the fragile nature of hedge funds' capital structure and limits to arbitrage; and (4) leverage aversion. This section provides a short overview of theoretical models and important empirical stylized facts.

Stylized facts about mutual fund performance show that the average mutual fund does not beat its benchmark (Fama & French 2010) and that returns do not persist (Carhart 1997). These findings suggest that the average mutual fund manager does not necessarily have the skills to pick stocks or time the market.

Developments in the theory of delegated portfolio management aim to rationalize the lack of skill and persistence among active managers. Theory tackles issues that are fundamental to the understanding the role of these active funds in the economy, that is, the economies of scale in the active money management industry.

Berk & Green (2004) propose a rational model of delegated portfolio management in which the ability of managers is measured by their alpha. The model has two building blocks. First, skilled investment managers have a differential ability to generate positive risk-adjusted returns, but face decreasing returns to scale in deploying their ability. Second, investors learn from managerial ability from past risk-adjusted returns and direct more capital toward funds with superior risk-adjusted returns. The model has an important consequence: in equilibrium, actively managed funds deliver zero risk-adjusted, net-of-fees returns to their investors. Therefore, the stylized fact that, on average, active managers do not beat passive managers does not imply that the average manager lacks skill. It means that capital markets are competitive.

Pastor & Stambaugh (2012) argue that the popularity of active management is not puzzling despite its poor track record. They build on Berk & Green (2004) by developing a model with competing investors and fund managers and show that the large observed size of the active management industry can be rationalized if investors believe that active managers face decreasing returns to scale. As in Berk & Green (2004), investors learn from managerial skill from realized returns. After observing negative performance, investors infer that the industry's alpha is lower than expected, and they reduce their allocation to active management. The main contribution in Pastor & Stambaugh (2012) is that investors' learning about returns to scale in active management industry is low. What they learn affects how much they allocate to active management, and what they allocate affects how much they learn. As a consequence of this endogeneity, the equilibrium allocation to active management varies little over time, resulting in slow learning about the degree of returns to scale in active management. They argue that their model's predictions are consistent with the large size of the mutual fund industry.[4]

Chen *et al.* (2004) show that the negative size–performance relation in mutual funds is most pronounced among funds that have to invest in small and illiquid stocks, suggesting that these adverse scale effects are related to liquidity. Second, they provide some evidence that the reason the fund size and liquidity do in fact erode performance may be due to organizational diseconomies related to hierarchical costs in the processing of 'soft information' (e.g., Stein 2002).

In contrast to mutual funds, hedge funds have been shown to add value and exhibit persistence in the risk-adjusted performance they generate for investors (Aragon & Martin 2012, Jagannathan *et al.* 2010, Fung *et al.* 2008, Baquero *et al.* 2005, Kosowski *et al.* 2007, Agarwal & Naik 2000). For example, Fung *et al.* (2008) used a comprehensive data set of fund-of-funds during the years 1995–2004. They find that a typical fund-of-fund delivers alpha only in the period between October 1998 and March 2000, but a subset of fund-of-funds consistently delivers alpha. Capital inflows, however, adversely affect the ability of have-alpha funds to deliver alpha in the future. Have-alpha funds that experience high (low) capital flows have a significantly lower (higher) t-statistic of alpha (and information ratio) in the future. Consistent with Berk & Green (2004), Fung *et al.* (2008) document a decline in the aggregate level of alpha toward the end of the sample period. Kosowski *et al.* (2007) show that (1) hedge funds' value added cannot be explained by luck alone; and (2) hedge funds' performance persists at annual horizon.

Glode & Green (2011) present a model that aims to rationalize performance persistence in hedge fund returns. They show that persistence can be explained through a need for secrecy. The source of superior returns may not be entirely skills or abilities intrinsic to the manager. Superior returns may also be attributable to strategies or techniques that could be exploited by others if they were informed about them.

Empirically, Sun *et al.* (2012) provide evidence that skilled hedge fund managers are likely to pursue unique investment strategies that result in superior performance. They construct a measure – the "Strategy Distinctiveness Index" (SDI) – describing

[4] According to the Investment Company Institute (2009), equity mutual funds of the U.S. mutual fund industry managed $3.7 trillion of assets at the end of 2008.

the extent to which a fund's returns differ from those of its peer funds. On average, a higher SDI is associated with better future performance. As Sun *et al.* (2012) show, hedge fund managers who pursue more distinctive strategies may be less subject to negative externalities owing to the "crowded-trade" effect and the leverage effect as described in Stein (2009). Agarwal *et al.* (2013) document evidence on the stock-picking skill of hedge funds from the superior performance of their holdings that are likely to be motivated by private information. They examine "confidential holdings" of hedge funds, where the quarterly holdings are disclosed with a delay through amendments to the Form 13F. Funds managing large risky portfolios with non-conventional strategies seek confidentiality more frequently. A model of Titman & Tiu (2011) illustrates that hedge fund managers with incentives to maximize the Sharpe ratios of their portfolios will choose greater exposure to priced risk factors if they have less confidence in their abilities to generate risk-adjusted performance from the active part of the portfolios. Consistent with this hypothesis, Titman & Tiu (2011) show empirically that hedge funds with less systematic factor exposure measured as the *R*-square of returns on systematic factors tend to have higher Sharpe ratios in present as well as future periods.

The model of Berk & Green (2004) does not account for more complex features of hedge fund management contracts.[5] Goetzmann *et al.* (2003) (henceforth GIR) propose the first quantitative valuation framework for management and incentive fees in the presence of the HWM. GIR conjecture that the existence of a high-water mark compensation is due to decreasing returns to scale in the industry. Payoffs of hedge funds' arbitrage strategies are not infinitely scalable, and therefore, the hedge fund industry has significant limits to growth. Consistently, GIR find that successful and large fund managers are less willing to take new money than small fund managers. Empirical studies have documented that well performing funds may not self-report to commercial databases (e.g., Fung & Hsieh 2009). Findings of GIR are consistent with the hypothesis that the strong performance of hedge funds may be in part due to the relative small size of the hedge fund sector. Option-like incentive contracts exist because managers cannot expect to trade on past superior performance to increase compensation through growth. Empirically, hedge funds with greater managerial

[5] Hedge fund managers typically receive a fraction (typically 15%–25%) of the fund's return each year in excess of the high-water mark (HWM). In addition, managers also charge a management fee of 1% to 2% of AuM. "Two-Twenty" (the management fee of 2% and the incentive fee of 20%) is often observed and viewed as the industry norm. High-water mark contracts require that managers must make up earlier losses before becoming eligible for performance-based bonuses. Hedge funds often set a "hurdle rate", which refers to the rate of return that the manager must beat before collecting incentive fees.

incentives seem to outperform their peers (Ackermann *et al.* 1999, Agarwal *et al.* 2009).

The model of GIR provides a few insights. The trade-off between the regular fees and the high-water mark fees depends upon the volatility of the portfolio and investors' withdrawal policy. If investors have a short-term investment horizon and the volatility of the assets is high, the incentive fee portion of the fee contract provides the greatest value to the manager. Instead, the regular fee portion of the fee contract is high if investors have a long-term investment horizon and the volatility of the assets is small.

Teo (2010) finds that hedge funds with binding capacity constraints set higher performance fees and lower management fees as they cannot grow assets without decreasing returns. Teo (2010) and Boyson (2008) suggest that hedge fund industry exhibits decreasing returns to scale and a negative–size performance relationship.

The proposed valuation equation of GIR allows the estimation of the division of wealth that the investor implicitly makes together with the portfolio manager upon entering into option-like incentive contracts. The valuation equation presents that the value of fees and other costs could be as high as 33% of the amount invested. For a fund volatility of 15%, the required excess return is 3%–4%, to justify a performance fee of 15%–20%. For a fund volatility of 25%, the excess return required to justify a performance fee of 20% is 3%–7.5%.

GIR focuses solely on valuation and does not allow for endogenous leverage or any other decisions such as fund closure or restart. Lan *et al.* (2013) (henceforth LWY) develop a model to analyze leverage policy and to value compensation contracts. The model consists of managers who maximize the present value of management and incentive fees. By leveraging alpha-generating strategies, skilled managers add value. The model of LWY considers the fact that leverage increases volatility and hence a likelihood of poor performance. In practice, a fund that performs poorly often faces money outflow or liquidation, causing the manager to lose future fees. The ratio between the fund's AUM and HWM measures the manager's moneyness and is a critical determinant of leverage and valuation.

In the dynamic framework of LWY with downside risks (e.g., liquidation), the risk-neutral manager has incentives to preserve the fund's going-concern value so as to collect fees in the future. The risk-neutral manager is averse to liquidation and this precautionary motive induces risk-averse behavior. Leverage policy in LWY is consistent with intuitive reasoning laid out in GIR in a sense that the optimal leverage increases with alpha and decreases with volatility. The higher the ratio of AUM/HWM, the more distant the fund is from liquidation, and the closer the manager is to collecting the HWM-indexed fees, the less risk aversely the manager behaves and the higher the leverage. Both GIR and LWY imply that as the fund's ratio of AUM/HWM decreases, the manager shall decrease the fund's volatility so as to preserve the fund's going-concern value and collect fees in the future.

LWY find that the manager needs to create a 20% surplus in the present value of the AUM to justify a "2%-20%" contract. Out of the total surplus, 75% is attributed to management fees and the remaining 15% is due to HWM-indexed fees. By incorporating additional risk seeking incentives such as (i) managerial ownership; (ii) performance-induced new money inflow; and (iii) the manager's option to restart a fund at a cost, the relative contributions of management and incentive fees to the manager's total value become more balanced. Therefore, the relative contribution of the incentive fee to the manager's value creation increases with volatility.[6]

Dai & Sundaresan (2010) show that hedge funds are short in two types of very valuable options: (1) the ability (and the willingness) of prime brokers to withdraw credit lines and/or increase margin requirements in the bad states of the world (the funding option); (2) the willingness of investors to redeem their partnership shares in the bad states of the world (the redemption option). The main contribution in their study is to model the influence of these options to optimal leverage, risk budgeting, and the active management of hedge funds' risk. If the funding and redemption options are exercised in the bad states of the world, this may increase funding costs and impair hedge funds' ability to maintain risk positions. This risk forces hedge funds to de-lever in the bad states of the world, thereby imposing losses, and threatening their survival. The model of Dai & Sundaresan (2010) implies that hedge funds typically have the optimal level of leverage that trades off rationally the ability to increase alpha with the risk of early exercise of short options, which may precipitate the liquidation of the fund.

The presence of lockups and gates will serve to lower the value of redemption options. Hedge funds' use of multiple prime brokers decreases the value of the funding option. Aragon (2007) documents a positive relationship between hedge

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[6] Panageas & Westerfield (2009) compute the optimal portfolio of a risk-neutral manager who maximizes the expected discounted value of compensation fees. They argue that the risk-seeking incentives of option-type contracts rely on the interaction between convex compensation and finite horizons. They show that even risk-neutral managers do not take unbounded risk, despite incentive fees, when the contract horizon is in(de)finite. Aggressive risk taking today could help increase the probability of crossing the current HWM, but it will also increase the probability that the assets in the fund will be substantially lower the next period, while the HWM will remain unchanged. Therefore, when the compensation contract horizon is in(definite), managers have less incentives to take excessive risk.

funds' value added and the lockup provision ("liquidity premium"). Share restrictions are especially valuable for those hedge funds that hold illiquid assets. Aiken *et al.* (2013a) find that hedge funds use discretionary liquidity restrictions (e.g., gates, side pockets) to restrict investors' liquidity when facing greater funding and asset liquidity risks to prevent damaging runs of money. The use of liquidity restrictions is related to (i) agency conflicts between managers and investors; and (ii) negative relative performance with respect to market benchmarks.

Dai & Sundaresan (2010) note that nonlinearities can arise in hedge fund returns due to the rational behavior of funds managing their short option positions even if their strategies did not involve option-like positions. The literature that documents non-linear payoffs in hedge funds returns includes Fung & Hsieh (2004), Fung & Hsieh (1997), Agarwal & Naik (2004). Patton & Ramadorai (2013) model the dynamic risk exposures of hedge funds using threshold conditioning information based on market-wide economic conditions.

Recently, Buraschi *et al.* (2013) consider a structural model of a hedge fund manager who is subject to (i) HWM-based incentives; (ii) funding options by prime brokers; and (iii) equity investors' redemption options. These features create a non-linear payoff structure that affects a manager's leverage decision. The model assumes that HWM-indexed fees motivate risk taking while put option-like features induce to decrease leverage. The relative importance of these effects depends on the moneyness of these options, that is, the distance of the net asset value from the HWM. Buraschi *et al.* (2013) show that structural measures that account for these features are less subject to a false discovery bias (especially for low-quality funds). In out-of-the sample tests, portfolios based on structural dynamic measures dominate portfolios based on traditional reduced-form rules.

Liu & Mello (2011) use global game theory methods to model the asset allocation decision of a hedge fund that is subject to the risk of a run by its investors. In their model, one key feature of the capital structure of hedge funds is the fragile nature of equity. As in Dai & Sundaresan (2010), the equity capital can be redeemed at investors' discretion (redemption option). Liu & Mello (2011) model theoretically that the coordination risk arises because investors suspect that other investors might redeem, and to meet redemptions, the hedge fund may be forced to liquidate positions at a loss. The hedge fund's trade-off is between lower liquidation costs, if it holds more cash, and a higher return, if it invests more in risky assets. The trade-off gives an optimal level of cash holdings.

In addition to equity, hedge funds use leverage. The debt of hedge funds is susceptible to runs such as margin calls or sudden increases in haircuts. Therefore, the whole right-hand side of the balance sheet of hedge funds is subject to runs. Prime brokers calling the debt extended to a fund can scare the clients of the fund and trigger redemptions. The model of Liu & Mello (2011) implies that hedge funds have strong incentives to run less risky portfolios and operate with lower leverage ratios because of their fragile capital structure. Liu & Mello (2011) contribute to the literature of limits to the arbitrage of sophisticated investors. In Liu & Mello (2011), the fragile capital structure is an essential limit to arbitrage. In Shleifer & Vishny (1997), investors worry about the quality of money managers' assets, and poor performance leads to early redemptions. Limits to arbitrage can cause a vicious cycle and prolong a financial crisis.

Many investors such as individuals and financial intermediaries are leverage-constrained.[7] As the CAPM predicts, a security's (or a portfolio's) expected excess returns are proportional to the beta with respect to the market portfolio. Investors prefer the portfolio with the maximum Sharpe ratio (tangency portfolio) with leverage according to their risk tolerance. As investors are leverage-constrained, they tend to tilt their portfolios towards high-risk securities, that is, securities with a high systematic risk.

Empirical evidence, starting from Black *et al.* (1972), documents that the high-beta stocks do not generate as high risk-adjusted returns as predicted by the CAPM. The result is a flatter security market line (SML) relative to the CAPM.[8] Recent literature suggests that this empirical stylized fact is better explained by the CAPM with restricted borrowing.

Frazzini & Pedersen (2013) propose a dynamic model of leverage and margin constraints that have effects on asset prices. Since constrained investors bid up high-beta assets, their model predicts that a high beta is associated with a low alpha.

In the model, some agents cannot use leverage and overweight high-beta assets, causing these assets to offer lower returns. Other agents have access to leverage but face margin constraints. They underweight high-beta assets (or take short positions) and are long low-beta assets that they lever up. Frazzini & Pedersen (2013) make five propositions:

1. The model implies a flatter SML, where the slope depends on the tightness of the funding constraints on average across agents;

[7] The fragile capital structure of hedge funds may restrict their use of leverage. Mutual funds and pension funds can have borrowing constraints due to regulation.
[8] The security market line is the connection between the actual excess returns across securities and the CAPM predicted excess return (beta times the market excess return).

2. The asset pricing effect of the funding friction is illustrated by using the returns of a market-neutral betting-against-beta (BAB) factor which holds low-beta assets (leveraged to a beta of 1) and which shorts high-beta assets (de-leveraged to a beta of 1). The model predicts that the BAB factors have positive average return, which increases in the ex-ante tightness of constraints and in the spread in betas between high- and low-beta securities.
3. When margin constraints become binding, leveraged agents must de-leverage. During the times of tightening funding liquidity constraints, the BAB factor realizes negative returns as its expected future return rises.
4. The betas of securities in the cross-section are compressed toward 1 when the funding liquidity risk is high.
5. The model predicts that more-constrained investors (e.g., mutual funds) overweight high-beta assets in their portfolios and less-constrained investors overweight low-beta assets and (possibly) apply leverage to bet against beta.

Leverage aversion changes the predictions of the modern portfolio theory. With constrained borrowing, the value-weighted market portfolio is not optimal. Instead, the optimal portfolio for investors includes larger allocation to safer assets. They find consistent evidence for each of the model's central predictions using a dataset of several assets classes including U.S. equities, 20 international equity markets, Treasury/corporate bonds, and futures.

If investors are leverage-constrained, they can gain substantial exposure without using outright leverage by buying options, leveraged ETFs, or other securities that embed leverage. Buying securities that embed leverage increases market exposure without violating leverage constraints (without risking a loss of more than 100%). Investors may be willing to pay a premium for securities that embed leverage.

Frazzini & Pedersen (2012) show that portfolios that are long low-embedded-leverage assets and short high-embedded-leverage assets and constructed to be market neutral, earn statistically significant abnormal returns. The main point is that embedded leverage alleviates investors' leverage constraints, and therefore, embedded leverage lowers required returns. Their evidence is consistent across equity and index options and levered ETFs.

Consuming the high risk-adjusted returns of safer assets requires leverage, creating an opportunity for investors with the ability to apply leverage. Leverage aversion is a consistent equilibrium theory that motivates "risk parity" (RP) investing (e.g., Asness *et al.* 2012) which exploits this opportunity by equalizing risk contributions across asset classes. As a result, RP portfolios have a larger weight in low-beta assets relative to their weight in the market portfolio. Asness *et al.* (2012) document that the levered RP portfolio constructed from the U.S. stocks and bonds (during the years 1926–2010) delivers positive risk-adjusted returns and outperforms both the value-weighted market portfolio and the 60/40 portfolio of stocks and bonds.

3 Summary and implications

3.1 Essay 1: Hedge fund performance: What do we know?

In Essay 1, *Hedge fund performance: What do we know?*, we show that several previously documented stylized facts facts about hedge fund performance depend strongly on which database is used. We motivate and specify four hypotheses that address how database selection biases affect stylized facts about average hedge fund performance, cross-sectional relations between fund characteristics and performance, and the persistence of hedge fund performance. We use a novel database aggregation and a comprehensive analysis of differences between the main commercial databases (Lipper TASS, Hedge Fund Research, BarclayHedge, EurekaHedge, and Morningstar) to explore the effects of different databases on previously documented stylized facts. The principal finding is that stylized facts based on the consolidated database are qualitatively different from those based on the individual databases. We contribute to Elton *et al.* (2001) and Harris *et al.* (2013), who examine the effects of the database choice on performance using mutual fund and private equity fund databases.

Consistent with the studies of performance analysis we find that the average hedge fund adds value after fees. The annualized alpha[9] of the equal-weighted (EW) index of the consolidated database is 5.32%, which is both statistically and economically significant. The highest average alphas are observed for EurekaHedge (6.95%) and Morningstar (6.35%). We show that the reason for this finding is that EurekaHedge and Morningstar have the smallest coverage of defunct funds. They exhibit an attrition rate close to zero in the time period until 2002 and 2004. Therefore, we find strong support for our Attrition Rate hypothesis (H1) suggesting that databases with fewer defunct funds outperform. We contribute to the literature of performance analysis by showing that the results of the average EW performance obtained using commercial databases are often different from those obtained using the aggregate database.

The values for beta (risk exposure) and R^2 are quite similar across databases. The performance differences among databases are therefore likely driven more by differences in survivorship bias than in risk exposures. We find that the Singapore-based EurekaHedge and the (original) London-based TASS are more exposed to emerging markets whereas the U.S.-based databases (e.g., HFR) are more exposed to

[9] We use the Fung & Hsieh (2004) model as a benchmark in performance evaluation.

the S&P 500 index. BarclayHedge shows the highest risk exposures to the trend-following factors because the database contains a relatively large proportion of CTAs.

The hedge fund industry (as proxied by the value-weighted (VW) aggregate index) delivered positive risk-adjusted performance: its average alpha is 4.66%, which is economically and statistically significant. EurekaHedge and Morningstar delivered high VW alphas (5.17% and 5.53%) due to a high proportion of alive funds in those databases. For each database (except TASS), the average EW performance is better than the average VW performance. We show that the AuM coverage is worst for the TASS database, which has one fourth fewer AuM observations (as a percentage of corresponding non-missing return observations) than the most complete individual database that is BarclayHedge.

Our findings support the Missing AuM Hypothesis (H2) which states that filling in missing AuM observations (for existing monthly return observations) with the last reported AuM observation (Stale AuM) will reduce the VW average performance differences across databases. The adjusted VW returns are lower for all databases, with a decrease of more than 50 basis points for TASS and of nearly 40 basis points for Morningstar. As a collar, database differences attributable to the EW versus the VW returns will converge once the missing AuM observations are filled in. The results are robust to the adjustment of backfill bias.

In robustness tests that compare the index of the non-reporting fund data by Edelman *et al.* (2013) to our aggregate database, we do not find statistically significant differences in performance between the two. Our aggregate database seems to fairly represent the true unobservable population of hedge funds.

Our Fund Characteristics Hypothesis (H3) states that the differences across the databases with regard to the completeness of information about fund characteristics will affect the conclusions drawn about the effect of such characteristics on average performance. We focus on share restrictions (H3a), managerial incentives (H3b), investment styles (H3c), and domiciles (H3d).

In the aggregate database, univariate sorts reveal that the alphas increase monotonically with respect to share restrictions, incentive fees, and high-water mark. However, we show that this relation is not robust across the commercial databases. This supports our hypothesis H3a and H3b. To test H3c, which concerns the effect of different style classification schemes on performance, we map the classifications used by different vendors into 12 main categories. Overall, hedge funds generate economically and statistically significant risk-adjusted returns across investment styles. The annualized alphas range from 6.6% (CTA) to 3.8% (Relative Value). The findings are consistent with the Attrition Rate Hypothesis (H1), since EurekaHedge and Morningstar typically exhibit higher performance for a given style (e.g., Market Neutral and CTA) than do the other three databases. Consistently with H3c, we find that there are greater differences between databases for styles that are difficult to classify. For instance, identifying emerging markets funds from HFR is problematic. EurekaHedge has high risk loadings to emerging market equity risk factor due to relatively high coverage of emerging market funds that are domiciled in offshore jurisdictions. BarclayHedge has high risk loadings to option-based trend-following factors due to the highest share of CTAs.

We find weak evidence for H3d suggesting that relative performance rankings hold in terms of specific domiciles. An exception is Morningstar, which contains the largest proportion and greatest number of funds domiciled in the Asia/Pacific yet exhibits a relatively low performance for that group. A plausible explanation for this result is the more comprehensive Asia/Pacific coverage which includes some poorly performing funds. Our findings of fund domicile highlight the importance of using an aggregate database that includes these Asia/Pacific funds. Overall, funds domiciled in United States, Asia/Pacific, or "Rest of the World" deliver higher performance than those domiciled in Europe or Caribbean.

The fourth hypothesis specifies that differences in databases with respect to survivorship bias and/or backfill bias will exhibit, overall, different levels of persistence. We contribute to the theory of Glode & Green (2011) by documenting the evidence of short-term persistence. For the aggregate database and a quarterly holding period, the top alpha decile portfolio generates an annualized EW alpha of 5.85%; this value is 4.19% higher than the alpha of the bottom-decile portfolio. We find no significant persistence for annual rebalancing/holdings periods. The results of persistence are sensitive to the choice of the database. Performance persistence is evident at semiannual horizons for TASS, HFR, and BarclayHedge. However, EurekaHedge and Morningstar show no evidence of persistence. The empirical methodology of performance persistence cannot separate good funds from bad funds in EurekaHedge and Morningstar because these databases have a poor coverage of defunct funds. Therefore, the top and bottom deciles of alpha sorted portfolios have similar out-of-sample performance in EurekaHedge and Morningstar.

This study concludes that hedge fund researchers should use the aggregate database in empirical analysis because stylized facts based on the consolidated database are qualitatively different from those based on the individual databases.

3.2 Essay 2: The effect of investment constraints on hedge fund investor returns

The aim of study in Essay 2 – *The effect of investment constraints on hedge fund investor returns* – is to examine the effect of frictions and real-world investment constraints on the returns that investors can earn from investing in hedge funds. We contribute to the existing literature by accounting for share restrictions, minimum diversification requirements and fund size restrictions – all of which are commonly faced by institutional investors. Research on hedge funds seldom accounts for such frictions or examines their effect on the performance of hedge fund portfolios and the persistence of that performance, although such studies exist in the empirical and theoretical asset pricing literature (e.g., Luttmer 1996). This study fills this research cap by documenting the effects of a combined set of investment constraints faced by real-world investors on their opportunity set as indicated by the consolidated hedge fund database for the 19-year period (1994–2012).

The first main insight of the study is that it is important to distinguish between the forward-looking and the backward-looking size–performance relationship: it is the former that matters to investors. The total AuM of single-manager hedge funds was about $2.2 trillion at the end of 2012. Only 4.1% of the funds in our sample have an AuM of at least $1 billion, but they account for 54.6% of the industry AuM at the end of 2014Q4. Therefore, instead of constructing size deciles/quintiles consisting of an equal number of funds, we use economically motivated size interval limits. We find that the larger funds tend to have generated higher returns than the smaller funds did in the past, but however, the larger funds tend to perform worse than the smaller funds will in the future. A portfolio of Mega funds (funds managing over $1 billion) generates an out-of-sample forward-looking alpha of 1.7% per year which underperforms a portfolio of Micro funds (managing less than $10 million) by 4.9% per year. This result is monotonic, and it holds when we take into account various data biases such as backfill, selection, or delisting bias.[10] Thus, our results are consistent with the theoretical models of the delegated portfolio management, which suggest decreasing returns to scale in the active asset management industry (Berk & Green 2004).

[10] We gather a large sample of hedge funds that do not report to commercial databases –following a procedure proposed by Aiken *et al.* (2013b). We exploit this dataset and extend the return series of hedge funds that have stopped reporting to the database (delisting bias) and include funds that have never reported (selection bias) to a commercial database. We find that forward-looking out-of-sample performance is robust when we control for delisting bias and self-selection bias.

The second insight of the study is related to economic mechanism, which may underlie the negative size–performance relationship. The optimal leverage model of Lan *et al.* (2013) implies that as a hedge fund grows larger its management may decide to reduce both leverage and risk in order to secure management fees (and forgo performance-based fees) from a larger asset base. We calculate gross and net returns for funds in different size intervals and find that the relative contributions of incentive fees to total compensation decreases along with the fund size, while the relative contribution of management fees increases along with the fund size. These findings are consistent with the implications of Goetzmann *et al.* (2003) suggesting that incentive fees are important for the small funds due to the decreasing returns to scale. We show that the higher capital allocation to larger funds could be the result of an equilibrium in which investors avoid the headline risk of smaller funds, since larger funds have a lower total risk (volatility) and attrition rates.

The third main contribution is to explore using both regressions and sorts whether hedge fund performance persistence is a robust phenomenon across size groups and under realistic restrictions. We find that performance persistence is significantly reduced when rebalancing rules reflect fund size restrictions and share restrictions. Our findings imply that fund size is an important determinant of performance persistence. Based on the spreads between the top and bottom quintiles across size groups, we demonstrate that the smallest funds persist more than the largest funds. Nonetheless, evidence of persistence is mild even for the smallest funds. We also examine top-quintile portfolio performance as an alternative measure of persistence since it is not possible to short hedge funds. The top-quintile of the smallest funds sorted based on historical risk-adjusted returns delivers higher performance than the respective quintile of the largest funds. We also demonstrate that the top-quintile performance of hedge funds is positively associated with strict redemption restrictions across size intervals.

The fourth main insight emerges from our simulations of hypothetical investor portfolios under further restrictions and even more realistic conditions. We demonstrate that a more concentrated portfolio of the 20 top funds outperforms better than portfolios that contain hundreds of funds in each performance interval. We construct three hypothetical portfolios that allocate to the 20 top past performing funds. Our analysis accounts for real-world liquidity constraints by incorporating share restrictions and maximum allocation requirements into the rebalancing process. We assume that sizes of hypothetical portfolios are $100 million, $500 million, and $1 billion, as of December 2012. We simulate the performance of a hypothetical investor conditional on the minimum size requirement faced by institutional investors.

During the recent period a portfolio of the 20 best performing hedge funds generates statistically significant risk-adjusted out-of-sample performance. We show that incorporating the set of investment frictions reduces, but does not eliminate, performance persistence. Therefore, even though the evidence of performance persistence is mild, we show that a real-world investor is able to exploit predictability in risk-adjusted returns of hedge funds by investing in top-performing funds, which are sorted based on historical risk-adjusted returns.

3.3 Essay 3: Hedge fund leverage and performance: New evidence from multiple leveraged share classes

Essay 3, *Hedge fund leverage and performance: New evidence from multiple leveraged share classes*, examines hedge funds' ability to enhance their performance through leverage. Using a hand-collected data for leveraged share classes constructed from the union of five major commercial databases, we show that the management companies establish high-leverage classes of their investment programs that exhibit higher levels of total returns and volatility.

We show that the average high-leverage class of the investment program underperforms its low-leverage counterpart after returns (and risk) of the both classes are adjusted to the same level. Our findings are in line with the theory of leverage aversion (Frazzini & Pedersen 2013, Asness *et al.* 2012, Black 1972) and suggest that costs of leverage and leverage constraints of investors have a negative impact on returns. The high-leverage classes generate economically and statistically significant alpha but not to the extent that could be expected based on their level of leverage.

We collect a dataset of levered hedge fund share classes from the union of five major databases by checking manually indicators of leverage (e.g., "1X", "2X") based on the names of share classes. We identify investment programs that contain at least two share classes with different levels of leverage and find 362 unique share classes for the January 1994 – December 2012 period. The main idea in this study is to compare the performance of a high-leverage class to its low-leverage counterpart within each of the investment programs. This dataset allows us to examine the effects of leverage on performance and risk within a specific investment program. We contribute to Ang *et al.* (2011), who examine hedge fund leverage in a cross-section of 208 hedge funds.

In the first part of the empirical analysis, we form equal-weighted (EW) portfolios of the low- and high-leverage share classes that are rebalanced monthly. Our findings show that the average high- and low-leverage class adds value for investors in terms of risk-adjusted returns. The results are consistent with the previous essays of this dissertation that provide evidence of positive risk-adjusted performance among hedge funds. We find that the high-leverage portfolio has a higher average excess return and a standard deviation of excess return as well as a higher overall systematic risk than the low-leverage portfolio. Both volatilities and estimated factor loadings (systematic risk) are about twice as large for the high-leverage portfolio suggesting that leverage magnifies both return and risk in hedge fund portfolios. This is a natural result since we find that a typical high-leverage class is 2-times levered. Thus, our findings suggest that hedge funds' use of leverage contributes positively to the value added during the 1994–2012 time period.

In the second part of the empirical analysis, we provide a direct test of the leverage aversion theory because the data contains investment programs with multiple leverage class structures. We construct three EW portfolios: (1) the portfolio of low-leverage classes; (2) the portfolio of high-leverage classes; and (3) the relative leverage spread (RLS) portfolio with long low-leverage funds and short high-leverage funds with appropriately scaled returns. The construction of the RLS portfolio is similar to the betting-against-beta portfolios in Frazzini and Pedersen (2012).[11] Based on the intuition of the RLS portfolio, it should provide risk-adjusted returns, which are statistically indistinguishable from zero, if hedge funds use leverage as indicated in their strategies. Alternatively, if the costs of leverage (and the leverage aversion) have negative effects on performance, the RLS performance is positive and statistically significant.

The RLS portfolio is an EW return of individual share classes' monthly spread returns between low- and high-leverage fund classes. It provides a statistically significant alpha for the January 1994 – December 2012 study period. The average RLS FH alpha is 1.63% per annum and statistically significant at 5% level. This suggests that the average high-leverage class on the short-side of the RLS portfolio (with adjusted market exposure) generates a 1.63% lower alpha than the average class on the long-side of the RLS portfolio consisting of the low-leverage classes. Although the high-leverage class generates an economically and statistically significant alpha which investors can exploit, the alpha is not as high as indicated based on their use of leverage. The RLS alpha result is robust to backfill-adjustment, inclusion of fund-of-funds, sub period analysis, and gross-of-fees returns. Finally, we show that the

[11] We do not term the RLS portfolio as a betting-against-beta portfolio (e.g., Frazzini & Pedersen 2012) due to the fact that hedge funds cannot be shorted. Therefore, we consider the long and short sides of the RLS portfolio separately.

general costs of leverage do not explain the result of the positive RLS performance. The RLS performance remains robust during the time period of 1994–2012.

The results of this study mirror the theoretical predictions of Frazzini & Pedersen (2013) and Dai & Sundaresan (2010) suggesting that leverage aversion has an impact on hedge fund performance. Therefore, investors may receive higher total returns by investing in share classes with high leverage. However, the RLS performance indicates that investors do not receive benefits from high leverage as much as suggested.

3.4 Implications

As well as contributing new insights to hedge fund literature, this dissertation leads to several important recommendations for investors and researchers.

Essay 1 makes three recommendations. First, it is recommended that an aggregate database be used since there is little overlap in the separate hedge fund databases. We recommend that caution should be exercised when comparing different studies due to the evolving nature and coverage of different databases. Second, to avoid biased inferences of average performance and return persistence, it is important to monitor the attrition rate, the resulting survivorship bias, and the backfill bias. This is especially important when individual commercial databases are used in empirical analysis. Third, when calculating average VW returns, in case there are corresponding returns available, it is advisable to “fill in” missing AuM observations rather than omitting the associated returns. Essay 1 shows that “stale-adjusted” VW average alphas converge across commercial databases.

Empirical findings shown in Essay 2 suggest that economically motivated size intervals to be used in empirical analysis of the size–performance relationship and performance persistence because hedge funds with a large AuM (e.g., $500 million or more) cover a very small proportion of the total number of hedge funds. We show that the size–performance relationship is positive (negative) when the past (future) performance is considered. We show that performance persistence decreases along with the fund size. Although evidence of performance persistence is mild, our simulations of hypothetical investor portfolios show that the concentrated portfolios of the 20 top individual funds deliver an economically and statistically significant risk-adjusted performance. This suggests that investors may exploit superior hedge fund performance by investing in top performing individual funds.

Essay 3 implies that hedge funds add value through leverage, which leverage-constrained investors (e.g., pension funds) can exploit. However, it is important to monitor the exposures of levered hedge funds since this study and theoretical literature suggest that hedge funds may have borrowing constraints that limit hedge funds' abilities to exploit arbitrage opportunities. Essay 3 finds that the high-leverage classes of investment programs deliver positive risk-adjusted performance but not to the extent that could be expected based on their level of leverage.

References

Ackermann C, McEnally R & Ravenscraft D (1999) The performance of hedge funds: Risk, return, and incentives. Journal of Finance 54(3): 833–874.

Agarwal V, Jiang W, Tang Y & Yang B (2013) Uncovering hedge fund skill from the portfolio holdings they hide. Journal of Finance 68(2): 739-783.

Agarwal V, Daniel ND & Naik NY (2009) Role of managerial incentives and discretion in hedge fund performance. Journal of Finance 64(5): 2221–2256.

Agarwal V & Naik NY (2004) Risk and portfolio decisions involving hedge funds. Review of Financial Studies 17(1): 63–98.

Agarwal V& Naik NY (2000) Multi-period performance persistence analysis of hedge funds. Journal of Financial and Quantitative Analysis 35(3): 327–342.

Aiken AL, Clifford CP & Ellis JA (2013a) Hedge funds and discretionary liquidity restrictions. University of Kentucky. Quinnipiac University. North Carolina State University.

Aiken AL, Clifford CP & Ellis JA (2013b) Out of the dark: Hedge fund reporting biases and commercial databases. Review of Financial Studies 26(1): 208–243.

Ang A, Gorovyy S & van Inwegen GB (2011) Hedge fund leverage. Journal of Financial Economics 102(1): 102–126.

Aragon GO & Martin JS (2012) A unique view of hedge fund derivatives usage: Safeguard or speculation? Journal of Financial Economics 105(2): 436–456.

Aragon GO (2007) Share restrictions and asset pricing: Evidence from the hedge fund industry. Journal of Financial Economics 83(1): 33–58.

Asness CS, Frazzini A & Pedersen LH (2012) Leverage aversion and risk parity. Financial Analyst Journal 68(1): 47–59.

Baquero G, ter Horst J &Verbeek M (2005) Survival, look-ahead bias, and the persistence in hedge fund performance. Journal of Financial and Quantitative Analysis 40(3): 493–518.

Berk JB & Green RC (2004) Mutual fund flows and performance in rational markets. Journal of Political Economy 112(6): 1269–1295.

Black F (1972) Capital market equilibrium with restricted borrowing. Journal of Business 45(3): 444–455.

Black F, Jensen MC & Scholes M (1972) The capital asset pricing model: Some empirical tests. In: Jensen MC (ed.) Studies in the theory of capital markets. New York, Praeger: 79–121.

Boyson NM (2008) Hedge fund performance persistence: A new approach. Financial Analyst Journal 64(6): 27–44.

Buraschi A, Kosowski R & Stritrakul, W (2013) Incentives and endogenous risk taking: A structural view of hedge fund alphas. Journal of Finance. Forthcoming.

Carhart M (1997) On persistence in mutual fund performance. Journal of Finance 52(1): 57–82.

Chen J, Hong HG, Huang M & Kubik JD (2004) Does fund size erode mutual fund performance? The role of liquidity and organization. American Economic Review 94(5): 1276–1302.

Dai J & Sundaresan S (2010) Risk management framework for hedge funds: Role of funding and redemption options on leverage. Working paper. Columbia University.

Edelman D, Fung W & Hsieh DA (2013) Exploring uncharted territories of the hedge fund industry: Empirical characteristics of mega hedge fund firms. Journal of Financial Economics 109(3): 734–758.

Elton EJ, Gruber MJ & Blake CR (2001) A first look at the accuracy of the CRSP mutual fund database and a comparison of the CRSP and Morningstar mutual fund databases. Journal of Finance 56(6): 2415–2430.

Fama EF & French KR (2010) Luck versus skill in the cross-section of mutual fund returns. Journal of Finance 65(5): 1915–1947.

Frazzini A & Pedersen LH (2013) Betting against beta. Journal of Financial Economics. Forthcoming.

Frazzini A & Pedersen LH (2012) Embedded leverage. NBER working paper no. w18558.

Fung W & Hsieh D (2009) Measurement biases in hedge fund performance data: An update. Financial Analysts Journal 65(3): 36–40.

Fung W, Hsieh DA, Naik NY & Ramadorai T (2008) Hedge funds: Performance, risk, and capital formation. Journal of Finance 63(4): 1777–1803.

Fung W & Hsieh DA (2001) The risk in hedge fund strategies: Theory and evidence from trend followers. Review of Financial Studies 14(2): 313–341.

Fung W & Hsieh DA (2000) Performance characteristics of hedge funds and CTA funds: Natural versus spurious biases. Journal of Financial and Quantitative Analysis 35(3): 291–307.

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

Fung W & Hsieh DA (2004) Hedge fund benchmarks: A risk-based approach. Financial Analyst Journal 60(5): 65–70.

Goetzmann WN, Ingersoll JE & Ross SA (2003) High-water marks and hedge fund management contracts. Journal of Finance 58(4): 1685–1718.

Glode V & Green RC (2011) Information spillovers and performance persistence for hedge funds. Journal of Financial Economics 101(1): 1–17.

Harris RS, Jenkinson T & Kaplan SN (2013) Private equity performance: What do we know? Journal of Finance. Forthcoming.

Ibbotson RG, Chen P & Zhu KX (2011) The ABCs of hedge funds: Alphas, betas, and costs. Financial Analyst Journal 67(1): 15–25.

Investment Company Institute (2009) A review of trends and activity in the investment company industry. Investment Company Fact Book.

Jagannathan R, Malakhov A & Novikov D (2010) Do hot hands exist among hedge fund managers? An empirical evaluation. Journal of Finance 65(1): 217–255.

Jensen MC (1968) The performance of mutual funds in the period 1945–1964. Journal of Finance 23(2): 389-416.

Kosowski R, Naik NY & Teo M (2007) Do hedge funds deliver alpha? A Bayesian and bootstrap analysis. Journal of Financial Economics 84(1): 229–264.

Lan Y, Wang N & Yang J (2013) The economics of hedge funds. Journal of Financial Economics 110(2): 300–323.

Liu X & Mello AS (2011) The fragile capital structure of hedge funds and the limits to arbitrage. Journal of Financial Economics 102(3): 491–506.

Luttmer EGJ (1996) Asset pricing in economies with frictions. Econometrica 64(6): 1439–1467.

Panageas S & Westerfield MM (2009) High-water marks: High risk appetites? Convex compensation, long horizons, and portfolio choice. Journal of Finance 64(1): 1–36.

Pastor L & Stambaugh RF (2012) On the size of the active management industry. Journal of Political Economy 120(4): 740–781.

Patton AJ, Ramadorai T & Streatfield M (2013) Change you can believe in? Hedge fund data revisions. Journal of Finance. Forthcoming.

Patton AJ & Ramadorai T (2013) On the high-frequency dynamics of hedge fund risk exposures. Journal of Finance 68(2): 597–635.

Patton AJ (2009) Are "market neutral" hedge funds really market neutral? Review of Financial Studies 22(7): 2495–2530.

Shleifer A & Vishny RW (1997) The limits of arbitrage. Journal of Finance 52(1): 35–55.

Stein JC (2009) Presidential address: Sophisticated investors and market efficiency. Journal of Finance 64(4): 1517–1548.

Stein JC (2002) Information production and capital allocation: Decentralized versus hierarchical firms. Journal of Finance 57(5): 1891–1921.

Stulz RM (2007) Hedge funds: Past, present, and future. Journal of Economic Perspectives. 21(2): 175–194.

Sun Z, Wang A & Zheng L (2012) The road less traveled: Strategy distinctiveness and hedge fund performance. Review of Financial Studies 25(1): 96–143.

Teo M (2010) Does size matter in hedge fund industry? Working paper. Singapore Management University.

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

Original articles

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