MANAGERIAL INCENTIVES AND RISK TAKING: EVIDENCE FROM HEDGE FUND LEVERAGE

by

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DISSERTATION ABSTRACT

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Using novel leverage and managerial ownership measures derived from public filings, this paper examines the role of managerial incentives in the use of leverage, in the context of hedge fund industry. I find a positive and convex relationship between fund leverage and the option-like compensation incentives, with the leverage level being significantly higher as the fund's asset under management (AUM) nears its high-water mark (HWM). I also find that hedge funds significantly reduce the leverage, when the incentive fee options are deep out of the money. Further, greater managerial ownership is associated with higher leverage, conditional on the incentive fee option being near the money. The findings lend support to option-like compensation contracts and managerial ownership improving incentive alignment between fund managers and investors. Interestingly, I find that investor flows and fund performance have an overall positive reaction to increases in leverage, which is mainly driven by well-performing funds with fund values sufficiently close to the HWMs.

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CHAPTER I

INTRODUCTION

The rapidly growing hedge fund industry has become an increasingly important player in the financial markets. Compared with $2 trillion in 2012, the total capital of hedge fund industry rose to a record of $3.15 trillion in the third quarter of 2017, according to data from Hedge Fund Research. One of the key features distinguishing hedge funds from other investment vehicles is the use of leverage. Hedge funds widely use external financing to lever up the underlying positions, with the intent to boost performance by assuming greater risk. For example, the gross assets of Citadel Advisors LLC and Millennium Management LLC soared ninefold to above $115 billion in 2012, when tallied with investments financed through borrowings.[1] The use of leverage by hedge funds has important implications on the welfare of investors, as well as the efficiency and stability of the financial markets (Brunnermeier and Pedersen (2009)). Given the systemic risk of hedge fund leverage on the financial markets, how leverage, a double-edged sword, is deployed has drawn substantial attention from the regulatory agencies, the media, and the academia (Kambhu, Schuermann, and Stiroh (2007) and Brunnermeier and Pedersen (2009)).[2]

Due to the opaque nature of lightly regulated hedge fund industry, fund managers have substantial discretion in making investment and financing decisions that are embedded with risk. Compensation contracts therefore play a vital role in aligning incentives of fund managers with investors. The total compensation

[1] "Citadel, Millennium Above $115 Billion With Rule Change" from Bloomberg on April 13, 2012 (https://www.bloomberg.com/news/articles/2012-04-13/citadel-soars-to-115-billion-with-reporting-rule-change).

[2] e.g., "Highly Leveraged Hedge Funds Harbor Risk" from Wall Street Journal on Sept. 21, 2017 (https://www.wsj.com/articles/highly-leveraged-hedge-funds-harbor-risk-1506030920).

of hedge fund managers features three components: the management fee, the incentive fee, and the capital gain on managers' ownership stake. The incentive fee component is typically subject to the high-water mark (HWM) provision ensuring that fund managers recover prior losses before being compensated with the incentive fee. Similar to the stock options granted to corporate executives, hedge fund managers receive asymmetric and nonlinear incentive fees that can be viewed as a portfolio of call options (Goetzmann, Ingersoll Jr, and Ross (2003)). In addition to the option-like incentive fee compensation, hedge fund managers typically have a portion of their own capital invested in the funds that they manage, which could account for a large proportion of their monetary rewards.

Given the unique compensation structure of hedge funds, it is important for researchers and investors to understand the role of managerial incentives in fund risk-taking measured by leverage. Prior theoretical literature has mixed predictions on the optimal use of leverage by hedge fund managers in various settings. The seminal work of Merton (1969) predicts that a CRRA-type manager should maintain a constant leverage over time under linear fee structure. Carpenter (2000) argues that the convexity of the incentive fee structure makes the manager shun near-the-money payoffs, which ends up with either large gains or large losses. Specifically, fund managers increase leverage and take on unbounded volatility, when fund value falls and the incentive fee option becomes out of money. Similarly, Hodder and Jackwerth (2007) predict that risk averse managers with short-horizons and outside career options will gamble by taking on higher risk, when the fund value approaches the liquidation threshold.

Other papers point out that the convexity effect could be mitigated by other factors, especially when the liquidation risk is high. Ross (2004) points out that a convex (concave) compensation schedule does not necessarily lead to less (more) risk aversion, depending on the distance of fund value to the HWM. The net effect of option-like contracts on risk aversion can be ambiguous and depends on the sum of three (sometimes offsetting) effects: the convexity effect, the translation effect, and the magnification effect. The translation effect captures that the compensation schedule moves the evaluation to a different part of the domain of the original utility function, where the risk aversion could be either higher or lower. The magnification effect depends on whether the fee schedule increases faster or more slowly than the underlying value. A faster increasing fee schedule magnifies the risk of any gamble and leads to more risk aversion. Depending on the convexity (concavity) of the compensation schedule, the utility function, and the domain, the convexity effect could be reinforced or mitigated by the other two effects. Panageas and Westerfield (2009) introduce the high-water mark (HWM) provision, and suggest that a risk-neutral hedge fund manager compensated by contracts with HWM behaves exactly as a Merton-type CRRA investor, and places a constant fraction of wealth in the risky assets. Buraschi, Kosowski, and Sritrakul (2014) consider investor redemption as short put options, and find that managers significantly reduce the leverage and risk-taking, when fund value approaches to the strike price of the put options. Lan, Wang, and Yang (2013) argue that, in the long-horizon setting, the concern of risk shifting may be overstated. They show that the manager is motivated to take on higher leverage when the fund value is close to HWM (i.e., when the manager is close to collecting incentive fees). However, when the incentive fee option is deep-out-of-the-money, the loss of future fees associated with costly liquidation induces the manager to reduce leverage to increase the likelihood of fund survival. ”

The aforementioned theories suggest that, with call-option like incentive fee contracts, the fund manager's decision on the optimal level of leverage depends on the distance of current fund value to HWM (the moneyness of the incentive fee option). Particularly, the convexity effect dominates when the incentive fee option is near the money, and thus leads to higher risk taking.

Despite several theoretical studies suggesting a close tie between fund leverage and managerial incentives, limited empirical evidence has been provided to support or refute the models' predictions, largely due to lack of high-quality leverage data. Ang, Gorovyy, and Van Inwegen (2011) are the first attempt to study the hedge fund leverage decisions using a proprietary dataset of leverage ratios from a large fund of hedge funds. They find that predictable changes in hedge fund leverage are mostly systematic, and there are few fund-level idiosyncratic effects. Jiang (2018) constructs the leverage of hedge fund advisors at the investment company level from public filings, and finds that highly-levered hedge funds are more likely to fire-sell long positions in adverse market conditions. Liang and Qiu (2019) obtain snapshots on fund leverage from TASS, and find that fund characteristics such as current leverage, past performance and governance quality affect the dynamics of leverage.

Using novel fund-level leverage and managerial ownership measures derived from regulatory filings Form ADV, this paper aims to provide the large-sample direct evidence on the relation between fund leverage and managerial incentives. With the implementation of the Dodd-Frank Act, stricter regulations have been imposed on the hedge fund industry in the aftermath of the financial crisis in 2008. As a result, the fund-level data of hedge fund industry has become available from

Form ADV since 2011.[3] In this study, I define fund leverage as the balance-sheet gross leverage, which is the ratio of gross asset value (collected from Form ADV) to net asset value (collected from commercial databases TASS and HFR). I also develop a new measure of managerial ownership from Form ADV. Previous hedge fund studies have used the cumulative value of the incentive fee reinvested as an estimate of managerial ownership, which may be disconnected from the reality.[4] First, while the conventional ownership estimate assumes that outflows are only from outside investors, I observe almost symmetric distribution of managerial ownership changes based on the information from Form ADV, suggesting that outflows are also likely from fund managers' own stake. Second, in my sample, more than 45% of the funds are launched with at least 10% managerial ownership, which suggests that fund managers usually invest their own money at the fund inception. To overcome these limitations, I obtain the data of managerial ownership directly from Form ADV, which is considerably more accurate than the one used in the hedge fund literature.[5] The time series variation of managerial ownership also allows us to further investigate the insider net flows, defined as the annual percentage change of managers' own stake.[6]

The hedge fund industry is an interesting research setting to study the relation between risk-taking and managerial incentives for several reasons. First, fund leverage is a measurement of risk-taking with more clear-cut interpretation,

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[3]Filing Form ADV is mandatory both for the advisors who are required to register with the SEC and for exempt reporting advisors.

[4]e.g. Agarwal, Daniel, and Naik (2009)

[5]Section 7.B of Form ADV mandate funds to provide fund-level information, in which Question 14 asks: "What is the approximate percentage of the private fund beneficially owned by you and your related persons?"

[6]As identified by Item 7.A of Form ADV, 88.5% of "related persons" include "sponsor, general partner, managing member (or equivalent) of pooled investment vehicles".

compared with other proxies of non-financial corporations, such as risky investments, R&D expenditures, and firm leverage. Further, I believe that the managerial incentive measures of hedge funds in my approach are less subject to the endogeneity concerns. As pointed out by Ross (2004), the main predictions from the aforementioned theories are about the optimal risk taking by fund managers in response to a set of predetermined compensation provisions. As argued by Agarwal et al. (2009), the compensation contracts of hedge funds are determined at the inception, and it is highly legally costly to modify the contracts afterwards. The proxies for managerial incentives, the distance to HWM measures (the moneyness of the incentive fee option), are purely based on the predetermined contracting terms and past performance records, and therefore have less reverse causality concerns.

I first find robust evidence that funds with greater option compensation incentives, proxied by the moneyness of the incentive fee option, take significantly higher leverage, which suggests that fund managers tend to increase the leverage as the fund value moves closer to or exceed the HWM. I also demonstrate that the positive relation between the option moneyness and fund leverage is convex, in which the managers take on higher leverage at an increasing rate, as the fund value nears the high-water mark. The results are consistent with the prediction in Ross (2004), Buraschi et al. (2014) and Lan et al. (2013), which show that compared with the out of the money scenarios, the convexity effect dominates around the HWM. Further, I find that hedge funds significantly reduce their leverage by 6 percentage points when the incentive fee options are deep out of the money, which is consistent with reducing risk due to liquidation concerns in the predictions of Lan et al. (2013). In addition, management fee and incentive fee are both positively associated with fund leverage. In short, the results demonstrate that managerial incentives have a strong connection with fund risk taking both statistically and economically.

Second, I examine the role of managerial ownership in leverage decisions. I find that greater managerial ownership is associated with higher leverage, which is consistent with the prediction of Lan et al. (2013). Further, I find that the role of managerial ownership varies in the moneyness of the incentive fee option. In the deep-out-of-the-money region, the relation between managerial ownership and leverage is reversed, with funds of high managerial stakes reducing leverage up to 13 percentage points, which suggests that larger personal stakes expose fund managers to more downside risk and thus discourage them from excess risk taking, when funds perform poorly. The findings suggest that managerial ownership improves incentive alignment between fund managers and outside investors, by making the managers care more about the fund value.

Third, I investigate the impact of leverage on fund flows and performance. I find a positive and significant relation between past leverage and future risk-adjusted NAV returns. Strikingly, the association is reversed, when fund value declines at least 15% below the HWM, in which an increase in leverage leads to a significant decline in fund performance. This result highlights the potential danger of levering up any high risk strategies that may have caused poor performance in the first place. Interestingly, I also find a positive relation between fund flows (both insider flows and outsider flows) and future performance, consistent with the smart money effect documented in the mutual fund literature. To alleviate the concern that fund leverage may be mechanically related to NAV returns, I follow Griffin and Xu (2009) and construct delivered returns based on disclosed equity holdings for fund advisors with at least 40% of assets invested in equities. I again find a strong and positive overall relation between leverage ratio and future performance, either on the four-factor adjusted alpha or on the Characteristic Selectivity (CS) alpha for fund advisors. This positive overall relation is also mainly driven by funds with values sufficiently close to the HWM.

Further, I extend the analysis to how fund leverage and managerial ownership are related to fund flows. I find that investors (both outsiders and insiders) have an overall positive reaction to an increase in leverage, conditional on fund value being near-the-money. The result suggests that investors react cautiously to higher leverage when fund value is deep below the HWM, consistent with the risk shifting concern when the fund performs poorly. Further, I also find that higher managerial ownership and better fund performance are associated with higher overall future fund net flows, outsider flows and new sales (inflows). This suggests that investments from managers and other insiders serve as a strong signal of aligning interests with outside investors. In summary, I find that investor flows and fund performance have an overall positive reaction to increases in leverage, which is mainly driven by well performing funds with values sufficiently close to the HWM. These results are consistent with the model predictions of Buraschi et al. (2014) and simulation results of Lim, Sensoy, and Weisbach (2016), which shed light on the welfare consequence of leverage decisions on fund investors.

Finally, I conduct comprehensive robustness tests. To mitigate the sample bias, I construct two samples with different sizes, one using perfect fund legal name match and the other using fuzzy fund legal name match. I then show that all the main results are robust to both of the samples, and to various alternate specifications, including alternative incentive measures and additional clustering.

To control for the effect of leverage constraints from the supply side of fund leverage, I include the prime broker, fund domicile and clientele information into the main regressions, and find that hedge funds with at least one prime broker, with offshore investment vehicles, and with less individual investors, take on higher leverage, likely due to more stable access to external financing, less legal restrictions, and higher risk tolerance of the investor base.

This paper is the first study, to my knowledge, to comprehensively examine the relation between hedge fund leverage and managerial incentives, using the high quality public datasets drawn from SEC filings. This study contributes to the literature by providing novel leverage and managerial ownership data to link the theories with large-sample evidence. The findings shed light on optimal contract design for hedge fund managers, and can also be relevant for managerial compensation in general. This paper is also related to the literature on the role of managerial incentives in managers' risk-taking broadly in the corporate finance literature, in which the empirical evidence has been mixed.[7]

The rest of the paper is organized as follows. Section 2 discusses the related literature and hypotheses. Section 3 describes the data and variable definitions. Section 4 presents the main results. Section 5 shows robustness tests and Section 6 concludes. Supplemental materials are included in the appendix.

[7]Coles, Daniel, and Naveen (2006) find that the convexity in the compensation contract is positively associated with R&D expenditures and firm leverage. Chava and Purnanandam (2010) also find that the convexity is positively correlated with leverage and negatively related to cash reserves. However, Lewellen (2006) finds that higher option compensation tends to deter debt financing. Hayes, Lemmon, and Qiu (2012) show the change in option usage is generally unrelated to firm risky investment and financial policies, by exploiting FAS 123R, an exogenous change in the accounting benefit of stock options.

CHAPTER II

HYPOTHESES DEVELOPMENT

Merton (1969) shows that, under a linear fee structure, an investor with constant relative risk aversion (CRRA) keeps a constant fraction of her portfolio in risky assets, i.e., a constant leverage ratio. This constant fraction is typically referred to as the Merton flat. Following the seminal work of Merton (1969), two strands of theoretical literature have emerged to examine the impact of nonlinear compensation incentives on the risk taking of fund managers. One strand examines how risk averse managers react to option-like compensation structures in finite period models. The other strand studies the optimal risk taking by risk neutral managers in infinite horizon models.

Carpenter (2000) is the first paper studying the impact of a call option-like fee structure on the optimal risk taking by a CRRA-type manager in a continuous time finite period model. The key insight is that the convexity of the fee structure makes the manager shun near-the-money payoffs and ends up with either large gains or large losses. When fund value is near the HWM, the manager takes more risk to increase her chance of ending up in the money. When fund value declines below the HWM and approaches zero, the manager takes on unlimited risk. Interestingly, the manager does not always increase her risk appetite with call option-like fees. She actually decreases risk taking once the option is in the money to a level even below the Merton flat and then gradually converge back to the flat as the option value becomes deep in the money.

Ross (2004) questions the common folklore that option-like compensation will make managers universally more or less risk averse. In a single-period model and for a broad class of utility functions with varying degrees of risk aversion, Ross shows that the net effect of option-like contracts on risk aversion can be ambiguous and depends on the sum of three (sometimes offsetting) effects: the convexity effect, the translation effect, and the magnification effect. The convexity effect reflects the common folklore that granting option-like compensation induces more or less risk taking. The translation effect captures the fact that the option shifts or translate the fee schedule to a different region of the utility function, which can be more or less risk averse. Finally, the magnification effect depends on whether the option-like structure makes the fee schedule increase faster or slower than the underlying fund value. A faster increasing schedule will magnify the risk of any gamble and thus make the risk-averse manger less willing to undertake the risky bet. In the case of a fund manager with decreasing absolute risk aversion (DARA) utility, adding a call option to the linear fee structure does not necessarily increase risk taking across all domains. When fund value gets close to the HWM, the convexity effect dominates and leads to more risk taking. When fund value exceeds the HWM, the addition of the call option increases the wealth of the fund manager and thus moves her utility to a less risk averse region. Such translation effect reinforces the convexity effect and induces more risk taking. However, the magnification effect makes any gambles appear riskier and thus reduces risk taking. Hence, contrary to the common folklore, the addition of a call option compensation may make the fund manager more risk averse if the magnification effect dominates the other two effects.

Hodder and Jackwerth (2007) explicitly model the risk taking of a CRRA-type manager compensated with a standard hedge fund package: a fixed management fee and an incentive fee with HWM. In a one-period model with endogenous fund closure, the paper presents analytical results consistent with Ross

(2004) that the incentive fee does not universally increase risk taking. In particular, the optimal risk taking depends on the distance of fund value to the HWM, or the moneyness of the incentive fee option. When fund value is near the HWM, the manager increases risk taking in an effort to make the incentive fee option in the money. Once in the money, the manager initially reduces the risk taking even below the Merton flat to lock in the incentive fee compensation and then revert back to the Merton flat when sufficiently in the money. When the incentive fee option is out of the money but away from liquidation, the optimal risk taking is the Merton flat. Interestingly, the fund manager does not always take on unbounded risk when fund value approaches the liquidation boundary. The optimal risk taking depends on the fund manager's outside options. When the outside options are high, the fund manager will gamble by substantially increasing risk taking. In the case of limited or no outside options, the fund manager will significantly reduce risk taking to avoid liquidation.

Buraschi et al. (2014) expand the finite horizon framework by explicitly modeling the impact of downside risk as short put options. Two types of risk emerge when fund value declines far below the HWM: the funding liquidity risk and the investor redemption risk. These two risks are akin to holding short positions in two put options by the fund manager. The key finding is that the CRRA-type fund manager significantly reduce risk taking to mitigate funding and redemption risks when the incentive fee option is deep out of the money. The optimal risk taking in other regions of moneyness is similar to the predictions in Hodder and Jackwerth (2007).

A common theme of the above papers is that risk averse managers do not always increase risk taking when compensated with a call option-like incentive fee structure. The other strand of the literature argues that risk aversion is not a necessary condition for this result. Instead, they show that even a risk-neutral manager will behave in a risk averse way in a infinite horizon framework.

Panageas and Westerfield (2009) develop an infinite horizon model with random fund liquidation. They show that even a risk-neutral manager will not take on unbounded volatility given the call-option like incentive fee with HWM. Instead, the manager behaves exactly like a Merton CRRA-type manager by investing a fixed proportion of her portfolio in risky asset, i.e., constant risk raking. The intuition for this surprising result is that incentive fee with HWM should be viewed as a sequence of call options with changing strike prices and infinite horizons. More risk taking today increases the likelihood that fund value drops below the HWM, and thus decreases the values of all future options. The tradeoff between the current and future payoffs lead the risk-neutral manager to behave like the Merton-type risk averse investors.

Lan et al. (2013) also model the optimal risk taking by a risk-neutral manager in an infinite horizon framework. They differ from Panageas and Westerfield (2009) by incorporating a much richer and realistic compensation structure including management fee, HWM-indexed incentive fee, endogenous liquidation, leverage constraint, and managerial ownership. Similar to Panageas and Westerfield (2009), the risk-neutral manager trades off the current payoff against future compensation and behave in a risk averse manner. However, the mechanisms for the trade-off differ between the two models and thus lead to different equilibrium risk taking. Compared with the constant risk taking in Panageas and Westerfield (2009), both the endogenous risk attitude and the optimal leverage ratio in Lan et al. (2013) is stochastic and depends on the distance of fund value to the HWM. An increase in leverage can amplify expected return (higher future compensation) but can also increase the risk of forced liquidation (permanent loss of future fees). The aversion to downside risk is the main driver for the key model prediction that the manager becomes more (less) risk averse and take on lower (higher) leverage when the fund value moves further away from (closer to) the HWM.

One consistent prediction from the aforementioned theoretical studies is that the convexity effect dominates when the incentive fee option is near the money and thus leads to higher risk taking. I therefore have the following hypothesis for near-the-money leverage ratio:

H1: All else equal, when fund value is near the HWM, the manager increases the leverage ratio.

When the incentive fee option is in the money, Ross (2004) shows that for a general class of utility function with risk aversion, the impact on the manager's risk attitude can be ambiguous. Assuming CRRA utility and reasonable parameter values, Carpenter (2000), Hodder and Jackwerth (2007), and Buraschi et al. (2014) all predict that the fund manager will first reduce leverage to lock in the incentive fee and then increase the leverage again when the incentive fee option is sufficiently in the money. I therefore have the following hypothesis for in-the-money leverage ratio:

H2: All else equal, when fund value exceeds the HWM, the manager initially decreases the leverage ratio and then increases again.

In the case of the incentive fee option being out of the money, the optimal leverage ratio depends on the assumptions on the downside risk and the manager's outside options. With limited downside risk and/or high outside options, Carpenter

(2000) and Hodder and Jackwerth (2007) both predict gambling behavior and thus higher leverage ratio. On the other hand, with high liquidation risk and limited outside options for the fund manager, Hodder and Jackwerth (2007) and Lan et al. (2013) show that the fund manager will significantly reduce the leverage ratio when fund value is near the liquidation boundary. I therefore have the following two alternative hypotheses for out-of-the-money leverage ratio:

H3A: All else equal, when fund value falls sufficiently below the HWM, the manager increases the leverage ratio for a better chance of ending up in the money.

H3B: All else equal, when fund value falls sufficiently below the HWM, the manager decreases the leverage ratio to avoid costly liquidation and loss of future fees.

Few theoretical studies have examined the role of managerial ownership in risk taking. Lan et al. (2013) directly models the impact of managerial ownership and show that higher managerial ownership in general leads to higher leverage. This is because a larger personal stake better aligns the interests between the manager and fund investors and thus mitigates the negative effect of risk aversion on risk taking. Basak, Pavlova, and Shapiro (2007) and Hodder and Jackwerth (2007) show that the same personal stake or a fixed management fee exposes the manager to downside risk due to the loss from personal capital or fee income from liquidation. The exposure to such downside risk would discourage the fund manager from taking big gambles when the fund is performing badly. I therefore have the following hypothesis on the impact of managerial ownership on leverage ratio:

H4: All else equal, higher managerial ownership in general induces the manager to take on higher leverage. However, when fund value falls sufficiently below the HWM, higher managerial ownership mitigates the risk taking incentives and leads to lower leverage.

CHAPTER III

DATA DESCRIPTION

In this section, I describe the data sources, the construction of key variables, and the summary statistics.

Data Sources

I obtain fund characteristics data from the following sources: Form ADV and Form D filings with the SEC, two commercial databases including Lipper TASS and Hedge Fund Research (HFR), Thomson Reuters 13F database, and the SEC 13F filings.

Prior to the 2008-2009 financial crisis, hedge funds mostly avoided the public disclosure mandated by the SEC for registered investment advisors. The passage of the Dodd Frank Act in 2011 requires all investment advisers with gross assets under management over $150 million to register and file Form ADV with the SEC on an annual basis. Part 1 of Form ADV provides fund-level information including fund legal names, fund advisors, fund type, gross asset value (GAV), and managerial ownership. I keep all private funds with self reported fund type as "hedge fund" and with GAV above $1 million. GAV is the key variable used later to compute fund-level leverage ratio. It is defined as the gross value of regulatory assets under management (RAUM), which include all of the assets for which the private fund provides continuous and regular supervisory or management services. Broadly speaking, RAUM includes cash and cash equivalents, long and short positions, leverage, margin, family or proprietary accounts, accounts for which the manager receives no compensation for its services, and accounts of clients who are not United States persons.[1] Hence, GAV is the gross value of assets funded

[1] see Item 5b of Form ADV and Filing Instructions for more information: https://www.sec.gov/rules/final/2016/ia-4509-appendix-b.pdf.

by both equity capital and debt (i,e, leverage). From Form ADV, I collect 69,984 observations for 21,021 hedge funds from 2011 to 2017. In addition, I obtain the fund-level new sales (money inflows) data from Form D and merge it with Form ADV data by filing numbers.

I next match the hedge fund sample collected from Form ADV with the combined list of hedge funds in two commercial databases TASS and HFR.[2] In the first stage, I identify overlapping fund management firms using the SEC filing numbers and names of fund advisors. In the second stage, within the matched fund management firms, I identify overlapping hedge funds matched with fund legal names. Because fund names may be recorded differently between Form ADV and commercial databases, I construct two matched hedge fund samples: one based on perfect name matches and the other based on fuzzy name matches. Finally, I manually check the matched funds based on the fund managers, the legal structure, and the domicile information to ensure that all fund identifiers retrieved from Form ADV are unique in the final data set. The initial smaller perfectly matched sample contains 1,892 hedge funds, 1,051 from HFR and 841 from TASS. The initial larger fuzzy-matched sample contains 3,131 hedge funds, 2,160 from HFR and 971 from TASS. For robustness purpose, I conduct all empirical analyses with both fund samples but only present the results based on the fuzzy name match sample for brevity. I report the results based on the exact name match sample in an online appendix.

I collect a host of fund-specific information that are reported to TASS and HFR, including net asset value (NAV), net-of-fee return, management fee, incentive

[2] I delete the duplicate funds from TASS and HFR by SEC fund identifier. I keep the TASS observations of duplicate funds becasue TASS has longer history of the data in the sample. I also delete the observations for which the return and net asset data in TASS and HFR are inconsistent.

fee, high-water mark provision, redemption period, lockup period, advance notice period, and fund strategies. In the next section, I define the main variable of interest, leverage ratio, by combining the GAV and NAV measures. In practice, the level of leverage likely depends on a fund's investment strategy. For example, long/short equity funds tend to use relatively low leverage due to high basis risk. In contrast, fixed income arbitrage funds tend to use high leverage to magnify small price discrepancies from exploring arbitrage strategies with low basis risk. Hence, I control for strategy fixed effect in the main regressions. Following Agarwal et al. (2009), I classify hedge funds into six broad strategy categories: directional, relative value, security selection, multi-process, fund of funds, and other.

I construct holdings-based returns for single-fund management firms based on both Thomson-Reuters 13F database and the SEC 13F filings. Franzoni, Ben-David, Moussawi, and Sedunov (2019) find that the Thomson-Reuters data have several quality issues causing a substantial increase in omitted institutions and excluded securities since 2013, compared with the original SEC 13F filings. For robustness, following Franzoni et al. (2019), I collect the quarterly holdings data from both Thomson-Reuters and the SEC EDGAR filings system. I then use historical holdings to map the CIK identifier from the SEC filings to the corresponding mgrno in Thomson Reuters to match management firms between the two databases. Finally, I supplement the Thomson Reuters data with the SEC 13F filings data for the post-2013 period.

Definition of Key Variables

I now define several key variables used in subsequent empirical analysis and present the summary statistics.

Leverage. My key measure of risk-taking by a hedge fund is the leverage ratio. Following Ang et al. (2011), I define the leverage ratio for fund i at year-end t as the balance-sheet gross leverage ratio: $L_{i,t} = \frac{GAV_{i,t}}{NAV_{i,t}}$, where GAV is from Form ADV and NAV is from TASS and HFR. It measures the total value of assets invested by the hedge fund as a multiple of its equity capital. One caveat of this explicit leverage definition is that I do not take into account the use of implicit leverage, e.g., derivatives. Hence, my measure of leverage may understate the total risk exposure for a hedge fund.

Managerial Incentives. One common implication from the theoretical literature reviewed in Section 2 is that a fund manager's risk taking incentives depend on the distance of fund value to the HWM, i.e., the moneyness of the incentive fee option. I therefore use the distance to HWM (the moneyness of the incentive fee option) as the main explanatory variable. The challenge is that I do not directly observe the HWM over time and have to estimate it. Following Aragon and Nanda (2012) and Agarwal et al. (2009), I construct two measures of the moneyness of the incentive fee option: one based on the net-of-fee returns and the other based on gross-of-fee returns, respectively. I assume that the fund manager will be evaluated for incentive fees at the end of the year based on the HWM determined at the beginning of the year. The two measures differ in whether the HWM is estimated based on net-of-fee return or gross-of-fee return.

For the net-of-fee return moneyness measure, I use the NAV returns provided by TASS and HFR to estimate the fund's HWM. I assume that fund i's initial HWM ($HWM_{i,1}$) is its NAV ($A_{i,0}$) at inception (normalized at \$1), i.e., $A_{i,0} = 1$ and $HWM_{i,1} = 1$. I then estimate the NAV and HWM recursively using $A_{i,t} = A_{i,t-1}(1 + R_{i,t})$ and $HWM_{i,t+1} = \max(HWM_{i,t},\ A_{i,t})$, where $R_{i,t}$

is the annual return based on the monthly NAV returns provided by TASS and HFR. This approach allows us to avoid dropping observations with missing NAV data.[3] I define the net-of-fee return moneyness measure at the beginning of yeat t as $D_{net,t} = \frac{A_t}{HWM_{t+1}}$, which by construction is capped by 1.[4]

For the gross-of-fee return moneyness measure, I follow the procedure in Agarwal et al. (2009) and estimate the gross return based on certain key assumptions.[5] I assume that fund flows occur at the year end and a new investor enters the fund at the year end in case of fund inflows. I treat the incentive fee contract for each investor as an independent option. For each investor, I separately estimate the market value of her investments (A) and HWM at each year end recursively based on the gross returns. The total incentive fee compensation for managers is viewed as the sum of the incentive fee options for all individual investors. I define the gross-of-fee return moneyness measure as a value-weighted average of each individual investor's distance to HWM: $D_{gross,t} = \sum_i \omega_i \frac{A_{i,t}}{HWM_{i,t+1}}$, where the weights are computed as the market value of each investor's investments divided by the total market value summed across all investors. This measure is also capped by 1 by construction.[6]

Both moneyness measures defined above are capped at 1 by construction. For robustness and a better understanding of managerial risk taking when the incentive fee option is in the money, I also construct two contemporaneous

[3]Missing NAV observations account for about 20% of my sample.

[4]For the funds that do not have the high-water mark provision, the option exercise price is higher than the current fund value by the hurdle rate. The results are robust when excluding those funds from the analysis, which account for 10% of the sample.

[5]See Appendix A in Agarwal et al. (2009) for a detailed description.

[6]The downside of using the gross-of-fee return moneyness measure is that I have to drop the funds without the full history of NAVs due to the need of using NAVs in calculating the fund flows for each investor.

moneyness measures: mid-year moneyness and year-end moneyness. Following Aragon and Nanda (2012), the mid-year moneyness measure is defined as the ratio between a fund's mid-year NAV and its HWM: $D_{mid-year,t+1} = \frac{A_t(1+R_{t,t+\frac{1}{2}})}{HWM_{t+1}}$, where $R_{t,t+\frac{1}{2}}$ is the cumulative NAV return in the first half of the year. The year-end moneyness is defined as the ratio between a fund's year-end NAV and its HWM: $D_{year-end,t+1} = \frac{A_{t+1}}{HWM_{t+1}}$. The mid-year moneyness and year-end moneyness measures could exceed 1, depending on fund performance over the year relative to the HWM.

Managerial Ownership and Insider Flows. I collect managerial ownership data directly from Form ADV and use it to compute insider flows. I believe that this is a marked improvement over the managerial ownership used in the prior literature. For example, Agarwal et al. (2009) use the cumulative value of the incentive fees reinvested as the proxy for managerial ownership, which is based on the restrictive assumptions that fund managers have no initial personal stake and never make any additional investments (except for the incentive fees) or withdrawals. my measure is based on regulatory filings and thus more accurate and comprehensive. Section 7.B.(1) of Form ADV mandates investment advisors to disclose a host of fund-level information, in which Question 14 specifically asks: "What is the approximate percentage of the private fund beneficially owned by you and your related persons".[7]

Following Goetzmann et al. (2003), I define the total net flows for fund i in year t as $Netflow_{i,t} = \frac{NAV_{i,t}-NAV_{i,t-1}(1+R_{i,t})}{NAV_{i,t-1}}$. By exploiting the managerial ownership data, I further separately define insider and outsider net flows as follows. Insider net flows are measured as the scaled dollar flows into the fund

[7]According to Item 7.A of Form ADV, 88.5% of "related persons" include "sponsor, general partner, managing member (or equivalent) of pooled investment vehicles".

from managers and realted persons: $Insider_{i,t} = \frac{M_{i,t}*NAV_{i,t}-M_{i,t-1}*NAV_{i,t-1}(1+R_{i,t})}{M_{i,t-1}*NAV_{i,t-1}}$, where $M_{i,t}$ is the managerial ownership of fund i at year-end t. Similarly, I define outsider net flows as the scaled dollar flows from outside investors: $Outsider_{i,t} = \frac{(1-M_{i,t})*NAV_{i,t}-(1-M_{i,t-1})*NAV_{i,t-1}(1+R_{i,t})}{(1-M_{i,t-1})*NAV_{i,t-1}}$,

Other Variables. High-water Mark is an indicator variable that equals 1 if the fund has HWM provision, and equals 0 otherwise. Prime Broker is an indicator variable that equals 1 if the fund has at least one prime broker, and equals 0 otherwise. Lockup Period is the minimum time (in months) that outside investors must keep their investments in the fund before requesting redemption. Advance Notice Period is the minimum notice period (in days) required for investors making redemption requests. Redemption Period is the time (in days) that the fund takes to return the money to investors after the redemption date. Fund Age is the time (in years) since the fund inception. Annual Return (Volatility) is the mean (standard deviation) of monthly returns during the year. I also construct two risk-adjusted performance measures. Alpha-4factors is the monthly alpha computed based on the factor loadings estimated from the Carhart (1997) four-factor model using the past 24-month NAV returns. Similarly, Alpha-7factors is the monthly alpha computed based on the factor loadings estimated from the Fung and Hsieh (2004) seven-factor model using the past 36-month NAV returns.

Summary Statistics

Table B.1 presents the summary statistics of key fund characteristics for my matched sample consisting of overlapping funds between the Form ADV sample and the TASS/HFR sample. The average fund GAV and NAV are \$390 million and \$267 million, respectively. Consistent with well documented evidence that hedge fund size is positively skewed, I also find that the mean fund size is much larger than the median. The average fund age is 9 years. Hedge fund managers tend to have a large personal stake in their funds, with an average managerial ownership of 21%. This highlights the importance of studying the impact of managerial ownership on risk taking. Regarding the compensation structure, the mean (median) management fee and incentive fee are 1.4% (1.5%) and 17% (20%), respectively. Moreover, 90% of funds in my sample have HWM provision. In terms of redemption policy, the average fund in my sample has a 6-month lockup period, a 53-day advance notice period, and a 75-day redemption period. Finally, about 70% of funds in my sample use prime brokers. To address the concern that my matched sample may not be representative of the hedge fund universe, I also report summary statistics based on either the entire Form ADV sample or the combined TASS/HFR sample. For most fund characteristics, the summary statistics for my matched sample are quite similar to those for the whole sample. Compared to the whole sample, funds in my matched sample tend to be older and more likely to use prime brokers. This provides comfort that funds in my matched sample have similar overall characteristics as the hedge fund universe.

Table B.2 Panel A reports the summary statistics of Gross Leverage, my key variable for managerial risk taking. The average gross leverage ratio in my sample is 1.42, lower than the average ratio of 2.13 as reported in Ang et al. (2011) based on proprietary data from 2004 to 2009. However, they also document that hedge funds started to delever since mid-2007 and the average leverage decreased to 1.5 in October 2009 at the end of their sample period, which is comparable to my sample average. Hence, it appears that the average hedge fund leverage in the postcrisis period did not revert to the precrisis level. Although the overall use of leverage by hedge funds appears to be modest, the cross-sectional variation is considerably large with a standard deviation of 88%. While about a quarter of hedge funds do not take on any leverage, the top 10% funds take on close to or over 3 times the leverage. There are also considerable variations in the use of leverage across investment strategies. Relative value funds have the highest average leverage ratio, followed by direction traders, multiprocess, and security selection funds with similar average leverage ratios. Funds of hedge funds on the other hand tend to take on the lowest leverage. The cross-strategy variation is largely consistent with the summary statistics disclosed in the SEC's "Annual Staff Report Relating to the Use of Form PF Data."[8] One notable difference is that the average leverage of relative value funds in the SEC's report is twice as large as the one in my sample, possibly due to the different strategy definition.

Table B.2 Panel B reports the summary statistics for other key variables used in the regression analyses. Regardless of the distance to HWM (the moneyness of incentive fee options) measures, I observe substantial clustering around the HWM as shown in Figures A.1 and A.2. The mean of the net-return moneyness measure is 96% with 9% standard deviation. I also find some large deviations from the HWM. For the midyear moneyness measure, the bottom 10% of fund years are at least 15% below the HWM, while the top 10% of fund years are at least 10% above the HWM. For the entire sample period, 38% fund years are below the HWM, or under the water. The net fund flows are on average 9% per year with a standard deviation of 63%. I further separately report the statistics for insider and outsider net flows. I find that, compared with outsider net flows, insider new flows

[8]In addition to Form ADV, the Dodd-Frank Act also requires investment advisors to file Form PF and report more detailed financial information. However, Form PF filings are strictly confidential and the SEC only makes some key summary statistics available to public in the annual report "Annual Staff Report Relating to the Use of Form PF Data."

are on average larger (30% vs. 11% per year) and are also more volatile (161% vs. 88% annual standard deviation). This suggests that flows from fund managers and related persons are an important part of total net fund flows and these insiders appear to adjust their capital even more actively than outside investors.

CHAPTER IV

EMPIRICAL RESULTS

In this section, I present the main results on how managerial incentives affect the use of leverage and the implications of leverage on fund flows and performance.

Baseline Linear Models of Managerial Incentives and Leverage

I begin with investigating the relation between managerial incentives and fund leverage using multivariate linear regression models, in which changes in leverage are regressed on distance to HWM measures (the moneyness of the incentive fee option) and managerial ownership. I believe that my empirical approach is less subject to the endogeneity concerns for the following reasons. As pointed out by Ross (2004), the main predictions from the theories reviewed in Section 2 are about the optimal risk taking by fund managers in response to a set of predetermined compensation provisions. To test these predictions, I develop my main proxies for managerial incentives, the distance to HWM measures (the moneyness of the incentive fee option), purely based on the predetermined contracting terms and past performance record. Because the compensation contracts for hedge fund managers are determined at fund inception and rarely change over the fund life due to high costs of modification (Agarwal et al. (2009)), my distance to HWM measures have less reverse causality concerns. [1]

[1] For the four distance measures, only the net-return and gross-return moneyness measures are purely based on past performance and are thus subject to less endogeneity concerns. The other two measures including mid-year and year-end moneyness use contemporary returns and thus have some concerns.

I estimate the following linear regression with the lagged dependent variable to examine how managerial incentives impact the dynamics of fund leverage.

$$L_{i,k,t} = \alpha + \beta_1 L_{i,k,t-1} + \beta_2 Moneyness_{i,k,t-1} + \beta_3 Managerial\ ownership_{i,k,t} + \beta_4 Management\ fee + \beta_5 Incentive\ fee + \beta_6 Controls_{i,k,t-1} + \lambda_t + \eta_k + \varepsilon_{i,k,t}, \tag{4.1}$$

where $L_{i,k,t}$ stands for the gross leverage of fund i with strategy k at year-end t. I include the lagged leverage $L_{i,k,t-1}$ in the specification to control for the mean reversion in leverage changes (Ang et al. (2011)). The variables potentially affecting managerial incentives of risk taking include the distance to HWM (net-return moneyness, gross-return moneyness, mid-year moneyness, and year-end moneyness), managerial ownership, management fee, and incentive fee.

I also control for other fund characteristics that may affect the leverage decision. Investments in illiquid assets could discourage fund managers from taking on high leverage. This is because the short-term financing and short notice on changes of financing terms from prime brokers result in a mismatch between the duration of fund assets and liabilities. Aragon (2007) shows that hedge funds investing illiquid assets tend to impose stricter terms for investor redemption to attenuate the duration mismatch of their balance sheet. I therefore control for asset illiquidity by including redemption period, advance notice period, and lockup periods in the regressions. Since hedge funds often use leverage to target a particular level of volatility, I control for the standard deviation of monthly NAV returns in the previous year. Larger and older funds are likely to have more established relation with prime brokers and thus easier to obtain financing. I therefore include fund net assets, fund age, and fund net flows in the regressions.

Finally, hedge funds are faced with maximum leverage constraints imposed by the providers of leverage, which are commonly their prime brokers. Hedge fund managers make a decision on optimal leverage as a function of the perceived risk-return trade-off, subject to exogenously imposed leverage limits. Further, the margin requirement and the implied level of leverage depends on the type of securities traded, the exchange and the creditworthiness of the fund, subject to regulations. For example, the Federal Reserve Board's Regulation T allows investors to borrow up to a maximum 50% of a position on margin with the implied leverage level at 2. Hedge funds can establish offshore investment vehicles and obtain higher leverage than the level allowed by regulation in less restrictive jurisdictions. Another significant financing source of hedge fund is their client base, which also has the ability to pull financing out of the fund. The financing risk is considered as a short put option in Buraschi et al. (2014), which also impacts the hedge fund leverage decision. In short, whether to have access to prime brokers, fund registration place, and investor clientele can also affect the use of leverage. To differentiate and control for the effect of leverage constraints from the supply side of fund leverage, I therefore include the use of prime brokers, onshore vs. offshore registration, and the percentage of high net worth individuals in the fund's investor base as additional control variables. All regressions include the year fixed effect λ_t to control for the macroeconomics conditions, and the strategy fixed effect η_k to control for the strategy-specific characteristics, as suggested in Ang et al. (2011). The standard errors are clustered both by fund. In the robustness tests with alternative specification, the results are also robust to additional clustering by strategy and by year.

Table B.3 presents the baseline linear regression results from estimating Equation 4.1. The coefficients on all four distance to HWM measures are positive and statistically significant at the 5% level or better. This result suggests that fund managers tend to increase the leverage as the fund value moves closer to or exceed the HWM. Regarding the economic significance, one standard deviation change in the net-return distance is associated with 5 percentage points change in fund leverage, which is considerably large given that borrowing on average accounts for 42% of the fund's net asset. I also find that higher managerial ownership is significantly associated with higher leverage. Specifically, a one standard deviation increase in managerial ownership is related to a 4 percentage points increase in fund leverage. This is consistent with the prediction in Hypothesis 4 based on Lan et al. (2013). In addition, management fee and incentive fee are both positively associated with fund leverage. Overall, the results from Table B.3 demonstrate that managerial incentives have a strong connection with fund leverage both statistically and economically.

The coefficients of the control variables are largely intuitive and consistent with the prior literature. The positive and significant coefficients of lagged leverage indicate persistence of leverage ratio, but the magnitude (about 0.30) is quite moderate. The negative coefficients of advance notice period, redemption period, and lockup period are consistent with the conjecture that funds with more illiquid holdings tend to take less risk, given the liquidity constraints. I also find that larger and older funds, presumably with larger borrowing capacity and better connection with prime brokers, tend to take on higher leverage.[2] Similar to the findings of Ang

[2]e.g., "U.S. Regulators to Focus on Borrowing at Large Hedge Funds" from Wall Street Journal on April 18, 2016 (https://www.wsj.com/articles/u-s-regulators-to-focus-on-borrowing-at-large-hedge-funds-lew-says-1461015212).

et al. (2011), the negative coefficient of return volatility confirms the prediction of Brunnermeier and Pedersen (2009) that more volatile returns require higher margins and thus lead to lower level of leverage. [3]

Finally, I find that funds with prime brokers, offshore registration, and larger institutional investor base tend to take on higher leverage. The higher risk taking by these funds is likely due to better access to prime brokers, less legal restrictions, and higher risk tolerance of the investor base.

Non-linear Models of Managerial Incentives and Leverage

Hypotheses 1 to 3 predict that fund managers' risk taking incentives are likely to vary, depending on the distance of fund value relative to the HWM (the moneyness of the incentive fee option). In this section, I explore the non-linear relation between managerial incentives and leverage. Specifically, I divide the distance to HWM measures into four regions: [0,0.85], (0.85,0.96], (0.96,1.1], and above 1.1. The cutoffs are chosen based on the distribution of mid-year distance measures as reported in Table B.2 Panel B. For the net-return and gross-return distance measures, only the first three regions apply because these two measures are capped at 1 by construction. The deep-out-of-the-money region ([0,0.85]) includes the bottom 10% fund-year observations in which fund values are at least 15% below the HWM. The out-of-the-money region ((0.85,0.96]) includes roughly the 10th-25th percentiles of fund-year observations in which fund values are 4-15% below the HWM. The close-to-the-money region ((0.96,1.1]) includes fund-year observations from 4% below to 10% above the HWM, accounting for about 65% of the fund-year observations. Finally, the deep-in-the-money region (above 1.1)

[3] e.g., "Highly Leveraged Hedge Funds Harbor Risk" from Wall Street Journal on Sept. 21, 2017 (https://www.wsj.com/articles/highly-leveraged-hedge-funds-harbor-risk-1506030920).

includes the top 10% of fund-year observations in which fund values are at least 10% above the HWM.

I first estimate the following piecewise linear specification based on the regions defined above:

$$\begin{aligned} L_{i,k,t} =& \alpha + \beta_1 L_{i,k,t-1} + \beta_2 Moneyness_{i,k,\ t-1} * D_{[0,0.85]} \\ & + \beta_3 (Moneyness_{i,k,\ t-1} - 0.85) * D_{(0.85,0.96]} + \beta_4 (Moneyness_{i,k,\ t-1} - 0.96) * D_{(0.96,1.1]} \\ & + \beta_5 (Moneyness_{i,k,\ t-1} - 1.1) * D_{(1.1,\infty)} + \beta_6 Managerial\ ownership_{i,k,t-1} \\ & + \beta_7 Controls_{i,k,t-1} + \lambda_t + \eta_k + \varepsilon_{i,k,t}, \end{aligned} \tag{4.2}$$

where D_{region} is an indicator variable that equals 1 if the distance to HWM (the moneyness of the incentive fee option) falls into the corresponding region and 0 otherwise. Other variables are defined as in Equation 4.1.

Table B.4 Panel A presents the piecewise regression results from estimating Equation 4.2. Columns (1) and (2) report the results using net-return and gross-return distance measured at the previous year-end. The coefficients for the distance to the HWM are positive and statistically significant at the 1 % level for the closed-to-the-money region (0.96,1]. This is consistent with the prediction in H1 that, compared with the out of the money scenarios, the convexity effect of incentive fee option is stronger when the option is close to the money. In contrast, the coefficients for the two out-of-the-money regions are largely insignificant.

Column (3) sheds light on how fund managers adjust risk taking based on the performance in the first half of the year. Similar to the previous two columns, fund managers significantly increase the leverage when fund value is close to the HWM. The insignificant coefficient in the out-of-the-money region (between 0.85 and 0.96) suggests that the leverage is close to Merton flat, consistent with the prediction of Hodder and Jackwerth (2007) and Buraschi et al. (2014). In contrast, the coefficient of the distance to HWM in the deep-in-the-money region (above 1.1) turns positive and significant, suggesting that fund managers become less risk averse when they feel secure about getting the incentive fees. This finding partially supports the predictions in H2 as I don't find evidence of any decline in risk taking when the incentive fee option is in the money. Column (4) presents the results when using year-end distance measure. The coefficients are qualitatively similar to those in Column (3) but less statistically significant.

To ensure robustness, I next estimate an alternative nonlinear specification without imposing a linear structure within each region:

$$\begin{aligned} L_{i,k,t} =& \alpha + \beta_1 L_{i,k,t-1} + \beta_2 D_{[0,0.85],i,k,t-1} + \beta_3 D_{(0.96,1.1],i,k,t-1} \\ & + \beta_4 D_{(1.1,\infty 0,i,k,t-1} + \beta_5 Managerial\ ownership_{i,k,t-1} \\ & + \beta_6 Controls_{i,k,t-1} + \lambda_t + \eta_k + \varepsilon_{i,k,t}. \end{aligned} \tag{4.3}$$

I omit the out-of-the-money region (between 0.85 and 0.96) and use it as the basis for comparison. As shown in Table B.5 Panel B, the estimation results from Equation (4.3) are similar to the results from the piecewise specification in Panel A. For the net-return and gross-return distance measures, I find strong convexity effect that fund leverage peaks in the close-to-money region (between 0.96 and 1.0). Compared to the out-of-the-money region, fund managers on average increase the leverage ratio by 6 percentage points when the incentive fee option is close to the money. When using mid-year distance measure, I find that fund managers significantly increase their risk taking by 5 percentage points when fund value is close to the HWM and continue to increase the leverage by another 8 percentage points when the incentive fee option is deep-in-the-money. In contrast, When the incentive fee option is deep-out-of-the money (less than 0.85), the coefficient on the moneyness becomes negative and statistically significant. Fund managers significantly decrease the leverage ratio by 6 percentage points when fund value is more than 15% below the HWM. The results using year-end distance measure is similar, except that the decline in risk taking in the deep-out-of-money region is smaller and not statistically significant. This result supports the prediction of H3B that fund managers reduce risk taking to increase the chance of survival when fund values are closer to liquidation boundaries. The results are consistent with the findings of costly liquidation in Lim et al. (2016), which show that indirect incentives from future inflows of capital, comprise the majority of managers' total incentives. Fund managers tend to be prudent when fund value is distant from its HWM, to increase the likelihood of fund survival and to collect indirect incentives from future inflows.

In summary, I find robust evidence that managerial incentives are strongly associated with the risk taking by hedge fund managers. The patterns discovered in regression analyses are largely consistent with the theoretical predictions. The convexity effect dominates around the HWM as fund managers increase leverage to become eligible of collecting incentive fees. They become less risk averse and further increase the leverage when sufficiently above the HWM. In contrast, they become more risk averse and significantly reduce the risk taking when sufficiently under the water to avoid liquidation.

The Role of Managerial Ownership in Leverage Decisions

In the previous section, I find that higher managerial ownership is associated with higher risk taking. It is plausible that the role of managerial ownership varies in the moneyness of the incentive fee option. As stated in H4, larger personal stakes expose fund managers to more downside risk and thus discourage them from excess risk taking when funds perform poorly. To explore the potential heterogeneous effects of managerial ownership, I add the interaction of managerial ownership with the distance to HWM measures in Equation (4.2) and Equation (4.3) and report the regression results in Table B.5.

Panel A presents the piecewise regression results from estimating Equation (4.2). The coefficients on managerial ownership remain positive and significant after adding the interaction terms. Regarding the interaction terms, the coefficients for the deep-out-of-the-money region ([0,0.85]) are all negative and statistically significant for the net-return, gross-return and year-end distance measures. This is consistent with the conjecture in H4 that a higher personal stake in the fund makes the manager more risk averse and reluctant to gamble when the fund is performing poorly. The coefficients in the other three regions are all statistically insignificant and do not exhibit a consistent pattern. The results from the indicator regression in Panel B are qualitatively similar. Panel C presents the indicator regression results with the interactions between the mnoney regions and high ownership indicator, which equals to 1 if the fund falls into top 30% ownership within the same strategy. The results of Panel C are consistent with the results of the piecewise regressions in Panel A, in which funds with high managerial stakes reduce leverage up to 13 percentage points in the deep-out-of-the-money region.

The Implication of Leverage on Fund Flows and Performance

Having examined the role of managerial incentives in determining fund leverage, I now turn to the impact of leverage on fund flows and performance. This will shed light on the welfare consequence of leverage decisions on fund investors.

I first examine the sensitivity of fund flows to leverage, especially whether the sensitivity changes in different distance to HWM (the moneyness of the incentive fee option) regions. Specifically, I estimate the following regression:

$$\begin{aligned} Flow_{i,k,t} = \alpha &+ \beta_1 L_{i,k,t-1} * D_{[0,0.85]} + \beta_2 L_{i,k,t-1} * D_{(0.85,0.96]} \\ &+ \beta_3 L_{i,k,t-1} * D_{(0.96,\infty)} + \beta_4 Managerial\ ownership_{i,k,t-1} \\ &+ \beta_5 Alpha - 7factors_{i,k,t-1} + \beta_6 D^{return\ below\ 50\%}_{i,k,t-1} + \beta_7 Volatility_{i,k,t-1} \\ &+ \beta_8 Controls_{i,k,t-1} + \lambda_t + \eta_k + \varepsilon_{i,k,t}, \end{aligned} \tag{4.4}$$

where the dependent variable is total net flows, outsider net flows, insider net flows, or new sales. The main explanatory variables include the leverage ratio or change in leverage ratio interacting with different distance to HWM regions measured at the previous year end, the managerial ownership at previous year end, and the lagged fund performance and return volatility. For fund performance, I include both Alpha-7factors computed based on the NAV returns from the previous 36 months and an indicator variable $D^{return\ below\ 50\%}$ that equals one if the fund's annual NAV return is below the median of all funds in the same strategy category in the previous year, and zero otherwise. All other control variables are defined in the previous tables.

Table B.6 presents the regression results of fund flows on leverage and managerial ownership. For each flow measures, I report the overall sensitivity to leverage and the sensitivity in each distance to HWM region as specified in Equation (4.4). As shown in Panel A, the coefficients of lagged leverage are positive and statistically significant for all flow measures, suggesting that investors (both outsiders and insiders) have an overall positive reaction to an increase in leverage. Panel B breaks down the flow-leverage sensitivity into the three distance to HWM (moneyness) regions based on net returns. I observe dramatic differences in flow-leverage sensitivities across regions. The coefficients are mostly insignificant when the net-return distance is below 0.96. This suggests that investors react cautiously to higher leverage when fund value is deep below the HWM, consistent with the risk shifting concern when the fund performs poorly. In contrast, the flow-leverage sensitivities are significantly positive when the net-return distance measure is above 0.96, or in the close-to-the-money region. Hence, investors tend to invest more capital into higher levered funds that are performing well. The results using gross-return distance measures are qualitatively similar, which are reported in the appendix for brevity. In Panel C, I use the change in leverage ratio to interact with the distance to HWM regions and find similar patterns as those reported in Panel B.

Further, higher managerial ownership is associated with higher overall fund flows, outsider flows and new sales (inflows). This suggests that investments from managers and other insiders serve as a strong signal of aligning interests with outside investors. Investors appear to chase not only past performance, but also managerial ownership, possibly understanding that managerial incentives are better aligned with investors' interests. The coefficients of control variables are intuitive and consistent with prior literature. Consistent with the mutual fund literature and prior hedge fund studies, I also document a strong positive flow-performance relation. I also find that funds performing poorly relative to their same-category peers experience large outflows from outside investors. Consistent with Aragon and Nanda (2012), I find that higher return volatility is associated with larger fund outflows.

Next, I examine the performance consequences of leverage decisions. Having shown that leverage decisions vary with managerial incentives (proxied by the moneyness of incentive option), I am particularly interested in both the overall performance impact of leverage and whether such impact differs depending on the closeness of fund value to the HWM. I estimate the following regression:

$$\begin{aligned} Perf_{i,k,t} = {} & \alpha + \beta_1 L_{i,k,t-1} * D_{[0,0.85]} + \beta_2 L_{i,k,t-1} * D_{(0.85,0.96]} \\ & + \beta_3 L_{i,k,t-1} * D_{(0.96,\infty)} + \beta_4 Managerial\ ownership_{i,k,t-1} \\ & + \beta_5 Net\ Flow_{i,k,t-1} + \beta_6 Net\ assets_{i,k,t-1} + \beta_7 Volatility_{i,k,t-1} \\ & + \beta_8 Controls_{i,k,t-1} + \lambda_t + \eta_k + \varepsilon_{i,k,t}, \end{aligned} \tag{4.5}$$

where $Perf$ denotes risk-adjusted monthly return computed using either the NAV returns or the holdings-based returns. $Alpha - 4factors$ and $Alpha - 7factors$ are monthly alphas computed based on the four-factor and seven-factor models as described in Section 3. One endogeneity concern with these two performance measures is that they are based on NAV returns and thus "contaminated" by the leverage effect. To address this concern, I also construct two unlevered performance measures using the holdings-based returns. $Holdings - 4factors$ denotes the monthly alpha computed from the four-factor model using holdings-based returns in the previous 36 months. $Holdings - CS$ denotes the Characteristic Selectivity (CS) measure computed by subtracting the benchmark portfolio returns from the holdings-based returns (Daniel, Grinblatt, Titman, and Wermers (1997)). The key control variables include managerial ownership, net flows, the logarithm of net assets, and return volatility. All other controls are defined as in the previous tables.

Table B.7 presents the regression results with NAV-based risk-adjusted returns as the dependent variable. The results are consistent between the four-factor and the seven-factor models. Overall, there is a positive and significant relation between past leverage and future risk-adjusted performance. This suggests that the use of leverage in general increases investor welfare. When breaking down into different regions based on the distance to HWM (moneyness), I observe a strikingly opposite pattern between the deep-out-of-the money and close-to-the-money regions. When fund value declines at least 15% below the HWM, an increase in leverage leads to a significant decline in fund performance. This highlights the potential danger of levering up any high risk strategies that may have caused poor fund performance in the first place. In contrast, when fund value is close to the HWM, levering up the well performing strategies leads to better risk-adjusted performance and thus further benefits fund investors. I find a positive relation between fund flows and future performance, consistent with the smart money effect documented in the mutual fund literature. Among the control variables, incentive fee is also positively related to fund performance. I also find evidence that past return volatility and fund size are negatively related to future returns.

Table B.8 reports the regression results with holdings-based risk-adjusted returns as the dependent variable. Since Form 13F is filed at the fund advisor level, I aggregate all explanatory variables across all funds managed by the same advisor. For total assets, I sum the net assets across all member funds. For other explanatory variables, I take the TNA-weighted average across all member funds. Given that fund advisors are only required by the SEC to disclose long equity positions, I restrict the sample to fund advisors with the disclosed equity positions accounting for at least 40% of total assets. This explains the drop in the number of observations available for the holdings-based analysis.

The regression results in Table B.8 are largely consistent with those reported in Table B.7. I again find a strong and positive overall relation between leverage ratio and future performance, either the four-factor adjusted alpha or the CS alpha. This positive overall relation is mainly driven by funds with values sufficiently close to the HWM. For funds with values sufficiently distant from the HWM, higher leverage remains negatively related to future performance but the coefficients are not statistically significant. The lack of statistical significance could be due to the smaller sample size given the data limitations.

In summary, I find that investor flows and fund performance have an overall positive reaction to increases in leverage. The positive relation is mainly driven by well performing funds with values at least sufficiently close to the HWM. These results are consistent with the model predictions of Buraschi et al. (2014) and simulation results of Lim et al. (2016).

CHAPTER V

ROBUSTNESS TESTS

In this section, I conduct several robustness tests using the various empirical specifications in the appendix.

To mitigate the sample bias, I construct two samples with different sizes, one using perfect fund legal name match and the other using fuzzy fund legal name match. I show that all the main results are robust in Table C.1 using the perfect-matched sample with equivalent economic magnitude.

To address the concern of endogenous contracting due to different skill levels, I estimate Equation 4.1 based on the sub-sample with the incentive fee exactly at 20%. In the sample, 70% of the funds have the 20% incentive fee that is regular for the whole hedge funds industry. As shown in Table C.2, all the results remain quantitatively the same with those in Table B.3.

I then conduct robustness tests using the sub-samples with high-water mark provisions, and with the fund of hedge funds excluded. To mitigate the concern that funds with or without high-water mark may have distinct managerial incentives, Table C.3 presents the results of estimating Equation 4.1 for the funds with high-water mark provisions, which accounts for 90% of the hedge funds. Table C.3 shows that the main results in Table B.3 are also robust to the sub-sample of the funds with high-water mark provisions. Given the fund of hedge funds may have distinct investment strategy than other hedge funds, I exclude them from the sample and estimate Equation 4.1. Table C.4 shows that the results become more significantly both statistically and economically after excluding the fund of hedge funds, which is not surprising considering the mean and variation of leverage levels of the fund of hedge funds are considerably small.

Further, I examine whether the estimates of Equation 4.1 are robust to the specification without the supply side controls, with standard deviation clustered by strategy, and clustered by fund and by year. Table C.5, Table C.7 and Table C.8 show that the findings are robust to various alternate specifications. I also show that the findings of performance analysis in Table B.8 for fund advisors with the disclosed equity positions at least 40% of total assets, is robust to the single-fund advisor in Table C.8.

CHAPTER VI

CONCLUSION

Hedge funds distinguish from other investment vehicles by the use of leverage that trades off the boosted return with the magnified risk exposure. Further, hedge fund is featured by stable compensation contracts and long-term investor commitment, which allow fund managers to deploy leverage with wide discretion.

This study presents the first analysis, to the best of my knowledge, to comprehensively examine the relation between hedge fund leverage and managerial incentives, using the new public dataset drawn from SEC filings Form ADV. I find several interesting and important results. First, I find a positive and convex relation between the option moneyness and fund leverage, which is particularly significant as the fund value nears the high-water mark. Second, I find that the manager becomes more prudent as the fund value distances from high-water mark, in contrast to risk shifting suggested by conventional wisdom. Further, the greater managerial ownership is associated with larger leverage, conditional on the fund value close to its high-water mark. I also find that investor flows and fund performance have an overall positive reaction to increases in leverage, which is mainly driven by well performing funds with values sufficiently close to the HWM. These results are consistent with the model predictions of Buraschi et al. (2014) and simulation results of Lim et al. (2016), which shed light on the welfare consequence of leverage decisions on fund investors.

The findings are consistent with the prediction in Ross (2004) and Buraschi et al. (2014), which show that compared with the out of the money scenarios, the convexity effect dominates around the HWM. The findings indicate that option-like compensation contracts and managerial ownership help align the incentives of fund managers and investors, and alleviate the agency cost, which lend support to the model predictions of Lan et al. (2013).

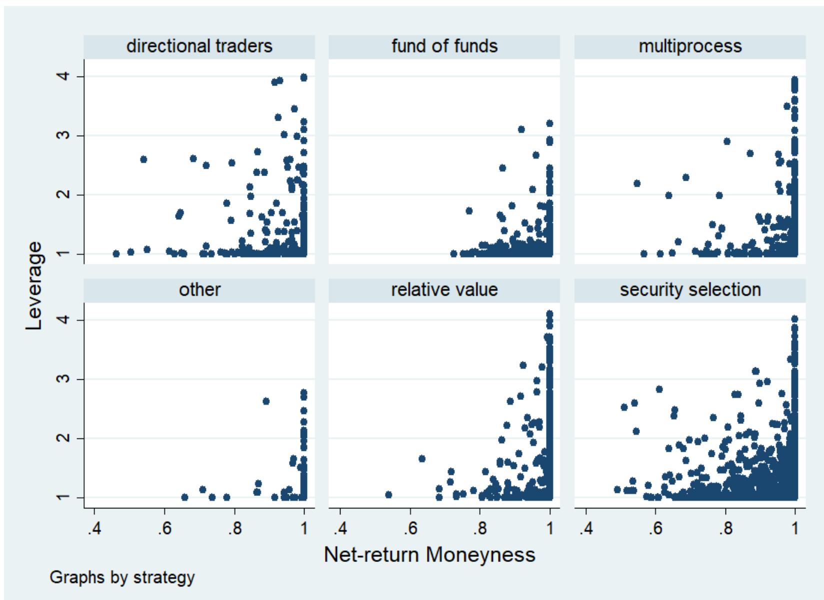
APPENDIX A

FIGURES

Figure A.1. The Scatter Plot of Fund Leverage and Managerial Incentives

This figure depicts the scatter plot of fund leverage with managerial incentives (the incentive fee option moneyness measures) by fund strategies. The fund leverage is the balance-sheet gross leverage, defined as the ratio of gross asset value (GAV) to net asset value (NAV). Following Agarwal et al. (2009), I classify funds into six broad strategies: Directional, Relative Value, Security Selection, Multi-Process, Fund of funds, and Other. Net-return moneyness is defined as the ratio of a fund's NAV divided by its HWM, calculated based on the net return following Aragon and Nanda (2012). Gross-return moneyness is defined as the ratio of fund's NAV divided by its HWM, calculated based on the algorithm following Agarwal et al. (2009).The sample period is from 2011 to 2016.

Panel A: Fund leverage and Net-return moneyness



Panel B: Fund leverage and Gross-return moneyness

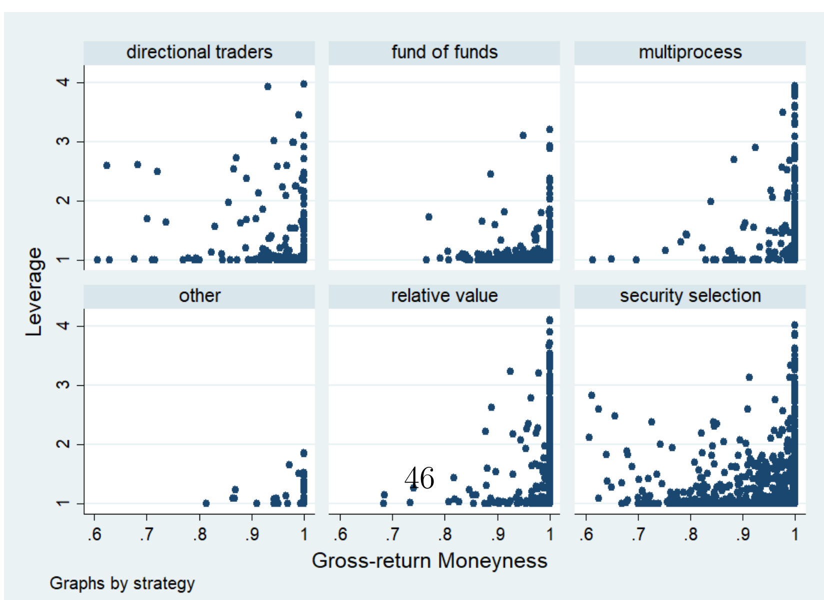
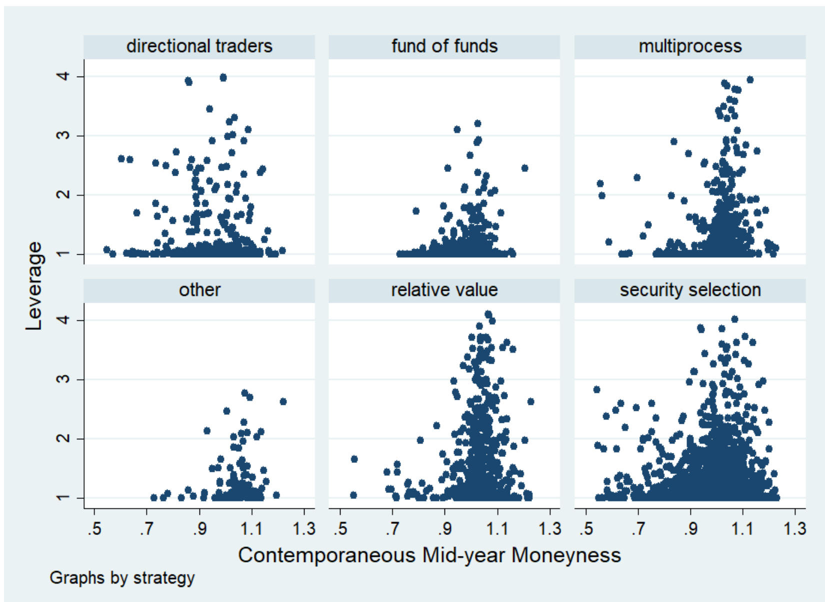


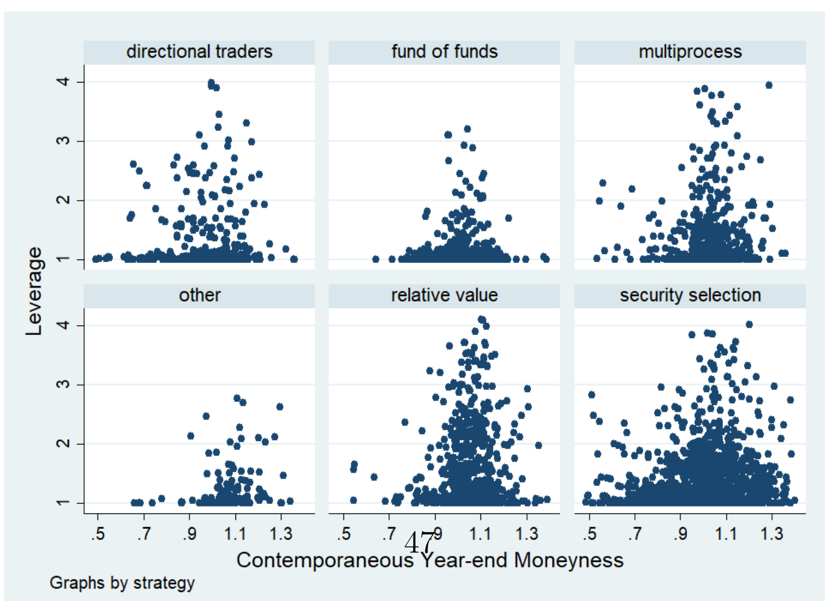
Figure A.2. The Scatter Plot of Fund Leverage and Contemporaneous Moneyness

This figure depicts the scatter plot of fund leverage with the contemporaneous moneyness measures. The fund leverage is the balance-sheet gross leverage, defined as the ratio of gross asset value (GAV) to net asset value (NAV). Following Agarwal et al. (2009), I classify funds into six broad strategies: Directional, Relative Value, Security Selection, Multi-Process, Fund of funds, and Other. Mid-year moneyness and Year-end moneyness are the ratios of fund's mid-year and year-end NAV divided by its prior HWM, respectively, following Aragon and Nanda (2012).The sample period is from 2011 to 2016.

Panel A: Fund leverage and contemporaneous Mid-year moneyness



Panel B: Fund leverage and contemporaneous Year-end moneyness



APPENDIX B

TABLES

Table B.1. The Comparison of Fund Characteristics

This table presents the summary statistics of the fund characteristics for the whole sample and the matched sample over the 2011-2016 period. Gross asset value (GAV) and managerial ownership data are collected from Form ADV, while net asset value (NAV) and all other fund characteristics are collected from TASS/HFR. Managerial ownership is the approximate percentage of the private fund beneficially owned by managers and the related persons from Form ADV. High-water mark is an indicator variable that equals 1 if the fund has high-water mark provision, and equals 0 otherwise. Prime broker is an indicator variable that equals 1 if the fund has at least one prime broker, and equals 0 otherwise. Lockup period is the minimum time period that outside investors must wait before they can withdraw their capital. Advance notice period is the time period that the investors must give notice to the fund about their intention to withdraw. Redemption period is the time period that the fund takes to return the money after the advance notice period. Age is the age of the fund after inception in years. There is no significant difference of fund characteristics between the whole sample and the matched sample, except for prime broker indicator and fund age. Gross Asset Value and Net Asset Value are winsorized at the 1st and 99th percentile levels.

	Whole Sample				Matched Sample			
	Obs	Mean	Median	SD	Obs	Mean	Median	SD
Gross Asset Value (million)	69,984	335	83	746	4,882	390	83	681
Net Asset Value (million)	24,395	217	59	446	4,882	267	66	418
Managerial Ownership (%)	69,984	18	3	30	4,882	21	9	27
Prime Broker Indicator*	69,984	0.54	1.0	0.5	4,882	0.7	1.0	0.5
Redemption Period (days)	26,501	82	90	77	4,882	75	90	65
Management Fee (%)	26,501	1.3	1.5	0.4	4,882	1.4	1.5	0.4
Incentive Fee (%)	26,501	16	20	7	4,882	17	20	7
High-water Mark	26,501	0.8	1.0	0.4	4,882	0.9	1.0	0.3
Advance Notice Period (days)	26,501	52	45	31	4,882	53	45	33
Lockup Period (months)	26,501	6	0	7	4,882	6	0	7
Fund Age* (years)	26,501	7	6	5	4,882	9	9	6

Table B.2. The Summary Statistics of Fund Leverage and Regression Variables

This table reports the summary statistics for the hedge fund leverage by fund strategies and the variables of interest in the baseline regression. In Panel A, the fund leverage is the balance-sheet gross leverage, defined as the ratio of gross asset value (GAV) to net asset value (NAV). Following Agarwal et al. (2009), I classify funds into six broad strategies: Directional, Relative Value, Security Selection, Multi-Process, Fund of funds, and Other. I report the number of observations, means, standard deviation, median, and 10th, 25th, 75th, and 90th percentiles of the fund leverage distribution. The average and standard deviation of fund leverage in the sample are similar to the ones of the proprietary data in Ang et al. (2011). Panel B summarizes key variables of interest in the main regressions for the matched sample. Alpha-4factors and Alpha-7factors are the intercepts from fund-level time-series regression of monthly excess net returns on the four factors of Carhart (1997) and the seven factors of Fung and Hsieh (2004). Volatility is standard deviation of monthly returns over the fiscal year. Net flows are the investors' net dollar flow at the fiscal year-end scaled by the net assets. Insider Net Flows are the percentage change of managerial stake. Outsider Net Flows are the percentage change of outside investors' equity investments. Net-return moneyness is defined as the ratio of a fund's NAV divided by its HWM, calculated based on the net return following Aragon and Nanda (2012). Gross-return moneyness is defined as the ratio of fund's NAV divided by its HWM, calculated based on the algorithm following Agarwal et al. (2009). Mid-year moneyness and Year-end moneyness are the ratios of fund's mid-year and year-end NAV divided by its prior HWM, respectively, following Aragon and Nanda (2012). Underwater is an indicator variable that equals 1 if net-return moneyness is less than 1, and equals 0 otherwise. Option Delta is the total expected percentage change in manager's incentive fee for a 1% change in investors' assets. Option Vega is the total expected percentage change in manager's incentive fee for a 1% change in the volatility. Dollar delta is the product of the option delta and the investors' assets, and Dollar vega is the product of the option vega and the investors' assets, following Agarwal et al. (2009). The sample period is from 2011 to 2016.

Panel A: The summary statistics of the fund leverage

Strategies	Num of Obs	Num of Funds	Mean	SD	
Relative Value	745	273	1.70	1.09	
Security Selection	2104	770	1.39	0.74	
Directional Traders	411	156	1.55	1.14	
Multiprocess	637	225	1.49	0.88	
Fund of Funds	843	282	1.15	0.72	
Other	142	46	1.34	0.79	
Total	4882	1752	1.42	0.88	
Ang et al. (2011)	8136	208	1.5 (after 2009)	0.616	
	P10	P25	Median	P75	P90
Relative Value	1	1.01	1.23	1.76	3.72
Security Selection	1	1	1.14	1.40	2.38
Directional Traders	1	1	1.06	1.36	3.94
Multiprocess	1	1.01	1.16	1.45	3.33
Fund of Funds	1	1	1.01	1.04	1.60
Other	1	1	1.07	1.24	2.47
Total	1	1	1.08	1.35	2.90

(Table B.2 continued)

Panel B: The summary statistics of the independent variables in the baseline regression

	Num of Obs	Mean	SD	P5	P10	P25
Net-return moneyness (%)	4,882	96	9	76	85	96
Gross-return moneyness (%)	3,626	97	8	80	89	97
Mid-year moneyness (%)	4,678	100	11	78	86	96
Year-end moneyness (%)	4,678	102	15	76	85	96
Underwater	4,882	0.38	0.49	0	0	0
Net Flows (%)	4,596	9	63	-49	-33	-15
Insider Net Flows (%)	2,875	30	161	-76	-48	-17
Outsider Net Flows (%)	3,226	11	88	-64	-45	-21
Annual Return (%)	4,715	6	12	-14	-8	-1
Volatility (%)	4,874	2.49	1.81	0.56	0.76	1.21
Monthly Alpha-7factors (%)	2,718	0.22	0.63	-0.85	-0.49	-0.09
Monthly Alpha-4factors (%)	2,696	0.12	0.61	-0.89	-0.58	-0.20
Option Delta (%)	3,497	0.07	0.04	0	0.01	0.04
Option Vega (%)	3,497	0.06	0.03	0	0.01	0.04
Option Delta (\$'000)	3,497	176	399	0	1	8
Option Vega (\$'000)	3,497	143	317	0	3	8

	Num of Obs	Median	P75	P90	P95
Net-return moneyness (%)	4,882	100	100	100	100
Gross-return moneyness (%)	3,626	100	100	100	100
Mid-year moneyness (%)	4,678	102	106	110	113
Year-end moneyness (%)	4,678	103	110	117	123
Underwater	4,882	0	1	1	1
Net Flows (%)	4,596	-2	12	48	103
Insider Net Flows (%)	2,875	0	20	78	204
Outsider Net Flows (%)	3,226	-4	13	54	119
Annual Return (%)	4,715	6	12	21	27
Volatility (%)	4,874	2.00	3.24	4.90	6.09
Monthly Alpha-7factors (%)	2,718	0.23	0.56	0.94	1.25
Monthly Alpha-4factors (%)	2,696	0.13	0.48	0.82	1.10
Option Delta (%)	3,497	0.10	0.10	0.10	0.11
Option Vega (%)	3,497	0.08	0.08	0.08	0.08
Option Delta (\$'000)	3,497	35	130	477	940
Option Vega (\$'000)	3,497	31	104	393	761

Table B.3. Managerial Incentives and Fund Leverage: Baseline Linear Models

This table presents the regression results on fund leverage, using the lagged and contemporaneous measures of option moneyness as independent variables. Net-return moneyness is defined as the ratio of a fund's NAV divided by its HWM, calculated based on the net return following Aragon and Nanda (2012). Gross-return moneyness is defined as the ratio of fund's NAV divided by its HWM, calculated based on the algorithm following Agarwal et al. (2009). Mid-year moneyness and Year-end moneyness are the ratios of fund's mid-year and year-end NAV divided by its prior HWM, respectively, following Aragon and Nanda (2012). $D_{primebrokers}$ is an indicator variable that equals 1 if the fund has at least one prime broker, and equals 0 otherwise. $D_{Onshore}$ is an indicator variable that equals 1 if the fund is organized in United States, and equals 0 otherwise. Individual number proportion is the percentage that individuals and high net worth individuals comprise of the total number of the clients. Individual AUM proportion is the percentage of the assets under management attributable to individuals and high net worth individuals. The sample period is from 2011 to 2016, where the Form ADV fund level data is available. In the regression, I control for year fixed effect and strategy fixed effect with standard error clustered at fund level. The t-value are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Panel A: Key variables of interest

	Lagged Moneyness		Contemporaneous Moneyness	
	Model 1	Model 2	Model 3	Model 4
Net return moneyness$_{t-1}$	0.47***			
	(3.6)			
Gross return moneyness$_{t-1}$		0.39**		
		(2.3)		
Mid − year moneyness$_t$			0.36***	
			(3.0)	
Year − end moneyness$_t$				0.17**
				(1.9)
Managerial Ownership$_{t-1}$	0.14***	0.11**	0.13***	0.13**
	(2.7)	(2.0)	(2.7)	(2.5)
Management fee	11.23***	13.20***	11.13***	11.00***
	(3.0)	(3.1)	(3.0)	(2.9)
Incentive fee	0.66**	0.66**	0.68***	0.70***
	(2.5)	(2.0)	(2.6)	(2.7)
$D_{\text{Prime brokers}}$	0.18***	0.18***	0.18***	0.18***
	(5.7)	(4.7)	(5.6)	(5.7)
D_{Onshore}	-0.10***	-0.11***	-0.10***	-0.10***
	(-3.5)	(-3.3)	(-3.5)	(-3.4)
Individual AUM proportion	-0.14***	-0.13***	-0.14***	-0.15***
	(-4.0)	(-3.2)	(-4.1)	(-4.2)

(Table B.3 continued)

Panel B: Control variables

	Lagged Moneyness		Contemporaneous Moneyness	
	Model 1	Model 2	Model 3	Model 4
Leverage$_{t-1}$	0.31***	0.29***	0.31***	0.31***
	(8.2)	(7.0)	(8.3)	(8.2)
Advance notice period	-0.08***	-0.05	-0.09***	-0.09***
	(-2.7)	(-1.4)	(-2.8)	(-2.8)
Redemption period	-0.01	-0.01	-0.01	-0.01
	(-0.7)	(-0.7)	(-0.9)	(-0.7)
Lockup period	-0.11	-0.25	-0.13	-0.13
	(-0.7)	(-1.4)	(-0.9)	(-0.8)
Volatility$_{t-1}$	-2.43***	-2.18***	-2.30***	-2.69***
	(-3.5)	(-2.9)	(-3.3)	(-4.1)
Net asset$_{t-1}$	0.05**	0.06**	0.05**	0.05**
	(2.1)	(2.1)	(2.2)	(2.1)
Net flow$_{t-1,\ t}$	-0.11***	-0.09***	-0.11***	-0.11***
	(-4.6)	(-3.6)	(-4.7)	(-4.7)
Fund age$_{t-1}$	0.64***	0.40	0.65***	0.67***
	(3.2)	(1.5)	(3.3)	(3.4)
Observations	3,025	2,279	3,025	3,025
Number of funds	1,299	979	1,299	1,299
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.43	0.44	0.44	0.43

Table B.4. Managerial Incentives and Fund Leverage: Piece-wise Regressions

This table presents the piecewise regression results on fund leverage with the same control variables and specification in the baseline regression. Net-return moneyness is defined as the ratio of a fund's NAV divided by its HWM, calculated based on the net return following Aragon and Nanda (2012). Gross-return moneyness is defined as the ratio of fund's NAV divided by its HWM, calculated based on the algorithm following Agarwal et al. (2009). Mid-year moneyness and Year-end moneyness are the ratios of fund's mid-year and year-end NAV divided by its prior HWM, respectively, following Aragon and Nanda (2012). $D^{moneyness}_{[0,0.85]}$ is the indicator variable that equals 1 if the moneyness measures fall below 0.85. $D^{moneyness}_{(0.96,1.1]}$ is the indicator variable that equals 1 if the moneyness measures fall between 0.96 and 1.1. The sample period is from 2011 to 2016, where the Form ADV fund level data is available. In the regression, I control for year fixed effect and strategy fixed effect with standard error clustered at fund level. The t-values are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Panel A: Piecewise regressions

	Net-return	Gross-return	Mid-year	Year-end
$\text{Moneyness}_{t-1}{*}D^{moneyness}_{[0,0.85],\ t-1}$	-0.05	0.02	-0.08*	-0.07
	(-1.2)	(0.4)	(-1.9)	(-1.3)
$(\text{Moneyness}_{t-1} - 0.85){*}D^{moneyness}_{[0.85,0.96],\ t-1}$	-0.05	0.77*	0.07	-0.25
	(-0.2)	(1.8)	(0.2)	(-0.7)
$(\text{Moneyness}_{t-1} - 0.96){*}D^{moneyness}_{(0.96,1.1],\ t-1}$	0.57***	3.06***	0.52**	0.38*
	(3.0)	(3.4)	(2.0)	(1.9)
$(\text{Moneyness}_{t-1} - 1.1){*}D^{moneyness}_{(1.1,\infty),\ t-1}$			1.16**	0.10
			(2.0)	(0.5)
Managerial Ownership$_{t-1}$	0.12**	0.12**	0.12***	0.12***
	(2.6)	(2.2)	(2.6)	(3.0)
Management fee	13.41***	14.49***	13.34***	14.4***
	(3.8)	(3.7)	(3.8)	(3.7)
Incentive fee	0.93***	0.88***	0.93***	1.05***
	(3.8)	(2.9)	(3.8)	(3.8)
Controls	Yes	Yes	Yes	Yes
Observations	2,916	2,224	2,916	2,916
Number of funds	1,252	951	1,252	1,252
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.44	0.45	0.45	0.45

(Table B.4 continued)

Panel B: Dummy regressions

	Net-return	Gross-return	Mid-year	Year-end
$D^{moneyness}_{[0,0.85],\ t-1}$	-0.01	-0.04	-0.06**	-0.01
	(-0.2)	(-1.2)	(-2.05)	(-0.2)
$D^{moneyness}_{(0.96,1.1],\ t-1}$	0.06**	0.05**	0.05**	0.05**
	(2.3)	(2.3)	(2.16)	(2.0)
$D^{moneyness}_{(1.1,\infty),\ t-1}$			0.08**	0.08**
			(2.11)	(2.4)
Managerial Ownership$_{t-1}$	0.12***	0.13***	0.13***	0.12**
	(2.6)	(2.7)	(2.6)	(2.6)
Management fee	13.29***	13.18***	13.41***	13.11***
	(3.8)	(3.8)	(3.9)	(3.8)
Incentive fee	0.94***	0.97***	0.93***	0.95***
	(3.9)	(4.0)	(3.8)	(3.9)
Controls	Yes	Yes	Yes	Yes
Observations	2,916	2,224	2,916	2,916
Number of funds	1,252	951	1,252	1,252
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.42	0.42	0.43	0.43

Table B.5. Interaction of Managerial Ownership with Option Incentives

This table presents the regression results on the fund leverage, using the interaction of managerial ownership with the option moneyness measures. Managerial ownership is the approximate percentage of the private fund beneficially owned by managers and the related persons from Form ADV. Net-return moneyness is defined as the ratio of a fund's NAV divided by its HWM, calculated based on the net return following Aragon and Nanda (2012). Gross-return moneyness is defined as the ratio of fund's NAV divided by its HWM, calculated based on the algorithm following Agarwal et al. (2009). Mid-year moneyness and Year-end moneyness are the ratios of fund's mid-year and year-end NAV divided by its prior HWM, respectively, following Aragon and Nanda (2012). $\mathrm{D}^{\mathrm{moneyness}}_{[0,0.85],\ \mathrm{t}-1}$ is the indicator variable that equals 1 if the moneyness measures fall below 0.85. $\mathrm{D}^{\mathrm{moneyness}}_{(0.96,1.1],\ \mathrm{t}-1}$ is the indicator variable that equals 1 if the moneyness measures fall between 0.96 and 1.1. The sample period is from 2011 to 2016, where the Form ADV fund level data is available. In the regression, I control for year fixed effect and strategy fixed effect with standard error clustered at fund level. The t-value are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Panel A: Piecewise regressions

	Net-return	Gross-return	Mid-year	Year-end
$\mathrm{Moneyness}_{\mathrm{t}-1}$*$\mathrm{D}^{\mathrm{moneyness}}_{[0,0.85],\ \mathrm{t}-1}$	0.04	0.03	-0.01	0.04
	(0.8)	(0.5)	(-0.2)	(0.6)
$(\mathrm{Moneyness}_{\mathrm{t}-1} - 0.85)$*$\mathrm{D}^{\mathrm{moneyness}}_{[0.85,0.96],\ \mathrm{t}-1}$	0.67*	0.94**	-0.13	0.24
	(1.8)	(2.1)	(-0.3)	(0.6)
$(\mathrm{Moneyness}_{\mathrm{t}-1} - 0.96)$*$\mathrm{D}^{\mathrm{moneyness}}_{(0.96,1.1],\ \mathrm{t}-1}$	2.41***	3.04***	0.44	0.29
	(3.3)	(3.3)	(1.1)	(1.2)
$(\mathrm{Moneyness}_{\mathrm{t}-1} - 1.1)$*$\mathrm{D}^{\mathrm{moneyness}}_{(1.1,\infty),\ \mathrm{t}-1}$			1.00*	0.11
			(1.8)	(0.4)
Managerial $\mathrm{Ownership}_{t-1}$	0.17***	0.13**	0.14**	0.19**
	(3.1)	(2.2)	(2.1)	(2.1)
$\mathrm{Ownership}_{t-1}$*$\mathrm{D}^{\mathrm{moneyness}}_{[0,0.85],\ \mathrm{t}-1}$	-0.24**	-0.07	-0.35**	-0.39**
	(-2.0)	(-0.4)	(-2.5)	(-2.0)
$\mathrm{Ownership}_{t-1}$*$(\mathrm{M}_{\mathrm{t}-1} - 0.85)$*$\mathrm{D}^{\mathrm{moneyness}}_{[0.85,0.96],\ \mathrm{t}-1}$	-1.49	-0.92	0.19	-1.88
	(-1.4)	(-0.9)	(0.1)	(-1.0)
$\mathrm{Ownership}_{t-1}$*$(\mathrm{M}_{\mathrm{t}-1} - 0.96)$*$\mathrm{D}^{\mathrm{moneyness}}_{(0.96,1.1],\ \mathrm{t}-1}$	4.25	3.94	1.16	-0.32
	(1.73)	(1.36)	(0.7)	(-0.4)
$\mathrm{Ownership}_{t-1}$*$(\mathrm{M}_{\mathrm{t}-1} - 1.1)$*$\mathrm{D}^{\mathrm{moneyness}}_{(1.1,\infty),\ \mathrm{t}-1}$			3.88	-0.77
			(1.17)	(-1.0)
Management fee	13.49***	14.52***	13.67***	13.54***
	(3.9)	(3.7)	(3.9)	(3.9)
Incentive fee	0.90***	0.88***	0.93***	0.96***
	(3.7)	(2.9)	(3.8)	(4.0)
Controls	Yes	Yes	Yes	Yes
Observations	2,916	2,224	2,916	2,916
Number of funds	1,252	951	1,252	1,252
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.44	0.46	0.46	0.46

(Table B.5 continued)

Panel B: Moneyness dummy regressions

	Net-return	Gross-return	Mid-year	Year-end
$D^{moneyness}_{[0,0.85],\ t-1}$	-0.03	-0.03	-0.05*	0.00
	(-1.0)	(-0.9)	(-1.7)	(0.0)
$D^{moneyness}_{(0.96,1.1],\ t-1}$	0.06***	0.05**	0.05**	0.06**
	(3.0)	(2.2)	(2.1)	(2.2)
$D^{moneyness}_{(1.1,\infty),\ t-1}$			0.08**	0.06*
			(2.1)	(1.7)
Managerial $\mathrm{Ownership}_{t-1}$	0.13***	0.13***	0.11**	0.12**
	(2.7)	(2.7)	(2.4)	(2.5)
$\mathrm{Ownership}_{t-1}$*$D^{moneyness}_{[0,0.85],\ t-1}$	-0.35**	-0.38	-0.22	-0.28
	(-2.1)	(-1.2)	(-1.4)	(-1.3)
$\mathrm{Ownership}_{t-1}$*$D^{moneyness}_{(0.96,1.1],\ t-1}$	0.07	0.03	0.16	0.09
	(0.7)	(0.3)	(1.6)	(1.0)
$\mathrm{Ownership}_{t-1}$*$D^{moneyness}_{(1.1,\infty),\ t-1}$			-0.35	-0.30
			(-1.3)	(-1.1)
Management fee	13.42***	13.17***	13.59***	13.15***
	(3.9)	(3.8)	(3.9)	(3.8)
Incentive fee	0.90***	0.96***	0.91***	0.94***
	(3.7)	(4.0)	(3.7)	(3.8)
Controls	Yes	Yes	Yes	Yes
Observations	2,916	2,224	2,916	2,916
Number of funds	1,252	951	1,252	1,252
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.43	0.43	0.44	0.44

(Table B.5 continued)

Panel C: Ownership dummy regressions

	Net-return	Gross-return	Mid-year	Year-end
$D^{moneyness}_{[0,0.85],\ t-1}$	-0.02	-0.03	-0.01	0.02
	(-0.5)	(-0.8)	(-0.3)	(0.5)
$D^{moneyness}_{(0.96,1.1],\ t-1}$	0.06***	0.05**	0.05**	0.05**
	(2.6)	(2.0)	(2.3)	(2.2)
$D^{moneyness}_{(1.1,\infty),\ t-1}$			0.08**	0.06
			(2.0)	(1.6)
$D_{ownership\ top30\%,\ t-1}$	0.08***	0.08***	0.07**	0.08**
	(2.7)	(2.8)	(2.2)	(2.5)
$D_{ownership\ top30\%,\ t-1}$*$D^{moneyness}_{[0,0.85],\ t-1}$	-0.07	-0.05	-0.13*	-0.12
	(-1.2)	(-0.7)	(-1.8)	(-1.3)
$D_{ownership\ top30\%,\ t-1}$*$D^{moneyness}_{(0.85,0.96],\ t-1}$	-0.03	-0.05	0.02	-0.03
	(-0.7)	(-1.4)	(0.4)	(-0.6)
$D_{ownership\ top30\%,\ t-1}$*$D^{moneyness}_{(1.1,\infty),\ t-1}$			0.01	-0.00
			(0.1)	(-0.0)
Management fee	13.29***	13.02***	13.37***	13.32***
	(3.8)	(3.7)	(3.8)	(3.8)
Incentive fee	0.93***	0.98***	0.95***	0.96***
	(3.8)	(4.1)	(3.8)	(3.9)
Controls	Yes	Yes	Yes	Yes
Observations	2,916	2,224	2,916	2,916
Number of funds	1,252	951	1,252	1,252
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.42	0.42	0.42	0.42

Table B.6. Regression of Fund Flows on Leverage and Managerial Ownership

This table presents the multivariate linear regression results on fund net flows, insider net flows, outsider net flows and new sales, respectively. Total net flows are the total net dollar flows at the fiscal year-end scaled by the net assets. Insider net flows are the percentage managerial stake net flows change. Outsider net flows are the percentage investors' asset net flow change. New sales is defined as fund new sales scaled by its net asset, which is derived from Form D. Alpha-7factors is the intercepts from fund-level time-series regression of monthly excess net returns on the seven factors of Fung and Hsieh (2004). $D_{t-1}^{\text{Return below 50\%}}$ is the indicator variable that equals 1 if the fund's annual raw return is below the median relative to other funds' within the same strategy during the same year. The sample period is from 2011 to 2016. In the regressions, I control for year fixed effect and strategy fixed effect with standard error clustered at fund level. The t-values are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Panel A: Leverage level

	Total net flows	Outsider net flows	Insider net flows	New sales
Leverage_{t-1}	0.13***	0.17***	0.16**	0.03
	(4.0)	(3.7)	(2.2)	(1.6)
$\text{Managerial Ownership}_{t-1}$	0.13**	0.86***	-0.96***	0.11**
	(2.4)	(5.3)	(-8.2)	(2.2)
$\text{Alpha} - \text{7factors}_{t-1}$	6.65***	7.40***	6.30	3.47**
	(3.7)	(3.0)	(1.5)	(2.2)
$D_{t-1}^{\text{Return below 50\%}}$	-0.16***	-0.20***	-0.07	-0.06***
	(-5.8)	(-5.0)	(-0.9)	(-3.0)
Volatility_{t-1}	-0.89***	-1.09***	-0.75*	-0.97*
	(-5.4)	(-4.6)	(-1.8)	(-1.7)
Fund age_{t-1}	1.45***	2.20***	1.18**	0.97***
	(6.9)	(7.0)	(2.2)	(5.7)
Management fee	-2.79	-2.26	-18.04**	-5.31**
	(-0.7)	(-0.4)	(-2.2)	(-2.1)
Incentive fee	-0.03	-0.22	-1.52*	-0.73*
	(-0.1)	(-0.4)	(-1.8)	(-1.8)
Redemption period	0.01	0.01	-0.04	-0.00
	(1.0)	(0.6)	(-1.0)	(-0.5)
Lockup period	-0.32**	-0.58***	0.60	0.11
	(-2.3)	(-2.9)	(1.3)	(1.0)
Advance notice period	-0.05*	-0.08**	-0.03	0.00
	(-1.7)	(-2.1)	(-0.4)	(0.1)
Net asset_{t-1}	-0.09***	-0.08***	-0.08	-0.00
	(-5.0)	(-3.1)	(-1.3)	(-0.2)
Observations	2,630	2,598	2,322	1,824
Number of funds	1,176	1,159	1,058	834
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.11	0.12	0.06	0.06

(Table B.6 continued)

Panel B: Interactions with moneyness

	Total net flows	Outsider net flows	Insider net flows	New sales
$\text{Leverage}_{\text{t}-1}*\text{D}^{\text{moneyness}}_{[0,0.85],\ \text{t}-1}$	0.00	-0.02	0.14	0.01
	(0.0)	(-0.5)	(1.5)	(0.2)
$\text{Leverage}_{\text{t}-1}*\text{D}^{\text{moneyness}}_{[0.85,0.96],\ \text{t}-1}$	0.05*	0.10	0.06	0.01
	(1.7)	(1.5)	(0.5)	(0.3)
$\text{Leverage}_{\text{t}-1}*\text{D}^{\text{moneyness}}_{(0.96,\infty),\ \text{t}-1}$	0.14***	0.18***	0.16**	0.03*
	(4.2)	(4.0)	(2.3)	(1.8)
$\text{Managerial Ownership}_{\text{t}-1}$	0.15***	0.89***	-0.90***	0.11**
	(3.0)	(5.5)	(-7.9)	(2.2)
$\text{Alpha} - \text{7factors}_{\text{t}-1}$	4.79***	5.29**	7.13*	2.98*
	(2.8)	(2.3)	(1.8)	(1.9)
$\text{D}^{\text{Return below 50\%}}_{\text{t}-1}$	-0.12***	-0.15***	-0.07	-0.05**
	(-4.5)	(-3.8)	(-0.9)	(-2.3)
Volatility_{t-1}	-0.69***	-0.84***	-0.75*	-0.78
	(-4.0)	(-3.8)	(-1.7)	(-1.3)
Fund age_{t-1}	1.35***	2.07***	0.94*	0.96***
	(6.6)	(6.8)	(1.8)	(5.6)
Management fee	-1.57	-0.20	-17.81**	-4.98**
	(-0.4)	(-0.0)	(-2.2)	(-2.0)
Incentive fee	-0.10	-0.32	-1.58*	-0.74*
	(-0.2)	(-0.6)	(-1.9)	(-1.9)
Redemption period	0.01	0.00	-0.05	-0.00
	(0.6)	(0.1)	(-1.4)	(-0.5)
Lockup period	-0.31**	-0.55***	0.66	0.11
	(-2.2)	(-2.9)	(1.4)	(1.0)
Advance notice period	-0.05*	-0.08**	-0.02	0.00
	(-1.8)	(-2.2)	(-0.2)	(0.0)
Net asset_{t-1}	-0.09***	-0.07***	-0.07	-0.00
	(-4.9)	(-3.2)	(-1.3)	(-0.2)
Observations	2,630	2,598	2,322	1,824
Number of funds	1,176	1,159	1,058	834
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.11	0.12	0.06	0.06

(Table B.6 continued)

Panel C: Leverage change

	Total net flows	Outsider flows	Insider flows	New sales
$\Delta \mathrm{Leverage}_{t-2,t-1} * \mathrm{D}^{\mathrm{moneyness}}_{[0,0.85],\ t-1}$	-0.08	-0.15	-0.02	-0.06
	(-1.2)	(-1.5)	(-0.1)	(-1.3)
$\Delta \mathrm{Leverage}_{t-2,t-1} * \mathrm{D}^{\mathrm{moneyness}}_{[0.85,0.96],\ t-1}$	0.13	0.00	0.09	0.14
	(1.2)	(0.0)	(0.5)	(1.0)
$\Delta \mathrm{Leverage}_{t-2,t-1} * \mathrm{D}^{\mathrm{moneyness}}_{(0.96,\infty),\ t-1}$	0.16**	0.29***	-0.03	-0.02
	(2.4)	(3.5)	(-0.2)	(-0.6)
Managerial $\mathrm{Ownership}_{t-1}$	0.13**	0.77***	-0.94***	0.11*
	(2.0)	(3.9)	(-6.0)	(1.8)
$\mathrm{Alpha} - 7\mathrm{factors}_{t-1}$	8.82***	8.96**	10.46	5.88**
	(3.4)	(2.4)	(1.2)	(2.4)
$\mathrm{D}^{\mathrm{Return\ below\ 50\%}}_{t-1}$	-0.11***	-0.16***	0.02	-0.04*
	(-3.8)	(-3.6)	(0.2)	(-1.7)
Controls	Yes	Yes	Yes	Yes
Observations	1,553	1,534	1,379	1,128
Number of funds	889	879	794	652
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.08	0.10	0.04	0.06

Table B.7. The Effect of Leverage and Flows on Fund NAV Returns

This table presents the multivariate linear regression results on monthly risk-adjusted nav return. Alpha-4factors and Alpha-7factors are the monthly risk-adjusted returns using Carhart four factor model and seven factor model of Fung and Hsieh (2004), respectively. Annual return is the net-of-fee annual return collected from TASS/HFR. Insider net flows are the percentage managerial stake net flows change. Outsider net flows are the percentage investors' asset net flow change. The sample period is from 2011 to 2016. In the regressions, I control for year fixed effect and strategy fixed effect with standard error clustered at fund level. The t-value are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

	$\text{Alpha} - 4_t$	$\text{Alpha} - 4_t$	$\text{Alpha} - 7_t$	$\text{Alpha} - 7_t$
Leverage_{t-1}	0.009***		0.006**	
	(3.0)		(2.1)	
$\text{Leverage}_{t-1}{}^*\text{D}^{\text{moneyness}}_{[0,0.85],\ \text{t}-1}$		-0.063***		-0.036***
		(-3.4)		(-2.9)
$\text{Leverage}_{t-1}{}^*\text{D}^{\text{moneyness}}_{[0.85,0.96],\ \text{t}-1}$		-0.010**		-0.003
		(-2.3)		(-0.8)
$\text{Leverage}_{t-1}{}^*\text{D}^{\text{moneyness}}_{(0.96,\infty),\ \text{t}-1}$		0.012***		0.007***
		(4.2)		(2.8)
Insider netflow_{t-1}	0.002**	0.002	0.003***	0.002***
	(2.1)	(1.5)	(3.3)	(2.8)
Outsider netflow_{t-1}	0.003***	0.003***	0.002	0.002
	(3.4)	(3.5)	(1.2)	(1.4)
Managerial Ownership_{t-1}	0.012	0.025**	-0.009	-0.000
	(0.9)	(2.1)	(-0.9)	(-0.0)
Management fee	1.054	1.214	2.671**	2.824***
	(1.0)	(1.2)	(2.5)	(2.8)
Incentive fee	0.126*	0.108*	0.176**	0.165**
	(1.8)	(1.7)	(2.5)	(2.6)
Redemption period	-0.001	-0.003	0.005	0.004
	(-0.2)	(-0.9)	(1.3)	(1.1)
Lockup period	0.007	0.004	-0.032	-0.033
	(0.1)	(0.1)	(-0.7)	(-0.8)
Advance notice period	0.027	0.021	0.016	0.012
	(1.6)	(1.3)	(1.2)	(0.9)
Volatility_{t-1}	-0.029***	-0.020**	-0.023***	-0.020***
	(-3.1)	(-2.4)	(-3.5)	(-3.1)
Net asset_{t-1}	-0.021*	-0.016*	-0.006	-0.004
	(-1.7)	(-1.7)	(-0.6)	(-0.5)
Observations	1,166	1,166	1,076	1,076
Number of funds	692	692	643	643
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.14	0.26	0.15	0.26

Table B.8. The Effect of Leverage on Fund Holding Performance

This table reports the multivariate panel regression results on the risk-adjusted holding return. Holdings-4factors is the intercept from time-series regression of quarterly excess holding returns on the four factors of Carhart (1997). Holdings-CS is the Characteristic Selectivity (CS) measure of the holding returns, which is defined as the difference between the holding return and the benchmark return of securities with similar size, book-to-market, and momentum characteristics as proposed by Daniel et al. (1997). The sample is based on the hedge fund advisor with at least 40% holdings in equity markets from 2011 to 2016. The t-value are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

	$\text{Holdings} - 4_t$	$\text{Holdings} - 4_t$	$\text{Holdings} - \text{CS}_t$	$\text{Holdings} - \text{CS}_t$
Leverage_{t-1}	0.005**		0.006**	
	(2.3)		(2.1)	
$\text{Leverage}_{t-1}*\text{D}^{\text{moneyness}}_{[0,0.85],\ t-1}$		-0.001		-0.003
		(-0.3)		(-0.4)
$\text{Leverage}_{t-1}*\text{D}^{\text{moneyness}}_{[0.85,0.96],\ t-1}$		0.003		0.002
		(1.2)		(0.4)
$\text{Leverage}_{t-1}*\text{D}^{\text{moneyness}}_{(0.96,\infty),\ t-1}$		0.005**		0.007**
		(2.3)		(2.1)
$\text{Turnover}_{\text{t}-1}$	0.016	0.014	0.043*	0.042*
	(1.5)	(1.3)	(1.9)	(1.8)
Redemption period	0.004**	0.004**	0.006	0.005
	(2.2)	(2.2)	(1.1)	(1.2)
$\text{Netflows}_{\text{t}-1}$	-0.02	-0.02	0.03	0.02
	(-1.2)	(-1.2)	(0.3)	(0.2)
$\text{Total assets}_{\text{t}-1}$	0.001	-0.001	-0.001	-0.001
	(0.1)	(-0.2)	(-0.6)	(-0.3)
$\text{Managerial Ownership}_{t-1}$	0.002	0.002	0.002	0.002
	(0.4)	(0.5)	(0.1)	(0.2)
Management fee	0.305	0.244	0.157	0.036
	(1.1)	(0.9)	(0.2)	(0.0)
Incentive fee	0.060	0.065	0.020	0.025
	(1.3)	(1.5)	(0.2)	(0.3)
Lockup period	0.032	0.031	-0.035	-0.030
	(1.5)	(1.5)	(-0.9)	(-0.7)
Advance notice period	-0.011	-0.012	-0.033*	-0.036*
	(-1.2)	(-1.3)	(-1.9)	(-1.9)
Volatility_{t-1}	-0.083**	-0.075**	-0.132***	-0.138***
	(-2.4)	(-2.3)	(-4.9)	(-5.6)
Strategy fixed effect	No	No	No	No
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
Observations	797	797	797	797
R-squared	0.47	0.48	0.24	0.25

APPENDIX C

ROBUSTNESS TESTS

Table C.1. Baseline Linear Model with the Perfect-matched Sample

This table presents the regression results on fund leverage, using the lagged and contemporaneous measures of option moneyness as independent variables. Net-return moneyness is defined as the ratio of a fund's NAV divided by its HWM, calculated based on the net return following Aragon and Nanda (2012). Gross-return moneyness is defined as the ratio of fund's NAV divided by its HWM, calculated based on the algorithm following Agarwal et al. (2009). Mid-year moneyness and Year-end moneyness are the ratios of fund's mid-year and year-end NAV divided by its prior HWM, respectively, following Aragon and Nanda (2012). The sample period is from 2011 to 2016, where the Form ADV fund level data is available. In the regression, I control for year fixed effect and strategy fixed effect with standard error clustered at fund level. The t-value are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Panel A: Key variables of interest

	Model 1	Model 2	Model 3	Model 4
$\text{Net} - \text{return distance}_{t-1}$	0.36**			
	(2.3)			
$\text{Gross} - \text{return distance}_{t-1}$		0.45**		
		(2.0)		
$\text{Mid} - \text{year distance}_{t}$			0.31*	
			(2.0)	
$\text{Year} - \text{end distance}_{t}$				0.19*
				(1.9)
$\text{Managerial Ownership}_{t-1}$	0.17***	0.17**	0.17***	0.17***
	(2.7)	(2.5)	(2.7)	(2.7)
Management fee	10.94***	15.21***	11.10***	10.97***
	(2.7)	(3.5)	(2.7)	(2.6)
Incentive fee	0.81***	0.86**	0.82***	0.82***
	(2.8)	(2.3)	(2.8)	(2.8)

(Table C.1 continued)

Panel B: Control variables

	Model 1	Model 2	Model 3	Model 4
Redemption period	-0.02***	-0.02**	-0.02***	-0.02***
	(-2.7)	(-2.5)	(-2.6)	(-2.6)
Lockup period	-0.11	-0.25	-0.13	-0.13
	(-0.5)	(-0.7)	(-0.5)	(-0.5)
Advance notice period	-0.08***	-0.05***	-0.09***	-0.09***
	(-3.2)	(-2.6)	(-3.3)	(-3.3)
Net asset$_{t-1}$	0.04*	0.06*	0.04*	0.04*
	(1.7)	(1.8)	(1.7)	(1.7)
Fund age$_{t-1}$	0.01**	-0.00	0.01**	0.01**
	(2.0)	(-0.3)	(2.1)	(2.1)
Volatility$_{t-1}$	-2.27***	-2.23***	-2.23***	-2.55***
	(-2.9)	(-2.8)	(-2.8)	(-3.3)
Net flow$_{t-1,\ t}$	-0.09***	-0.05	-0.10***	-0.10***
	(-3.1)	(-1.5)	(-3.1)	(-3.1)
Leverage$_{t-1}$	0.36***	0.30***	0.35***	0.36***
	(7.2)	(5.2)	(7.0)	(7.1)
Observations	1,872	1,420	1,872	1,872
Number of funds	765	587	765	765
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.52	0.46	0.48	0.48

Table C.2. Robustness Tests: Subsample with 20% Incentive Fee

This table presents the regression results on fund leverage for funds with 20% incentive fee. Net-return moneyness is defined as the ratio of a fund's NAV divided by its HWM, calculated based on the net return following Aragon and Nanda (2012). Gross-return moneyness is defined as the ratio of fund's NAV divided by its HWM, calculated based on the algorithm following Agarwal et al. (2009). Mid-year moneyness and Year-end moneyness are the ratios of fund's mid-year and year-end NAV divided by its prior HWM, respectively, following Aragon and Nanda (2012). The sample period is from 2011 to 2016, where the Form ADV fund level data is available. In the regression, I control for year fixed effect and strategy fixed effect with standard error clustered at fund level. The t-value are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

	Model 1	Model 2	Model 3	Model 4
Net return moneyness$_{t-1}$	0.47***			
	(2.8)			
Gross return moneyness$_{t-1}$		0.35*		
		(1.8)		
Mid − year moneyness$_t$			0.35**	
			(2.3)	
Year − end moneyness$_t$				0.17
				(1.6)
Managerial Ownership$_{t-1}$	0.13**	0.12*	0.12**	0.12**
	(2.2)	(1.7)	(2.1)	(2.1)
Management fee	14.51***	18.17***	14.35***	14.08***
	(3.0)	(3.7)	(3.0)	(2.9)
Controls	Yes	Yes	Yes	Yes
Observations	2,133	1,642	2,133	2,133
Number of funds	914	702	914	914
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.41	0.40	0.41	0.41

Table C.3. Robustness Tests: Subsample with High-water Mark Provision

This table presents the regression results on fund leverage for funds with high-water mark provision. Net-return moneyness is defined as the ratio of a fund's NAV divided by its HWM, calculated based on the net return following Aragon and Nanda (2012). Gross-return moneyness is defined as the ratio of fund's NAV divided by its HWM, calculated based on the algorithm following Agarwal et al. (2009). Mid-year moneyness and Year-end moneyness are the ratios of fund's mid-year and year-end NAV divided by its prior HWM, respectively, following Aragon and Nanda (2012). The sample period is from 2011 to 2016, where the Form ADV fund level data is available. In the regression, I control for year fixed effect and strategy fixed effect with standard error clustered at fund level. The t-value are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

	Model 1	Model 2	Model 3	Model 4
Net return moneyness$_{t-1}$	0.47***			
	(3.2)			
Gross return moneyness$_{t-1}$		0.32*		
		(1.8)		
Mid − year moneyness$_t$			0.35***	
			(2.6)	
Year − end moneyness$_t$				0.15
				(1.6)
Managerial Ownership$_{t-1}$	0.14**	0.12**	0.14**	0.13**
	(2.6)	(2.1)	(2.5)	(2.4)
Management fee	10.67**	13.52***	10.75**	10.61**
	(2.4)	(2.7)	(2.4)	(2.3)
Incentive fee	0.66*	0.77	0.68*	0.68*
	(1.9)	(1.6)	(1.9)	(1.9)
Controls	Yes	Yes	Yes	Yes
Observations	2,631	2,018	2,631	2,631
Number of funds	1,140	873	1,140	1,140
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.41	0.40	0.41	0.41

Table C.4. Robustness Tests: Subsample with the Fund of Hedge Funds Excluded

This table presents the regression results on fund leverage with the fund of hedge funds excluded. Net-return moneyness is defined as the ratio of a fund's NAV divided by its HWM, calculated based on the net return following Aragon and Nanda (2012). Gross-return moneyness is defined as the ratio of fund's NAV divided by its HWM, calculated based on the algorithm following Agarwal et al. (2009). Mid-year moneyness and Year-end moneyness are the ratios of fund's mid-year and year-end NAV divided by its prior HWM, respectively, following Aragon and Nanda (2012). The sample period is from 2011 to 2016, where the Form ADV fund level data is available. In the regression, I control for year fixed effect and strategy fixed effect with standard error clustered at fund level. The t-value are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

	Model 1	Model 2	Model 3	Model 4
Net return moneyness$_{t-1}$	0.49***			
	(3.5)			
Gross return moneyness$_{t-1}$		0.43**		
		(2.4)		
$\mathrm{Mid-year\ moneyness}_t$			0.37***	
			(2.9)	
$\mathrm{Year-end\ moneyness}_t$				0.17*
				(1.8)
Managerial Ownership$_{t-1}$	0.15**	0.12*	0.15**	0.14**
	(2.4)	(1.9)	(2.4)	(2.3)
Management fee	11.13**	13.70***	11.06**	10.93**
	(2.5)	(2.8)	(2.5)	(2.4)
Incentive fee	0.81**	0.81*	0.84**	0.85**
	(2.4)	(1.9)	(2.5)	(2.5)
Controls	Yes	Yes	Yes	Yes
Observations	2,483	1,894	2,483	2,483
Number of funds	1,074	815	1,074	1,074
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.41	0.40	0.41	0.41

Table C.5. Robustness Tests: Specification without Supply Side Controls

This table presents the regression results on fund leverage without supply side controls. Net-return moneyness is defined as the ratio of a fund's NAV divided by its HWM, calculated based on the net return following Aragon and Nanda (2012). Gross-return moneyness is defined as the ratio of fund's NAV divided by its HWM, calculated based on the algorithm following Agarwal et al. (2009). Mid-year moneyness and Year-end moneyness are the ratios of fund's mid-year and year-end NAV divided by its prior HWM, respectively, following Aragon and Nanda (2012). The sample period is from 2011 to 2016, where the Form ADV fund level data is available. In the regression, I control for year fixed effect and strategy fixed effect with standard error clustered at fund level. The t-value are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

	Model 1	Model 2	Model 3	Model 4
Net return moneyness$_{t-1}$	0.33***			
	(2.6)			
Gross return moneyness$_{t-1}$		0.33**		
		(2.1)		
$\mathrm{Mid-year\ moneyness}_t$			0.34***	
			(3.1)	
$\mathrm{Year-end\ moneyness}_t$				0.16**
				(2.1)
Managerial Ownership$_{t-1}$	0.12***	0.11**	0.12***	0.12***
	(2.7)	(2.1)	(2.6)	(2.6)
Management fee	14.55***	15.70***	14.36***	14.21***
	(4.4)	(4.2)	(4.3)	(4.3)
Incentive fee	0.84***	0.89***	0.84***	0.86***
	(3.6)	(3.0)	(3.6)	(3.7)
Controls	Yes	Yes	Yes	Yes
Observations	3,025	2,279	3,025	3,025
Number of funds	1,299	979	1,299	1,299
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.41	0.40	0.41	0.41

Table C.6. Robustness Tests: Standard Error Clustered by Strategy

This table presents the regression results on fund leverage with standard error clustered by strategy. Net-return moneyness is defined as the ratio of a fund's NAV divided by its HWM, calculated based on the net return following Aragon and Nanda (2012). Gross-return moneyness is defined as the ratio of fund's NAV divided by its HWM, calculated based on the algorithm following Agarwal et al. (2009). Mid-year moneyness and Year-end moneyness are the ratios of fund's mid-year and year-end NAV divided by its prior HWM, respectively, following Aragon and Nanda (2012). The sample period is from 2011 to 2016, where the Form ADV fund level data is available. In the regression, I control for year fixed effect and strategy fixed effect with standard error clustered by strategy. The t-value are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

	Model 1	Model 2	Model 3	Model 4
Net return moneyness$_{t-1}$	0.47***			
	(4.4)			
Gross return moneyness$_{t-1}$		0.39***		
		(3.3)		
$\mathrm{Mid-year\ moneyness}_t$			0.36***	
			(3.2)	
$\mathrm{Year-end\ moneyness}_t$				0.17**
				(2.1)
Managerial Ownership$_{t-1}$	0.14***	0.11**	0.13***	0.13**
	(2.7)	(2.3)	(2.8)	(2.6)
Management fee	11.23***	13.20***	11.13***	11.00**
	(2.6)	(3.3)	(2.6)	(2.5)
Incentive fee	0.66***	0.66**	0.68***	0.70***
	(3.6)	(2.0)	(3.7)	(3.8)
Observations	3,025	2,279	3,025	3,025
Number of funds	1,299	979	1,299	1,299
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By strategy	By strategy	By strategy	By strategy
R-squared	0.43	0.44	0.44	0.43

Table C.7. Robustness Tests: Standard Error Clustered by Fund and Year

This table presents the regression results on fund leverage with standard error clustered by fund and year. Net-return moneyness is defined as the ratio of a fund's NAV divided by its HWM, calculated based on the net return following Aragon and Nanda (2012). Gross-return moneyness is defined as the ratio of fund's NAV divided by its HWM, calculated based on the algorithm following Agarwal et al. (2009). Mid-year moneyness and Year-end moneyness are the ratios of fund's mid-year and year-end NAV divided by its prior HWM, respectively, following Aragon and Nanda (2012). The sample period is from 2011 to 2016, where the Form ADV fund level data is available. In the regression, I control for year fixed effect and strategy fixed effect with standard error clustered by fund and year. The t-value are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

	Model 1	Model 2	Model 3	Model 4
Net return moneyness$_{t-1}$	0.42***			
	(6.4)			
Gross return moneyness$_{t-1}$		0.25*		
		(2.2)		
$\mathrm{Mid-year\ moneyness}_t$			0.30**	
			(4.1)	
$\mathrm{Year-end\ moneyness}_t$				0.17
				(1.9)
Managerial Ownership$_{t-1}$	0.14*	0.12*	0.14*	0.14*
	(2.7)	(2.2)	(2.8)	(2.7)
Management fee	6.03***	6.59	5.96***	5.79***
	(4.7)	(2.1)	(5.0)	(4.7)
Incentive fee	0.32	0.27	0.34	0.36
	(1.5)	(1.0)	(1.5)	(1.6)
Observations	3,025	2,279	3,025	3,025
Number of funds	1,299	979	1,299	1,299
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund&year	By fund&year	By fund&year	By fund&year
R-squared	0.43	0.44	0.44	0.43

Table C.8. The Effect of Leverage on Performance for Single-fund Family

This table reports the multivariate panel regression results on the risk-adjusted holding return for the single-fund family. Holdings-4factors is the intercept from time-series regression of quarterly excess holding returns on the four factors of Carhart (1997). Holdings-CS is the Characteristic Selectivity (CS) measure of the holding returns, which is defined as the difference between the holding return and the benchmark return of securities with similar size, book-to-market, and momentum characteristics as proposed by Daniel et al. (1997). The sample is based on the hedge fund advisor with at least 40% holdings in equity markets from 2011 to 2016. The t-value are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

	Holdings-CS	Holdings-CS	Holdings-4	Holdings-4
Leverage_{t-1}	0.0012***		0.0005	
	(3.9)		(0.3)	
$\text{Leverage}_{t-1}\text{*D}^{\text{moneyness}}_{[0,0.85],\ t-1}$		-0.0019		-0.0001
		(-1.6)		(-0.0)
$\text{Leverage}_{t-1}\text{*D}^{\text{moneyness}}_{[0.85,0.96],\ t-1}$		0.0022		-0.0003
		(0.2)		(-0.0)
$\text{Leverage}_{t-1}\text{*D}^{\text{moneyness}}_{(0.96,\infty),\ t-1}$		0.0013***		0.0052
		(3.5)		(1.5)
Net flows	0.02***	0.03***	-0.02	-0.04
	(4.1)	(4.1)	(-0.3)	(-0.1)
Turnover	0.001	0.004	-0.101*	-0.138**
	(0.0)	(0.1)	(-1.8)	(-2.3)
Total assets	0.002	0.001	0.023*	0.025*
	(0.2)	(0.2)	(1.8)	(1.9)
Managerial Ownership_{t-1}	-0.002	-0.003	0.005	0.018
	(-0.1)	(-0.2)	(0.2)	(0.7)
Management fee	-1.26	-1.27	0.72	0.35
	(-1.3)	(-1.4)	(0.5)	(0.3)
Incentive fee	0.25***	0.25***	0.32***	0.33**
	(3.2)	(3.1)	(2.8)	(2.8)
Lockup period	0.02	0.02	-0.06	-0.06
	(0.6)	(0.6)	(-0.6)	(-0.6)
Redemption period	0.01	0.01	0.01	0.01
	(1.3)	(1.3)	(1.1)	(1.1)
Advance notice period	-0.03	-0.03	-0.04	-0.06
	(-1.5)	(-1.5)	(-1.4)	(-1.7)
Volatility_{t-1}	-0.48	-0.42	-0.14	0.05
	(-1.4)	(-1.2)	(-0.5)	(0.2)
Strategy fixed effect	No	No	No	No
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
Observations	242	242	41	41
R-squared	0.29	0.30	0.45	0.50

APPENDIX D

OTHER RESULTS

Table D.1. Option Delta/Vega and Fund Leverage

This table presents the baseline multivariate linear regression results on fund leverage, using the option delta and vega, while controlling for the lagged leverage. Option Delta is the total expected percentage change in manager's incentive fee for a 1% change in investors' assets. Option Vega is the total expected percentage change in manager's incentive fee for a 1% change in the volatility, based on the algorithm following Agarwal et al. (2009). The sample period is from 2011 to 2016, where the Form ADV fund level data is available. In the regression, I control for year fixed effect and strategy fixed effect with standard error clustered at fund level. The t-value are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Panel A: Key variables

	Model1	Model2	Model3	Model4
Option Delta$_{t-1}$	153.62***		154.79***	
	(4.3)		(3.9)	
Option Delta$_{t-1} * D^{Delta}_{top30\%,\ t-1}$			-23.86	
			(-0.9)	
Option Delta$_{t-1} * D^{Delta}_{bottom30\%,\ t-1}$			-88.91**	
			(-2.0)	
Option Vega$_{t-1}$		215.60***		164.66***
		(4.1)		(3.2)
Option Vega$_{t-1} * D^{Vega}_{top30\%,\ t-1}$				51.64*
				(1.6)
Option Vega$_{t-1} * D^{Vega}_{bottom30\%,\ t-1}$				-161.89***
				(-2.8)
Managerial Ownership$_{t-1}$	0.11**	0.11**	0.11**	0.11**
	(2.2)	(2.2)	(2.1)	(2.1)
Management fee	14.54***	14.62***	14.14***	13.91***
	(3.8)	(3.8)	(3.7)	(3.6)
Incentive fee	0.26	0.16	0.33	0.22
	(0.8)	(0.5)	(1.0)	(0.7)

(Table D.1 continued)

Panel B: Control variables

	Model1	Model2	Model3	Model4
Leverage$_{t-1}$	0.30***	0.30***	0.30***	0.30***
	(7.0)	(7.0)	(7.0)	(7.0)
Redemption period	-0.02	-0.02	-0.02	-0.02
	(-1.2)	(-1.2)	(-1.2)	(-1.3)
Lockup period	-0.26	-0.26	-0.25	-0.26
	(-1.5)	(-1.5)	(-1.4)	(-1.5)
Advance notice period	-0.06	-0.06	-0.06	-0.06
	(-1.6)	(-1.6)	(-1.6)	(-1.5)
Volatility$_{t-1}$	-2.38***	-2.46***	-2.31***	-2.25***
	(-3.4)	(-3.4)	(-3.3)	(-3.2)
Net asset$_{t-1}$	0.07***	0.07***	0.07***	0.07***
	(2.8)	(2.7)	(2.8)	(2.8)
Net flow$_{t-1,\ t}$	-0.07***	-0.07***	-0.07***	-0.07***
	(-3.9)	(-3.9)	(-3.9)	(-3.9)
Fund age$_{t-1}$	0.30	0.31	0.31	0.33
	(1.2)	(1.2)	(1.2)	(1.3)
Constant	0.72***	0.72***	0.73***	0.75***
	(5.8)	(5.7)	(5.8)	(6.0)
Observations	2,224	2,224	2,224	2,224
Number of funds	951	951	951	951
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.45	0.45	0.45	0.45

Table D.2. Heterogeneous Effect of Option Delta/Vega

This table presents the regression results on fund leverage, using the contemporaneous measures of option delta and vega as independent variables. ContemporaneousOption Delta_t is calculated based on the mid-year moneyness, which is the mid-year percentage differences between fund's NAV and its HWM, following Aragon and Nanda (2011). $D_{in\ the\ money}$ is the indicator variable that equals 1 if the mid-year moneyness is no less than 1. The sample period is from 2011 to 2016, where the Form ADV fund level data is available. In the regression, I control for year fixed effect and strategy fixed effect with standard error clustered at fund level. The t-values are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

	Full sample with interaction		In-the-money subsample	
Option Delta_t	162.78**		214.31***	
	(2.3)		(2.8)	
Option Delta_t*$D_{in\ the\ money}$	-110.59*			
	(-1.7)			
Option Vega_t		141.10***		-194.47***
		(3.5)		(-2.6)
Option Vega_t*$D_{in\ the\ money}$		-204.43***		
		(-3.1)		
Managerial Ownership_{t-1}	0.12**	0.12**	0.18***	0.18***
	(2.5)	(2.6)	(3.2)	(3.2)
Management fee	14.15***	14.20***	15.65***	15.93***
	(3.9)	(4.0)	(4.1)	(4.1)
Incentive fee	0.51*	0.52*	-1.06	1.02
	(1.8)	(1.8)	(-1.4)	(1.2)
Observations	2,663	2,663	1,871	1,871
Number of fund	1,169	1,169	963	963
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.45	0.45	0.46	0.46

Table D.3. Dela/Vega with Supply Side Controls

This table presents the regression results on fund leverage with supply side controls. $D_{primebrokers}$ is an indicator variable that equals 1 if the fund has at least one prime broker, and equals 0 otherwise. $D_{Onshore}$ is an indicator variable that equals 1 if the fund is organized in United States. Individual number is the percentage that individuals and high net worth individuals comprise of the total number of the clients. Individual amount is the percentage of the assets under management attributable to individuals and high net worth individuals. The sample period is from 2011 to 2016, where the Form ADV fund level data is available. In the regression, I control for year fixed effect and strategy fixed effect with standard error clustered at fund level. The t-values are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

	Model 1	Model 2	Model 3	Model 4
$D_{Prime\ brokers}$	0.18***	0.18***	0.18***	0.18***
	(5.7)	(4.8)	(4.8)	(4.8)
$D_{Onshore}$	-0.11***	-0.12***	-0.12***	-0.12***
	(-3.7)	(-3.4)	(-3.4)	(-3.5)
Individual num portion	-0.08**	-0.09***	-0.08**	-0.08**
	(-2.4)	(-2.6)	(-2.4)	(-2.4)
Net return moneyness$_{t-1}$	0.46***			
	(3.5)			
Gross return moneyness$_{t-1}$		0.35**		
		(2.1)		
Option Vega$_{t-1}$			215.33***	
			(3.9)	
Option Delta$_{t-1}$				160.07***
				(4.2)
Managerial Ownership$_{t-1}$	0.12**	0.09*	0.09	0.09*
	(2.3)	(1.6)	(1.6)	(1.7)
Management fee	13.88***	15.70***	15.82***	15.76***
	(3.7)	(3.7)	(3.7)	(3.7)
Incentive fee	0.75***	0.74**	0.03	0.11
	(2.9)	(2.3)	(0.1)	(0.3)
Controls	Yes	Yes	Yes	Yes
Observations	2,916	2,916	2,916	2,916
Number of funds	1,252	1,252	1,252	1,252
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund
R-squared	0.44	0.44	0.44	0.44

APPENDIX E

SAMPLE FORM ADV

Figure E.1. An Excerpt from Form ADV

This figure is an sample excerpt from Form ADV of Two Sigma compass enhanced fund for the fiscal year 2016. Section 7.B provides fund-level information including GAV and ownership by "related persons", and Item 7.A identifies "related persons".

Panel A: Item 7.A of the sample Form ADV

FORM ADV

UNIFORM APPLICATION FOR INVESTMENT ADVISER REGISTRATION AND REPORT BY EXEMPT REPORTING ADVISERS

Primary Business Name: TWO SIGMA INVESTMENTS, LP	**CRD Number: 137137**
Annual Amendment - All Sections	**Rev. 10/2012**
3/31/2017 11:29:20 AM	

WARNING: Complete this form truthfully. False statements or omissions may result in denial of your application, revocation of your registration, or criminal prosecution. You must keep this form updated by filing periodic amendments. See Form ADV General Instruction 4.

Item 1 Identifying Information

Responses to this Item tell us who you are, where you are doing business, and how we can contact you.

A. Your full legal name (if you are a sole proprietor, your last, first, and middle names):
TWO SIGMA INVESTMENTS, LP

B. Name under which you primarily conduct your advisory business, if different from Item 1.A.:
TWO SIGMA INVESTMENTS, LP

List on Section 1.B. of Schedule D any additional names under which you conduct your advisory business.

C. If this filing is reporting a change in your legal name (Item 1.A.) or primary business name (Item 1.B.), enter the new name and specify whether the name change is of
☐ your legal name or ☐ your primary business name:

D. (1) If you are registered with the SEC as an investment adviser, your SEC file number: **801-70476**

Item 7 Financial Industry Affiliations

In this Item, we request information about your financial industry affiliations and activities. This information identifies areas in which conflicts of interest may occur between you and your *clients*.

A. This part of Item 7 requires you to provide information about you and your *related persons*, including foreign affiliates. Your *related persons* are all of your *advisory affiliates* and any *person* that is under common *control* with you.

You have a *related person* that is a (check all that apply):

☑ (1) broker-dealer, municipal securities dealer, or government securities broker or dealer (registered or unregistered)
☑ (2) other investment adviser (including financial planners)
☐ (3) registered municipal advisor
☐ (4) registered security-based swap dealer
☐ (5) major security-based swap participant
☑ (6) commodity pool operator or commodity trading advisor (whether registered or exempt from registration)
☐ (7) futures commission merchant
☐ (8) banking or thrift institution
☐ (9) trust company
☐ (10) accountant or accounting firm
☐ (11) lawyer or law firm
☑ (12) insurance company or agency
☐ (13) pension consultant
☐ (14) real estate broker or dealer
☐ (15) sponsor or syndicator of limited partnerships (or equivalent), excluding pooled investment vehicles
☑ (16) sponsor, general partner, managing member (or equivalent) of pooled investment vehicles

(Figure E.1 continued)
Panel B: Section 7.B of the sample Form ADV

A. PRIVATE FUND

Information About the *Private Fund*

1. (a) Name of the *private fund*:
TWO SIGMA COMPASS ENHANCED U.S. FUND, LP
(b) *Private fund* identification number:
(include the "805-" prefix also)
805-8185648199

2. Under the laws of what state or country is the *private fund* organized:
State: Delaware
Country: United States

3. Name(s) of General Partner, Manager, Trustee, or Directors (or persons serving in a similar capacity):

Name of General Partner, Manager, Trustee, or Director
TWO SIGMA PRINCIPALS, LLC

10. What type of fund is the *private fund*?
◉ hedge fund ○ liquidity fund ○ private equity fund ○ real estate fund ○ securitized asset fund ○ venture capital fund ○ Other *private fund*

NOTE: For funds of funds, refer to the funds in which the *private fund* invests. For definitions of these fund types, please see Instruction 6 of the Instructions to Part 1A.

11. Current gross asset value of the *private fund*:
$ 1,113,622,871

Ownership

12. Minimum investment commitment required of an investor in the *private fund*:
$ 1,000,000
NOTE: Report the amount routinely required of investors who are not your *related persons* (even if different from the amount set forth in the organizational documents of the fund).

13. Approximate number of the *private fund*'s beneficial owners:
139

14. What is the approximate percentage of the *private fund* beneficially owned by you and your *related persons*:
24%

15. What is the approximate percentage of the *private fund* beneficially owned (in the aggregate) by funds of funds:
16%

16. What is the approximate percentage of the *private fund* beneficially owned by non-*United States persons*:
50%

REFERENCES CITED

Agarwal, V., Daniel, N. D., & Naik, N. Y. (2009). Role of managerial incentives and discretion in hedge fund performance. *The Journal of Finance*, *64*(5), 2221–2256.

Ang, A., Gorovyy, S., & Van Inwegen, G. B. (2011). Hedge fund leverage. *Journal of Financial Economics*, *102*(1), 102–126.

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

Aragon, G. O., & Nanda, V. (2012). Tournament behavior in hedge funds: High-water marks, fund liquidation, and managerial stake. *The Review of Financial Studies*, *25*(3), 937–974.

Brunnermeier, M. K., & Pedersen, L. H. (2009). Market liquidity and funding liquidity. *The review of financial studies*, *22*(6), 2201–2238.

Buraschi, A., Kosowski, R., & Sritrakul, W. (2014). Incentives and endogenous risk taking: A structural view on hedge fund alphas. *The Journal of Finance*, *69*(6), 2819–2870.

Carhart, M. M. (1997). On persistence in mutual fund performance. *The Journal of finance*, *52*(1), 57–82.

Carpenter, J. N. (2000). Does option compensation increase managerial risk appetite? *The journal of finance*, *55*(5), 2311–2331.

Chava, S., & Purnanandam, A. (2010). Ceos versus cfos: Incentives and corporate policies. *Journal of financial Economics*, *97*(2), 263–278.

Coles, J. L., Daniel, N. D., & Naveen, L. (2006). Managerial incentives and risk-taking. *Journal of financial Economics*, *79*(2), 431–468.

Daniel, K., Grinblatt, M., Titman, S., & Wermers, R. (1997). Measuring mutual fund performance with characteristic-based benchmarks. *The Journal of finance*, *52*(3), 1035–1058.

Franzoni, F., Ben-David, I., Moussawi, R., & Sedunov, J. (2019). The granular nature of large institutional investors.

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

Goetzmann, W. N., Ingersoll Jr, J. E., & Ross, S. A. (2003). High-water marks and hedge fund management contracts. *The Journal of Finance*, *58*(4), 1685–1718.

Griffin, J. M., & Xu, J. (2009). How smart are the smart guys? a unique view from hedge fund stock holdings. *The Review of Financial Studies*, *22*(7), 2531–2570.

Hayes, R. M., Lemmon, M., & Qiu, M. (2012). Stock options and managerial incentives for risk taking: Evidence from fas 123r. *Journal of financial economics*, *105*(1), 174–190.

Hodder, J. E., & Jackwerth, J. C. (2007). Incentive contracts and hedge fund management. *Journal of Financial and Quantitative Analysis*, *42*(4), 811–826.

Jiang, W. (2018). Leveraged speculators and asset prices. *Available at SSRN 2525986*.

Kambhu, J., Schuermann, T., & Stiroh, K. J. (2007). Hedge funds, financial intermediation, and systemic risk. *Economic Policy Review*, *13*(3).

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

Lewellen, K. (2006). Financing decisions when managers are risk averse. *Journal of Financial Economics*, *82*(3), 551–589.

Liang, B., & Qiu, L. (2019). Hedge fund leverage: 2002–2017. *European Financial Management*, *25*(4), 908–941.

Lim, J., Sensoy, B. A., & Weisbach, M. S. (2016). Indirect incentives of hedge fund managers. *The Journal of Finance*, *71*(2), 871–918.

Merton, R. C. (1969). Lifetime portfolio selection under uncertainty: The continuous-time case. *The review of Economics and Statistics*, 247–257.

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

Ross, S. A. (2004). Compensation, incentives, and the duality of risk aversion and riskiness. *The Journal of Finance*, *59*(1), 207–225.

Schwartz, S. H. (2012). An overview of the Schwartz theory of basic values. *Online Readings in Psychology and Culture*, *2*(1), 1–20.