Managerial Incentives and Risk Taking: Evidence from Hedge Fund Leverage*

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ABSTRACT

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. We 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. We also find that funds with larger delta and vega of the option-like incentive fee contracts, take on higher leverage. Further, larger managerial ownership is associated with higher leverage when the option-like incentive fee is near the money. The findings lend support to option-like compensation contracts and managerial ownership improving incentive alignment between fund managers and investors. Interestingly, we also find that managerial ownership and insider flows are positively related to the future raw return and risk-adjusted return, suggesting that managers may have information advantage over outside investors about future fund performance.

JEL classification: G23, G32.

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1. 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 leverage up the underlying positions, with the intent to boost performance by assuming greater risk. For example, according to the report from Bloomberg, the gross assets of Citadel Advisors LLC and Millennium Management LLC soared ninefold to above $115 billion in 2012, when tallied under the SEC new rule that requires hedge funds to disclose investments financed through borrowings. [1] Given the significant potential impact of hedge fund leverage on the financial markets and investors, how leverage, a double-edged sword, is deployed has drawn substantial attention. [2]

Given the opaque nature of the lightly regulated hedge fund industry, the fund managers have wide discretion in making investment and financing decisions that are embedded with risk. Compensation contracts therefore play a vital role to align incentives of fund managers with investors. The total compensation of hedge fund managers features three components: management fee, incentive fee, and the capital gain on managers' own stake. The incentive fee contracts are subject to the high-water mark (HWM) provision that ensures the fund managers are not compensated by the incentive fees, until the prior loss is recovered. Parallel 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, and Ross (2003)). In addition to the option-like incentive fee compensation, to closely align the interests of fund managers with investors, hedge fund managers typically have a por-

[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., "Layers of Leverage Boost Risk At 'Funds of Hedge Funds"' from Wall Street Journal on May 26, 2004 (https://www.wsj.com/articles/SB108551961103321010). "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).

tion of their own capital invested in the funds that they manage, which could account for a large proportion of the fund managers' 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 studies have shown mixed predictions based on different assumptions. Hodder and Jackwerth (2007) predict that a fund manager with the short-term perspective takes on higher risk, as the fund value moves close to the liquidation line. Panageas and Westerfield (2009) suggest that a risk-neutral hedge fund manager compensated by high-water mark contracts, behaves exactly as a Merton-type constant relative risk aversion (CRRA) investor, and places a constant fraction of wealth in the risky assets. In contrast to the limited downside risk suggested in the short-horizon setting (e.g. Hodder and Jackwerth (2007)), Lan, Wang, and Yang (2013) argue that, in the long-term perspective setting, the concern of risk shifting may be overstated, as costly liquidation induces the manager to behave in a risk-averse manner. Thus, the fund manager will instead reduce leverage to increase the likelihood of fund survival, when the incentive fee option is deep out of the money. On the other hand, the closer the fund value is to the HWM (i.e., the closer the manager is to collecting incentive fees), the more motivated the manager is to take on higher leverage. Similarly, using structural approach, Buraschi, Kosowski, and Sritrakul (2014) find the state-dependent fund leverage will peak when the fund's AUM is just below the high-water mark.

Despite several theoretical studies suggesting a close tie between fund leverage and managerial incentives, very 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-fund. They find that predictable changes in hedge fund leverage are mostly systematic and there are few fund-level idiosyncratic effects. Jiang (2015) 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.

Using novel fund-level leverage and managerial ownership measures derived from regulatory filings Form ADV, this paper aims to provide the large-sample evidence on the model predictions by Lan, Wang, and Yang (2013) and Buraschi, Kosowski, and Sritrakul (2014). 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, and the fund-level data of hedge fund industry have become available from Form ADV since 2011.[3] In this study, we 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). To capture the dynamic managerial incentives, we break down the total managerial incentives to the incentives of the option-like incentive fee contracts, and managerial ownership. Following Agarwal, Daniel, and Naik (2009) and Aragon and Nanda (2011), we use three measures for the incentives of the option-like compensation: the distance of fund value to HWM (the moneyness of the incentive fee option), the delta and vega of the incentive fee option.

In this study, we develop a new measure of managerial ownership directly obtained from Form ADV, which we believe is more accurate than the one used in the hedge fund literature.[4] Previous studies (e.g. Agarwal, Daniel, and Naik (2009)) have used the cumulative value of the incentive fee reinvested as an estimate of managerial ownership, which is based on certain unrealistic assumptions. First, while the conventional ownership estimate assumes that outflows are only from outside investors, we observe almost symmetric distribution of managerial ownership changes in our sample, suggesting that outflows are also equally likely from fund managers' own stake. Second, in our sample, more than 40% of the funds are launched with at least 10% managerial ownership, which means that fund managers usually invest their own money at the fund inception. To overcome these limitations, we obtain the more accurate data of managerial ownership directly from Form ADV, which allows us to

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

[4]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". 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".

further investigate the insider net flows, defined as the annual percentage change of managers' own stake.

Consistent with the model predictions of Lan, Wang, and Yang (2013) and Buraschi, Kosowski, and Sritrakul (2014), we first find robust evidence that funds with larger option compensation incentives, proxied by the moneyness, the delta and vega of the incentive fee option, take significantly higher leverage. We then show that the positive relationship between option compensation incentives and fund leverage is convex, in which the managers take on more leverage at an increasing rate, as the fund value nears the high-water mark. The results suggest that the incentive fee contracts with liquidation concern motivate fund managers to reduce risk, when the incentive fee contracts are deep out of the money. Our results are consistent with the findings of Lim, Sensoy, and Weisbach (2016), which show that indirect incentives from future inflows of capital that are amplified by the use of leverage, comprise the majority of managers' total incentives, at least 1.4 times as large as direct incentives.

Second, we find that larger managerial ownership is associated with higher leverage, and the positive association only holds when the fund value is close to the HWM, which also lends support to the model predictions of Lan, Wang, and Yang (2013). 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, especially when the option-like incentive fee contract is near the money.

Third, we extend our analysis to how fund leverage and managerial ownership are related to fund flows. By exploiting the data of managerial ownership, we break down the fund net flows into insider net flows from the fund managers, and outsider net flows from the outside investors, which allows us to examine the heterogeneous effect on fund flows. We also collect the total sales data of hedge funds, and construct the measure of fund inflow from SEC filings Form D. We find outsider net flows are negatively associated with leverage increase, while insider net flows respond positively, suggesting that investors appear to be averse to risk hike. We also find that fund inflows and fund net flows are positively related to managerial ownership and past relative performance, suggesting that investors appear to chase not only past performance, but also managerial ownership. These findings indicate that the investors seem

to prefer funds with higher managerial ownership, possibly understanding that managerial incentives are better aligned with investors' interests.

Further, we investigate the relationship between fund leverage, managerial ownership, and fund performance. We find that while the unconditional level of fund leverage is positively associated with the risk-adjusted return, the change of fund leverage barely predicts future performance. Also, the positive relationship of leverage level and the risk-adjusted return is reversed, when the fund value are distant from the HWM. More interestingly, in addition to the findings of Ozik and Sadka (2015), we find that insider net flows and managerial ownership are positively related to both the future raw return and risk-adjusted return. These findings suggest that fund managers may have information advantage over outside investors, and are likely better-informed when allocating their own investments. Finally, we show that our results are robust to various alternate specifications, including alternative incentive measures and additional controls.

This paper is the first study, to our knowledge, to comprehensively examine the relationship between hedge fund leverage and managerial incentives, using the new public dataset drawn from Form ADV. This study contributes to the literature by providing novel leverage and managerial ownership measures to link the theory with the large-sample evidence. Our findings have important implications for optimal contract design. On one hand, we show that the option-like compensation together with managerial stake can mitigate excessive risk-taking by fund managers. On the other hand, our evidence suggests while managerial ownership serves as an incentive alignment mechanism, it also likely provides incentives for fund managers to trade in advance of their clients.

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. [5] The hedge fund industry is an interesting research setting for several rea-

[5]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 Liu (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.

sons. First, fund leverage is a measure of risk-taking with the more clear-cut interpretation, compared with other proxies of non-financial corporations, such as risky investments, R&D expenditures, and firm leverage. Also, as argued by Agarwal, Daniel, and Naik (2009), the managerial incentive measures of hedge funds suffer less from the endogeneity concern, since the compensation contracts are determined at the inception, and it is highly legally costly to modify the contracts afterwards.

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.

2. Literature and Hypothesis

The previous empirical studies on fund risk-taking mainly concentrate on the risk shifting concern with risk-taking measured by the return volatility. Brown, Harlow, and Starks (1996) and Aragon and Nanda (2012) suggest the "tournament behavior", the idea that mid-year losers tend to increase fund risk in the second half year, following the relative poor performance in the first half year.

Ang, Gorovyy, and van Inwegen (2011) are the first study of the hedge fund leverage using a proprietary dataset of leverage ratios from a fund-of-fund. They find that the changes in hedge fund leverage tend to be more predictable by macroeconomic factors than by fund-specific characteristics. Jiang (2015) constructs the leverage of hedge fund advisors at the investment company level from the public SEC filings, and finds that the use of leverage by market speculators can increase the likelihood and magnitude of price crash in the financial markets. Several other studies focus on the interaction between leverage and market liquidity from the perspective of systemic implications. [6] Empirically, due to the secretive and

[6] e.g., Brunnermeier and Pederson (2009), Tang (2011), Aragon and Strahan (2009), Adrian and Shin (2010), and Acharya and Vishwanathan (2010).

opaque nature of the hedge funds, it is still unclear how the hedge fund compensation features influence the dynamic leverage decisions.

Prior theoretical studies have examined how hedge fund managers adjust fund leverage to maximize the value of their total compensation. Hodder and Jackwerth (2007) investigate the incentives of a typical hedge fund contract with endogenous liquidation, and show that the fund managers faced with liquidation, are motivated to take more risk to increase the value of their incentive fee, in the short-horizon setting. In other words, the manager chooses to gamble with high levels of risk when the likelihood of liquidation is high. However, hedge funds usually rely on short-term financing from their prime brokers, which is collateralized by the assets owned by the fund, known as "hair cut". In adverse market conditions, prime brokers can quickly withdraw their loans, then seize and liquidate the collaterals to recoup any losses, which makes the manager less motivated to engage in risk-shifting against the creditors. Panageas and Westerfield (2009) predict that fund managers who are compensated by high-water mark contracts do not take excessive risk. Instead, they invest a constant fraction of funds into a mean-variance efficient risky portfolio, as constant relative risk aversion (CRRA) investors would do. The intuition is the magnified fund performance by leverage would become the high-water mark for future incentive fee options, which will decline the value of future options. The fund manager trades off the current payoffs with future payoffs, and chooses a constant fraction of risky assets optimally.

In the dynamic long-horizon setting, managers may be overly concerned with fund liquidation, since the fund manager loses all future management and incentive fees in the case of liquidation, which makes the downside risk much larger than prior literature suggest. Lim, Sensoy, and Weisbach (2016) show that indirect incentives from future inflows of capital comprise the majority of managers total incentives, at least 1.4 times as large as direct incentives, which lend support to the costly liquidation. Buraschi, Kosowski and Sritrakul (2014) show that the manager's risk-taking is state-dependent, and is determined by time-varying interaction of the manager's option-like compensation (long call options) and the investors' withdrawal (short put options). The call-option-like incentive fees motivate the manager to use more leverage, while the put-option-like features induce the manager to reduce leverage. They show that the relative importance of these two effects depend on the moneyness of these options, the dis-

tance of the fund value from the high-water mark (HWM). They predict the leverage will peak when the fund's AUM is just below the HWM.

In the infinite-horizon setting of Lan, Wang and Yang (2013), given the compensation contract, the managers dynamically trade off the benefit of leverage on the alpha generating strategy and the downside risk of leverage: liquidation and money outflows. To maximize the present value of their fees, not only from current but also future managed funds, the fund managers in the model use dynamic leverage to affect the liquidation likelihood of the fund. In the dynamic framework with liquidation risk, the risk-neutral manager therefore has the precautionary motivation to survive and collect fees in the future, which induces risk-averse behavior when the fund value is close to the liquidation line, in contrast to excessive risk-taking suggested in Hodder and Jackwerth (2007).

Based on the model predictions of Buraschi, Kosowski, and Sritrakul (2014) and Lan, Wang, and Yang (2013), we develop the following hypothesis:

H1: All else being equal, the higher the moneyness of the incentive fee option, the more distant the fund is from liquidation, the more likely the manager collects the incentive fee and the higher the fund leverage is.

H2: All else being equal, funds with greater delta and vega of the option-like incentive fees will take more leverage. In addition, the management fee and incentive fee are positively associated with fund leverage.

Hedge fund managers typically have a portion of their own capital invested in the funds that they manage, which aims to better align the motivation of the fund managers with the objectives of outside investors in the fund. Kouwenberg and Ziemba (2007) argue the fund manager's own stake is an essential factor influencing the relationship between incentives and risk taking. The model indicates that risk-taking behavior is dampened significantly when a manager invests a substantial fraction of his own money in the fund. In the model of Lan, Wang, and Yang (2013), however, a larger managerial equity position encourages the manager to choose higher leverage, especially when the option contract is near the money, as manage-

rial ownership improves the incentive alignment between the manager and the investors, by making managers care more about the fund value.

H3: All else being equal, the larger managerial ownership is, the higher leverage a manager will take on, when the fund's AUM is close to the HWM.

3. Data Description

In this section, we describe the data sources and key variable construction.

3.1. Data

In this paper, we obtain data from four sources: Form ADV and Form D from SEC filings, and commercial databases Lipper TASS and Hedge Fund Research (HFR). Prior to the financial crisis, due to light regulation and limited disclosure requirements on the hedge fund industry, hedge funds were exempt from reporting major regulatory filings to U.S. Securities and Exchange Commission (SEC). The primary source of our hedge fund data sample is Form ADV from 2011 to 2017, when fund-level information is made available by the Dodd-Frank Act. Our TASS data is till June 2016, and HFR data is till June 2015. We collect all the fund-level financial information, including fund legal names, fund advisors, gross asset value (GAV) and managerial ownership from Form ADV.[7] We exclude observations with less than 1 million GAV and we end up with 66,806 observations from 21,021 hedge funds, where the fund type is "hedge fund". We obtain the fund new sales (money inflows) data from Form D, and merge it with Form ADV by the Form D filing number.

To construct the fund-level leverage, we first match Form ADV data and commercial databases TASS and HFR by fund management firm, using the SEC filing number of fund advisors and fund advisors' names. Within the matched fund families, we then match the funds by fund legal names. We delete the duplicate funds from TASS and HFR by SEC fund

[7]We preliminarily clean up the Form ADV data by only keeping the latest amendment to a previously filing, within the same reporting period.

identifier. [8] Then we manually check the match, to make sure the fund identifier in Form ADV is unique in our final dataset, which leaves us 1,051 funds from HFR and 841 funds from TASS, totally 1,892 hedge funds in our matched sample. Then we delete all the outliers with the ratio of GAV over NAV less than 0.95, which account for 8% of the matched sample. In our final sample, we only keep the funds with complete history of net-of-fee returns obtained from TASS and HFR. We winsorize the leverage by 1% and 99% percentile. Finally, we end up with 2,871 fund-year observations from 1,152 funds.

We collect other fund-specific information that are reported to two major hedge fund databases, TASS and HFR, including net asset value (NAV), net-of-fee return, management fee, incentive fee, high-water mark provision, redemption period, lockup period, advance notice period and fund strategies. In practice, the level of leverage likely depends on the type of the investment strategy. For example, long and short equity funds tend to use relatively low leverage with high basis risk. In contrast, fixed income arbitrage funds tend to use high leverage to magnify small discrepancies being arbitraged with low basis risk. Thus, the leverage used in one strategy may not be comparable to other strategies, and the strategy fixed effect needs to be controlled in the main regression. Following Agarwal et al. (2009), we classify funds into six broad strategies: Directional, Relative value, Security selection, Multi-process, Fund of funds, and Other.

3.2. Key variable definitions

3.2.1. Leverage

Following Lan, Wang, and Yang (2013), our measure of risk-taking is fund leverage, which generally can be defined as the size of the risky positions as a multiple of net asset value. Due to the availability of the fund holding data, following Ang, Gorovyy, and van Inwegen (2011), we define the fund leverage as the balance-sheet gross leverage, which is the ratio of gross asset value (GAV) and net asset value (NAV): $L_{i,t} = \frac{GAV_{i,t}}{NAV_{i,t}}$. For the numerator of the gross

[8] We keep the TASS observations in case of duplicate funds with HFR, since TASS has longer history of the data in our sample. We also delete the observations, in which the return and net asset data in TASS and HFR are not consistent.

leverage, the SEC adopted the gross asset value (GAV) measure in Form ADV, to determine the value of the fund's assets. TASS and HFR report the net asset value (NAV) of the funds, the denominator of leverage, to reflect their true size. One important caveat of this explicit leverage definition is that we do not consider the derivative exposure for hedge funds, which can be large. This explicit gross leverage based on the balance sheet, may understate economic risk exposure, without accounting for the implicit leverage.

Table 2 reports the summary statistics of the gross leverage. The equal-weighted average is 132% and the value-weighted average is 147%, which is close to the proprietary data shown in Ang, Gorovyy, and van Inwegen (2011). The average hedge fund leverage is modest, but its variation is considerably large with 61% standard deviation. From Table 2, we observe that at least 25% of hedge funds do not take on leverage at all, while other funds rely on leverage substantially, nearly 200%. We break down the fund leverage into six fund strategies, and we find that the fund of hedge funds barely takes any leverage, while relative value funds heavily rely on leverage. The data is also largely consistent with the summary statistics disclosed in SEC's "Annual Staff Report Relating to the Use of Form PF Data", except for relative value funds. [9] The average leverage of relative value funds in SEC's report is twice as large as the one in our sample, possibly due to the different definition of the strategy.

3.2.2. Managerial incentives

Distance from high-water mark (moneyness of the incentive fee option)

Following Aragon and Nanda (2011), we use two measures for the distance from high-water mark (moneyness of the incentive fee option) in the baseline regression: net-of-fee return distance and gross-return distance. For the net-of-fee return distance measure, we use the net-of-fee return directly from TASS and HFR to solve for the fund's high-water mark. We assume the fund i's asset under management ($A_{i,0}$) is initially at its HWM benchmark ($HWM_{i,1}$), i.e., $A_{i,0} = 1$ and $HWM_{i,1} = 1$. We then solve recursively for the HWM using $A_{i,t} = A_{i,t-1}(1+R_{i,t})$ and $HWM_{i,t+1} = \max(HWM_{i,t-1},\ A_{i,t})$, which allows us to avoid dropping observations with

[9] Form PF is also imposed by the Dodd-Frank Act that requires hedge funds to report more detailed financial information. However, Form PF is strictly confidential, and SEC only disclose some summary statistics in the annual report "Annual Staff Report Relating to the Use of Form PF Data".

missing net asset data in HFR and in TASS. [10] We define the net-of-fee return distance measure as $D_{net,t} = \frac{A_t}{HWM_{t+1}}$, which by construction is capped by 100%.

Following the procedure in Agarwal, Daniel, and Naik (2009), we solve for the gross-return and the high-water mark based on certain key assumptions. We assume each investor invests in the fund at the year end and we treat the incentive fee contract for each investor as an independent option. The total incentive fee compensation for managers is viewed as the sum of the incentive fee options for all individual investors. We define the gross-return distance measure as a value-weighted average of each individual investor's distance to HWM:$D_{gross,t} = \sum_i \omega_i \frac{A_{i,t}}{HWM_{i,t+1}}$, which by construction is also capped by 100%. The shortcoming of using the gross-return distance measure is we have to drop the funds without the full history of net asset value (NAV), since NAV is vital in calculating the fund flows for each investor.

For robustness, we also construct two other distance measures, mid-year distance and year-end distance, to capture the contemporaneous effect of managerial incentives on leverage decisions. Following Aragon and Nanda (2011), mid-year distance is defined as the mid-year percentage differences between a fund's NAV and its high-water mark, $D_{mid-year,t+1} = \frac{A_t(1+R_{t,t+\frac{1}{2}})}{HWM_{t+1}}$. Year-end distance is defined as the year-end percentage differences between a fund's NAV level and its high-water mark, $D_{year-end,t+1} = \frac{A_{t+1}}{HWM_{t+1}}$. Mid-year distance and year-end distance could exceed 100%, depending on fund performance relative to the high-water mark.

Delta and Vega of incentive fee contracts

We use the option delta and option vega to measure the sensitivity of incentive fees to fund performance, and to the volatility, respectively. Following the procedure in Agarwal, et al. (2009), we consider the incentive fee contract for each investor as an independent option. We define the individual option delta as the expected percentage change in manager's incentive fee for a 1% change in investors' assets. The individual option vega is defined as the expected percentage change in manager's incentive fee for a 1% change in the return volatility. The

[10] about 20% of our sample.

total option delta and vega is the asset-weighted average of the individual option delta and vega.

3.2.3. Managerial ownership and insider flows

We argue that our new measure of managerial ownership directly obtained from Form ADV is more accurate than the one use in the prior literature. Prior literature (e.g. Agarwal et al. (2009)) use the cumulative value of the incentive fee reinvested as the proxy for managerial ownership, which is based on the critical assumption that outflows only from investors (i.e., fund managers never take money out of the fund). We obtain the measure for management ownership directly from Form ADV. Section 7.B.(1) of Form ADV mandate funds to provide fund-level information, in which Question 14 is: "What is the approximate percentage of the private fund beneficially owned by you and your related persons". 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".

In this paper, following Goerzmann et al. (2003), we define the total fund net flows as $Netflow_{i,t} = \frac{AUM_{i,t} - AUM_{i,t-1}(1+R_{i,t})}{AUM_{i,t-1}}$.By exploiting the managerial ownership data, we define insider net flows as the scaled dollar flows into the fund from manager's own equity investments: $Insider_{i,t} = \frac{M_{i,t} * AUM_{i,t} - M_{i,t-1} * AUM_{i,t-1}(1+R_{i,t})}{M_{i,t-1} * AUM_{i,t-1}}$, and the outsider net flows as the scaled dollar flows from investors' equity: $Outsider_{i,t} = \frac{(1-M_{i,t}) * AUM_{i,t} - (1-M_{i,t-1}) * AUM_{i,t-1}(1+R_{i,t})}{(1-M_{i,t-1}) * AUM_{i,t-1}}$,where $M_{i,t}$ stands for managerial ownership of fund i at time t.

In our sample, we find that the key assumptions of the conventional estimate of managerial ownership do not hold. First, from Table 3, we observe almost symmetric insider net flows, suggesting that outflows not only come from the investors, but also frequently from fund managers' own equity. Second, more than 40% of the funds are launched with at least 10% ownership, which means that fund managers invest their own money into the fund at the inception of the fund, possibly serving as a signal of incentive alignment to outside investors.

3.3. Summary statistics

To alleviate the selection bias concern of the matched sample, Table 1 presents the comparison of the summary statistics of fund characteristics from the whole sample and from the matched sample, which shows that the matched sample are not significantly different from the whole sample, in terms of the distribution of GAV, NAV, managerial ownership and annual return. Other variables reported in Table 1 are control variables used in the regressions. From Form ADV, the compensation structure and managerial ownership vary substantially in cross-sections. Almost 60% of the hedge funds have less than 10% of managers' own investment, while 10% of the funds have more than 90% managerial ownership. From Table 1, there are more than 20% of hedge fund that do not have the high-water mark provision. Among those with high-water mark, incentive fees vary substantially with mean 12% and standard deviation 9%.

Table 3 summarizes key variables of interest in the main regressions for the matched sample over the 2011-2016 sample period. From Table 3, we find that the insider new flows, with standard deviation 129%, is more volatile than fund net flows and outsider net flows, indicating the fund managers adjust their equity allocation even more frequently than investors do. Underwater indicator is defined as a dummy variable that equals to 1 if the distance to HWM $D_{net,t}$ is below 1. The mean of the distance to HWM is 96% with 10% standard deviation and the mean of underwater is 0.4 with 0.49 standard deviation, implying that a large proportion of funds do not meet the high-water mark with large variation in cross-sections. Regarding the dollar incentives, managers on average earn $157,000 in incentive fee compensation for a 1% change in investors' assets, which is consistent with the estimation shown in Agarwal et al. (2009).

4. Empirical Results

4.1. Baseline linear models of managerial incentives and leverage

In this section, we begin by investigating the linear relationship between managerial incentives and fund leverage using multivariate linear regression models, in which changes in leverage are regressed on option incentives and managerial ownership. As argued by Agarwal et al. (2009), the managerial incentive measure suffers less from the endogeneity concern, since the compensation contract are determined at the inception, and it is highly costly to modify the contract afterwards. Following Ang, et al. (2011), we use the linear models with lagged dependent variables to show the dynamics of fund leverage and managerial incentives:

$$\begin{aligned} L_{i,k,t} = \alpha + \theta L_{i,k,t-1} + \beta Option\ incentives_{i,k,t-1} + \varphi Managerial\ ownership_{i,k,t} \\ + \gamma Controls_{i,k,t-1} + \lambda_t + \eta_k + \varepsilon_{i,k,t} \end{aligned} \tag{1}$$

, where $L_{i,k,t}$ stands for the leverage of fund i with strategy k at year t. We include the lagged leverage $L_{i,k,t-1}$ in our specification to control for the mean reversion in leverage changes (Ang, et al. (2011)). The variables of managerial incentives of interest include net-return distance, gross-return distance, option delta, option vega, managerial ownership, management fee and incentive fee.

Hedge funds feature short duration and short notice on changes of financing from prime brokers, which result in a potential mismatch between the duration of the fund's assets and liabilities. To invest in the illiquid assets, hedge funds commonly adopt longer redemption and advance notice period to address the duration mismatch of their balance sheet. In the regressions, we control the fund illiquidity by incorporating redemption period and advance notice period in the regressions. We also control fund relative performance by using the indicator variable that equals 1 if the fund's annual raw return is below the median relative to other funds' during the same year. Since hedge funds often use leverage to target a particular level of volatility, we also control for the volatility in the regression, which is defined as the 12-month rolling window standard deviation of monthly net returns. In addition to hedge fund volatility, we also include hedge fund net flows as a control variable. We impose the time fixed

effect λ_t to control for the macroeconomics conditions, and strategy fixed effect η_k to control for the strategy-specific characteristics, as suggested in Ang, et al. (2011).

Table 4 presents the baseline regression results from estimating Equation (1). The results of Model 1 and Model 2 show that the coefficients of both measures of the distance to HWM are positively related to fund leverage. Regarding the economic significance, one standard deviation change in the distance to HWM is associated with 6% percentage point change in fund leverage, which is considerably large given the borrowing on average only accounts for 31% of the fund's net asset. In Model 3, we break down the total delta to the manager's option delta and managerial ownership, and we find both of them are significantly positive. The results of Model 4 show that the vega coefficient of the incentive fee contracts is also positively related to fund leverage. With respect to economic significance, one standard deviation change in vega or delta corresponds to 8% percentage point change in leverage. Interestingly, the incentive fee has no explanatory power on fund leverage, once controlling for option vega and option delta, implying that the option vega and delta better capture managerial incentives of the incentive fee contract, consistent with the findings of Agarwal et al. (2009). Table 4 also shows that managerial ownership is positively associated with the fund leverage across all the models. Regarding economic significance, one standard deviation change in the managerial ownership is related to 5% percentage point change in fund leverage. In addition, management fee and incentive fee are positively associated with fund leverage. Overall, Table 4 shows that managerial incentives and fund leverage are positively related statistically and economically.

Regarding the control variables, we observe that the coefficients of lagged leverage are positively significant, indicating that leverage tends to follow mean-reversion, consistent with the findings of Ang et al. (2003). From Table 4, the coefficients of redemption period and advance notice period are negative, showing that the funds that invest more in the illiquid assets with larger redemption and advance notice period, tend to take less risk, given the liquidity constraints.

From Table 4, volatility is negatively correlated with fund leverage, which is consistent with the findings of Ang et al. (2011). Also, we find funds with larger size tend to take

on higher leverage, which is consistent with the anecdotal evidence. [11] Hedge funds may be under competitive pressure from the market and investors to produce higher returns, which can possibly lead to borrowing cash to make bigger bets. We control for the performance relative to peers, in the spirit of "tournament behavior" from Brown, Harlow and Starks (1996) and Aragon and Nanda (2012), by including the past relative performance indicator, the dummy variable that equals 1 when the annual return is lower than the median of the peers'. We find that past losers tend to use more leverage than past winners.

The empirical results in Table 4 are consistent with the model predictions of Lan et al. (2013). The intuition is that to maximize the present value of their current and future management and incentive fees, when the fund value is low relative to its high-water mark, managers would prefer to reduce leverage to increase the probability of fund survival. On the other hand, when managers have little concern about liquidation jeopardizing the value of future fees, the managers increase leverage to boost the value of the incentive fee portion of their compensation.

4.2. Non-linear structures of managerial incentives and leverage

In this section, we explore the non-linear relationship between the managerial incentive and leverage. We first examine the non-linearity between the option incentives and leverage, using the following piecewise specifications:

$$\begin{aligned} L_{i,k,t} =& \alpha + \theta L_{i,k,t-1} + \beta_1 Option\ incentives_{i,k,\ t-1} + \beta_2 Option\ incentives_{i,k,\ t-1} * D^{Option\ incentives}_{top\ 30\%,t-1} \\ &+ \beta_3 Option\ incentives_{i,k,\ t-1} * D^{Option\ incentives}_{bottom\ 30\%,\ t-1} + \varphi Managerial\ ownership_{i,k,t} \\ &+ \gamma Controls_{i,k,t-1} + \lambda_t + \eta_k + \varepsilon_{i,k,t} \end{aligned} \tag{2}$$

[11] 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). "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).

, where $D_{top\ 30\%}$ is the indicator variable that equals 1 if the variables of interest fall into the top 30% relative to other funds' during the same year. $D_{bottom\ 30\%}$ is the indicator variable that equals 1 if the variables of interest fall into the bottom 30% relative to other funds' during the same year. Table 5 presents the piecewise regression results from estimating Equation (2). From Table 5, for all the models using various incentive measures, we find that the positive relationship between option incentives and leverage is stronger in the top area and weaker in the bottom area, implying that the positive relation between option incentives and fund leverage is convex, in which managers take on more leverage at an increasing rate as the fund value approaches the high-water mark. The findings indicate fund managers become very prudent when the incentive fee options are deep out of the money, due to liquidation concerned.

Following Aragon and Nanda (2011), we also construct two contemporaneous distance measures, mid-year distance and year-end distance, to capture the contemporaneous effect of managerial incentives on leverage using the following specification:

$$\begin{aligned} L_{i,k,t} =& \alpha + \theta L_{i,k,t-1} + \beta Option\ incentives_{i,k,t} + \varphi Managerial\ ownership_{i,k,t} \\ &+ \gamma Controls_{i,k,t-1} + \lambda_t + \eta_k + \varepsilon_{i,k,t} \end{aligned} \tag{3}$$

, where $Option\ incentives_{i,k,t}$ include the distance of mid-year and year-end fund performance to the high-water mark in year t.

Table 6 presents the contemporaneous regression results from estimating Equation (3), and shows consistent evidence with the results of baseline regression in Table 3. All the contemporaneous measures of the distance to HWM are positive related to fund leverage from Model 1 to Model 3. Table 6 also shows that the fund in the bottom area takes significantly lower leverage, with the funds with bottom 30% taking 11% less leverage. The results imply that fund manager is extremely concerned about the possibility of liquidation and take less leverage when the fund value is distant from the HWM.

Further, we explore the heterogeneous effect of managerial ownership on leverage using the interaction of managerial ownership with the distance to HWM dummies in the following specification:

$$\begin{aligned} L_{i,k,t} =& \alpha + \theta L_{i,k,t-1} + \beta Option\ incentives_{i,k,t-1} + \varphi_1 Managerial\ ownership_{i,k,t} \\ &+ \varphi_2 Managerial\ ownership_{i,k,t} * D^{dist}_{below\ med} + \gamma Controls_{i,k,t-1} + \lambda_t + \eta_k + \varepsilon_{i,k,t} \end{aligned} \tag{4}$$

, where $D^{dist}_{below\ med}$ is the indicator variable that equals 1 if the fund's distance to HWM is below the median relative to other funds during the same year. Table 7 presents the regression results from estimating Equation (4). Table 7 shows that all the coefficients of the interaction of managerial ownership and the distance to HWM dummies are negative, with the magnitude close to that of positive coefficients of managerial ownership. In other words, the positive association of managerial ownership and leverage is largely offset when the fund value is distant to HWM. Consistent with the model predictions by Lan, Wang and Yang (2013), these findings suggest that managerial ownership improves incentive alignment between fund managers and investors by making the managers care more about the fund value, especially when the option contract is near the money.

4.3. Implication for fund flows and fund performance

In this section, we first examine how fund flows respond to fund leverage change and managerial ownership. Table 8 presents the regression results of the change of fund leverage on fund flows, insider flows and outsider flows. From from Model 2 and Model 3, insider flows are positively related to the leverage change, while outsider net flows and total inflows are negatively associated with it, implying that investors are averse to risk hike. Also, the flows are negatively associated with the under-performance indicator, showing that flows chase performance. Interestingly, from Model 1 and Model 4, we also observe that fund net flows and inflows appear to chase the funds with high managerial stake, implying that investors are more willing to invest the funds with high managerial ownership, understanding managerial incentives are better aligned with investors' interest.

Further, we examine the relationship of fund leverage and managerial ownership with fund performance. Buraschi, Kosowski, and Sritrakul (2014) argue that the incentive fee contract makes optimal leverage endogenous. As a result, the reduced-form alpha is predicted to be affected by the time-varying fund leverage. We show that empirically how the fund leverage and managerial ownership influence the risk-adjusted return. Panel A of Table 9 presents the results of reduced form regression of the level of leverage on the risk-adjusted return using Fama-French 3-factor model and 7-factor model of Fung and Hsieh (2004). We find that the level of fund leverage is positively associated with the risk-adjusted return, but the change of leverage barely predicts the risk-adjusted return in Panel C of Table 9. Further, Panel B of Table 9 explores the piecewise relationship between the leverage level and the risk-adjusted return, which shows that the positive relationship of leverage level and the risk-adjusted return is reversed, when the fund value is distant from HWM. Consistent with the model predictions of Buraschi, et al. (2014) and simulation results of Lim et al.(2016), these results suggest that the use of leverage amplifies the incentive effects, not only from the direct incentives of the option-like compensation, but also from the indirect incentives from future compensation.

Ozik and Sadka (2015) find that fund flows can predict future fund returns for share-restricted funds. Table 9 provides additional evidence on the association between managerial ownership, insider flows and future performance. Interestingly, both managerial ownership and insider net flows can positively predict the fund future performance. One standard deviation increase of managerial ownership change and insider net flows change correspond to 5 and 3 basis points increase of the monthly alpha, respectively, which together are relatively large considering the average monthly alpha is 10 basis points. The results imply that fund managers may have information advantage distributing their own capital over the outside investors. Fund managers may withdraw their own capital in anticipation of future loss, and increase their equity in the case of good investment opportunities. It is also possible that the fund managers, facing the capacity constraints and limited investment opportunities, favor the fund with larger managerial ownership with better investment opportunities. This findings have important implications for financial contracting. While the managerial ownership serves as the incentive alignment mechanism, it also appears to provides incentives for managers to trade in advance of their clients.

5. Robustness tests

In this section, we conduct several robustness tests using the various empirical specifications. We first show that the main results in Table 4 are robust to using the sub-samples with high-water mark provisions, with 20% incentive fee and with the fund of hedge funds excluded.

To address the concern of endogenous contracting due to different skill levels, we estimate Equation (1) based on the sub-sample with the incentive fee exactly at 20%. In our sample, 70% of the funds have the 20% incentive fee that is regular for the whole hedge funds industry. As shown in Table 10, all the results remain quantitatively the same with those in Table 4. Table 11 presents the results of estimating Equation (1) for the funds with high-water mark provisions, which accounts for 80% of the hedge funds. Table 11 shows that the main results in Table 4 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, we exclude them from our sample and estimate Equation (1). Table 12 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, we show, in the appendix, that the findings are robust to the specification using the change of managerial ownership, and to the specification without year fixed effect.

6. Conclusion

Hedge funds distinguish from other investment vehicles by the use of leverage that trades off the boosted return with the magnified risk exposure. Also, 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 our knowledge, to comprehensively examine the relationship between hedge fund leverage and managerial

incentives, using the new public dataset drawn from SEC filings Form ADV. We find several interesting and important results.

First, our findings suggest that the manager becomes more prudent as the fund value distances from high-water mark, in contrast to risk shifting suggested by conventional wisdom. Also, the greater managerial ownership is associated with larger leverage only when the fund value is close to high-water mark. 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). Interestingly, we also show that both managerial ownership and insider net flows are positively related to fund future performance. The future work includes exploiting the 13-F holding data to construct un-levered performance measures in performance analysis. An interesting direction for future work is to further explore the dynamics of fund performance and allocation of managers' own investments.

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Table 1
The comparison of fund characteristics

This table presents the summary statistics of 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. Returns are the annual net-of-fee returns. 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. Lockup period is the minimum time that outside investors must wait before they can withdraw. Advance notice period is the time that the investors must give notice to the fund about their intention to withdraw. Redemption period is the time that the fund takes to return the money after the advance notice period. Age is the age of the fund after inception in years.

	Fund Characteristics	Mean	SD	P25	P50	P75
Whole sample	Gross Asset Value ($million)	333	753	21	78	277
	Net Asset Value ($million)	194	518	9	34	130
	Managerial Ownership (%)	19	30	0	3	21
	Annual Return (%)	5	12	-1.9	5	11
	Redemption Period (days)	38	47	1	30	30
	Management Fee (%)	1.38	0.7	1	1.5	2
	Incentive Fee (%)	12	9	0	15	20
	High Watermark	0.59	0.49	0	1	1
	Advance Notice Period (days)	31	35	0	30	45
	Lockup Period (months)	2	6	0	0	0
	Fund Age (years)	8	5	4	7	10
Matched sample	Gross Asset Value ($million)	387	941	37	95	327
	Net Asset Value ($million)	282	626	30	80	262
	Managerial Ownership (%)	22	26	2	10	31
	Annual Return (%)	6	13	-0.7	5	12
	Redemption Period (days)	79	68	30	90	90
	Management Fee (%)	1.32	0.44	1	1.5	1.5
	Incentive Fee (%)	16	7	10	20	20
	High Watermark	0.85	0.36	1	1	1
	Advance Notice Period (days)	53	31	30	45	65
	Lockup Period (months)	6	7	0	0	12
	Fund Age (years)	11	6	6	10	14

Table 2
The summary statistics of fund leverage by fund strategies

This table reports summary statistics for the hedge fund leverage broken down by fund strategies over the 2011-2016 sample period. The fund leverage is the balance-sheet gross leverage: the ratio of gross asset value (GAV) to net asset value (NAV). Following Agarwal et al. (2009), we classify funds into six broad strategies: Directional, Relative Value, Security Selection, Multi-Process, Fund of funds, and Other. We report the number of observations, means, standard deviation, median, and 25 and 75 percentiles of the fund leverage distribution.

Strategies	Num of Obs	Equal-weighted Avg	Value-weighted Avg	SD	P25	P50	P75
Fund of funds (%)	583	105	108	16	100	100	104
Relative value (%)	391	156	196	76	101	122	176
Multi-process (%)	339	140	147	61	100	117	150
Directional traders (%)	242	138	154	72	100	105	139
Security selection (%)	1,118	133	146	51	100	113	146
Other (%)	87	115	124	29	100	104	111
Total (%)	2,871	132	147	61	100	106	138

Table 3

The summary statistics of variables of interest in the baseline regressions

This table summarizes key variables of interest in the main regressions for the matched sample over the 2011-2016 sample period. The fund leverage is defined as the gross leverage: the ratio of GAV to NAV. Alpha-3factors and Alpha-7factors are the intercepts from fund-level time-series regression of monthly excess net returns on the 3 factors of Fama and French (1995) and the 7 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 distance is defined as the ratio of a fund's NAV divided by its HWM, calculated based on the net return. Gross-return distance 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 distance and Year-end distance are the mid-year and year-end percentage differences between a fund's NAV and its HWM, respectively, following Aragon and Nanda (2011). Underwater is an indicator variable that equals 1 if net-return distance 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 rate and the investors' assets. Total delta is the sum of the delta from investors' assets and the delta from manager's equity investments in the fund, following Agarwal et al. (2009).

Fund Characteristics	Num of Obs	Mean	SD	P25	P50	P75
Gross Leverage (%)	2,871	132	61	100	106	138
Net Flows (%)	2,757	6	58	-15	-3	8
Insider Net Flows (%)	1,669	23	129	-16	0	18
Outsider Net Flows (%)	1,842	5	70	-21	-5	9
Monthly Alpha-3factors (%)	2,448	0.13	0.63	-0.16	0.13	0.42
Monthly Alpha-7factors (%)	2,554	0.1	0.16	-0.4	0.1	0.6
Volatility (%)	2,869	3	10	1	2	3
Net-return distance (%)	2,871	96	10	96	100	100
Gross-return distance (%)	2,141	97	9	98	100	100
Mid-year distance (%)	2,786	99	12	96	102	105
Year-end distance (%)	2,786	101	15	96	103	109
Underwater	2,871	0.4	0.49	0	0	1
Manager Option Delta in dollars ($'000)	2,045	194	528	7	37	137
Manager Option Vega in dollars ($'000)	2,045	157	420	7	32	112
Manager Option Vega (%)	2,045	0.06	0.03	0.04	0.08	0.08
Manager Option Delta (%)	2,045	0.07	0.04	0.03	0.1	0.1
Total Delta (%)	2,200	0.27	0.26	0.09	0.16	0.36

Table 4
Managerial incentives and the fund leverage: Baseline linear model

This table presents the baseline multivariate linear regression results on fund leverage, using the various measures of managerial incentives, while controlling for the lagged dependent variable. $D^{\text{Perf}}_{\text{below median}}$ is the indicator variable that equals 1 if the fund's annual raw return is below the median relative to other funds' during the same year. The sample period is from 2011 to 2017, where the Form ADV fund level data is available. In the regression, we 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					
Independent variables	Expected Sign	Model1	Model2	Model3	Model4
$\text{Net} - \text{return distance}_{t-1}$	+	0.39**			
		(2.3)			
$\text{Gross} - \text{return distance}_{t-1}$	+		0.73***		
			(2.8)		
Option Vega_{t-1}	+			315***	
				(4.6)	
$\text{Option Delta}_{t-1}$	+				233***
					(4.8)
$\text{Managerial Ownership}_{t}$	+	0.21***	0.18**	0.18**	0.18**
		(2.9)	(2.4)	(2.3)	(2.4)
Management fee	+	14.44***	18.99***	19.11***	18.93***
		(2.9)	(3.5)	(3.6)	(3.6)
Incentive fee	+	0.97***	1.09***	-0.01	0.09
		(3.0)	(2.7)	(-0.0)	(0.3)

(Table 4 continued)

Panel B: Control variables				
Controls:				
Redemption period	-0.0003**	-0.0003**	-0.0003**	-0.0003**
	(-2.6)	(-2.1)	(-2.1)	(-2.1)
Lockup period	-0.0011	-0.0016	-0.0016	-0.0016
	(-0.5)	(-0.7)	(-0.7)	(-0.7)
Advance notice period	-0.0016***	-0.0014**	-0.0014**	-0.0014***
	(-3.0)	(-2.6)	(-2.6)	(-2.6)
$D^{Perf}_{\text{below median, t}-1}$	0.1199***	0.1312***	0.1390***	0.1467***
	(3.9)	(3.5)	(3.7)	(3.8)
Volatility_{t-1}	-2.6970***	-1.7375	-2.2129*	-2.0682*
	(-2.8)	(-1.5)	(-1.9)	(-1.8)
Net asset_{t-1}	0.0537*	0.0589*	0.0581*	0.0577*
	(1.9)	(1.8)	(1.8)	(1.8)
$\text{Net flow}_{t-1,\,t}$	-0.0314	-0.0309	-0.0346	-0.0362
	(-0.9)	(-0.8)	(-0.8)	(-0.9)
Fund age_{t-1}	0.0066**	0.0002	0.0002	0.0001
	(2.3)	(0.1)	(0.1)	(0)
Leverage_{t-1}	0.2899***	0.3206***	0.3179***	0.3171***
	(4.8)	(6)	(5.9)	(5.9)
Constant	0.3347	-0.278	0.4309***	0.4299***
	(1.4)	(-0.9)	(2.7)	(2.7)
Observations	1,698	1,312	1,312	1,312
Number of funds	724	564	564	564
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	0.45	0.45	0.45

Table 5
Managerial incentives and the fund leverage: Piecewise regression

This table presents the piecewise regression results on fund leverage. $D_{top\ 30\%}$ is the indicator variable that equals 1 if the variable of interest fall into the top 30%, relative to other funds during the same year. $D_{bottom\ 30\%}$ is the indicator variable that equals 1 if the variable of interest fall into the bottom 30%, relative to other funds during the same year. $D_{below\ median}$ is the indicator variable that equals 1 if the variable of interest fall into the bottom 50%, relative to other funds during the same year. The sample period is from 2011 to 2017, where the Form ADV fund level data is available. In the regression, we 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				
Independent variables	Model1	Model2	Model3	Model4
$\text{Net} - \text{return distance}_{t-1}$	0.21			
	(1.2)			
$\text{Net} - \text{return distance}_{t-1} * D^{Net\ dis}_{below\ median,\ t-1}$	-0.08***			
	(-2.6)			
$\text{Gross} - \text{return distance}_{t-1}$		0.53**		
		(2.0)		
$\text{Gross} - \text{return distance}_{t-1} * D^{Gross\ dis}_{below\ median,\ t-1}$		-0.11***		
		(-3.1)		
Option Vega_{t-1}			257***	
			(4.0)	
$\text{Option Vega}_{t-1} * D^{Vega}_{top30\%,\ t-1}$			106**	
			(2.2)	
$\text{Option Vega}_{t-1} * D^{Vega}_{bottom30\%,\ t-1}$			-79	
			(-0.9)	
$\text{Option Delta}_{t-1}$				209***
				(4.0)
$\text{Option Delta}_{t-1} * D^{Delta}_{top30\%,\ t-1}$				31
				(0.8)
$\text{Option Delta}_{t-1} * D^{Delta}_{bottom30\%,\ t-1}$				-24
				(-0.3)
$\text{Managerial Ownership}_{t}$	0.21***	0.19**	0.18**	0.18**
	(2.9)	(2.4)	(2.4)	(2.4)
Management fee	14.49***	18.60***	18.09***	18.92***
	(2.9)	(3.5)	(3.4)	(3.6)
Incentive fee	0.94***	1.10***	-0.07	0.12
	(2.9)	(2.7)	(-0.2)	(0.3)

(Table 5 continued)

Panel B: Control variables				
Controls:				
Redemption period	-0.0003**	-0.0003**	-0.0003**	-0.0003**
	(-2.5)	(-2.3)	(-2.3)	(-2.1)
Lockup period	-0.0009	-0.0016	-0.0017	-0.0016
	(-0.5)	(-0.7)	(-0.8)	(-0.7)
Advance notice period	-0.0016***	-0.0015***	-0.0014**	-0.0014***
	(-3.1)	(-2.7)	(-2.5)	(-2.6)
$D^{Perf}_{\text{below median, t}-1}$	0.1306***	0.1353***	0.1423***	0.1501***
	(4.1)	(3.6)	(3.8)	(3.9)
Volatility_{t-1}	-2.6057***	-1.8593	-1.5614	-2.1674*
	(-2.7)	(-1.6)	(-1.3)	(-1.9)
Net asset_{t-1}	0.0506*	0.0573*	0.0568*	0.0591*
	(1.9)	(1.8)	(1.8)	(1.9)
$\text{Net flow}_{t-1,\,t}$	-0.0326	-0.0320	-0.0353	-0.0365
	(-1.0)	(-0.8)	(-0.9)	(-0.9)
Fund age_{t-1}	0.0064**	0.0001	0.0004	0.0000
	(2.2)	(0.0)	(0.1)	(0.0)
Leverage_{t-1}	0.2895***	0.3200***	0.3162***	0.3172***
	(4.7)	(5.9)	(5.8)	(5.9)
Constant	0.5338**	-0.0497	0.4544***	0.4350***
	(2.3)	(-0.2)	(2.8)	(2.7)
Observations	1,698	1,312	1,312	1,312
Number of funds	724	564	564	564
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	0.45	0.45	0.45

Table 6
Managerial incentives and the fund leverage: Contemporaneous incentive measures

This table presents the regression results on fund leverage, using the contemporaneous measures of option incentives as independent variables. $D_{top30\%}$ is the indicator variable that equals 1 if the variable of interest fall into the top 30% relative to other funds during the same year. $D_{bottom\ 30\%}$ is the indicator variable that equals 1 if the variable of interest fall into the bottom 30% relative to other funds during the same year. The sample period is from 2011 to 2017, where the Form ADV fund level data is available. In the regression, we 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					
Independent variables	Model1	Model2	Model3	Model4	Model5
$Mid-year\ distance_t$	0.37**				
	(2.0)				
$Net-return\ distance_t$		0.40**			
		(2.2)			
$Year-end\ distance_t$			0.23**		
			(2.1)		
$D^{Mid-year\ dist}_{top30\%,\ t}$				-0.015	
				(-0.5)	
$D^{Mid-year\ dist}_{bottom\ 30\%,\ t}$				-0.11***	
				(-3.8)	
$D^{Year-end\ dist}_{top30\%,\ t}$					0.003
					(0.1)
$D^{Year-end\ dist}_{bottom\ 30\%,\ t}$					-0.053*
					(-1.7)
Managerial Ownership$_t$	0.18**	0.18**	0.18**	0.20***	0.21***
	(2.5)	(2.5)	(2.5)	(2.9)	(2.9)
Management fee	13.62***	13.69***	13.57***	14.34***	14.7967***
	(2.8)	(2.8)	(2.8)	(2.9)	(3.0)
Incentive fee	1.03***	1.03***	1.04***	0.96***	0.98***
	(3.2)	(3.2)	(3.2)	(3.0)	(3.0)

(Table 6 continued)

Panel B: Control variables					
Controls:					
Redemption period	-0.0003**	-0.0003**	-0.0003**	-0.0003***	-0.0003**
	(-2.5)	(-2.5)	(-2.5)	(-2.6)	(-2.6)
Lockup period	-0.0011	-0.0010	-0.0010	-0.0011	-0.0010
	(-0.5)	(-0.5)	(-0.5)	(-0.5)	(-0.5)
Advance notice period	-0.0017***	-0.0016***	-0.0016***	-0.0016***	-0.0016***
	(-3.2)	(-3.1)	(-3.2)	(-3.1)	(-3.0)
$D^{Perf}_{\text{below median, t}-1}$	0.1217***	0.1132***	0.1135***	0.1164***	0.1146***
	(4.0)	(4.0)	(4.0)	(4.0)	(3.8)
Volatility_{t-1}	-2.5667***	-2.6134***	-2.9141***	-3.0746***	-3.1943***
	(-2.7)	(-2.8)	(-3.2)	(-3.2)	(-3.2)
Net asset_{t-1}	0.0449	0.0440	0.0440	0.0487*	0.0501*
	(1.6)	(1.6)	(1.6)	(1.8)	(1.8)
$\text{Net flow}_{t-1,\,t}$	-0.0885**	-0.0840**	-0.0872**	-0.0323	-0.0308
	(-2.1)	(-2.0)	(-2.1)	(-0.9)	(-0.9)
Fund age_{t-1}	0.0077***	0.0077**	0.0079***	0.0066**	0.0067**
	(2.6)	(2.6)	(2.6)	(2.3)	(2.3)
Leverage_{t-1}	0.2892***	0.2905***	0.2893***	0.2919***	0.2896***
	(4.8)	(4.8)	(4.8)	(4.8)	(4.7)
Constant	0.3876	0.3644	0.5262***	0.7615***	0.7580***
	(1.6)	(1.5)	(2.7)	(4.9)	(4.9)
Observations	1,734	1,734	1,734	1,698	1,698
Number of funds	735	735	735	724	724
Strategy fixed effect	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund	By fund
R-squared	0.43	0.43	0.43	0.43	0.43

Table 7
Managerial incentives and the fund leverage: Interaction of managerial ownership with option incentives

This table presents the piecewise regression results on fund leverage, using the interaction of managerial ownership with option incentives, while controlling for the lagged dependent variable. $D^{dis}_{below\ median}$ is the indicator variable that equals 1 if the distance of fund's AUM to HWM is below the median relative to other funds' during the same year. The sample period is from 2011 to 2017, where the Form ADV fund level data is available. In the regression, we 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					
Independent variables	Model1	Model2	Model3	Model4	Model5
$Managerial\ Ownership_t$	0.28***	0.24***	0.23***	0.26***	0.26***
	(3.4)	(2.8)	(2.9)	(3.4)	(3.3)
$Ownership_t * D^{Net\ dist}_{below\ median,\ t-1}$	-0.2278***				
	(-3.2)				
$Ownership_t * D^{Gross\ dist}_{below\ median,\ t-1}$		-0.2037**			
		(-2.1)			
$Ownership_t * D^{Mid-year\ dist}_{below\ median,\ t}$			-0.0793		
			(-0.8)		
$Ownership_t * D^{Year-end\ dist}_{below\ median,\ t}$				-0.2125**	
				(-2.4)	
$Ownership_t * D^{Net\ dist}_{below\ median,\ t}$					-0.1997**
					(-2.2)
Management fee	14.31***	18.70***	14.37***	14.29***	14.27***
	(2.9)	(3.5)	(2.9)	(2.9)	(2.9)
Incentive fee	0.98***	1.12***	0.99***	1.01***	1.01***
	(3.0)	(2.8)	(3)	(3.1)	(3.1)
$Net-return\ distance_{t-1}$	0.1991				
	(1.1)				
$Gross-return\ distance_{t-1}$		0.5922**			
		(2.3)			
$Mid-year\ distance_t$			0.2536		
			(1.3)		
$Net-return\ distance_t$				0.0768	
				(0.7)	
$Year-end\ distance_t$					0.1718
					(0.9)

(Table 7 continued)

Panel B: Control variables					
Controls:					
Redemption period	-0.0003**	-0.0003**	-0.0003***	-0.0003**	-0.0003**
	(-2.5)	(-2.3)	(-2.6)	(-2.5)	(-2.5)
Lockup period	-0.0011	-0.0017	-0.0012	-0.0012	-0.0012
	(-0.6)	(-0.8)	(-0.6)	(-0.6)	(-0.6)
Advance notice period	-0.0015***	-0.0015***	-0.0016***	-0.0016***	-0.0016***
	(-3.0)	(-2.6)	(-3.1)	(-3.1)	(-3.1)
$D^{Perf}_{\text{below median, t}-1}$	0.1264***	0.1325***	0.1196***	0.1140***	0.1140***
	(4.1)	(3.6)	(3.9)	(4)	(4)
Volatility_{t-1}	-2.6171***	-1.7818	-2.9706***	-3.1550***	-2.9884***
	(-2.7)	(-1.5)	(-3.0)	(-3.2)	(-3.1)
Net asset_{t-1}	0.0564**	0.0609*	0.0551**	0.0556**	0.0559**
	(2)	(1.9)	(2)	(2)	(2)
$\text{Net flow}_{t-1,\,t}$	-0.0306	-0.0316	-0.0307	-0.0326	-0.0326
	(-0.9)	(-0.8)	(-0.9)	(-0.9)	(-1.0)
Fund age_{t-1}	0.0063**	-0.0003	0.0066**	0.0065**	0.0065**
	(2.2)	(0.1)	(2.3)	(2.3)	(2.3)
Leverage_{t-1}	0.2906***	0.3221***	0.2895***	0.2913***	0.2916***
	(-4.8)	(-5.9)	(-4.7)	(-4.7)	(-4.7)
Constant	0.5069**	-0.1563	0.4810*	0.6385***	0.5465**
	(2.2)	(-0.5)	(1.9)	(3.2)	(2.2)
Observations	1,698	1,312	1,698	1,698	1,698
Number of funds	724	564	724	724	724
Strategy fixed effect	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund	By fund
R-squared	0.43	0.45	0.43	0.43	0.43

Table 8
Leverage changes, managerial ownership and fund flows

This table presents the multivariate linear regression results on fund net flows, insider net flows, outsider net flows and total inflows, 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. The total inflows are defined as fund new sales scaled by its net asset, which is derived from Form ADV. $D^{Perf}_{\text{below median}}$ is the indicator variable that equals 1 if the fund's annual raw return is below the median relative to other funds' during the same year. The sample period is from 2011 to 2017. In the regressions, we control for year fixed effect and strategy fixed effect with standard error clustered at fund level. The t-value are reported in parentheses, with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Independent variables	Total net flow	Insider net flow	Outsider net flow	Total inflow
$\Delta Leverage_{t-1,t}$	-0.15***	0.29***	-0.19***	-0.10*
	(-2.7)	(2.9)	(-2.7)	(-1.7)
Managerial Ownership$_{t-1}$	0.24***	-0.74***	0.87***	0.25**
	(3.2)	(-6.0)	(5.6)	(2.3)
$D^{Perf}_{\text{below median, t}-1}$	-0.11***	-0.13*	-0.12**	-0.03
	(-2.9)	(-1.9)	(-2.5)	(-0.8)
Management fee	-1.4853	-6.7132	-6.4535	2.6733
	(-0.4)	(-0.8)	(-1.1)	(0.5)
Incentive fee	0.1169	-0.636	-0.0413	-1.4526*
	(0.2)	(-0.7)	(-0.1)	(-1.8)
Redemption period	0.0001	0.0001	0.0001	0
	(1.1)	(0.4)	(0.6)	(-0.0)
Lockup period	-0.0023	0.001	-0.0037*	0.0014
	(-1.4)	(0.2)	(-1.7)	(0.6)
Advance notice period	-0.0006	-0.0013	-0.0007	-0.0002
	(-1.3)	(-1.2)	(-1.0)	(-0.2)
Volatility$_{t-1}$	-0.0165	2.9765	-0.2173	-1.0206
	(-0.0)	(1.2)	(-0.2)	(-0.6)
Net asset$_{t-1}$	-0.0792***	-0.0548	-0.0614*	-0.003
	(-3.4)	(-0.8)	(-1.9)	(-0.1)
Fund age$_{t-1}$	0.0215***	0.0212***	0.0282***	0.0203***
	(7.4)	(3.8)	(6.7)	(4.8)
Constant	0.4381***	0.8011***	0.5077**	0.5651***
	(2.7)	(2.6)	(2.3)	(2.9)
Observations	1,734	1,497	1,709	1,241
Number of funds	735	651	718	530
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	0.09	0.05	0.1	0.05

Table 9
Leverage, managerial ownership, insider flow and fund performance

This table presents the multivariate linear regression results on annual return and monthly risk-adjusted return. Alpha-3 and Alpha-7 are the monthly risk-adjusted returns using Fama-French 3 factors and 7-factor model of Fung and Hsieh (2004), respectively. Annual return is the net-of-fee annual return collected from TASS/HFR. The insider net flow is defined as the scaled flow into the fund from manager's own stake. The outsider net flow is defined as the scaled flow into the fund from investors. The sample period is from 2011 to 2017. In the regressions, we 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: leverage level				
	Alpha-3	Alpha-3	Alpha-7	Alpha-7
$Managerial\ Ownership_{t-1}$	0.0019***	0.0018***	0.0022***	0.0017***
	(2.7)	(2.6)	(4)	(2.9)
$Leverage_{t-1}$	0.0008**	0.0008**	0.0004*	0.0004*
	(2)	(2.1)	(1.7)	(1.8)
$Insider\ net flow_{t-1}$	0.0002		0.0001*	
	(1.5)		(1.7)	
$Outsider\ net flow_{t-1}$		-0.0005**		0.0001
		(-2.1)		(0.8)
Management fee	0.1276***	0.1134**	0.0660**	0.0699**
	(2.6)	(2.6)	(2)	(2.2)
Incentive fee	0.0023	0.004	-0.0002	0.0009
	(0.5)	(1)	(-0.1)	(0.3)
Redemption period	0	0	0	0
	(-1.1)	(-1.6)	-0.2	(-0.7)
Lockup period	0	0	0.0000**	0
	-0.6	(-0.1)	(2)	(1.1)
Advance notice period	0	0.0000**	0	0
	(1.1)	(2)	(0.1)	(1.6)
$Volatility_{t-1}$	-0.1181***	-0.1001***	-0.0615***	-0.0524***
	(-4.6)	(-4.1)	(-3.8)	(-3.3)
$Net\ asset_{t-1}$	-0.0001	0	0.0004**	0.0004**
	(-0.5)	(-0.0)	(2.5)	(2.2)
$Fund\ age_{t-1}$	0	0	0	0
	(0.3)	(0.2)	(0.7)	(-0.2)
$Alpha_{t-1}$	0.5067***	0.5235***	0.6708***	0.6701***
	(9.8)	(10.7)	(20.4)	(19.7)
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	0.5	0.5	0.62	0.62

(Table 9 continued)

Panel B: Interaction of leverage level with the distance to HWM						
	Alpha-7	Alpha-3	Alpha-7	Alpha-3	Alpha-7	Alpha-3
$Managerial\ Ownership_{t-1}$	0.0019***	0.0017***	0.0021***	0.0020***	0.0020***	0.0019***
	(4.0)	(2.6)	(3.9)	(2.7)	(4.1)	(2.7)
$Leverage_{t-1}$	0.0008***	0.0014***	0.0004**	0.0006***	0.0008***	0.0015***
	(3.9)	(4.8)	(2.5)	(2.8)	(3.6)	(3.2)
$Leverage_{t-1}*D^{Net\ dist}_{below\ median,\ t-1}$	-0.0016***	-0.0028***				
	(-7.6)	(-9.3)				
$Leverage_{t-1}*D^{Gross\ dist}_{below\ median,\ t-1}$			-0.0006***	-0.0007*		
			(-2.7)	(-2.0)		
$Leverage_{t-1}*D^{Year-end\ dist}_{below\ median,\ t-1}$					-0.0011***	-0.0020***
					(-6.1)	(-5.9)
$Insider\ net\ flow_{t-1}$	0.0001	0.0001	0.0001	0.0002*	0.0001	0.0001
	(0.9)	(1.0)	(1.5)	(1.7)	(0.9)	(1.1)
Management fee	0.0507*	0.1103**	0.0594*	0.1355***	0.0507*	0.1160**
	(1.7)	(2.5)	(1.9)	(2.8)	(1.7)	(2.5)
Incentive fee	0.0013	0.0040	0.0010	0.0042	0.0011	0.0041
	(0.5)	(1.0)	(0.4)	(0.9)	(0.4)	(1.0)
Redemption period	0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000*
	(0.6)	(-0.6)	(0.0)	(-1.0)	(-0.4)	(-1.7)
Lockup period	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000
	(1.3)	(0.1)	(1.6)	(0.4)	(1.9)	(0.7)
Advance notice period	-0.0000	0.0000	-0.0000	0.0000	-0.0000	0.0000
	(-0.5)	(0.6)	(-0.3)	(1.0)	(-0.5)	(0.6)
$Volatility_{t-1}$	-0.0399***	-0.0876***	-0.0501***	-0.1070***	-0.0481***	-0.1018***
	(-2.7)	(-4.0)	(-3.2)	(-4.5)	(-3.2)	(-4.4)
$Net\ asset_{t-1}$	0.0004***	-0.0001	0.0004***	-0.0001	0.0004***	-0.0001
	(3.0)	(-0.4)	(2.8)	(-0.3)	(2.8)	(-0.4)
$Fund\ age_{t-1}$	0.0000**	0.0000	0.0000	0.0000	-0.0000	-0.0000
	(2.0)	(1.4)	(1.1)	(0.5)	(-0.2)	(-0.9)
$Alpha-7_{t-1}$	0.6284***		0.6499***		0.6684***	
	(21.5)		(19.2)		(22.4)	
$Alpha-3_{t-1}$		0.4259***		0.4624***		0.4646***
		(9.6)		(8.9)		(10.0)
Strategy fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	By fund	By fund	By fund	By fund	By fund	By fund
R-squared	0.64	0.54	0.62	0.48	0.63	0.51

(Table 9 continued)

Panel C: leverage changes						
	Annual return	Annual return	Alpha-3	Alpha-3	Alpha-7	Alpha-7
$Insider\ net flow_{t-1}$	0.0054**		0.0002*		0.0001	
	(2.1)		(1.7)		(1.6)	
$Outsider\ net flow_{t-1}$		-0.0093**		-0.0006**		0.0001
		(-2.0)		(-2.3)		(0.8)
$Managerial\ Ownership_{t-1}$	0.0162	0.0217	0.0020***	0.0019***	0.0023***	0.0018***
	(1.1)	(1.4)	(2.8)	(2.8)	(4.0)	(3.0)
$\Delta Leverage_{t-1,t}$	0.0136	0.0085	0	-0.0002	-0.0005	-0.0002
	(1.4)	(1)	(-0.0)	(-0.4)	(-1.2)	(-0.6)
Management fee	1.1979	0.6984	0.1444***	0.1290***	0.0750**	0.0778**
	(1.1)	(0.7)	(2.9)	(2.9)	(2.2)	(2.4)
Incentive fee	0.0041	0.0185	0.0033	0.005	0.0002	0.0014
	(0)	(0.2)	(0.7)	(1.3)	(0.1)	(0.5)
Redemption period	0	0	0	-0.0000*	-0.0000	-0.0000
	(0.2)	(0.3)	(-1.3)	(-1.8)	(-0.0)	(-0.9)
Lockup period	0.0005	0.0002	0	0	0.0000*	0.0000
	(0.9)	(0.4)	(0.5)	(-0.2)	(1.9)	(1.0)
Advance notice period	0.0002	0.0003**	0	0.0000**	-0.0000	0.0000
	(1.2)	(2)	(1)	(2)	(-0.2)	(1.5)
$Volatility_{t-1}$	0.6372	0.7766*	-0.1179***	-0.1009***	-0.0627***	-0.0531***
	(1.5)	(1.9)	(-4.7)	(-4.2)	(-3.9)	(-3.4)
$Net\ asset_{t-1}$	-0.004	0.0001	-0.0001	0	0.0005***	0.0004**
	(-0.7)	(0)	(-0.4)	(0)	(2.7)	(2.2)
$Fund\ age_{t-1}$	-0.001	-0.0005	0	0	0.0000	0.0000
	(-1.5)	(-0.8)	(0.5)	(0.5)	(0.8)	(0.0)
$Annual\ return_{t-1}$	-0.0625	-0.0509				
	(-1.3)	(-1.1)				
$Alpha_{t-1}$			0.5085***	0.5236***	0.6698***	0.6705***
			(9.9)	(10.8)	(20.2)	(19.6)

Table 10
Robustness check for funds with 20% incentive fee

This table presents the multivariate linear regression results on fund leverage for funds with 20% incentive fee, using the same specification with Table 4. The sample period is from 2011 to 2017, where the Form ADV fund level data is available. In the regression, we 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				
Independent variables	Model1	Model2	Model3	Model4
Net − return distance$_{t-1}$	0.36*			
	(1.7)			
Gross − return distance$_{t-1}$		0.73**		
		(2.3)		
Option Vega$_{t-1}$			305***	
			(4.0)	
Option Delta$_{t-1}$				230***
				(4.2)
Managerial Ownership$_t$	0.24***	0.19**	0.19**	0.18**
	(2.7)	(2.0)	(2.0)	(2.0)
Management fee	13.13**	16.52**	16.67***	16.52***
	(2.0)	(2.6)	(2.6)	(2.6)
Observations	1,158	915	915	915
Number of funds	497	395	395	395
Controls	Yes	Yes	Yes	Yes
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	0.45	0.45	0.45

Table 11
Robustness check for funds with high water mark provision

This table presents the multivariate linear regression results on fund leverage for funds with high water mark provision, using the same specification with Table 4. The sample period is from 2011 to 2017, where the Form ADV fund level data is available. In the regression, we 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				
Independent variables	Model1	Model2	Model3	Model4
$\text{Net} - \text{return distance}_{t-1}$	0.33*			
	(1.7)			
$\text{Gross} - \text{return distance}_{t-1}$		0.62**		
		(2.3)		
Option Vega_{t-1}			307***	
			(4.2)	
$\text{Option Delta}_{t-1}$				239***
				(4.5)
$\text{Managerial Ownership}_{t}$	0.20***	0.17**	0.17**	0.17**
	(2.6)	(2.1)	(2.0)	(2.1)
Management fee	16.70**	22.33***	22.22***	22***
	(2.5)	(3.5)	(3.5)	(3.5)
Incentive fee	1.85***	2.14***	1.12*	1.18*
	(3.3)	(3.0)	(1.7)	(1.8)
Observations	1,448	1,130	1,130	1,130
Number of funds	625	491	491	491
Controls	Yes	Yes	Yes	Yes
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	0.45	0.45	0.45

Table 12
Robustness check with the fund of hedge funds excluded

This table presents the multivariate linear regression results on fund leverage with the fund of hedge funds excluded, using the same specification with Table 4. The sample period is from 2011 to 2017, where the Form ADV fund level data is available. In the regression, we 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				
Independent variables	Model1	Model2	Model3	Model4
$\text{Net} - \text{return distance}_{t-1}$	0.45**			
	(2.3)			
$\text{Gross} - \text{return distance}_{t-1}$		0.90***		
		(3.1)		
Option Vega_{t-1}			356***	
			(4.7)	
$\text{Option Delta}_{t-1}$				267***
				(4.9)
$\text{Managerial Ownership}_{t}$	0.23***	0.20**	0.20**	0.20**
	(2.7)	(2.2)	(2.2)	(2.2)
Management fee	15.27**	20.87***	20.95***	20.71***
	(2.5)	(3.4)	(3.4)	(3.4)
Incentive fee	1.15**	1.31**	0.016	0.13
	(2.5)	(2.4)	(0.0)	(0.2)
Observations	1,330	1,040	1,040	1,040
Number of funds	573	449	449	449
Controls	Yes	Yes	Yes	Yes
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	0.42	0.43	0.43

A. Appendix: Sample Form ADV containing fund-level information

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

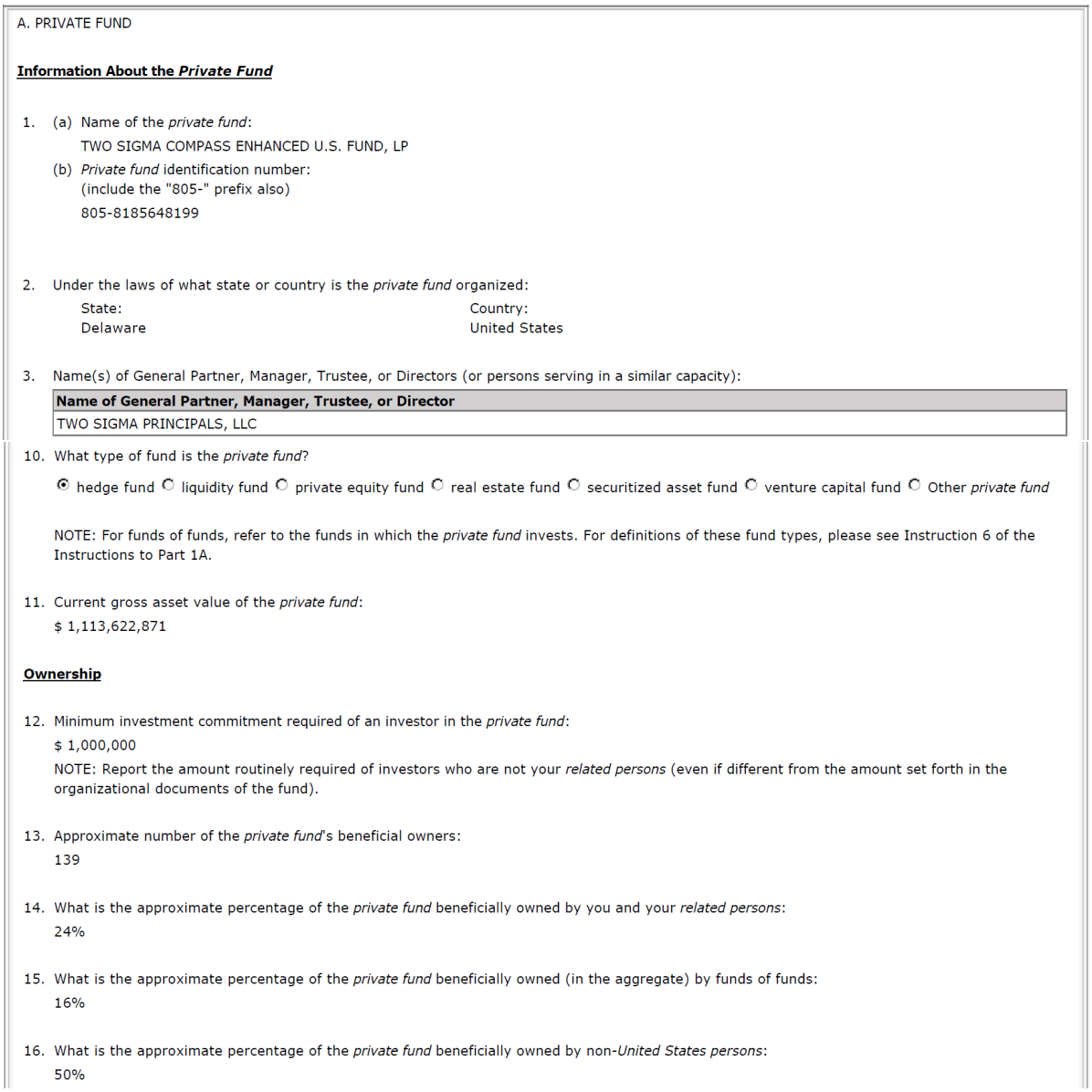
In this Item, we request information about your financial industry affiliations and activities. This information identifies areas in which conflicts of interest may occur between you and your *clients*.

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

Panel A: Sample Item 7.A in 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:	Country:
Delaware	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%

Panel B: Sample Section 7.B in Form ADV

Figure 1. Sample Form ADV: TWO SIGMA COMPASS ENHANCED U.S. FUND

Figure 1 is an 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".

Table 13
Additional tests: robustness with changes of managerial ownership

This table presents the multivariate linear regression results on fund leverage with changes of managerial ownership, using the same specification with Table 4. The sample period is from 2011 to 2017, where the Form ADV fund level data is available. In the regression, we 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				
Independent variables	Model1	Model2	Model3	Model4
Net − return distance$_{t-1}$	0.3455*			
	(1.9)			
Gross − return distance$_{t-1}$		0.6885**		
		(2.6)		
Option Vega$_{t-1}$			303.7692***	
			(4.4)	
Option Delta$_{t-1}$				225.8007***
				(4.6)
ΔManagerial Ownership$_{t-1,t}$	0.3532***	0.3203***	0.3129***	0.3140***
	(3.0)	(2.7)	(2.7)	(2.7)
Management fee	13.0020***	17.9283***	18.0445***	17.8672***
	(2.6)	(3.4)	(3.5)	(3.4)
Incentive fee	1.0453***	1.1427***	0.0667	0.1755
	(3.2)	(2.8)	(0.2)	(0.4)
Observations	1,698	1,312	1,312	1,312
Number of funds	724	564	564	564
Controls	Yes	Yes	Yes	Yes
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	0.42	0.43	0.43

Table 14
Additional tests: robustness without year fixed effect

This table presents the multivariate linear regression results on fund leverage without year fixed effect. The sample period is from 2011 to 2017, where the Form ADV fund level data is available. In the regression, we 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				
Independent variables	Model1	Model2	Model3	Model4
Net − return distance$_{t-1}$	0.2925*			
	(1.9)			
Gross − return distance$_{t-1}$		0.5613**		
		(2.2)		
Option Vega$_{t-1}$			258.4933***	
			(4.0)	
Option Delta$_{t-1}$				181.4230***
				(4.0)
Managerial Ownership$_t$	0.2056***	0.1747**	0.1695**	0.1701**
	(2.9)	(2.3)	(2.3)	(2.3)
Management fee	14.3783***	18.7969***	18.7907***	18.6661***
	(2.9)	(3.5)	(3.5)	(3.5)
Incentive fee	0.9794***	1.1152***	0.2077	0.3436
	(3.0)	(2.8)	(0.5)	(0.8)
Observations	1,698	1,312	1,312	1,312
Number of fund_id1	724	564	564	564
Controls	Yes	Yes	Yes	Yes
Strategy fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	No	No	No	No
Cluster	By fund	By fund	By fund	By fund
R-squared	0.41	0.42	0.43	0.43