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Jongha Lim
Berk A. Sensoy
Michael S. Weisbach

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ABSTRACT

Indirect incentives exist in the money management industry when good current performance increases future inflows of new capital, leading to higher future fees. We quantify the magnitude of indirect performance incentives for hedge fund managers. Flows respond quickly and strongly to performance; lagged performance has a monotonically decreasing impact on flows as lags increase up to two years. Conservative estimates indicate that indirect incentives for the average fund are four times as large as direct incentives from incentive fees and returns to managers' own investment in the fund. For new funds, indirect incentives are seven times as large as direct incentives. Combining direct and indirect incentives, for each dollar generated for their investors in a given year, managers receive close to another dollar in direct performance fees plus the present value of future fees over the expected life of the fund. Older and capacity constrained funds have considerably weaker relations between future flows and performance, leading to weaker indirect incentives. There is no evidence that direct contractual incentives are stronger when market-based indirect incentives are weaker.

Jongha Lim
Department of Finance
Trulaske College of Business School
University of Missouri
Columbia, MO 65211
limjong@missouri.edu

Berk A. Sensoy
Ohio State University
2100 Neil Ave.
Columbus, OH 43210
sensoy_4@fisher.osu.edu

Michael S. Weisbach
Department of Finance
Fisher College of Business
Ohio State University
2100 Neil Ave.
Columbus, OH 43210
and NBER
weisbach.2@osu.edu

1. Introduction

Hedge fund managers are among the most highly paid individuals today. According to Kaplan and Rauh (2010), the top five hedge fund managers likely earned more than all 500 CEOs of S&P 500 firms in 2007 (p. 1006). Therefore, the payoff to becoming a top hedge fund manager is enormous. The logic of Holmström (1999), Berk and Green (2004) and Chung et al. (2012) provides a framework for understanding hedge fund manager's careers: Investors allocate capital to funds based on their perception of the managers' abilities, which is a function of the performance of the fund. Good performance, especially early in one's career, increases a manager's lifetime income not only through incentive fees earned at the time of the performance but also by increasing future flows of new investment to the fund, thereby increasing future fees.

The extremely high level of pay for the top hedge fund managers suggests that the effect of current performance on lifetime income through future flows is likely to be important. However, there are no estimates of its magnitude. For an incremental percentage point of returns to investors, how much additional capital does the market allocate to that particular hedge fund? How much of this additional capital do hedge fund managers end up receiving as compensation in expectation? How does this "expected future pay for today's performance" compare in magnitude with the direct fees from incentive fees that they earn from an incremental return? How do these effects differ across types of funds, and over time for a particular fund? To what extent are these results consistent with theories of optimal capital allocation, and also of optimal compensation?

In this paper, we evaluate the way in which hedge fund investors allocate their capital, the extent that it depends on performance, and the way that this relation affects long-term incentives of hedge fund managers. In a sample of 2,687 hedge funds from 1995 to 2010, we first estimate the relation between hedge fund performance and inflows to the fund. As predicted by learning models of fund allocation and consistent with prior work on mutual funds and private equity funds, this relation is substantially stronger for newer funds, whose managers' abilities the market knows with less certainty. For an average fund, the estimates imply that a 10 percentage point incremental return in a given year leads to a 22 percent increase in the fund's assets under management from inflows of new investment over the next two years. For a new fund the effect is much larger: every 10 percentage points of return in a fund's first year leads to a 41 percent increase in assets under management over the next two years.

The estimates suggest that investors respond remarkably quickly to performance. Estimated using annual data, about half of the increase in assets under management occurs in the year of the abnormal performance. Using quarterly or even monthly data, the estimated impact on inflows is strongest for performance in the immediately preceding quarter or month and declines monotonically so that inflows in a particular period are much more affected by recent performance one to two years prior. In addition, performance has a greater impact on flows for funds engaged in more "scalable" strategies. These results are consistent with the view that investors are continually updating their assessment of managers and adjust their portfolios based on these updated assessments relatively quickly.

The way in which the inflow-performance relation affects managers' compensation depends on the fee structure in hedge funds. Typically, hedge fund managers receive a management fee equal to 2 percent of assets under management, together with incentive fees equal to 20 percent of profits above a high water mark. As Goetzmann et al. (2003) emphasize, the incentive fee portion of the fee structure is a call option on the fund's return, with the high water mark as the exercise price. These authors provide an analytical formula for calculating the fraction of an incremental dollar invested in the fund that, in expectation, will be received by the fund's managers as compensation over the life of the fund. We use this formula, parameters estimated from our data or suggested by Goetzmann et al. (2003), and our estimates of the impact of fund performance on inflows to estimate the magnitude of indirect performance-based compensation. In other words, for an incremental percentage point of current return, we calculate the additional lifetime income the fund's managers receive in expectation due to future inflows of new investment.

As a benchmark for assessing the importance of this effect, we calculate its magnitude relative to the direct performance pay managers receive from incentive fees and changes in the value of their own investment in the fund. We use the Agarwal et al. (2009) contingent-claims framework to estimate the change in the value of managers' direct incentive fees claim for an incremental return. We make these estimates under different assumptions about managers' ownership and reinvestments in the fund.

Our estimates suggest that incentives coming from future fund flows are particularly important in hedge funds, substantially larger than direct incentives from carried interest and the managers' personal stakes. For an average-sized hedge fund ($230m in assets under management), conservative estimates indicate that a one percentage point increase in returns generates, in expectation, $378,000 in extra incentive fees and profits on the management's personal stake. The indirect compensation comes from a predicted extra $7.4 million in assets under management ($5.1 million from new capital flows and $2.3 million from increase in value of existing investors' stakes), of which $1.65 million are expected to go to the hedge fund manager in future fees. These calculations imply that for an average-sized fund, the indirect, career-based incentive effect is about four times larger than the direct income managers receive from incentive fees and returns on their personal investments. For every extra dollar in value created, 83 cents go to investors and 17 cents go to hedge fund managers in incentive fees and returns on their personal stake. However, the managers also receive an additional 58 cents from expected fees on future income, so the total expected return to the hedge fund manager from a dollar of additional profits is 75 cents, which is similar to the 83 cents returned to their investors today.

Incentives from future flows are even larger for young funds. Our estimates indicate that for brand new funds, the indirect effect is about seven times as large as the direct effect. We estimate that the increase in future compensation for a new fund is $0.84 for every $1.00 in additional value to the investors. The importance of indirect incentives also depends on the "style" of the fund; for an average fund following a style unlikely to be capacity-constrained, the ratio of the indirect to direct effect is four to five, while it is three to four for a fund that is likely to be constrained and hence unable to grow as much in response to good performance.

Overall, pecuniary incentives in the hedge fund industry over a manager's career are vastly higher than direct incentive fees alone would suggest, consistent with the huge earnings of managers who have built a track record of strong performance over many years. In a final test, we examine whether parties appear to take into account differences in indirect incentives across funds when agreeing to explicit contracts. The logic of Gibbons and Murphy (1992) suggests that funds with weaker market-based incentives from future flows should have stronger explicit incentives (e.g., a higher incentive fee rate) put in place at the fund's inception. Contrary to this view, we find that direct and indirect incentives are positively correlated. Presumably, this positive correlation reflects heterogeneity in required total incentives across funds.

This paper proceeds as follows. Section 2 discusses the way in which we quantify the direct and indirect components of hedge fund pay for performance. Section 3 describes the data. Section 4 presents estimates of they way in which inflows into hedge funds respond to the funds' performance. Section 5 estimates the change in hedge fund managers' expected lifetime incomes through the direct and indirect channels in response to a change in performance. Section 6 investigates the relation between explicit contractual incentives and indirect incentives, while Section 7 concludes.

2. Quantifying the Magnitude of Pay for Performance of Hedge Fund Managers

2.1. Direct Pay for Performance

Hedge fund managers' compensation generally consists of management fees that are a percentage of assets under management (often around 2%), plus incentive fees, which is a percentage (usually 20%) of profits, or of profits earned above the historical "high water mark" if the fund has the high-water mark provision. In addition, hedge fund managers usually make a personal investment into the fund. The direct pay for performance a manager receives come from the incentive fees and his personal investment in the fund, both of which increase in value with the fund's performance. Quantifying the hedge fund manager's direct performance incentives (i.e. the manager's expected dollar gains from increasing returns) is complicated because of the option-like features contained in the hedge fund manager's incentive fee contract. In particular, the incentive fee contract resembles a call option whose exercise price is determined by each investor's time of entrance into the fund, the fund's hurdle rate and/or historical high water mark level. Even if different managers have the same 20% incentive fee rate, the actual pay-performance sensitivity they face will vary depending on the distance between the current asset value and the exercise price.

To estimate the direct pay-performance sensitivity, we utilize Agarwal et al. (2009)'s total delta approach, which measures the impact of an incremental 1% return to fund investors on the increase in the value of the manager's incentive fees, plus the increase in the value of the manager's own ownership stake. Agarwal et al. (2009) show that the incentive fee contract of the manager can be considered as "a *portfolio* of call options" written on various investors' assets. The total delta is the sum of these individual option's deltas plus the change in the value of the manager's stake, with the manager's stake calculated assuming that managers reinvest all of their after-tax incentive fees back into the fund. Details on this calculation are described in the Appendix.

2.2. Indirect Pay for Performance

In addition to the pay for performance from incentive fees and their own investment in the fund, hedge fund managers' lifetime incomes change with performance through a reputational effect: Good performance increases the market's perception of a manager's ability, leading to higher inflows of new investment to the fund. Ultimately, part of these incremental inflows will be received by the fund's managers as future management fees and incentive fees. The expectation of this future income will change with today's performance, leading to what we refer to as indirect incentives.

There are two components that must be known to evaluate the magnitude of these indirect incentives. First, we have to estimate the way in which performance affects expected inflows to the fund. Second, we must have a model of the present value of the manager's expected lifetime compensation as a fraction of fund assets. This model should predict, for each incremental dollar under management, the increase in the manager's expected compensation over the future lifetime of the fund.

While the first issue, the relation between fund performance and inflows, is straightforward to estimate, the second is more complex. Total lifetime payoffs are a call option (or a portfolio of call options) with the high water mark as a strike price, the high water mark potentially resets annually or quarterly, and inflows to both the hedge fund industry and the fund in particular have a large stochastic element. Goetzmann, Ingersoll, and Ross (2003) (henceforth GIR) provide a contingent-claims solution to this problem. GIR view the hedge fund management contract as a potentially *perpetual* option contract with a path-dependent payoff.[1] GIR theoretically model the present value of this option using an equivalent martingale framework in a continuous time, assuming that the fund's value follows a lognormal diffusion process. Details on the GIR model and the choice of its parameters are described in the Appendix.

After calculating the present value of the total future fees that the manager earns for an extra dollar of assets under management, we calculate indirect pay for performance by multiplying this present value by an estimate of the number of extra dollars of fund flows that result from a one-percentage point incremental improvement in returns to investors.

3. Hedge Fund Data

Our data come from the TASS database, which covers about 40% of the hedge fund universe (Agarwal et al. (2009)). Summary statistics of key fund characteristics for our sample are very close to those for the sample considered by Agarwal et al. (2009) (see Table 1), who merge and consolidate four major databases (CISDM, HFR, MSCI, and TASS). For this reason, we believe that our sample of hedge funds is representative of the hedge fund universe.

Our sample period extends from January 1995 to December 2010. We focus on the post-1994 period because the TASS started reporting information on 'defunct' funds only after 1994.[2] We exclude managed futures/CTAs and fund-of-funds, which have a different treatment of incentive fees and are likely to have different inflow-performance relations than typical individual hedge funds. We also exclude

[1] The estimates we emphasize are conservative, meaning that they likely understate indirect incentives, because we make assumptions that imply a finite expected fund life.

[2] Defunct funds include funds that are liquidated, merged, or restructured as well as those stopped reporting returns to TASS (Fung et al. (2008)).

closed-end hedge funds, since subscriptions in these funds are only possible during the initial issuing period and future flows are not possible. This initial filter leaves us with 4,939 open-end hedge funds.

We drop funds for which TASS does not contain information on organizational characteristics such as management fees, incentive fees, and high-watermark provisions. In addition, we only consider funds with an uninterrupted series of net asset values and returns so that we can calculate inflows. Further, we restrict our sample to funds with at least 12 consecutive monthly returns available during the sample period. If there is a 'break' in return data (i.e., a fund reports returns for more than 12 consecutive months, stops reporting for a while, and then resumes reporting), we only consider the first sequence of uninterrupted data. Finally, we exclude funds with an incentive fee of zero, since there can be no direct pay-for-performance for these funds. Our final monthly sample contains 159,235 fund-month observations for 3,073 individual funds, of which 1,039 are live as of December 2010 and the remaining 2,036 are considered 'defunct'.

To construct quarterly and annual samples, we further drop all quarters or years that have return information only for a fraction of the period (e.g. a quarter with only 2 month returns available). This sample construction process leaves us with a quarterly sample of 3,073 funds (51,300 fund-quarter observations) and an annual sample of 2,687 funds (10,811 fund-year observations).

Table 1 presents descriptive statistics for the sample of funds in our annual data. Time-varying variables such as annual flows and returns are measured at the fund-year level, and other contractual characteristics such as management and incentive fees rate are measured at the fund level.[3] All time-varying variables except fund age are winsorized at the 1st and 99th percentiles to minimize the effect of outliers.

[3] TASS provides information on funds' organizational characteristics as of the last available date of fund data. Like most previous studies, we also assume that these organizational characteristics do not change throughout the life of the fund. Agarwal et al. (2009) argue that funds' organizational characteristics are unlikely to change much over time based on their discussions with practitioners, which suggest that if a manager wants to impose new contractual terms, it is easier for him to start a new fund with different terms than to go through the legal complications of changing an existing contract. Consistently, Liang and Schwarz (2008), Liang (2001) and Deuskar et al. (2012) find that hedge fund fees do not change much over time.

The mean annual flow is 53.6%, and the median 3.8%, so the distribution is highly skewed. The mean and median annual returns are 11.7% and 9.2%. Both the flows and returns are similar to those in Agarwal et al. (2009), who report mean (median) annual flow of 60.6% (5.9%) and mean (median) annual return of 12.2% (9.7%). However, the average fund size in our sample ($227 million) is about twice the average size reported in Agarwal et al. ($120 million), reflecting the fast growth of the sector as well as the recent trend of raising mega hedge funds.[4]

The remaining variables reflect time-invariant contractual features. Summary statistics on various fund characteristics except fund size are very close to those reported in other prior studies (e.g. Agarwal et al (2009), Baquero and Verbeek (2009), amd Aragon and Nanda (2012)). The management fee is the annual percentage of the asset under management received by the manager as compensation and has a sample mean (median) of 1.4% (1.5%). The incentive fee is the annual percentage of positive profits (or profits earned above high-water mark in case high-water mark provision is present) and has a sample mean (median) of 19.3% (20%). High-water mark is an indicator variable that equals one if the fund has a high-water mark provision, and zero otherwise. About 69% of our sample funds have a high-water mark provision. About 67.7% of our sample funds report that they use leverage, 19.5% are open to public investors, and about a quarter are on-shore funds.

We also consider three variables that reflect potential restrictions on the behavior of flows. Total redemption period is defined as the sum of the notice period and the redemption period, where the notice period is the time (in years) the investor has to give notice to the fund about an intention to withdraw money from the fund, and the redemption period is the time that the fund takes to return the money after the notice period is over. The lockup period is the minimum time in years that an investor has to wait before withdrawing invested money. The subscription period is a time delay, measured in years, between investing in a fund and actually purchasing fund shares. In our sample the mean total redemption period,

[4] According to HFR Industry Reports, by the end of 2010, mega hedge funds collectively managed around 60% of total industry AUM.

lock-up period, and subscription period are 0.273 years (3.2 months), 0.247 years (three months), and 0.089 years (one month), respectively.

4. Estimating the Sensitivity of Fund Inflows to Performance

To understand the impact of performance on fund flows, we use a Bayesian learning framework that presumes that investors are continually evaluating managers trying to assess his ability (see Berk and Green (2004) and Chung et al. (2012)). A fund's performance provides information about the manager's ability, so an observation of performance causes investors to update their assessment of his ability and allocate more capital to a fund when the manager's estimated ability increases. These models suggest that investors should update their portfolios relatively quickly. The magnitude of the updates and hence the sensitivity of inflows to performance should depend on the informativeness of the signal relative to the precision of the prior estimate of the fund manager's ability. In addition, the sensitivity of inflows to performance should also depend on the extent to which ability can be "scaled" to replicate a fund's return distribution on new capital.

Measuring the indirect incentives of hedge fund managers requires an estimate of the relation between fund performance and future inflows. There is a long literature beginning with Ippolito (1992) that estimates this relation to be relatively strong in the mutual fund industry.[5] Similarly, beginning with Kaplan and Schoar (2005) the literature has documented a clear positive relation between performance and inflows in the private equity industry. However, the results for hedge funds are less clear; Goetzmann et al. (2003) find a negative and concave relation while other studies generally find a positive one.[6]

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[5] See Ippolito (1992), Brown, Harlow and Stark (1996), Sirri and Tufano (1998), Chevalier and Ellison (1999), Barclay, Pearson and Weisbach (1998), Del Guercio and Tkac (2002), Bollen (2007), Huang, Wei and Yan (2007), Sensoy (2009), etc.

[6] Agarwal et al. (2003) find a positive and convex relation similar to that documented for mutual funds. Baquero and Verbeek (2009) find a linear relationship but the shape of relation depends on the time horizon being analyzed. Ding et al. (2009) investigate the impact of share restrictions on the flow-performance relation of hedge funds and find a convex relation in the absence of share restrictions, a concave relation in the presence of restrictions, but a linear relation when consider all hedge funds together. We focus on linear specifications for simplicity but our results are not materially affected by allowing for nonlinearities in the flow-performance relations.

4.1. Empirical Specification

Consequently, we estimate equations predicting the relation between fund inflows and fund performance. We estimate the following specification:

$$\begin{aligned} Flow_{i,t} = {} & \beta_0 + \beta_1 Return_{i,t} + \beta_2 Return_{i,t-1} + \beta_3 Return_{i,t-2} + \beta_4 Flow_{i,t-1} + \gamma X_t + \lambda Y \\ & + StrategyFE + Year\ FE + \varepsilon_{i,t} \end{aligned} \tag{4}$$

Following the literature on flows to mutual funds (for example, Chevalier and Ellison (1997), Sirri and Tufano (1999)) or hedge funds (for example, Goetzmann et al. (2003), Fung et al. (2008), Agarwal et al. (2009)), we compute annual flows of capital into a fund as follows:

$$Flow_{i,t} = \frac{AUM_{i,t} - AUM_{i,t-1}(1 + Return_{i,t})}{AUM_{i,t-1}} \tag{5}$$

where $AUM_{i,t}$ and $AUM_{i,t-1}$ are the assets under management of fund *i* at the end of year *t* and *t-1,* respectively, and $Return_{i,t}$ is the net of fee return for fund *i* during year *t*.[7] When considering quarterly or monthly horizons, we compute quarterly or monthly flows in a similar manner using the *AUM* at the quarter (month) end and quarterly (monthly) returns.

For young funds that have, for example, only one year's worth of return history, we cannot compute lagged returns and flows. In such cases, instead of dropping these young funds from the estimation, we "dummy out" missing lagged variables to retain observations. In other words, we treat missing values of lagged flows and returns as zero and include a dummy that indicates missing values.

The vector *X* consists of time-varying fund characteristics that include the natural logarithm of asset under management for fund *i* at the end of year *t-1*, the natural logarithm of fund *i*'s age plus one at the end of year *t-1*, and annualized return volatility of fund *i* during year *t*. The vector *Y* is of snapshot fund characteristics that include the management fee rate, the incentive fee rate, the total redemption period, the lock-up period, the subscription period, and a set of indicator variables that equal one if fund *i*

[7] This standard method of measuring flows implicitly assumes that flows occur at the end of each period, after fund returns are observed.

has a high-water mark provision, if its manager invests personal capital in the fund, if it uses leverage, and if it is open to public investors, if it is an on-shore fund, and if it is capacity constrained, respectively.

We include 11 strategy dummies listed in Table 1 to capture the differences in average flows between funds that have different strategies. We also control for time effects by including time dummies, to capture economy-wide shocks. Standard errors are calculated using double clustering by fund and time.

A key issue in designing a specification is the choice of time units. Most of the prior literature uses annual data, estimating the effect of performance in one year on flows in the next.[8] Yet, a learning model like Berk and Green's predicts that investors will update their assessments and change their allocations of capital at the time performance is observed, so current performance influences current flows. Since the appropriate time unit is not obvious, we estimate Equation (4) using annual, quarterly, and monthly data.

4.2. Estimates of the Flow-Performance Relation.

We present estimates of the flow-performance relation for our sample of hedge funds in Panel A of Table 2 using annual data, in Panel A of Table 3 using quarterly data, and in Panel B of Table 3 using monthly data. In all specifications, the estimates indicate that there is a strong relation between inflows and performance.

In the annual specification in Panel A of Table 2, we include returns in the current year and the two prior years as independent variables in Column (1). In Column (2) we add a number of fund-level controls. In each specification, the coefficients on returns are all positive and statistically significant, and decline sharply over time, so the coefficient on contemporaneous returns is the largest. The coefficients on returns lagged one and two years are substantially lower. If we sum the coefficients on the contemporaneous and past returns, the sum in Column (1) is 2.09 and in Column (2) is 2.23. These coefficients imply that a one standard deviation increase in returns (24.6%), will lead to between a 51% and 55% increase in fund size in two years following the return.

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[8] An exception is Baquero and Verbeek (2009), who investigate both quarterly and annual horizons.

Comparable equations using quarterly and monthly data are presented in Panels A and B of Table 3. In each column, the coefficients on lagged performance are positive and statistically significantly different from zero. Moreover, they decline sharply with the time away from the potential inflows to the fund, so that recent performance affects inflows substantially more than performance farther away. The effect is monotonic using both quarterly and monthly data, so that the coefficient on the most recent period's performance is larger than the one on the prior period, which in turn is larger than the period before that; this pattern holds for the six quarters prior to the quarter in question in the quarterly specification and for the 13 months in the monthly specification. In the quarterly specification, performance in the most recent prior quarter has four times as large an effect on inflows as performance in quarter -4, and almost 10 times as large an effect as performance in quarter -8. Using monthly data, performance in the most recent month has about twice the effect of performance in month -6 and about 5 times the effect of performance in month -12. These results strongly suggest that investors quickly adjust their assessments of hedge fund managers and consequently their portfolios.

Several other points are worth noting about the equations estimated using quarterly and monthly data. First, the coefficients tend to be small and statistically insignificant for time periods more than two years prior to the period for which inflows are measured, suggesting that focusing on the two or three years prior to any potential inflows is reasonable. Second, the coefficients on contemporaneous returns are smaller than those for returns in the immediately preceding period, suggesting that the large positive contemporaneous coefficient in the equations using annual data are picking up returns in the same year but preceding the potential inflows. Finally, the sum of the coefficients in quarterly and monthly specifications is somewhat smaller than those in the annual specification, totaling around 1.6. These equations imply that a one-standard-deviation increase in annual returns (24.6%, or 5.7% per quarter compounded) leads to an increase of 9.1% in quarterly inflows, which when annualized is equivalent to a 41.7% increase.

4.3. Age and Strategy Interactions.

Theoretically, a learning framework such as Berk and Green (2004) suggests that the sensitivity of fund flows to performance should depend on the precision of the prior distribution of ability. The precision of the prior distribution is likely to be related to the experience of the fund managers. Intuitively, a more experienced manager is more of a "known quantity", so given an observation of performance, an observer will update their assessment of his ability less than if the same performance were observed from a new manager. In addition, the sensitivity of inflows to performance should depend on the extent to which it is possible to replicate the current distribution of returns if the fund increases in size, in other words, the fund strategy's "scalability". Consistent with these arguments, Chung et al. (2012) use data on private equity funds, and find that the sensitivity of inflows to performance is larger for younger managers than for older ones, and also larger for relatively scalable buyout funds than for venture capital funds that require a substantial investment of personal partner time for each dollar invested.

We first estimate the extent to which the sensitivity of inflows to performance depends on the fund's age. To do so, we estimate Equation (4) using annual data, including interaction terms of the log of the fund's age plus one with prior performance, and present these estimates in Panel B of Table 2. In each estimated equation, the coefficients are negative and are statistically significant for the current period and the period immediately preceding the potential change in inflows. The negative coefficient on the interaction term means that as hedge funds get older, the effect of performance on inflows declines. The coefficients from Column (1) of Panel B of Table 2 imply that a 1.5 year-old fund (the 25th percentile) that has a one standard deviation increase in returns (24.6%) has an extra 63.8% increase in size over the two years following the increase. In contrast, a 6 year-old fund (the 75th percentile) with the same increase in performance would experience only an extra 25.1% growth.

A fund's strategy likely affects the sensitivity of inflows to performance because some strategies can be replicated with more capital, while others will face diminishing returns. For example, arbitrage strategies (e.g. Convertible Arbitrage), where opportunities disappear as they are exploited, are unlikely to be infinitely scalable by nature. Strategies that invest in illiquid assets and have high market impact costs (e.g. Event-driven) are also more likely to face capacity constraints (Getmansky (2005), Aragon (2007), Teo (2009)). On the other hand, strategies that involve liquid instruments (e.g. Long/Short Equity, Equity Market Neutral) are less prone to capacity constraints (Getmansky (2005), Ding et al. (2009)).

To evaluate whether the scalability in fact does affect the way in which fund performance affects inflows, we rely on the classification of Ding et al. (2009), who consider Emerging Market, Fixed-income Arbitrage, Event Driven, and Convertible Arbitrage strategies to be "capacity constrained". The other strategies (Long/Short Equity, Dedicated Short Bias, Equity Market Neutral, Global Macro, Multi-Strategy, Options Strategy) are classified as "unconstrained".[9] We create a dummy variable equal to one if the fund is capacity constrained and zero if it is unconstrained. We interact this variable with the prior performance variables, and present the results in Panel C of Table 2.

As with the previous estimates, the coefficients on contemporaneous performance as well as two lags of performance are positive and significantly different from zero. However, the coefficients on this variable interacted with the "Constrained" dummy variable are negative, with the terms reflecting more recent performance significantly different from zero. Consistent with the logic of the learning model, this result suggests that the strategies we consider to be constrained are less responsive in size to a performance shock.[10] Presumably, even though a shock to performance for "constrained" funds would cause the market to update its assessment of the fund managers' abilities, the fact that they are less scalable limits the extent to which investors are willing to change their investments in these funds as a result.

[9] Ding et al. (2009) use the methodology of Getmansky (2005) to determine which strategies experience decreasing returns-to-scale (i.e. concave performance-asset relation). Naik et al. (2007) similarly identify four capacity constrained strategies (Emerging market, Fixed-income arbitrage, Relative value, Directional) based on a negative relation between past flow and future alphas, although they do not exactly map to the four in Ding et al. due to the different categorizations of strategies used by different databases. These findings are also consistent with practitioners' observations. For example, Commonfund Institute explains that Long/Short Equity and Global Macro are not as capacity-constrained as Convertible Arbitrage, Fixed-income Arbitrage, and Event-driven in which managers try to identify and capture relative pricing inefficiencies between related securities (Commonfund Institute, 2004, "Hedge Fund and Absolute Return Strategies." The report is available at http://www.commonfund.org/InvestorResources/Publications/Pages/WhitePapers.aspx).

[10] We also estimate the interactive effects of age and strategy with performance on flows using quarterly and monthly data, and obtain similar results. For brevity we do not tabulate these results.

5. Calculating Indirect and Direct Pay for Performance

In this section, we use the models discussed in Section 2 and in the Appendix, together with the estimates presented in Section 4, to quantify the magnitude of direct and indirect pay-performance sensitivities facing hedge fund managers. We utilize Agarwal et al.'s (2009) total delta and the parameters discussed in Appendix to calculate direct pay for performance.

For indirect pay for performance, we estimate the incremental inflows into a fund for a specified level of performance using the estimates presented in Table 2. We then use the Goetzmann et al. (2003) approach (characterized by Equation (A7) in their paper) with the parameters described in Appendix to estimate the expected fraction of each incremental dollar in capital will ultimately be paid out to managers in fees and incentive fees. A particularly important parameter is b, which represents the minimum asset value relative to the high water mark that the investor will tolerate before withdrawing all his money from the fund. If b=0, such liquidation never takes place and the fund operates forever. Positive values of b imply a positive probability of liquidation each period and therefore a finite expected fund life. Our preferred estimates use b=0.8 as recommended by Goetzmann et al. This choice means that a 20% loss results in liquidation of an investor's stake. We present estimates using b=0 and b=0.5 for comparison.

5.1. Direct and Indirect Incentives for a "Typical" Fund

The estimates of direct and indirect incentives are summarized in Table 4. Panel A of this table indicates that there are 10,645 fund years in the sample, with an average AUM of \$230m.[11] Panel A presents calculations of direct and indirect incentives for a "typical" fund of average size and age (4 years).

Direct incentives come from two sources: incentive fees and the manager's personal stake. Valued using the Agarwal et al. (2009) approach, the expected dollar increase in incentive fees for an incremental percentage point increase in annual net return equals \$195,000 (Row 3 of Table 4, Panel A,

[11] We drop 166 observations from the full sample (10,811 observations), since the sum of the values of all investors' stake is zero for these cases according to the computations described in the Appendix.

when b=0.8), or roughly 8.3 cents for every dollar returned to investors (row 9).[12] Even with a 20% incentive fee rate, the expected incentive fees equal only 8.3 percent because the option is not always in the money.

Our data do not include information on the personal investment of the fund managers. Our calculations follow Agarwal et al. (2009) and assume that there is no initial investment by managers but that they reinvest all after-tax incentive fee payments in the fund. These calculations probably understate managers' stakes at the time the fund is formed and overstate them as the fund ages. Given these assumptions, profits on managers' stakes are $183,000 for an incremental 1% return for an average fund (Row 4 of Table 4, Panel A) and 8.2 cents for every dollar returned to investors (Row 10).[13]

Row 6 of Table 4, Panel A does the comparable calculation for indirect fees given a one percentage point incremental return: An extra one percentage point return leads to an expected extra $5.1 million inflow to the $230 million average-size fund (using coefficients from Column (2) of Table 2, Panel A), of which the Goetzmann et al. (2003) model predicts that $1.07 million in present value will go to the managers in expectation in future fees. In addition to the effect of new capital flows, indirect incentives further increases by changes in value of existing investors' assets. For the $230 million average-sized fund, an additional one-percentage point return leads to an increase in asset base of extra $2.3 million. Row 7 indicates that the manager receives additional $0.58 million future fees in expectation from this change in existing investors' asset values. Row 14 calculates that this indirect effect in sum translates into a 58 cent increase in the manager's lifetime income for every additional dollar generated for investors in the current fund.

These calculations suggest that hedge fund managers' indirect incentives resulting from future fund flows are substantially larger than the direct incentives coming from incentive fees and management's direct investment in the fund. Indirect incentives are so large for hedge funds because

[12] Pay for performance per $1 increase in fund value is calculated by dividing pay for performance per 1% increase in fund value by one hundredth of the fund size.
[13] We also perform all the calculations in Table 4 under the alternative assumption that there is no management ownership and managers do not reinvest their carried interest fees. The results are similar to those of Table 4 and are presented in Appendix Table A1.

inflows are very sensitive to performance, and also that the fee structure of hedge funds is such that a high fraction of incremental dollars into the fund end up going to the fund's managers as fees over time. The ratio of the expected extra indirect fees to expected extra direct fees for the average fund is 3.51 (Row 15). Taking the ratio for each fund-year and then averaging these ratios results in a somewhat larger figure, 4.76.[14] Either way one does the calculation, it is evident that indirect incentives are substantially larger than direct incentives for a typical fund.

5.2. Direct and Indirect Incentives by Fund Age

Panel B of Tables 2 document that the magnitude of the return-inflow relation declines sharply with the fund's age, consistent with the logic of Berk and Green (2004). Since the indirect incentives managers face come directly because of the influence of returns on inflows, it is likely that managers' indirect incentives also decline with a fund's age.

Panel B of Table 4 examines this hypothesis by calculating indirect incentives for funds of different ages. The first row indicates that the number of fund-years in the sample of each age decreases with the age of the fund, because new funds are initiated and existing funds sometimes exit. Average fund size tends to increase with fund age until the fund turns 13 years old, implying that surviving funds tend to grow over time. Direct pay for performance increases with fund age because managers' ownership increases; however, the portion coming from incentive fees declines somewhat when measured as a fraction of an incremental dollar (10.1 cents of one dollar increase in fund value for new funds compared to 5.9 cents for funds more than 15 years old). As funds age, the ones that do well will continually reset their high water marks over time so that their incentive fees claims remains at the money, while the ones that do relatively badly will fall behind their high water marks, especially if the funds have hurdle rates that the fund must earn before managers receive incentive fees. On average, as funds get older, their values tend to lag relative to their high water marks, leading to lower direct incentives relative to newer funds.

[14] When computing the ratio of indirect to direct incentives for each fund year, direct incentives are floored at 0.05% of AUM to avoid the effects of outliers having infinitesimal values.

Indirect incentives, however, change dramatically as a fund ages. For new funds, an incremental dollar returned to investors today results in an extra \$0.84 in expected future fees (Row 14). For new managers, this indirect effect is about seven times as important as the direct effect of performance on current income from incentive fees and gains on the manager's own stake. The indirect effect declines sharply with the fund's age, and is below the magnitude of the direct effect after a fund is over 14 years old.

5.3. Direct and Indirect Incentives and Fund Scalability

Indirect incentives result from managers being able to increase their funds' sizes when performance has been good. Their ability to do so depends on the ability of managers to "scale" their investments: Some funds are relatively unconstrained in that they adopt strategies that are "scalable", implying that the fund can likely invest new capital with the same ex ante return distribution as existing funds. In contrast, other more constrained funds typically cannot accept more capital without significantly reducing expected returns.

Panel C of Table 4 provides statistics on funds classified as "Not Capacity-Constrained" and "Capacity-Constrained". There are about twice as many fund-years classified as "Not Constrained" (7,058) as "Constrained" (3,587). Not surprisingly, funds in the 'Not Capacity-Constrained' subsample are, about 20% larger in terms of AUM. The direct incentives of each type are very similar (16.4 cents of each dollar returned to investors for not constrained funds compared to 17.0 cents for constrained funds). The differences in indirect incentives, however, are substantial; 64 cents for each dollar returned to investors for the unconstrained funds compared to 50 cents for constrained funds. This difference implies an average indirect/direct ratio of about 3.9 for the not constrained funds, compared to 3.0 for the constrained funds (5.4 vs. 3.9 if one uses the average of fund by fund ratios). These differences suggest that indirect incentives are relatively more important in funds adopting more scalable investment strategies.

6. Do Indirect Incentives Affect Contracting?

We have documented that indirect incentives facing hedge fund managers are substantial. For most funds, they are several times larger than the direct incentives hedge fund managers receive. There is wide variation in the magnitude of these indirect incentives, both across funds and over time for the same fund. The cross-sectional and time series variation in indirect incentives appears to occur because of both differences in the informativeness of returns as a signal of managerial quality, and the ability of funds to scale their investment strategies when more capital is invested into their funds.

Given the magnitude of these indirect incentives, it is plausible that that they affect the way in which direct incentives are structured in hedge funds at the inception of the fund. Hedge funds are set up contractually in a sophisticated manner with a fee structure containing a combination of management fees and incentive contracts that use high water marks that adjust their effective strike price. Presumably, these contracts are set up to solve a principal-agent problem of some sort. Yet, as emphasized by Gibbons and Murphy (1992), what matters in any principal-agent problem is the total pay for performance that agents receive, and not the distribution between its direct and indirect components. Therefore, when indirect incentives are higher for one group of hedge funds than for another group that are identical in other respects, optimal contracting would imply that the group with lower indirect incentives would offset these lower indirect incentives with higher direct incentives.

The proposition that funds adjust their managers' direct incentives depending on the magnitude of market-based indirect incentives applies both to individual funds over time, and across funds. Funds do at times change their fee structure, but such changes are infrequent. Deuskar et al. (2012) report a number of findings about the factors that lead hedge funds to change their fees. None of the findings in Deuskar et al. (2012) suggest that changes in the hedge fund fee structure are driven by a desire to offset changes in indirect incentives faced by fund managers.

The common view of economists is that contracts are structured so total incentives are determined by the solution to a principal-agent problem. This argument implies that all other things equal, direct incentive fees should be negatively related to the flow-performance relation, since this relation is the primary determinant of a fund manager's indirect incentives. To test this hypothesis on our sample, we estimate equations estimating inflows to a fund similar to those reported in Table 2, except that we add interaction terms designed to explore the way the return-inflow relation varies with the fee structure. This equation also includes a number of other variables designed to control for other factors that potentially affect inflows. We estimate this equation using annual data on flows and returns. Since each fund appears more than once in the equation, we calculate the standard errors, double-clustering by fund and year.

Table 5 contains estimates of these equations. Column (1) includes interaction terms containing the product of the annual return for the current year and the previous two lags of returns with the level of the incentive fee. Inconsistent with the notion that fund contracts are structured to adjust direct fees for indirect incentives, the coefficient on each interaction term is *positive,* and the coefficient on current returns interacted with incentive fees is statistically significantly from zero. Column (2) includes interactions of returns with dummy variables indicating whether the fund-year is one of 11.1% of the sample that has an incentive fee of less than 20%, and also if they are one of the 3.4% of the sample with incentive fees greater than 20%. The coefficients on the interaction terms indicating that the fund has less than a 20% incentive fee are negative, and are statistically significantly different from zero for current returns and returns lagged one year. This negative coefficients are counter to the notion that stronger direct incentive fees are set to compensate for weaker indirect incentives, since they imply that indirect incentives are lower when direct incentive fees are also lower. Column (3) interacts annual returns with management fees, and the coefficients on the interaction coefficients are positive, although not significantly different from zero for the year of the inflows and the year immediately preceding it. Overall, there is no evidence in Table 5 consistent with the notion that contracts are structured to provide direct incentives that offset differences in fund managers' indirect incentives.

While we do not have a definitive explanation for the positive correlation between direct and indirect incentives, we suspect the answer stems from unobserved heterogeneity of some sort. Presumably, the underlying agency conflict varies with fund strategies, so it is possible that fund strategies for which direct incentives are more important also have higher sensitivity of fund flows to performance, leading to higher indirect incentives. Another mechanism that would produce the observed positive correlation in the data is a matching mechanism whereby more talented managers self-select into funds with higher-powered incentives.

7. Conclusion

At least since Fama (1980) and Holmström (1999), it has been recognized that managers' incentives to perform well come not only through direct pay for performance plans, but also through the managerial labor market. The market draws inferences about managers' abilities from their observed performance and rewards or penalizes them accordingly, providing an additional channel through which managers' performance can affect their welfare. The money management industry is one place where the managerial labor market can provide substantial incentives, since investors can observe managers' performance and reallocate capital easily between alternative investments. This paper estimates the magnitude of this effect for hedge fund managers.

Our estimates indicate that indirect incentives are particularly large for hedge fund managers. For a typical fund, for an incremental dollar returned to investors, managers' expected lifetime incomes increase by 71 cents due to their ability to earn fees on incremental inflows of new investment to the fund. This effect is 4 or 5 times as large as the pecuniary incentives received from incentive fees in our estimate of their personal ownership stakes. The large indirect incentives for hedge fund managers come from the fact that inflows to hedge funds are very sensitive to performance, and the fee structure in hedge funds is such that managers expect to receive a large fraction of each dollar invested in the fund as compensation over time.

The estimates indicate that the allocation process to hedge funds is consistent with the Bayesian learning framework used by Berk and Green (2004) and Chung et al. (2012) to study allocations to mutual funds and private equity funds. First of all, consistent with the notion that investors update their assessment of ability to performance, inflows react to performance quickly. All of the effect of performance on inflows occurs in the two years subsequent to the performance, and within the two-year period, it declines sharply over time. Even using monthly data, the decline in the performance-inflow relation is evident on a month-to-month basis.

Second, the sensitivity of inflows to performance and hence the magnitude of the indirect pay for performance relation declines for a given fund over time. For a new fund, indirect pay for performance is sufficiently large so an incremental dollar returned to investors leads to more than a dollar in expected pay to the managers. Indirect pay for performance declines with the age of the fund, becoming smaller than direct pay for performance when a fund is about 10 years old. This pattern is consistent with Bayesian updating, because as a fund ages, its management's ability becomes more of a known quantity, so investors assessment of it do not change as much for a given observed return.

Third, the performance-inflow relation and indirect pay for performance are larger for funds with strategies that are likely to be replicable for larger quantities of capital. For funds using strategies that are likely to be replicable for larger quantities of capital, managers receive 84 cents for an incremental dollar returned to investors. In contrast, for funds using strategies that are harder to replicate, managers receive 53 cents. This pattern is again with Bayesian allocation of capital to fund managers, because if the ability of managers to earn returns on new capital in the fund is limited by fund's strategy, then it is rational for investors to allocate less capital to that fund in response to a given return.

Finally, we consider the whether funds are set up contractually taking account of the indirect pay for performance that managers will receive. The idea, originally proposed by Gibbons and Murphy (1992), is that what should matter in a principal-agent problem is the total amount of pay for performance rather than its distribution into direct and indirect components. Therefore, it should be optimal to adjust direct pay for performance for the amount of indirect pay for performance managers face. The evidence we present is not consistent with this view; in contrast, indirect pay for performance is actually larger for funds when direct pay for performance is higher.

Hedge funds managers' interests are generally considered to be well-aligned with those of their investors, because they receive a large part of their compensation in the form of incentive fees and often additionally make a substantial equity contribution to the fund. The evidence in this paper strongly suggests that hedge fund managers' pecuniary incentives are substantially higher than is implied by their ownership and incentive fees stakes. Combining direct and indirect incentives, for each dollar generated for their investors in a given year, managers receive close to another dollar in direct performance fees plus the present value of future fees over the expected life of the fund. Understanding why hedge funds are structured the way they are, and, more generally, the effects of the very high indirect incentives hedge fund managers face, would be an excellent topics for future research.

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Table 1. Summary Statistics

This table presents descriptive statistics for the sample of 2,687 funds during the sample period of 1995-2010. Time-varying variables are reported at the fund-year level, and other time-invariant contractual characteristics are reported at the fund level. *Annual flow* is the difference between the reported year-end AUM and the year-beginning AUM times (1+Auunal Returns), scaled by year-beginning AUM. *Annual returns* are the reported annual net-of-fee returns. *AUM* is the assets under management. *Age* is the number of years from the fund's inception date, measured at the beginning of year. *Volatility* is annualized standard deviation of monthly returns estimated over the calendar year. All time-varying variables except fund age are winsorized at the 1st and 99th percentiles. *Management fees* are the percentage of the assets charged by the fund as regular fees. *Incentive fees* are the percentage of positive profits (or profits earned above high-water mark in case high-water mark provision is present) received by the manager as performance incentives. *High-water mark* is an indicator variable that equals one if the fund has a high-water mark provision, and zero otherwise. *Leverage* is an indicator variable that equals one if the fund uses leverage, and zero otherwise. *Open-to-public* is an indicator variable that equals one if the fund allows public investment, and zero otherwise. On-shore is an indicator variable that equals one if the fund is domiciled in the U.S., and zero otherwise. *Total redemption period* is the sum of the notice period and the redemption period, where the *notice period* is the time the investor has to give notice to the fund about an intention to withdraw money from the fund, and the *redemption period* is the time that the fund takes to return the money after the notice period is over. *Lockup period* is the minimum time in years that an investor has to wait before withdrawing invested money. Lockup period is considered to be zero for the fund that does not have a lock-up provision. *Subscription period* is a time delay, measured in years, between investing in a fund and actually purchasing fund shares. *Constrained* is an indicator variable that equals one if the fund's strategy belongs Convertible Arbitrage, Fixed Income Arbitrage, Emerging Markets, and Event Driven strategies, and zero otherwise (Ding et al. (2009).

Variable	N	Mean	25^{th} Pctl.	Median	75^{th} Pctl.	SD
Annual flow	10,811	0.536	-0.184	0.038	0.504	1.830
Annual returns	10,811	0.117	0.012	0.092	0.193	0.246
AUM ($M)	10,811	227.2	13.1	45.6	145.5	679.9
Age (years)	10,811	4.238	1.499	3.164	6.000	3.754
Volatility (annualized)	10,811	0.125	0.048	0.090	0.164	0.112
Management fees (%)	2,687	1.4	1.0	1.5	2.0	0.5
Incentive fees (%)	2,687	19.3	20.0	20.0	20.0	3.4
High-water mark provision indicator	2,687	0.691	0.000	1.000	1.000	0.462
Leverage indicator	2,687	0.677	0.000	1.000	1.000	0.468
Open-to-public indicator	2,687	0.195	0.000	0.000	0.000	0.397
On-shore indicator	2,687	0.240	0.000	0.000	0.000	0.427
Total redemption period (years)	2,687	0.273	0.137	0.164	0.329	0.256
Lockup period (years)	2,687	0.247	0.000	0.000	0.000	0.526
Subscription period (years)	2,687	0.089	0.082	0.082	0.082	0.064
Strategy						
Constrained indicator	2,687	0.305	0.000	0.000	1.000	0.460
Constrained=1						
Convertible Arbitrage	2,687	0.035				
Fixed Income Arbitrage	2,687	0.052				
Emerging Markets	2,687	0.121				
Event Driven	2,687	0.098				
Constrained=0						
Equity Market Neutral	2,687	0.069				
Global Macro	2,687	0.081				
Long/Short Equity Hedge	2,687	0.418				
Multi-Strategy	2,687	0.076				
Dedicated Short Bias	2,687	0.008				
Options Strategy	2,687	0.003				
Other	2,687	0.040				

Table 2: Flow-Performance Sensitivity

This table presents the OSL coefficient estimates of Equation (4) and corresponding *p-values* (in parentheses) using annual data. The dependent variable is *Annual flow*. The sample period is from 1995 to 2010. See Table 1 for definitions of all independent variables. In Panel B, Equation (4) is augmented to include interaction terms of the log of the fund's age plus one with prior performance, and in Panel C, to include interaction terms of *Constrained* indicator with prior performance. All specifications include strategy fixed effects and year fixed effects. Standard errors are double clustered by fund and year. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Panel A: Base-case

	(1)		(2)	
Dep.Var. = Annual Flow(t)	**coef**	**(p-val)**	**coef**	**(p-val)**
Annual Return(t)	1.117***	(0.000)	1.077***	(0.000)
Annual Return(t-1)	0.762***	(0.000)	0.830***	(0.000)
Annual Return(t-2)	0.209**	(0.033)	0.324***	(0.000)
Annual Flow(t-1)			0.052***	(0.000)
Log(Age in years +1)			-0.139***	(0.009)
Log(AUM(t-1)+1)			-0.209***	(0.000)
Annual return volatility			-1.328***	(0.001)
Constrained?			-0.070	(0.793)
ManagementFee			2.112	(0.615)
IncentiveFee			0.178	(0.747)
High Water Mark?			0.125***	(0.003)
Leveraged?			0.044	(0.210)
Open-to-public?			-0.002	(0.969)
Oh-shore?			-0.264***	(0.000)
Log(Total redemption period in years +1)			0.409***	(0.003)
Log(Lock-up period in years +1)			-0.044	(0.448)
Log(Subscription period in years +1)			-0.431	(0.235)
Missing Annual Return(t-1)	1.277***	(0.000)	1.025***	(0.000)
Missing Annual Return(t-2)	0.537***	(0.000)	0.164**	(0.023)
Missing Annual Flow(t-1)			0.175*	(0.051)
Constant	-0.373***	(0.000)	0.700**	(0.016)
Number of observations	10,811		10,811	
Adjusted R2	0.158		0.198	

Panel B: Age Interactions

	(1)		(2)	
Dep.Var. = Annual Flow(t)	**coef**	**(p-val)**	**coef**	**(p-val)**
Annual Return(t)*Log(Age in years +1)	-1.329***	(0.000)	-1.296***	(0.000)
Annual Return(t-1)*Log(Age in years +1)	-0.481*	(0.059)	-0.439*	(0.063)
Annual Return(t-2)*Log(Age in years +1)	0.279	(0.306)	0.319	(0.210)
Annual Return(t)	2.918***	(0.000)	2.842***	(0.000)
Annual Return(t-1)	1.464***	(0.001)	1.498***	(0.000)
Annual Return(t-2)	-0.384	(0.436)	-0.257	(0.563)
Annual Flow(t-1)			0.051***	(0.000)
Log(Age in years +1)	-0.219**	(0.023)	0.006	(0.936)
Log(AUM(t-1)+1)			-0.207***	(0.000)
Annual return volatility			-1.301***	(0.001)
Constrained?			-0.051	(0.841)
ManagementFee			2.689	(0.502)
IncentiveFee			0.096	(0.868)
High Water Mark?			0.127***	(0.005)
Leveraged?			0.047	(0.171)
Open-to-public?			0.000	(0.995)
Oh-shore?			-0.272***	(0.000)
Log(Total redemption period in years +1)			0.376***	(0.009)
Log(Lock-up period in years +1)			-0.035	(0.555)
Log(Subscription period in years +1)			-0.363	(0.305)
Missing Annual Return(t-1)	1.119***	(0.000)	1.067***	(0.000)
Missing Annual Return(t-2)	0.113	(0.179)	0.093	(0.238)
Missing Annual Flow(t-1)			0.150	(0.103)
Constant	0.110	(0.493)	0.520*	(0.085)
Number of observations	10,811		10,811	
Adjusted R2	0.180		0.212	

Panel C: Strategy Interactions

	(1)		(2)	
Dep.Var. = Annual Flow(t)	**coef**	**(p-val)**	**coef**	**(p-val)**
Annual Return(t)*Constrained	-0.543**	(0.012)	-0.562***	(0.006)
Annual Return(t-1)*Constrained	-0.335	(0.108)	-0.395*	(0.067)
Annual Return(t-2)*Constrained	-0.025	(0.855)	-0.044	(0.725)
Annual Return(t)	1.342***	(0.000)	1.311***	(0.000)
Annual Return(t-1)	0.897***	(0.000)	0.992***	(0.000)
Annual Return(t-2)	0.226*	(0.051)	0.350***	(0.000)
Annual Flow(t-1)			0.052***	(0.000)
Log(Age in years +1)			-0.137***	(0.007)
Log(AUM(t-1)+1)			-0.209***	(0.000)
Annual return volatility			-1.356***	(0.000)
Constrained?	0.295**	(0.042)	0.020	(0.938)
ManagementFee			2.573	(0.537)
IncentiveFee			0.122	(0.828)
High Water Mark?			0.120***	(0.004)
Leveraged?			0.040	(0.272)
Open-to-public?			-0.000	(0.994)
Oh-shore?			-0.266***	(0.000)
Log(Total redemption period in years +1)			0.404***	(0.004)
Log(Lock-up period in years +1)			-0.045	(0.432)
Log(Subscription period in years +1)			-0.431	(0.245)
Missing Annual Return(t-1)	1.279***	(0.000)	1.030***	(0.000)
Missing Annual Return(t-2)	0.535***	(0.000)	0.164**	(0.019)
Missing Annual Flow(t-1)			0.172*	(0.054)
Constant	-0.638***	(0.000)	0.658**	(0.021)
Number of observations	10,811		10,811	
Adjusted R2	0.160		0.199	

Table 3. Flow-Performance Sensitivity at Higher Frequency

This table presents the OSL coefficient estimates of Equation (4) and corresponding *p-values* (in parentheses) using higher frequency data. In Panel A, we presents the estimates using quarterly data, and in Panel B, using monthly data. The dependent variable is *Quarterly flow* in Panel A, and *Monthly flow* in Panel B. The sample period is from 1995 to 2010. See Table 1 for definitions of all independent variables. All specifications include strategy fixed effects. In Panel A, we additionally include year-quarter fixed effects, and in Panel B, year-month fixed effects. Standard errors are double clustered by fund and time. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

Panel A: Quarterly

	(1)		**(2)**	
Dep.Var. = Quarterly Flow(t)	**coef**	**(p-val)**	**coef**	**(p-val)**
Quarterly Return(t)	0.180***	(0.000)	0.177***	(0.001)
Quarterly Return(t-1)	0.452***	(0.000)	0.445***	(0.000)
Quarterly Return(t-2)	0.294***	(0.000)	0.247***	(0.000)
Quarterly Return(t-3)	0.205***	(0.000)	0.186***	(0.000)
Quarterly Return(t-4)	0.116***	(0.000)	0.111***	(0.000)
Quarterly Return(t-5)	0.086***	(0.001)	0.096***	(0.000)
Quarterly Return(t-6)	0.062**	(0.045)	0.076***	(0.008)
Quarterly Return(t-7)	0.095***	(0.000)	0.115***	(0.000)
Quarterly Return(t-8)	0.050**	(0.012)	0.065***	(0.001)
Quarterly Return(t-9)	0.009	(0.756)	0.031	(0.271)
Quarterly Return(t-10)	-0.008	(0.773)	0.025	(0.363)
Quarterly Return(t-11)	0.021	(0.463)	0.053*	(0.051)
Other Control	No		Yes	
Number of observations	51,300		51,300	
Adjusted R2	0.157		0.189	

Panel B: Monthly

	(1)		(2)	
Dep.Var. = Monthly Flow(t)	**coef**	**(p-val)**	**coef**	**(p-val)**
Monthly Return(t)	-0.029*	(0.064)	-0.032**	(0.045)
Monthly Return(t-1)	0.167***	(0.000)	0.176***	(0.000)
Monthly Return(t-2)	0.150***	(0.000)	0.132***	(0.000)
Monthly Return(t-3)	0.138***	(0.000)	0.122***	(0.000)
Monthly Return(t-4)	0.125***	(0.000)	0.112***	(0.000)
Monthly Return(t-5)	0.116***	(0.000)	0.104***	(0.000)
Monthly Return(t-6)	0.085***	(0.000)	0.075***	(0.000)
Monthly Return(t-7)	0.077***	(0.000)	0.071***	(0.000)
Monthly Return(t-8)	0.076***	(0.000)	0.071***	(0.000)
Monthly Return(t-9)	0.067***	(0.000)	0.062***	(0.000)
Monthly Return(t-10)	0.049***	(0.000)	0.045***	(0.000)
Monthly Return(t-11)	0.049***	(0.000)	0.049***	(0.000)
Monthly Return(t-12)	0.034***	(0.004)	0.032***	(0.005)
Monthly Return(t-13)	0.029**	(0.012)	0.030***	(0.008)
Monthly Return(t-14)	0.043***	(0.000)	0.044***	(0.000)
Monthly Return(t-15)	0.010	(0.362)	0.010	(0.324)
Monthly Return(t-16)	0.022**	(0.038)	0.026**	(0.015)
Monthly Return(t-17)	0.024**	(0.034)	0.027**	(0.019)
Monthly Return(t-18)	0.014	(0.227)	0.015	(0.167)
Monthly Return(t-19)	0.012	(0.219)	0.016*	(0.095)
Monthly Return(t-20)	0.024**	(0.019)	0.027***	(0.007)
Monthly Return(t-21)	0.021**	(0.033)	0.023**	(0.017)
Monthly Return(t-22)	0.015*	(0.059)	0.018**	(0.025)
Monthly Return(t-23)	0.015*	(0.077)	0.019**	(0.028)
Monthly Return(t-24)	0.019**	(0.029)	0.022**	(0.012)
Monthly Return(t-25)	0.020**	(0.032)	0.024**	(0.012)
Monthly Return(t-26)	0.002	(0.855)	0.005	(0.593)
Monthly Return(t-27)	0.011	(0.360)	0.017	(0.161)
Monthly Return(t-28)	0.006	(0.605)	0.011	(0.318)
Monthly Return(t-29)	0.000	(0.983)	0.006	(0.570)
Monthly Return(t-30)	-0.018	(0.109)	-0.011	(0.335)
Monthly Return(t-31)	0.010	(0.329)	0.020*	(0.058)
Monthly Return(t-32)	0.004	(0.723)	0.009	(0.404)
Monthly Return(t-33)	0.013	(0.286)	0.019	(0.129)
Monthly Return(t-34)	-0.005	(0.685)	-0.000	(0.979)
Monthly Return(t-35)	0.001	(0.921)	0.009	(0.407)
Other Control	No		Yes	
Number of observations	159,235		159,235	
Adjusted R2	0.103		0.122	

Table 4. Direct and Indirect Pay-for-Performance: With manager's re-investment

This table presents the magnitude of direct and indirect pay-performance sensitivities for all funds include in our sample (Panel A), by age group (Panel B), and by scalability (Panel C). We report estimates for b=0, 0.5, and 0.8 in Panel A, and for b=0.8 in Panel B and Panel C, where b represents investors' asset value-based liquidation point in Equation (A7). Pay for performance indicates the expected increase in the hedge fund manager's wealth to incremental performance. Rows (3)-(8) of each panel report direct and indirect pay for performance per 1% change in fund value (in million dollars), and Rows (9)-(14) report direct and indirect pay for performance per 1$ change in fund value. Direct pay for performance is estimated by Agarwal et al.'s (2009) total delta as described in Appendix A.1. When estimating direct incentives we assume that the manager does not have personal stake in the fund at inception, but re-invests all of his after-tax incentive fees back into the fund over time. Total direct pay for performance (total delta) is the sum of the expected increase in incentive fees and the manager's personal stake for having an incremental performance today. Indirect pay for performance is the incremental expected long-term payoff to the hedge fund manager for having an incremental performance today, and is estimated using the coefficient estimates in Table 2, and using the Goetzman et al. (2003) framework and parameters described in Appendix A.2. Coefficient estimates in Panel A, Column (2) of Table 2 are used to compute values reported in Panel A, and coefficient estimates in Panel B and Panel C of Table 2 to compute values in Panel B and C, respectively. We drop 166 observations from the full sample, since the sum of the values of all investors' stake is zero for these cases according to the computations described in the Appendix. At the bottom of each panel we report the ratio of indirect to direct fees in two different ways. First, we take the ratio for a typical fund reported in Row (14) and Row (11) of each panel. Second, we take the ratio for each fund-year, and then average these ratios. When computing the fund-by-fund Indirect/Direct ratios, direct fees are floored at 0.05% of AUM to avoid the effects of outliers having infinitesimal values.

Panel A: All funds

		b=0	b=0.5	b=0.8
(1)	N	10,645	10,645	10,645
(2)	AUM ($M)	230	230	230
Pay for performance per 1% Change in Fund Value ($M)				
(3)	Direct effect from incentive fees	0.19	0.19	0.19
(4)	Direct effect from managers' personal stake	0.18	0.18	0.18
(5)	**Total direct effect**	**0.38**	**0.38**	**0.38**
(6)	Indirect effect from new money	1.61	1.50	1.07
(7)	Indirect effect from change in value of existing assets	0.75	0.72	0.58
(8)	**Total indirect effect**	**2.36**	**2.23**	**1.65**
Pay for performance per 1$ Change in Fund Value ($M)				
(9)	Direct effect from incentive fees	0.08	0.08	0.08
(10)	Direct effect from managers' personal stake	0.08	0.08	0.08
(11)	**Total direct effect**	**0.17**	**0.17**	**0.17**
(12)	Indirect effect from new money	0.73	0.64	0.42
(13)	Indirect effect from change in value of existing assets	0.32	0.26	0.16
(14)	**Total indirect effect**	**1.05**	**0.91**	**0.58**
(15)	**Indirect/Direct (= (14)/(11))**	**6.34**	**5.47**	**3.51**
(16)	**Fund-by-fund Indirect/Direct**	**8.81**	**7.52**	**4.76**

Panel B: By Age group (b=0.8)

	Fund age (years)	0~1	1~2	2~3	3~4	4~5	5~6	6~7	7~8	8~9	9~10	10~11	11~12	12~13	13~14	14~15	≥15
(1)	N	1,924	1,745	1,469	1,191	989	738	594	466	361	285	232	174	137	94	69	177
(2)	AUM ($M)	149	185	182	208	220	257	283	281	300	393	451	500	544	536	326	347
	Pay for performance per 1% Change in Fund Value ($M)																
(3)	Direct effect from incentive fees	0.15	0.17	0.16	0.17	0.19	0.20	0.23	0.22	0.24	0.34	0.35	0.40	0.42	0.40	0.19	0.20
(4)	Direct effect from managers' personal stake	0.02	0.05	0.07	0.11	0.15	0.22	0.27	0.33	0.35	0.44	0.58	0.80	1.02	1.12	0.55	0.94
(5)	**Total direct effect**	**0.17**	**0.22**	**0.23**	**0.28**	**0.34**	**0.42**	**0.50**	**0.55**	**0.59**	**0.78**	**0.93**	**1.20**	**1.44**	**1.52**	**0.73**	**1.14**
(6)	Indirect effect from new money	1.09	1.04	0.84	0.84	0.75	0.73	0.70	0.69	0.60	0.73	0.62	0.57	0.48	0.36	0.13	-0.12
(7)	Indirect effect from change in value of existing assets	0.33	0.47	0.46	0.50	0.48	0.58	0.60	0.77	0.65	1.63	1.50	1.59	1.31	1.77	0.81	0.73
(8)	**Total indirect effect**	**1.42**	**1.52**	**1.30**	**1.34**	**1.23**	**1.31**	**1.30**	**1.47**	**1.24**	**2.36**	**2.12**	**2.16**	**1.79**	**2.13**	**0.94**	**0.61**
	Pay for performance per 1$ Change in Fund Value ($)																
(9)	Direct effect from incentive fees	0.10	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.05	0.06
(10)	Direct effect from managers' personal stake	0.02	0.04	0.05	0.07	0.09	0.11	0.13	0.15	0.17	0.17	0.19	0.21	0.21	0.23	0.25	0.26
(11)	**Total direct effect**	**0.12**	**0.13**	**0.14**	**0.15**	**0.17**	**0.19**	**0.20**	**0.22**	**0.24**	**0.24**	**0.26**	**0.27**	**0.28**	**0.28**	**0.31**	**0.32**
(12)	Indirect effect from new money	0.66	0.53	0.43	0.37	0.32	0.27	0.23	0.20	0.17	0.14	0.12	0.10	0.07	0.06	0.04	-0.02
(13)	Indirect effect from change in value of existing assets	0.18	0.17	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.15	0.16	0.16	0.16	0.16	0.13	0.16
(14)	**Total indirect effect**	**0.84**	**0.70**	**0.59**	**0.53**	**0.47**	**0.43**	**0.38**	**0.35**	**0.32**	**0.29**	**0.28**	**0.26**	**0.23**	**0.22**	**0.17**	**0.15**
(15)	**Indirect/Direct (= (14)/(11))**	**7.14**	**5.46**	**4.32**	**3.58**	**2.77**	**2.25**	**1.85**	**1.60**	**1.35**	**1.22**	**1.09**	**0.95**	**0.83**	**0.76**	**0.55**	**0.46**
(16)	**Fund-by-fund Indirect/Direct**	**7.81**	**6.39**	**5.29**	**4.53**	**3.85**	**3.16**	**2.63**	**2.26**	**2.04**	**1.77**	**1.61**	**1.33**	**1.21**	**1.19**	**0.85**	**0.62**

Panel C: By Scalability (b=0.8)

		Not Capacity Constrained	Capacity Constrained
(1)	N	7,058	3,587
(2)	AUM ($M)	242	207
Pay for performance per 1% Change in Fund Value ($M)			
(3)	Direct effect from incentive fees	0.20	0.19
(4)	Direct effect from managers' personal stake	0.19	0.16
(5)	**Total direct effect**	**0.39**	**0.35**
(6)	Indirect effect from new money	1.25	0.82
(7)	Indirect effect from change in value of existing assets	0.59	0.57
(8)	**Total indirect effect**	**1.84**	**1.39**
Pay for performance per 1$ Change in Fund Value ($)			
(9)	Direct effect from incentive fees	0.08	0.08
(10)	Direct effect from managers' personal stake	0.08	0.08
(11)	**Total direct effect**	**0.16**	**0.17**
(12)	Indirect effect from new money	0.48	0.33
(13)	Indirect effect from change in value of existing assets	0.16	0.18
(14)	**Total indirect effect**	**0.64**	**0.50**
(15)	**Indirect/Direct (= (14)/(11))**	**3.90**	**2.97**
(16)	**Fund-by-fund Indirect/Direct**	**5.42**	**3.87**

Table 5. Flow-Performance Sensitivity: Fees Interactions

This table presents the OSL coefficient estimates of Equation (4), including various interaction terms. The *p-values* are reported in parentheses. The dependent variable is *Annual flow*. In Column (1), interactions of annual returns with the incentive fee level are included, in Column (2), interactions of annual returns with dummy variables indicating whether the fund charges incentive fee rate of below or above 20%, and in Column (3), interactions of annual returns with the management fee level. The sample period is from 1995 to 2010. See Table 1 for definitions of all independent variables. All specifications include strategy fixed effects and year fixed effects. Standard errors are double clustered by fund and year. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% level, respectively.

	(1)		(2)		(3)	
Dep.Var. = Annual Flow(t)	**coef**	**(p-val)**	**coef**	**(p-val)**	**coef**	**(p-val)**
Annual Return(t)* IncentiveFee	8.001***	(0.002)				
Annual Return(t-1)* IncentiveFee	2.974	(0.281)				
Annual Return(t-2)* IncentiveFee	1.162	(0.677)				
Annual Return(t)* Below 20% Ifee			-0.827***	(0.000)		
Annual Return(t-1)* Below 20% Ifee			-0.510**	(0.046)		
Annual Return(t-2)* Below 20% Ifee			0.001	(0.998)		
Annual Return(t)* Above 20% Ifee			0.070	(0.906)		
Annual Return(t-1)* Above 20% Ifee			-0.743*	(0.052)		
Annual Return(t-2)* Above 20% Ifee			0.115	(0.771)		
Annual Return(t)* ManagementFee					33.572	(0.273)
Annual Return(t-1)* ManagementFee					8.779	(0.712)
Annual Return(t-2)* ManagementFee					-3.084	(0.839)
Annual Return(t)	-0.461	(0.305)	1.171***	(0.000)	0.593	(0.220)
Annual Return(t-1)	0.256	(0.619)	0.901***	(0.000)	0.703**	(0.041)
Annual Return(t-2)	0.095	(0.862)	0.311***	(0.001)	0.359*	(0.095)
Below 20% Ifee			0.022	(0.808)		
Above 20% Ifee			-0.073	(0.582)		
Annual Flow(t-1)	0.052***	(0.000)	0.051***	(0.000)	0.052***	(0.000)
Log(Age in years +1)	-0.138**	(0.011)	-0.132**	(0.015)	-0.141***	(0.008)
Log(AUM(t-1)+1)	-0.209***	(0.000)	-0.209***	(0.000)	-0.208***	(0.000)
Annual return volatility	-1.322***	(0.001)	-1.355***	(0.001)	-1.330***	(0.001)
Constrained?	-0.071	(0.792)	-0.083	(0.750)	-0.071	(0.793)
ManagementFee	2.053	(0.620)	1.578	(0.709)	-2.917	(0.625)
IncentiveFee	-0.993	(0.270)			0.182	(0.741)
High Water Mark?	0.129***	(0.002)	0.131***	(0.002)	0.126***	(0.003)
Leveraged?	0.051	(0.169)	0.045	(0.208)	0.046	(0.196)
Open-to-public?	-0.002	(0.969)	0.000	(0.996)	-0.005	(0.916)
Oh-shore?	-0.267***	(0.000)	-0.274***	(0.000)	-0.264***	(0.000)
Log(Total redemption period in years +1)	0.399***	(0.004)	0.406***	(0.004)	0.413***	(0.003)
Log(Lock-up period in years +1)	-0.046	(0.435)	-0.049	(0.414)	-0.044	(0.444)
Log(Subscription period in years +1)	-0.402	(0.277)	-0.454	(0.222)	-0.416	(0.258)
Missing Annual Return(t-1)	1.028***	(0.000)	1.019***	(0.000)	1.024***	(0.000)
Missing Annual Return(t-2)	0.162**	(0.027)	0.163**	(0.027)	0.163**	(0.025)
Missing Annual Flow(t-1)	0.173*	(0.053)	0.183**	(0.039)	0.176**	(0.050)
Constant	0.923***	(0.006)	0.763***	(0.008)	0.776***	(0.003)
Number of observations	10,811		10,811		10,811	
Adjusted R2	0.198		0.199		0.198	

Appendix

A.1. Calculating direct pay for performance

Our proxy for direct pay for performance is given by total delta, as defined in Argawal et al. (2009). Total delta is the expected incremental dollar change in the manager's wealth for an additional 1% increase in the fund's net asset value (NAV). The total delta can be decomposed into two parts: the portion coming from investors' assets (manager's option delta) and the portion coming from the manger's ownership stake in the fund. The manager's option delta is in turn the sum of the deltas from different set of investors, since a hedge fund manager's incentive fee contract indeed resembles a 'portfolio' of call options, not a single option, because of the fact that different investors in the fund face different spot prices (*S*) and exercise prices (*X*) depending on the timing of the entrance into the fund. Following Agarwal et al. (2009), we compute each individual option's delta using the Black-Sholes model for a one-year maturity European call option as follows:

$$Individual\,Option\,Delta = N(Z) \times S \times 0.01 \times k\ , \tag{A1}$$

where $Z=\{ln(S/X) + T(r+\sigma^2/2)\}/ \sigma T^{0.5}$, *S* is the investor-specific spot price (i.e., the market value of the investor's assets at the end of the calendar year), *k* is the contractual incentive fee rate, and *X* is the investor-specific exercise price. Given the structure of hedge fund contracts, *X* is the high water mark level for the investor's assets (i.e., the historic high that the investor's asset has ever reached since her investment in the fund) if the fund has a high water mark provision, and simply the market value of the investor's assets at the beginning of the year if the fund has no such provision. Therefore, *S/X* measures whether and to what degree the option is in-the-money or out-of-the-money. *T* is time to maturity of the option. *r* is the natural logarithm of one plus risk-free rate, which is measured by a 12-month LIBOR rate that is observed at the end of the year and therefore governs the next calendar year. σ is annualized standard deviation of monthly (net of fee) returns over the calendar year, and *N*(.) is cumulative distribution function of the standard normal distribution.

A complication in computing individual option delta is that various investors' assets are pooled together for management so they earn the same rate of gross return, but different investors will in general have different spot prices (*S*) and exercise prices (*X*) depending on the time in which they entered the fund. Unfortunately, the exact times and prices at which each investor entered each fund is not publicly available. To compute the investor-specific spot price (*S*) and exercise price (*X*) for each investor, we make the following assumptions:

1. The first investor enters the fund at the end of year 0. We assume no capital investment by the manager at inception. Therefore, the entire assets at inception are assumed to come from a single investor.
2. All cash flows including fee payments, investors' capital allocation, and manager's reinvestment are assumed to take place once a year at the end of each calendar year.
3. Exercise price (*X*) for each option is assumed to be reset annually at the end of the year and is applied to the next calendar year.
4. All new capital inflows are assumed to come from a single new investor.
5. When capital outflows occur, we adopt the FIFO rule to decide which investor's money leaves the fund by how much. In particular, the net asset value of the first investor is reduced by the magnitude of outflow. If the absolute magnitude of outflow exceeds the first investor's net asset value, then the first investor is considered to liquidate her stake in the fund and leave, and the balance of outflow is deducted from the second investor's asset, and so on.
6. We assume that a hurdle rate is LIBOR if the fund has a high-water mark provision. For others, the hurdle rate is assumed to be 0%.
7. We assume that managers reinvest all of the after-tax incentive fees into the fund.

An algorithm for estimation is as follows:

1. First, we solve the following recursive problem iteratively to back out gross returns (*gross*), using observable information on net-of-fee returns (*net*), assets under management (*AUM*), and the parameters of the compensation contract (*k,c*).

$$net_t = \frac{\sum_i \left\{ S_{i,t-1} \times (1+gross_t) - ifee_{i,t} - mfee_{i,t} \right\} + MS_{t-1} \times (1+gross_t)}{AUM_{t-1}} - 1, \qquad \text{(A2)}$$

where $ifee_{i,t} = Max\left[\left(S_{i,t-1} \times (1+gross_t) - X_{i,t-1}\right), 0\right] \times k$, $mfee_{i,t} = S_{i,t-1} \times c$, and MS_t denotes the market value of manager's stake in the fund. We start the algorithm with the following initial values:

$$\begin{Bmatrix} S_{1,0} = X_{1,0} = AUM_0 \\ MS_0 = 0 \end{Bmatrix}, \qquad \text{(A3)}$$

2. We update the market value of the manager's stake as follows.

$$MS_t = MS_{t-1} \times (1+gross_t) + \sum_i ifee_{i,t} \times (1-t_p), \qquad \text{(A4)}$$

3. The new spot price and exercise price of investor i are updated recursively as follows:

$$\begin{aligned} S_{i,t} &= S_{i,t-1} \times (1+gross_t) - (ifee_{i,t} + mfee_{i,t}) \\ X_{i,t} &= \begin{cases} \left\{ X_{i,t-1} + Max\left[S_{i,t} - X_{i,t-1}, 0\right]\right\} \times (1+LIBOR), \; \textit{if with HWM provision} \\ S_{i,t}, \; \textit{if without HWM provision} \end{cases} \end{aligned}, \qquad \text{(A5)}$$

4. The net flow into the fund is defined as the difference between the reported value of year-end AUM and the current market value of all existing investors' and the manager's assets.

$$Flow_t = AUM_t - \left(\sum_i S_{i,t} + MS_t \right), \qquad \text{(A6)}$$

If (A6) > 0, then we assume that a new investor enters the fund, with the beginning spot price and exercise price equal to $Flow_t$. If (A5) < 0, then we apply the FIFO rule as described above.

5. Using S and X for each investor and equation (A1), we compute the delta from each investor's asset, and then sum them up to compute the manager's option delta. The total delta of the fund is

the sum of the manager's option delta and the delta from the manager's stake, which is equal to $0.01*MS_t$.[15]

A.2. Calculating indirect pay for performance

We compute the present value of the total future fees (both management and incentive fees) as a fraction of the asset value of the fund using the following equation provided by GIR:

$$f(S/X) = \frac{1}{c+\omega+\lambda-\alpha}\left[c + \frac{(\omega+\lambda-\alpha)k + [\eta(1+k)-1]cb^{1-\eta}}{\gamma(1+k)-1-b^{\gamma-\eta}[\eta(1+k)-1]}(S/X)^{\gamma-1} \right. , \quad \text{(A7)}$$
$$\left. - \frac{b^{\gamma-\eta}(\omega+\lambda-\alpha)k + [\gamma(1\_k)-1]cb^{1-\eta}}{\gamma(1+k)-1-b^{\gamma-\eta}[\eta(1+k)-1]}(S/X)^{\eta-1} \right]$$

where γ and η are the larger and smaller roots of the following characteristic quadratic equation:

$$\begin{pmatrix}\gamma \\ \eta\end{pmatrix} \equiv \frac{\frac{1}{2}\sigma^2 + c - r - \alpha - c' + g \pm \sqrt{\left(\frac{1}{2}\sigma^2 + c - r - \alpha - c' + g\right)^2 + 2\sigma^2(r + c' - g + \omega + \lambda)}}{\sigma^2}, \quad \text{(A8)}$$

To give intuition, it is helpful to look at a simple case in which b=0. In that case, (A7) can be simplified as follows:

$$f(S/X)_{b=0} = \left[\frac{c}{c+\omega+\lambda-\alpha}\left\{ S - \frac{kX}{\gamma(1+k)-1}(S/X)^{\gamma} \right\} + \frac{kX}{\gamma(1+k)-1}(S/X)^{\gamma} \right] \times \frac{1}{S}, \quad \text{(A7')}$$

The first term in (A7') measures the present value of the perpetuity of the management fees. The first factor in the second term measures the present value of the incentive fee when S=X, i.e. when the option becomes at the money. The factor $(S/X)^{\gamma}$ is the reduction in the present value of the future incentive fees due to the time required before the currently out-of-money becomes at-the-money (i.e. S reaches X). Combined, the second term in the equation measures the present value of the incentive fees at any level of asset value.

[15] This is because all the return from the manager's stake in the fund is retained and hence additional 1% of return to the fund leads to a 1% increase in the manager's stake.

There are 11 parameters in the valuation equation (A7): c and k are contractual management fee and incentive fee rate, respectively; c' is the costs and fees allocated to reducing the high-water mark, usually determined by an accounting choice of the fund; σ is the volatility of fund returns; g is the contractual growth rate in the high-water mark level, which is usually zero or risk-free rate; α is the risk-adjusted expected return on the fund's assets, reflecting manager skill; S is the market value (or net asset value) of the investor's position (i.e., the spot price) and X is the high-water mark that applies to this position (i.e., the strike price); $\omega+\lambda$ is the effective withdrawal rate of the investor that captures liquidation as a chance occurrence, while b is the lowest acceptable level of the asset value below which the investor loses his confidence in the fund and liquidates all of his position. As such, b captures intended liquidation based on asset value. r is the risk-free interest rate.

We estimate the parameters of Equation (A7) from observable fund level data whenever possible. In particular, for c and k we use individual fund's contractual information available from *TASS*. σ is computed as the annualized standard deviation of monthly returns over the concurrent calendar year. S and X for each investor are obtained from the estimation procedure described in A.1. We use the 12-month LIBOR available at the beginning of the year as a proxy for r.

For the rest of the parameters that are not observable or reasonably estimable, we adopt the base-case parameter values used by GIR: α is set to zero, assuming no superior skill of the hedge fund manager; g is assumed to be r if a fund has a hurdle rate, and zero otherwise; c' is assumed to be 5%: $\omega+\lambda$ and b are unobservable investment policies of individual investors. $\omega+\lambda$ is assumed to be 5%. We look at liquidation policies of b=0, 0.5, and 0.8. The assumption that b=0 implies that there is no asset value-based liquidation and the fund operates forever. Higher values of b imply a finite expected fund life. For example, with b=0.8 an investor liquidates his entire stake if it falls in value by 20% from its high water mark.

Indirect effects come from two sources: new money flows and changes in the value of existing investors' stakes, both of which result from incremental returns. The GIR fraction for new money, $f(S/X)_{new}$, can be computed using Equation (A7) with S/X defined as follows:

$$S/X_{new}=\begin{cases} 1, & if\ the\ fund\ has\ no\ hurdle\ rate \\ \dfrac{1}{1+r}, & if\ the\ fund\ has\ hurdle\ rate \end{cases}, \tag{A9}$$

Then indirect pay-performance from new money flows is calculated as $f(S/X)_{new}$ times the regression estimate of the amount of new flows (as a fraction of AUM) times AUM.

To compute indirect pay-performance from changes in the value of existing investors' stakes, we take the following steps. First, we compute the GIR fraction for *each* existing investor assuming that the fund earns a baseline return, $f(S/X)^{base}_{old,i}$.[16] To obtain each individual investor's *S/X* under the baseline return, we take each investor's *S/X* at the beginning of the year, multiply by (1+baseline return), and then if the result is greater than one, set *S/X* to either 1 or 1/(1+r), depending on whether there is a hurdle rate or not. *S/X* is adjusted in this way, because if the result is greater than one, then the option becomes in-the-money, incentive fees are paid, and the strike resets. We sum these individual investor GIR fractions over all investors in the fund as follows:

$$f(S/X)^{base}_{old}=\sum_i w_i f(S/X)^{base}_{old,i}, \quad where \quad w_i=\frac{S_i}{\sum_i S_i}, \tag{A10}$$

Similarly, we compute GIR fraction for existing investors assuming that the fund earns an additional one percentage point return in addition to the baseline return ($f(S/X)^{base+1\%}_{old}$). Then we estimate the impact of an incremental 1% return on the manager's future pay due to the increase in the asset values of existing investors as the difference between $f(S/X)^{base+1\%}_{old}$ $\times AUM\times(1+baseline\ return+1\%)$ from $f(S/X)^{base}_{old}$ $\times AUM\times(1+baseline\ return)$.[17]

[16] Baseline return is a mean return computed by age group and fund strategy.
[17] Note that regression estimates are irrelevant for existing investors, since what is be considered here is the increase in asset base due to incremental performance itself, not due to capital inflows resulting from incremental performance.

Table A1. Direct and Indirect Pay-for-Performance: Without manager's re-investment

This table presents the magnitude of direct and indirect pay-performance sensitivities for all funds include in our sample (Panel A), by age group (Panel B), and by scalability (Panel C). Pay for performance indicates the expected increase in the hedge fund manager's wealth to incremental performance. Rows (3) and (6) of each panel report direct and indirect pay for performance per 1% change in fund value (in million dollars), and Rows (7) and (10) report direct and indirect pay for performance per 1$ change in fund value. Direct pay for performance is estimated by Agarwal et al.'s (2009) total delta as described in Appendix. When estimating direct incentives we assume that the manager neither has personal capital invested into the fund at inception nor re-invests the received fees back into the fund over time. Under this assumption, direct pay for performance solely consists of the expected increase in incentive fees for having an incremental performance today. The 166 observations dropped in Table 4 now can be included, since the sum of the values of all investors' stake is non-zero in all cases under the no re-investment assumption. Indirect pay for performance is the incremental expected long-term payoff to the hedge fund manager for having an incremental performance today, and is estimated using the coefficient estimates in Table 2, and using the Goetzman et al. (2003) framework and parameters described in Appendix. At the bottom of each panel we report the ratio of indirect to direct fees in two different ways. First, we take the ratio for a typical fund reported in Row (10) and Row (7) of each panel. Second, we take the ratio for each fund-year, and then average these ratios. When computing the fund-by-fund Indirect/Direct ratios, direct fees are floored at 0.05% of AUM to avoid the effects of outliers having infinitesimal values.

Panel A: All funds

		b=0	b=0.5	b=0.8
(1)	N	10,811	10,811	10,811
(2)	AUM ($M)	227	227	227
	Pay for performance per 1% Change in Fund Value ($M)			
(3)	**Direct effect**	**0.21**	**0.21**	**0.21**
(4)	Indirect effect from new money	1.59	1.48	1.05
(5)	Indirect effect from change in value of existing assets	0.75	0.72	0.59
(6)	**Total indirect effect**	**2.34**	**2.20**	**1.65**
	Pay for performance per 1$ Change in Fund Value ($)			
(7)	**Direct effect**	**0.09**	**0.09**	**0.09**
(8)	Indirect effect from new money	0.73	0.64	0.42
(9)	Indirect effect from change in value of existing assets	0.32	0.26	0.16
(10)	**Total indirect effect**	**1.05**	**0.91**	**0.58**
(11)	**Indirect/Direct (= (10)/(7))**	**11.54**	**9.95**	**6.37**
(12)	**Fund-by-fund Indirect/Direct**	**12.16**	**10.21**	**6.26**

Panel B: By Age group (b=0.8)

Fund age (years)	0~1	1~2	2~3	3~4	4~5	5~6	6~7	7~8	8~9	9~10	10~11	11~12	12~13	13~14	14~15	≥15
(1) N	1,926	1,752	1,476	1,205	1,003	745	604	479	380	303	242	182	143	101	76	194
(2) AUM ($M)	149	184	181	206	217	255	279	274	286	371	433	479	524	502	302	322
Pay for performance per 1% Change in Fund Value ($M)																
(3) Direct effect	**0.15**	**0.17**	**0.17**	**0.18**	**0.20**	**0.22**	**0.25**	**0.25**	**0.26**	**0.37**	**0.39**	**0.46**	**0.51**	**0.49**	**0.22**	**0.26**
(4) Indirect effect from new money	1.09	1.04	0.84	0.83	0.74	0.73	0.69	0.67	0.57	0.68	0.60	0.54	0.46	0.33	0.12	-0.11
(5) Indirect effect from change in value of existing assets	0.33	0.47	0.45	0.47	0.73	0.57	0.62	0.76	0.64	1.37	1.41	1.54	1.23	1.55	0.71	0.70
(6) Total indirect effect	**1.42**	**1.51**	**1.29**	**1.31**	**1.47**	**1.29**	**1.31**	**1.44**	**1.21**	**2.05**	**2.01**	**2.08**	**1.70**	**1.88**	**0.83**	**0.59**
Pay for performance per 1$ Change in Fund Value ($)																
(7) Direct effect	**0.10**	**0.10**	**0.09**	**0.09**	**0.08**	**0.09**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.09**	**0.09**	**0.08**	**0.07**	**0.08**
(8) Indirect effect from new money	0.66	0.53	0.43	0.37	0.32	0.27	0.23	0.20	0.17	0.14	0.12	0.10	0.07	0.06	0.04	-0.01
(9) Indirect effect from change in value of existing assets	0.18	0.17	0.16	0.16	0.16	0.15	0.15	0.15	0.16	0.15	0.16	0.16	0.16	0.16	0.13	0.16
(10) Total indirect effect	**0.84**	**0.70**	**0.59**	**0.53**	**0.47**	**0.42**	**0.38**	**0.35**	**0.33**	**0.29**	**0.28**	**0.26**	**0.23**	**0.22**	**0.16**	**0.14**
(11) Indirect/Direct (= (10)/(7))	**8.16**	**7.22**	**6.52**	**6.06**	**5.59**	**4.83**	**4.47**	**4.16**	**3.83**	**3.52**	**3.39**	**3.01**	**2.62**	**2.66**	**2.19**	**1.72**
(12) Fund-by-fund Indirect/Direct	**8.42**	**7.29**	**6.38**	**5.88**	**5.31**	**4.66**	**4.21**	**3.88**	**3.55**	**3.14**	**3.01**	**2.59**	**2.39**	**2.44**	**1.76**	**1.34**

Panel C: By Scalability (b=0.8)

		Not Capacity Constrained	Capacity Constrained
(1)	N	7,159	3,652
(2)	AUM ($M)	239	204
Pay for performance per 1% Change in Fund Value ($M)			
(3)	**Direct effect**	**0.21**	**0.21**
(4)	Indirect effect from new money	1.24	0.80
(5)	Indirect effect from change in value of existing assets	0.62	0.55
(6)	**Total indirect effect**	**1.85**	**1.35**
Pay for performance per 1$ Change in Fund Value ($)			
(7)	**Direct effect**	**0.09**	**0.09**
(8)	Indirect effect from new money	0.48	0.33
(9)	Indirect effect from change in value of existing assets	0.16	0.18
(10)	**Total indirect effect**	**0.64**	**0.50**
(11)	**Indirect/Direct (= (10)/(7))**	**7.09**	**5.39**
(12)	Fund-by-fund Indirect/Direct	**7.06**	**5.17**