Duration of poor performance and risk shifting by hedge fund managers

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ABSTRACT

A typical hedge fund manager receives greater compensation after strong performance but does not lose compensation after weak performance, and therefore might take on more risk for the second half of the year after poor returns in the first half. We refer to this as "risk shifting." However, continual risk shifting over a long period would likely make the fund too volatile to attract investors. We find that hedge funds with poor first-half-year performance do tend to increase risk during the second half-year. The effect is larger for funds that began the year "under water" and for smaller funds. The effect is smaller, however, if the poor performance lasts long.

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1. Introduction

Hedge funds have grown rapidly into an industry with trillions of dollars under management. Hedge fund managers are known not only for their unique compensation structure but for "being good with risk" (Levisohn & Light, 2012). They receive payoffs that are convex functions of fund performance, with many earning 20% performance fees (Liang, 2000). However, there usually is no "claw-back" policy—that is, managers are not penalized for poor performance. The payoff from such a contract is similar to that of a call option. With performance fees usually determined at the end of each calendar year, the asymmetric payoff structure may lead managers to respond to poor performance as of mid-year by taking on more risk— and thus increasing the volatility of returns—for the rest of the year (Aragon & Nanda, 2012; Carpenter, 2000). We refer to this as "risk shifting." The risk-shifting incentive, however, could be lower for managers with long investment horizons (Panageas & Westerfield, 2009).

In this paper, we examine hedge fund managers' risk-shifting behavior by focusing on the effect of cumulative past poor performance and duration of the poor performance. We build on a robust literature on the relationship between hedge fund managers' risk-shifting incentives and behavior. Ray (2011) finds evidence for risk shifting as funds fall below their high-water marks. Aragon and Nanda (2012) examine in depth how hedge fund managers' tournament incentives influence midyear changes in fund volatility. They were the first to show that the propensity to increase risk in the second half-year is significantly weaker when incentive pay is tied to the fund's high-water mark and when a manager has a significant amount of personal capital invested. Our paper investigates the effects of a managerial incentive similar to that studied by Ray (2011), namely the monetary incentive to shift risk-taking midyear in response to poor performance. Unlike that paper, ours emphasizes the duration of poor hedge-fund performance and the “moneyness” of a manager’s portfolio of compensation options. We build on a theoretical paper by Panageas and Westerfield (2009), which describes hedge fund managers’ risk strategies over multiple periods.

We face a major empirical challenge. High-water marks (HWMs) are investor-specific, and a fund-specific HWM is not defined, so that a hedge fund manager actually holds a portfolio of compensation options rather than a single option. To address this issue, we construct a proxy for a fund-specific HWM as the fund’s maximum net asset value (NAV) over a fixed period using reported net-of-fees returns. We then consider a manager’s portfolio of compensation options to be mostly, if not entirely, out of the money if its NAV at the beginning of a year is less than 90% of its maximum NAV during the fixed period. We describe such a fund as starting the year under water.

We hypothesize that both recent and cumulative past performance are likely to matter for risk shifting for hedge funds. We use performance in the first half of the evaluation year to capture risk shifting in response to recent performance and use the interaction of performance and a proxy for “moneyness” to reflect risk shifting in response to cumulative past performance. Continual risk shifting over a long period would likely make the fund too volatile to attract investors, and this effect could reduce the manager’s incentive to shift risk as the duration of poor performance increases. We therefore construct a measure, time under the HWM, for the duration of the poor performance, and examine Morningstar CISDM hedge funds data over the window of 1997–2017.

Our paper adds to a large literature on hedge funds’ managerial risk-taking incentives and behavior by focusing on the effect of cumulative past poor performance and duration of the poor performance. A number of empirical studies have examined hedge fund managers’ risk taking by investigating the impacts of survival and career concerns (Aragon & Nanda, 2012; Brown, Goetzmann, & Park, 2001; Fung & Hsieh, 1997), presence of high-water mark provisions and managerial stakes (Aragon & Nanda, 2012), usage of derivatives (Chen, 2013), and past performance history (Aragon & Nanda, 2012; Ray, 2011). Studies also document a convex relationship between fund flows and performance for mutual funds (Chevalier & Ellison, 1997; Sirri & Tufano, 1998) and for hedge funds (Agarwal, Daniel, & Naik, 2002), how fund flows are related to risk-taking decisions in the mutual fund industry (Basak, Pavlova, & Shapiro , 2007; Hu, Kale, Pagani, & Subramanian , 2011), and how a less convex flow-performance relation leads to less risk shifting in the pension fund industry (Del Guercio & Tkac, 2002). The importance of liquidity provisions in affecting hedge-fund risk-return profiles is examined by Getmansky, Lo, and Makarov (2004) and Aragon (2007). Li and Kazemi (2007) and Cumming and Dai (2010) investigate the conditional properties of hedge funds' return distributions.

This paper's structure is as follows. Section 2 presents the method, testable hypotheses, and data, section 3 discusses the research design and results, section 4 presents tests for robustness, and section 5 concludes.

2. Data and hypotheses

2.1. Data source

We use the Morningstar-CISDM Hedge Fund Database for this study.[1] This database provides information on performance and various characteristics of thousands of hedge funds,

[1] The Morningstar Hedge Fund Database is built on the CISDM database, which used to be Zurich Hedge Fund Universe, formerly known as the MAR database.

funds of hedge funds, and CTAs.[2] For each fund, we observe monthly net-of-fees returns, NAV, major trading strategy claimed by the fund, whether the fund is listed on an exchange, and the regulatory agency for the fund.[3] We do not have data on manager's ownership share of the fund or the reasons for a fund to appear in the database as defunct.

We focus on U.S.-dollar-denominated individual hedge funds and exclude funds of hedge funds, which have less obvious incentive to shift risk.[4] Each fund in our sample is required to have 48 months of return history[5] and information on fund size (AUM) and the strategy followed by the manager (style). Our sample includes funds in 26 of Morningstar's strategy categories, which we summarize into nine styles according to asset classes: equity-related, debt-related,

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[2] Funds of hedge funds are portfolios of individual hedge funds. CTAs are funds that specialize in futures trading.

[3] We use net-of-fees returns for this study. We recognize that the HWM and fees are based on returns computed before all management fees and performance fees are subtracted; hence gross returns would be most appropriate to use. However, past research demonstrates little difference from using net-of-fees returns versus using gross returns. So we use net-of-fees returns for the ease of calculation.

[4] For example, Agarwal et al. (2002) find that funds of hedge funds do not exhibit strategic risk-taking behavior and attribute this finding to the inflexibility of the business. However, robustness checks show that our results are robust to including all funds of hedge funds. These additional results are available upon request.

[5] We relax this requirement in robustness tests, and our results are qualitatively the same.

convertible arbitrage, emerging markets, event driven, global macro, multistrategy, CTA, and volatility-related.[6] After applying the above filters, we have 16,841 individual observations for the full sample and 12,147 observations for the no-backfill-bias sample. The no-backfill-bias sample excludes returns that occurred before the time when the fund was added to the database, because using such "backfilled" data may bias estimates (see Fung & Hsieh, 2000).[7]

2.2. *"Moneyness"*

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[6] Hedge funds are categorized to reflect the fact that different strategies may entail very different risk profiles. For our sample, there are 26 original categories: Europe HF global emerging markets equity, HF Asia/pacific long/short equity, HF bear market equity, HF China long/short equity, HF convertible arbitrage, HF debt arbitrage, HF distressed securities, HF diversified arbitrage, HF emerging markets long-only equity, HF emerging markets long/short equity, HF equity market neutral, HF Europe long/short equity, HF event driven, HF global long/short equity, HF global macro, long-only debt, long-only equity, long-only other, long/short debt, merger arbitrage, multi-strategy, U.S. long/short equity, U.S. small cap long/short equity, HF systematic futures, HF currency, and volatility.

[7] The Morningstar-CISDM Hedge Fund Database uses a dummy variable where "1" means the fund has a high-water mark provision. About 80% of the hedge funds in our sample report that they have such a provision, 13,690 out of the full sample and 9,924 out of the no-backfill sample. (Some funds have missing information.) The results reported below assume that all hedge funds with missing information have high-water mark provisions. The results from a sample that excludes funds with missing information on their high-water mark provisions are largely the same, and are available upon request.

Theories of optimal risk-taking by a fund manager assume a unique fund-level high-water mark or HWM (Carpenter, 2000; Panageas & Westfield, 2009). In practice, however, to avoid the free-rider problem, hedge funds issue new share classes as new investors contribute capital. This means the HWM is defined at the investor level and not at the fund level. The incentive to change the fund's volatility, therefore, is based on how sensitive to such changes is the value of a portfolio of call options with different strike prices (i.e., HWMs).

From the limited data disclosed by hedge funds, we use a rolling three-year window to estimate the maximum HWM of each fund's current investments. We then estimate a state related to past performance, which we refer to as the "moneyness" of the compensation option. We use these estimates to examine the responses of hedge fund managers to poor performance in the first half of the fourth year. The maximum value of each fund's NAV during the three-year window is compared to the fund's NAV at the beginning of the fourth year (evaluation year) as the measure of moneyness of the compensation option:

$$Moneyness_{i,t} = \frac{NAV_{i,t}}{HWM_{i,t}} \tag{1}$$

In the above definition of *Moneyness*, $NAV_{i,t}$ is the net asset value of a share of hedge fund i as of the end of the three-year (36-month) window (the beginning of the evaluation year), and $HWM_{i,t} = \max\,(NAV_{i,t-\tau}; 0 \leq \tau < 36)$ is the maximum level of NAV_i over the three-year window.

It is important to emphasize that *Moneyness* is a conditioning variable that refers to the status of the compensation option at the beginning of the evaluation year. Depending on the timing of the investment, each share class will have its own specific high-water mark, and therefore its own specific degree of moneyness. This means that the variable defined as *Moneyness* in Equation (1) should be interpreted as a proxy for the aggregated moneyness of all share classes of a given fund at the beginning of the year. If *Moneyness* is equal to one, the manager's compensation options for all assets under management are likely to be at the money at the start of the year. If *Moneyness* is less than one, the manager's compensation options are out of the money for at least some of the assets under management. Before we say that a fund as whole is under water, however, we wish to be fairly certain that all or nearly all of the manager's compensation options are out of the money. For that reason, we define an underwater fund as having *Moneyness* < 0.9 at the beginning of the evaluation year. We construct a dummy variable $M = 1$ if *Moneyness* < 0.9 and 0 otherwise.

A fund-specific high-water mark is not defined, as it resets for each new capital inflow. That is, the high-water mark is investor-specific, is based on past performance, and applies to new capital. Therefore, a hedge fund manager actually holds a portfolio of compensation options. The ratio of current (mid-year) *NAV* to past maximum *NAV* at the point when a fund manager makes decisions on risk-taking contains information on the likelihood that the manager will be collecting performance fees from the capital that entered the fund after its best performance. A high ratio (close to or greater than 1) implies that the manager has had good performance since achieving the maximum NAV, and most of his/her compensation options are in the money. Thus, there is little incentive to take more risks to increase the likelihood of collecting performance fees. A low ratio (less than 0) implies that the manager has had poor performance since achieving the maximum NAV, and at least some of his/her compensation options are not in the money. So the manager has incentives to take more risks in the second half-year to increase the likelihood of collecting performance fees. The construction of our proxy for moneyness reflects a compromise between the need for a fund-level HWM to study the manager's risk-shifting incentives and the limited data hedge funds disclose.

It is important to make a clear distinction between performance in the first half of the year and *Moneyness* at the start of the year. Negative first-half-year returns are necessary and sufficient to increase the manager's risk-shifting incentives. In other words, poor first-half-year performance is critical for risk shifting. If the fund begins the year *not* under water, then a negative first-half-year return drives the fund under water, creating the incentive to shift risk. If the fund begins the year under water with *NAV* less than *HWM*, then it has an even greater incentive to shift risk.

2.3. *Hypotheses*

Following Aragon and Nanda (2012), we investigate the change in the return volatility of each hedge fund in our sample during the second half of the year compared to the volatility in the first half of the year. Without inflows, the manager of a fund with negative returns during the first half of the year will not collect a performance fee unless the fund has positive returns during the second half of the year.

To increase the chances of ending the year in the money despite poor early-year performance, the manager alters the hedge-fund portfolio to increase expected return and risk:

Hypothesis 1. A hedge fund with a negative return in the first half of the year increases return volatility (shifts risk) in the second half of the year.

The effect is likely to be stronger if the hedge fund is under water at the beginning of the year. In that case, the manager will need to increase the volatility by an even larger amount to obtain the same amount of benefits.

Hypothesis 2. Risk shifting is greater for a hedge fund that begins the year under water.

How does the length of time under water affect risk shifting? On the one hand, if a fund has not collected performance fees for a long time, the fund may have attempted risk shifting in the past, or the manager's compensation option may be so deeply out-of-the-money that risk shifting no longer helps. In other words, a fund that has been long under water may not shift risk at all. On the other hand, a manager may decide to increase fund volatility as a last-ditch attempt to collect performance fees (Drechsler, 2014). Thus, the fund may further increase its return volatility after poor first-half-year performance.

Hypothesis 3. The length of time a hedge fund has been under water affects risk shifting.

2.4. *Time under water*

We create the variable *TimeUnder* to capture the duration of poor performance for hedge fund managers. By focusing on managers with return history of at least four years, we are examining those with a long horizon. *TimeUnder* is an abbreviation for time under water, a continuous integer that ranges between 0 and 35 and is defined as

$$TimeUnder_{i,t} = \begin{cases} 36 - t_{HWM,i,t} & if \;\; Moneyness_{i,t} < 0.9 \\ 0 & if \;\; Moneyness_{i,t} \geq 0.9 \end{cases} \qquad (2)$$

for fund *i* as of time *t*, the beginning of each evaluation year. *TimeUnder* is an estimate of the number of months that a fund's *NAV* has been less than 0.9 of its *HWM*, suggesting that the fund has not collected performance fees for at least some of its assets under management during those months.

2.5. *Fund flow*

Following Agarwal et al. (2002), we adopt hedge fund flow as a control variable. We estimate the fund-level aggregate flow by comparing the actual assets under management to the expected assets under management as of the midpoint of the evaluation year. We base calculation of expected assets on the fund's cumulative return since the time the HWM was achieved. The aggregated fund-level flow over $[t_{HWM}, t+6]$ is calculated following Sirri and Tufano (1998):

$$Flow_{i,t_{HWM},t+6} = \frac{AUM_{i,t+6} - \left(1 + AR_{i,t_{HWM},t+6}\right) \times AUM_{i,t_{HWM}}}{AUM_{i,t_{HWM}}}, \qquad (3)$$

where t_{HWM} is the time when the *HWM* was reached, *t* is the beginning of the evaluation year, and [*t*, *t*+6] is a six-month window. $AUM_{i,t+6}$ is the amount of assets under management six months after *t*, as of June 30 of the evaluation year, and $AUM_{i,t_{HWM}}$ is the amount of assets under management at the time (during the three-year window) when the *HWM* was reached. $AR_{i,t_{HWM},t+6}$ is the cumulative return over the window $[t_{HWM}, t+6]$. We construct a dummy variable *F* and set *F* equal to 1 if $Flow < 0$, indicating that the fund has experienced outflows after reaching its *HWM*.[8] Following Sirri and Tufano (1998), we use monthly AUM and returns to calculate aggregated fund flows occurring after a fund has achieved its HWM.

3. Empirical results

[8] We conduct robustness checks for various *M* and *F* definitions in section 4.

3.1. *Summary statistics*

We examine monthly returns data from January 1994 to December 2017 to evaluate hedge funds' risk-shifting behavior from 1997 to 2017. We include both live and defunct funds to minimize survivorship bias. To mitigate unwarranted noise from outliers, we also winsorize our sample at 1% and 99% for the following measures: the fund's return volatility in the first and second half-years, the moneyness of the fund manager's compensation options, and fund flow.

The summary statistics of the full sample are reported in Table 1, Panel A. There are 16,841 individual observations appearing in the database between January 1994 and December 2017. Excluding missing observations, the number of observations in Panel A is 15,624. The mean level of AUM at the beginning of each evaluation year increased from $131.83 million in 1997 to $234.92 million in 2008, then fell to $155.81 million in 2012 before increasing again to $500.93 million in 2017. Panel B reports the number of fund-year observations for the nine styles of funds in our study (namely, convertible arbitrage, debt-related, equity-related, event driven, global macro, merger arbitrage, multistrategy, volatility, and CTA). The most prominent one, equity-related funds, represents about 45% of both the full and the no-backfill-bias samples.

Panels C and D report the summary statistics of our dependent variable, independent variables, and control variables used in base case regressions for both no-backfill-bias and full samples. Out of 12,147 fund-year observations in the no-backfill-bias sample, 3,415 (28%) have M = 1 (indicating an underwater fund). Out of the 16,841 fund-year observations in the full sample, 4,497 (27%) have M = 1.

[Table 1 about here]

3.2. *Equation to be estimated*

To investigate the risk shifting of hedge fund managers, we use a multivariate regression to estimate the following equation over the period 1997–2017:

$$DifStd = \alpha + \beta_1 M + \beta_2 F + \beta_3 TimeUnder + \beta_4 Perf + \beta_5 M \times Perf + \beta_6 F \times Perf + \beta_7 TimeUnder \times Perf + \beta_8 Small + \beta_9 Small \times Perf + \beta_{10} Size + \beta_{11} AuCorr + \beta_{12} FirstFlow + \beta_{13} SecondFlow + \beta_{14} PStd + Style/Fund\ Dummies + YearDummies + \varepsilon \ . \qquad (4)$$

M = 1 if *Moneyness* < 0.9 and 0 otherwise.

F = 1 if *Flow* < 0 and 0 otherwise.

DifStd is the standard deviation of returns during the second half of the (evaluation) year minus the standard deviation of returns in the first half of the (evaluation) year.

Perf is a measure of fund performance in the first half of the (evaluation) year. We use three different measures of the variable *Perf*:

1. *NegRet*, a dummy variable that equals one if the cumulative return over the first half of an evaluation year is negative and zero otherwise,

2. *LowRetRank*, a dummy that equals one if a fund's cumulative return over the first half-year is below the median of all funds and zero otherwise,

3. *LowRelRetRank*, a dummy that equals one if the cumulative return over the first half-year is below the median of funds within the same style and zero otherwise.

If funds engage in mid-year risk shifting (Hypothesis 1), the coefficient for *Perf* will be positive, as funds with poor first half-year performance increase volatility in the second half-year. If risk shifting is greater for hedge funds that begin the year under water (Hypothesis 2), the coefficient for *M* × *Perf* will also be positive. We initially focus on *NegRet* to explore how the explicit incentives arising from out-of-the-money compensation contracts affect hedge fund risk shifting. We consider the other two variables (*LowRetRank* and *LowRelRetRank*) in additional tests in section 4.

TimeUnder is the number of months for which the fund's *NAV* has been below 90% of its *HWM*, indicating that the fund manager has not collected a performance fee for most, if not all, of the assets under management during those months. If the length of time a hedge fund has been under water affects risk shifting (Hypothesis 3), the coefficient for $Perf \times TimeUnder$ will differ significantly from zero. Recall from section 2 that there could be offsetting effects, so the sign of the coefficient is an empirical issue.

We include a dummy variable, *Small*, and the assets under management in millions of dollars (*Size*) as controls for fund size. *Small* = 1 if a fund has below-median AUM and 0 otherwise. Smaller funds collect less in fees for general management, which could make performance fees more important. They may also have a shorter investment horizon than larger funds. Either of these patterns could lead to greater risk shifting after a poor performance for smaller funds. That would imply a positive coefficient for *Small* × *Perf*. Smaller funds, on the other hand, may be less able to weather the loss of assets than larger funds. Given that higher volatility of returns could lead to greater negative returns and the outflow of funds, smaller firms might exhibit less risk shifting after a poor performance. That would imply a negative coefficient for *Small*×*Perf*. So again the sign of the coefficient for *Small* × *Perf* is an empirical issue.

Because each of the following variables has been found by other authors to affect the volatility of hedge fund returns, we control for lagged fund volatility (*PStd*), the percentage of net flow in the first and second half-years (*FirstFlow* and *SecondFlow*), and return autocorrelation (*AuCorr*). *PStd* controls for mean reversion in risk changes that may be induced by mismeasurement (Aragon & Nanda, 2012; Koski & Pontiff, 1999). We expect the coefficient to be negative and greater than -1. Getmansky et al. (2004) show that autocorrelation in fund returns may be a symptom of return smoothing by fund managers and may lead to a downward bias in estimating the true return volatility. Because less liquid strategies usually have higher autocorrelation, higher *AuCorr* may reflect less liquid asset holdings, which may exhibit lower volatility. Both the downward estimation bias and less liquid asset holding predict a negative coefficient for *AuCorr*. Fund flow in the first half-year influences managers' compensation and hence risk-shifting incentives, so we include *FirstFlow* as a control. *SecondFlow* controls for a spurious relation between midyear performance and changes in fund risk (Ferson & Warther, 1996; Koski & Pontiff, 1999).

Besides performance, a number of time-invariant manager characteristics such as the manager's physical location, education, and risk aversion could influence a fund's risk-shifting incentives. The manager is typically part of the ownership of a hedge fund, and therefore remains with the fund throughout its life (Liang, 2000). We estimate regressions with fund fixed effects to mitigate bias from omitted time-invariant variables.[9]

We also include year fixed effects: dummy variables that represent each year the fund manager makes decisions on volatility. There are 21 such evaluation years (1997–2017) for our sample, and the base year is 1997.[10]

Table 2 reports the correlation coefficients for the major variables in Equation (3).

[Table 2 about here]

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[9] Firm fixed-effects regression models are widely used in the corporate finance literature to reduce endogeneity concerns due to time-invariant omitted variables (e.g., Adams & Ferreira, 2009; Oikonomou, Brooks, & Pavelin, 2012).

[10] Our results do not change with the selection of base year.

Table 3 reports the results from estimating Equation (3) for the no-backfill-bias sample, with *Perf* represented by *NegRet*. The reported *t*-statistics are based on robust standard errors that cluster at the fund level. Columns 1 and 2 report results of OLS estimation using style fixed effects, and columns 3 and 4 report results for estimation using fund fixed effects. The results are robust across the four columns.

To summarize our findings,

1. Hedge funds with negative returns in the first half of the year show a greater volatility of returns in the second half of the year. In other words, risk shifting does occur (hypothesis 1).
2. The risk-shifting effect is larger for funds that begin the year under water (hypothesis 2).
3. The risk-shifting effect gets smaller as the fund remains under water for a longer time (hypothesis 3).
4. The risk-shifting effect is larger for smaller funds, i.e., funds with below-median assets under management.

Findings 1 and 2 come from the combination of the highly significant positive coefficients for *NegRet* and for $M \times NegRet$ in Table 3. The coefficients for *NegRet* apply to funds that start the year above water ($M = 0$). These funds shift risk in response to negative returns. The positive and highly significant coefficients for $M \times NegRet$ indicate that funds that start the year below water ($M = 1$) shift risk much more than funds that start above water ($M = 0$). Indeed, the estimated effect of a negative first-half-year return on second-half-year volatility of returns ranges from 108% to 195% higher for a fund that is under water than for a fund that is not under water. For a fund not under water, the estimated effect of a negative return ranges from

9.0% to 16.8% of the standard deviation of changes in return volatility (which is 2.94). For a fund that is under water, the corresponding estimates range from 26.7% to 35.1%.

Finding 3 comes from the significant negative coefficients for *Time x NegRet* in Table 3. As a fund remains under water for a longer period, the effect of having a negative first-half return on volatility grows smaller—that is, there is less risk shifting. The estimated effect on risk shifting of each additional month a fund is under water ranges from -0.51% to -0.68% of the standard deviation of return volatility. The estimates imply that after twelve months of being under water, the amount of risk shifting would be between 6.1% and 8.2% of a standard deviation lower than if the fund were not under water. The significant positive coefficient for *TimeUnder* indicates higher volatility for an average fund with a long time under water. It does not relate to risk shifting, however, because it applies to funds that did not suffer a negative return in the first half of the year.

Finding 4 comes from the positive and significant coefficients for *Small* × *NegRet*. In general, large funds tend to have lower volatility of returns. A small fund with negative first-half return increases the volatility of returns (relative to other funds). In other words, small funds are more likely to shift risk after poor performance than large funds.

An increased flow of funds (*F*) reduces volatility significantly in only one of the four estimated equations, and we do not observe a flow-related risk-shifting effect, as the coefficient for *F x NegRet* is not statistically significant. Neither *Size, AuCorr*, *FirstFlow*, nor *SecondFlow* significantly affects the volatility of returns.

[Table 3 about here]

3.3. *Time spent under water*

We next explore in more detail how the duration of underperformance is associated with changes in a hedge fund's return volatility during the second half of the year. *TimeUnder* is a highly skewed variable. The mean is 8.53 months, with the range being 0 to 35 months, but the median is only 4 months, and the 90th percentile is 27 months. It is, therefore, possible that the relationship between risk shifting and *TimeUnder* is nonlinear. To explore that possibility, we create a dummy variable for funds that begin the year under water: *M_LT* = 1 if *M* = 1 for more than 12 months and 0 otherwise. *M_LT* is more evenly distributed than *TimeUnder*, with mean of 18.2%. We replace *TimeUnder* with *M_LT* in Equation (3) and report the estimation results in Table 4.

The findings are consistent with those from Table 3: hedge funds with negative first-half returns increase the volatility of second-half returns (shift risk), with the effects being larger for funds that start the year under water and for small funds. Additional findings are as follows:

1. Funds under water for more than a year yield more volatile returns than funds under water for less than a year (the coefficients for *M_LT* are positive and significant). By our estimates, the volatility is between 9.8% and 10.7% of a standard deviation higher.
2. Funds under water for less than a year increase volatility in response to a negative return (shift risk) more than do funds that are not under water (the coefficients for *M* × *NegRet* are positive and significant), by 108% to 305%, with the higher estimate for the equation using fund fixed effects.
3. A long time under water mitigates managers' risk-shifting behavior, as the coefficient for *M_LT*×*Negret* is negative and significant. In fact, funds under water for more than a year

shift risk by no more than funds that are not under water (the sums of the coefficients for $M \times NegRet$ and $M\_LT \times NegRet$ are not statistically significant).[11]

[Table 4 about here]

4. Additional tests

4.1. *Alternative performance measures*

In this section, we consider measures of the performance of the hedge fund relative to other funds. We measure first-half-year performance ($Perf$) either by the rank of performance among all hedge funds (*LowRetRank*) or by the rank of relative within-style performance (*LowRelRetRank*). *LowRetRank* = 1 for funds with first-half-year returns below the median for all hedge funds. *LowRelRetRank* = 1 for funds with first-half-year returns below the median for hedge funds of the same "style."

Table 5, Panel A reports the results from estimating Equation (3), which includes the variable *TimeUnder*, the number of months the fund has been under water as of the beginning of the year (as in Table 3). The results for *LowRetRank* are broadly consistent with those reported in

[11] An alternative explanation is related to different behavior for defunct funds. We explore whether the higher volatility of funds that are under water for a long time is related to the chaos before a fund ceases operation, by investigating the risk-shifting behavior in the final year of funds in the defunct funds database. We find no differences in risk shifting from funds in the live funds database (results available on request). Since the defunct funds database includes both funds that liquidate and cease operation and those that stop reporting to the database, it is likely that we do not have return data for the actual final year of a fund that ceases operation.

Table 3. Hedge funds with poor relative performance in the first half of the year show greater volatility of returns in the second half of the year (they shift risk). The risk-shifting effect is larger for funds that are under water at the beginning of the year. However, the risk-shifting effect does not change as the fund remains under water for a long time. The results for *LowRelRetRank* are similar except that the coefficient for $M \times Perf$ is not statistically significant for the estimate with fund fixed effects, column 4.

[Table 5 about here]

Table 5, Panel B reports the results from estimating the model using the dummy variable for funds with time under water greater than 12 months (*M_LT*) instead of *TimeUnder*. For *LowRetRank,* the results are consistent with those reported in Table 4: hedge funds with time under water less than one year increase risk shifting compared to funds not under water, but hedge funds under water more than a year do not. For *LowRelRetRank*, however, the difference in results for funds more and less than 12 months under water is not statistically significant in either column.

4.2. *Other tests for robustness*

The results presented above are for a restricted sample designed to minimize backfill bias. Results for the full sample are essentially the same and are not reported here to save space.

The results reported so far are based on *HWM* observed over a rolling three-year window starting from January 1, 1994, where we treat the maximum *NAV* over such a window as a proxy for the high-water mark of a typical investor. We relax the requirement of a three-year window and use the maximum *NAV* as a proxy for the high-water mark for a fund with at least four years of return history over a period which starts from January 1, 1994, and ends right before the beginning of the evaluation year. This maximum *NAV* can be viewed as the maximum high-water mark of a hedge fund's investors starting after January 1, 1994, at the fund. Using this alternative definition of *HWM*, we recalculate summary statistics and reestimate Equation (3) with the three performance measures (*NegRet*, *LowRetRank*, and *LowRelRetRank*) and find that the main results are unchanged.[12]

5. Conclusion

In this paper, we find empirical evidence indicating that hedge fund managers shift risk at midyear when the fund has shown poor recent performance, compared either with all hedge funds or with those using a similar strategy. Consistently with the managerial incentives provided by poor performance fees, we find that hedge fund managers shift risk by more when their compensation options are likely to be out of the money (the fund is under water). However, risk shifting is driven largely by funds that have been under water only for a short period. This finding suggests that a fund manager's investment horizon is a factor in decisions about risk taking, in accord with the theoretical model of Panageas and Westfield (2009).

The findings highlight the importance of the explicit incentive for risk shifting arising from the convex payoff structure of compensation contracts for hedge fund managers, an issue of interest to the investment community and scholars of corporate finance. More research is needed, however, to fully understand the relationships between risk taking and a fund manager's investment horizon.

[12] The estimates mentioned in this section are available from the authors.

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Appendix: Definition of variables

PStd	Fund volatility calculated using monthly returns in the first half of an evaluation year. $PStd_i = \sigma_{t,t+6} * 100$
NStd	Fund volatility calculated using monthly returns in the second half of an evaluation year. $NStd_i = \sigma_{t+7,t+12} * 100$
DifStd	(*NStd*-*PStd*) *100, dependent variable.
HWM	High-water-mark proxy as of the beginning of the evaluation year based on the previous 36-month window. $HWM_{i,t} = \max\,(NAV_{i,t-\tau}; 0 \leq \tau < 36)$
$t_{i,HWM}$	The month when hedge fund i reaches its HWM.
Moneyness	$Moneyness_{i,t} = NAV_{i,t} / HWM_{i,t}$, where $NAV_{i,t}$ is net asset value per hedge fund share at the beginning of the evaluation year.
Flow	$Flow_{i,t+6} = \frac{AUM_{i,t+6} - (1 + AR_{i,t_{HWM},t+6}) \times AUM_{i,t_{HWM}}}{AUM_{i,t_{HWM}}}$, where AUM is the assets under management and $AR_{i,t_{HWM},t+6}$ is the accumulative return between t_{HWM} and $t+6$ (June 30 of the evaluation year). *Flow* is a proxy for the net flow from the month a fund achieves its HWM to June 30 of the evaluation year.
M	A dummy variable that equals 1 if *Moneyness* < 0.9 and 0 otherwise.
M_ST	A dummy variable that equals 1 if M=1 and TimeUnder is less than 1 year and 0 otherwise.
M_MT	A dummy variable that equals 1 if M=1 and TimeUnder is more than 1 year and less than 2 years. It is 0 otherwise.
M_LT	A dummy variable that equals 1 if M=1 and TimeUnder is longer than 2 years and 0 otherwise.
F	A dummy variable that equals 1 if *Flow* < 0 and 0 otherwise.
NegRet	A dummy variable that equals 1 if cumulative return over the first half of the evaluation year is negative and 0 otherwise.
LowRetRank	A dummy variable that equals 1 if accumulative return over the first half of the evaluation year is ranked below median among all funds and 0 otherwise.
LowRelRetRank	A dummy variable that equals 1 if accumulative return over the first half of the evaluation year is ranked below median among funds within a given style and 0 otherwise.
Leverage	A dummy variable that equals 1 if the fund reports that it uses leverage and 0 otherwise.
Small	A dummy variable that equals 1 if the fund's assets under management are below median and 0 otherwise.
ShortNotice	A dummy variable that equals 1 if a fund has a short redemption notice that is less than or equal to 30 days and 0 otherwise.
TimeUnder	The number of months a fund has been under its maximum NAV in a three-year window.
SecondFlow	Net flow to the fund from July 1 to December 31 of the evaluation year.
AuCorr	First-order autocorrelation coefficient on a fund's return in a 3-year historical return window.

Table 1

Summary statistics of hedge funds sample, 1994–2017.

Panel A. Hedge fund counts and fund size by evaluation year (full sample).

Period	Evaluation Year	Frequency	Min	25th Pctl	50th Pctl	75th Pctl	Max	Mean
94-96	1997	74	0.20	18.00	43.94	90.40	2818.00	131.83
95-97	1998	122	0.20	20.05	58.60	120.37	3054.00	153.59
96-98	1999	185	0.20	15.00	45.93	111.40	3054.00	131.07
97-99	2000	289	0.20	16.00	48.00	132.10	3054.00	146.74
98-00	2001	406	0.20	17.36	45.57	139.00	3054.00	153.74
99-01	2002	537	0.20	17.30	49.20	140.03	2580.27	150.35
00-02	2003	730	0.20	14.80	47.10	120.00	2829.00	131.05
01-03	2004	924	0.20	19.08	60.42	166.70	2877.00	167.64
02-04	2005	1132	0.20	19.42	65.00	198.05	3054.00	193.01
03-05	2006	1267	0.20	18.77	66.67	199.80	3054.00	196.45
04-06	2007	1294	0.20	18.80	65.00	210.39	3054.00	209.95
05-07	2008	1155	0.20	21.00	72.49	237.50	3054.00	234.92
06-08	2009	1071	0.20	13.00	41.33	131.54	3054.00	166.30
07-09	2010	1004	0.20	15.60	46.00	141.00	3054.00	162.05
08-10	2011	941	0.28	17.81	50.76	140.56	3054.00	163.93
09-11	2012	805	0.28	15.25	45.39	136.79	3054.00	155.81
10-12	2013	1040	.013	9.87	39.9	133.305	24889	238.839
11-13	2014	896	.004	10.97	42.434	164.298	28471	294.823
12-14	2015	739	.022	12.708	50	184	31349	365.145
13-15	2016	577	.015	.015	37.796	163.4	28603	399.129
14-16	2017	436	.015	11.126	49.85	183.736	35194	500.928
97-17		15624	.004	14.899	52.6	170	35194	236.76

Panel B. Style Distribution

	No-Backfill-Bias Sample	Full Sample
Style	*Counts*	
Convertible Arbitrage	280	391
CTA	1707	2233
Debt-related	1202	1786
Equity-related	5452	7667
Event Driven	707	932
Global Macro	674	947
Merger Arbitrage	255	335
Multi-strategy	732	1010
Volatility	45	72
Missing	56	75
Total	12147	16841

Panel C. Summary Statistics for No-Backfill-Bias Sample.

	No-Backfill Sample All			$M = 1$			$F = 1$		
Variable	N	Mean	Std	N	Mean	Std	N	Mean	Std
$PStd$	12147	3.454	3.144	3415	5.209	4.127	6999	3.558	3.165
$NStd$	12003	3.451	3.339	3345	4.594	4.148	6885	3.436	3.23
$DifStd$	12003	.002	2.924	3345	-.631	4.018	6885	-.117	2.852
M	12147	.281	.45	3415	1	0	6999	.362	.481
F	12147	.576	.494	3415	.743	.437	6999	1	0
$TimeUnder$	12147	8.526	10.506	3415	18.388	9.782	6999	10.887	11.103
$Small$	12147	.487	.5	3415	.629	.483	6999	.544	.498
$AuCorr$	12147	.094	.223	3415	.1	.23	6999	.097	.227

Panel D. Summary Statistics for Full Sample.

Variable	Full Sample All			M = 1			F = 1		
	N	Mean	Std	N	Mean	Std	N	Mean	Std
$PStd$	16841	3.44	3.258	4497	5.288	4.291	9158	3.533	3.189
$NStd$	16617	3.468	3.493	4400	4.703	4.446	8982	3.45	3.377
$DifStd$	16617	.033	3.036	4400	-.602	4.211	8982	-.083	2.995
M	16841	.267	.442	4497	1	0	9158	.353	.478
F	16841	.544	.498	4497	.718	.45	9158	1	0
$TimeUnder$	16841	7.941	10.196	4497	17.997	9.789	9158	10.303	10.834
$Small$	16841	.488	.5	4497	.623	.485	9158	.545	.498
$AuCorr$	16841	.098	.222	4497	.105	.227	9158	.1	.226

Note: Summary statistics are reported for the hedge funds sample from the Morningstar-CISDM database. We include only funds that have returns in Morningstar-CISDM after January 1994 to minimize survivorship bias. To be included in the sample, each fund must have at least four years of return history; information on assets under management, management fee and performance fee rates, and strategy; and returns for the entire four-year window. The sample is winsorized at 1% and 99% values of *DifStd*, *Moneyness*, and *Flow* to minimize the impact from outliers. The appendix provides a detailed definition for each variable.

Table 2
Correlation matrix with p-values in parentheses.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) *DifStd*	1.000									
(2) *M*	-0.135 [0.00]	1.000								
(3) *F*	-0.047 [0.00]	0.211 [0.00]	1.000							
(4) *NegRet*	0.064 [0.00]	0.094 [0.00]	0.061 [0.00]	1.000						
(5) *M×NegRet*	0.008 [0.38]	0.568 [0.00]	0.106 [0.00]	0.509 [0.00]	1.000					
(6) *F×NegRet*	0.026 [0.00]	0.133 [0.00]	0.433 [0.00]	0.723 [0.00]	0.460 [0.00]	1.000				
(7) *TimeUnder*	-0.055 [0.00]	0.587 [0.00]	0.262 [0.00]	0.112 [0.00]	0.335 [0.00]	0.159 [0.00]	1.000			
(8) *Small*	0.003 [0.76]	0.178 [0.00]	0.134 [0.00]	0.083 [0.00]	0.142 [0.00]	0.107 [0.00]	0.185 [0.00]	1.000		
(9) *PStd*	-0.397 [0.00]	0.349 [0.00]	0.039 [0.00]	0.133 [0.00]	0.190 [0.00]	0.091 [0.00]	0.193 [0.00]	0.155 [0.00]	1.000	
(10) *AuCorr*	0.002 [0.82]	0.014 [0.11]	0.011 [0.21]	-0.085 [0.00]	-0.032 [0.00]	-0.051 [0.00]	-0.051 [0.00]	-0.126 [0.00]	-0.085 [0.00]	1.000

Note: Pairwise correlation coefficients are reported for our main variables in regression analyses for the no-backfill-bias sample, which contains 12,147 individual hedge fund–year observations over the period 1997–2017. The appendix provides a detailed definition for each variable. *M*×*F*, *M*×*NegRet*, and *F*×*NegRet* represent interactions between *Moneyness* and *Flow*, *Moneyness* and *NegRet*, and *Flow* and *NegRet*, respectively.

Table 3

Baseline results: no-backfill-bias sample.

VARIABLES	(1) OLS	(2) OLS	(3) Fund FE	(4) Fund FE
M	0.200**	0.207**	-0.225**	-0.219**
	(2.233)	(2.346)	(-2.477)	(-2.429)
F	-0.096	-0.190***	-0.046	-0.110
	(-1.569)	(-2.650)	(-0.672)	(-1.427)
$NegRet$	0.495***	0.367***	0.360***	0.266***
	(5.065)	(4.068)	(3.610)	(2.966)
$Time\_Under$	0.016***	0.017***	0.017***	0.017***
	(4.758)	(5.121)	(4.150)	(4.431)
$M \times NegRet$	0.537***	0.519***	0.531***	0.518***
	(2.877)	(2.835)	(2.812)	(2.783)
$F \times NegRet$	-0.279		-0.204	
	(-1.468)		(-1.246)	
$Time \times NegRet$	-0.018**	-0.020**	-0.015*	-0.016**
	(-2.001)	(-2.516)	(-1.714)	(-2.087)
$Small$	0.071	0.077	0.057	0.064
	(0.881)	(0.951)	(0.499)	(0.557)
$Small \times NegRet$	0.352***	0.331***	0.294**	0.278**
	(2.932)	(2.874)	(2.455)	(2.371)
$Size$	-0.033	-0.033	-0.065	-0.062
	(-1.293)	(-1.307)	(-1.242)	(-1.186)
$AuCorr$	-0.165	-0.163	-0.096	-0.087
	(-1.364)	(-1.347)	(-0.567)	(-0.519)
$FirstFlow$	0.028	0.017	-0.144	-0.148
	(0.285)	(0.172)	(-1.308)	(-1.338)
$SecondFlow$	-0.005	-0.007	-0.081	-0.083
	(-0.045)	(-0.064)	(-0.709)	(-0.726)
$PStd$	-0.418***	-0.418***	-0.764***	-0.764***
	(-27.405)	(-27.373)	(-36.255)	(-36.176)
Constant	2.362***	2.385***	3.985***	3.991***
	(7.574)	(7.685)	(9.752)	(9.767)
Observations	11,090	11,090	11,090	11,090
R-squared	0.306	0.306	0.459	0.459
Style FE	Yes	Yes		
Year FE	Yes	Yes	Yes	Yes

Fund FE	No	No	Yes	Yes
Number of funds			2,309	2,309

Note: This table reports pooled OLS and fund fixed-effects (FE) estimates from Equation (3), the regression of midyear change in fund volatility on the fund's negative return in the first half-year, conditional on past performance, fund flow, and fund characteristics using the no-backfill-bias sample. The dependent variable is *DifStd*, midyear change in fund volatility. The performance measure is *NegRet***.** The no-backfill-bias sample includes a total of 12,147 individual hedge fund-year observations, representing 2,309 individual funds. The appendix provides a detailed definition for each variable. Numbers in parentheses are *t*-statistics based on robust standard errors clustered at the fund level. Columns 1–2 report results from pooled OLS regressions, and columns 3–4 report results from a fund fixed-effects regression. The symbols ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively. Robust t-statistics are given in parentheses.

Table 4
The impact of duration of underperformance: no-backfill-bias sample.

VARIABLES	(1) OLS	(2) Fund FE
M	0.247**	-0.225*
	(2.187)	(-1.868)
M_LT	0.287**	0.314**
	(2.368)	(2.315)
F	-0.157**	-0.074
	(-2.228)	(-0.974)
$NegRet$	0.273***	0.179**
	(3.731)	(2.344)
$M \times NegRet$	0.568**	0.725***
	(2.396)	(2.785)
$M_{LT} \times NegRet$	-0.508*	-0.677**
	(-1.825)	(-2.395)
$Small$	0.087	0.072
	(1.083)	(0.626)
$Small \times NegRet$	0.315***	0.272**
	(2.727)	(2.312)
$Size$	-0.036	-0.072
	(-1.426)	(-1.361)
$AuCorr$	-0.167	-0.074
	(-1.384)	(-0.437)
$FirstFlow$	0.017	-0.151
	(0.177)	(-1.363)
$SecondFlow$	-0.017	-0.100
	(-0.156)	(-0.878)
$PStd$	-0.418***	-0.766***
	(-27.207)	(-35.914)
Constant	2.408***	4.050***
	(7.693)	(9.912)
Observations	11,090	11,090
R-squared	0.305	0.459
year FE	Yes	Yes
style FE	Yes	Yes
Number of funds		2,309
Fund FE		Yes

This table reports pooled OLS and fund fixed-effects (FE) estimates from Equation (3), the regression of midyear change in fund volatility on the fund's poor performance in the first half-year for the no-backfill sample. The dependent variable is *DifStd*, midyear change in fund volatility. The performance measure is *NegRet*. The no-backfill-bias sample includes a total of 12,147 individual hedge fund–year observations, representing 2,309 individual funds. Instead of *M* and *TimeUnder*, which is the number of months a fund has been below its HWM, three dummy variables, *M_ST*, and *M_LT* are used to capture the possible nonlinear relationship between *DifStd* and *NegRet* conditional on *M* and different amounts of *TimeUnder*. *M_ST* is set to 1 if *M*=1 and *TimeUnder* is less than 12 months and 0 otherwise; *M_LT* equals 1 if *M*=1 and *TimeUnder* is over 12 months and 0 otherwise. The appendix provides a definition for each variable. Numbers in parentheses are *t*-statistics based on robust standard errors clustered at the fund level. The symbols ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively.

Table 5

Regression results with alternative performance measures: no-backfill-bias sample.

Panel A: The impact of *Moneyness* and *Flow* with alternative performance measures, *LowRetRank* and *LowRelRetRank*.

	Perf=LowRetRank		Perf=LowRelRetRank	
	(1)	(2)	(3)	(4)
VARIABLES	OLS	Fund FE	OLS	Fund FE
M	0.230**	-0.149	0.235**	-0.118
	(2.233)	(-1.410)	(2.435)	(-1.223)
F	-0.181**	-0.075	-0.183**	-0.105
	(-2.460)	(-1.034)	(-2.492)	(-1.348)
$Perf$	0.122**	0.183***	0.095*	0.171***
	(2.173)	(2.853)	(1.757)	(3.123)
$Time\_Under$	0.009*	0.010**	0.008*	0.008**
	(1.961)	(2.434)	(1.802)	(2.217)
$M \times Perf$	0.359**	0.321**	0.374**	0.190
	(2.262)	(2.252)	(2.367)	(1.250)
$Time \times Perf$	0.002	0.001	0.005	0.006
	(0.526)	(0.178)	(1.124)	(1.361)
$Small$	0.104	0.074	0.085	0.058
	(1.207)	(0.604)	(0.954)	(0.475)
$Small \times Perf$	0.191*	0.176*	0.233**	0.217**
	(1.952)	(1.702)	(2.411)	(2.276)
$Size$	-0.029	-0.050	-0.030	-0.055
	(-1.152)	(-0.887)	(-1.190)	(-1.059)
$AuCorr$	-0.189	-0.177	-0.198	-0.133
	(-1.553)	(-0.995)	(-1.624)	(-0.782)
$FirstFlow$	0.022	-0.114	0.012	-0.150
	(0.227)	(-0.983)	(0.126)	(-1.356)
$SecondFlow$	-0.028	-0.117	-0.036	-0.081
	(-0.258)	(-0.966)	(-0.336)	(-0.707)
$PStd$	-0.409***	-0.766***	-0.411***	-0.762***
	(-26.720)	(-34.735)	(-27.005)	(-36.155)
Constant	2.278***	4.087***	2.323***	3.896***
	(7.030)	(9.417)	(7.277)	(9.585)
Observations	11,090	10,335	11,090	11,090
R-squared	0.302	0.462	0.303	0.458
Style FE	Yes		Yes	
Year FE	Yes	Yes	Yes	Yes
Number of funds		2,223		2,309

Fund FE	Yes	Yes

Panel B The impact of duration of underperformance with alternative performance measures, *LowRetRank* and *LowRelRetRank*.

	Perf=LowRetRank		Perf=LowRelRetRank	
	(1)	(2)	(3)	(4)
VARIABLES	OLS	Fund FE	OLS	Fund FE
M	0.147	-0.261*	0.202	-0.164
	(1.169)	(-1.957)	(1.538)	(-1.193)
F	0.330**	0.353**	0.244	0.246
	(2.365)	(2.180)	(1.640)	(1.479)
$Perf$	-0.155**	-0.074	-0.157**	-0.071
	(-2.185)	(-0.969)	(-2.212)	(-0.939)
$TimeUnder$	0.124**	0.177***	0.100*	0.169***
	(2.211)	(2.984)	(1.854)	(3.101)
$M \times Perf$	0.669***	0.662***	0.575***	0.460**
	(3.321)	(3.042)	(2.733)	(2.066)
$Time \times Perf$	-0.494**	-0.636**	-0.307	-0.411
	(-2.051)	(-2.382)	(-1.221)	(-1.529)
$Small$	0.100	0.076	0.329***	0.288**
	(1.157)	(0.630)	(2.942)	(2.216)
$Small \times Perf$	0.208**	0.180*	-0.248***	-0.237**
	(2.145)	(1.769)	(-2.581)	(-2.463)
$Size$	-0.032	-0.074	-0.033	-0.070
	(-1.264)	(-1.405)	(-1.306)	(-1.329)
$AuCorr$	-0.192	-0.105	-0.205*	-0.118
	(-1.580)	(-0.624)	(-1.690)	(-0.697)
$FirstFlow$	0.020	-0.152	0.008	-0.158
	(0.200)	(-1.373)	(0.083)	(-1.430)
$SecondFlow$	-0.039	-0.097	-0.047	-0.100
	(-0.367)	(-0.856)	(-0.440)	(-0.879)
$PStd$	-0.409***	-0.763***	-0.411***	-0.764***
	(-26.600)	(-35.835)	(-26.850)	(-35.926)
Constant	2.292***	3.929***	2.334***	3.969***
	(7.048)	(9.583)	(7.311)	(9.746)
Observations	11,090	11,090	11,090	11,090
R-squared	0.302	0.458	0.302	0.458
Year FE	Yes	yes	yes	yes
Style FE	Yes	yes	yes	yes
Number of funds		2,309		2,309
Fund FE		yes		yes

Notes: This table reports results using alternative performance measures in estimation of Equation (3), the regression of midyear change in fund volatility on the fund's alternative poor performance measures in the first half-year, conditional on performance, fund flow, and fund characteristics for the no-backfill sample. The dependent variable is *DifStd*, midyear change in fund volatility. The no-backfill-bias sample includes a total of 12,147 individual hedge fund–year observations, representing 2,309 individual funds. The two alternative poor performance measures are *LowRetRank* and *LowRelRetRank*. Panel A focuses on the impact of *M* and *F* and Panel B focuses on the impact of duration of underperformance. The appendix provides a detailed definition for each variable. Numbers in parentheses are t-statistics based on robust standard errors clustered at the fund level. The symbols ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively.