On Tournament Behavior in Hedge Funds: High Water Marks, Managerial Horizon, and the Backfilling Bias

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ABSTRACT

Brown, Goetzmann, and Park (2001) report a negative relation between changes in hedge fund risk and mid-year relative fund performance. We find that such "tournament" behavior is more prevalent in the (backfilled) period when funds may be at an incubation stage, before they start voluntarily reporting to a database. Excluding backfilled data, we find that variance shifts depend on absolute rather than relative fund performance. Specifically, hedge funds are more likely to increase risk if they are below their high-water mark at mid-year. However, the propensity for losing funds to increase risk is significantly weaker among the funds that tie the manager's performance pay to the fund's high-water mark – suggesting a possible benefit from such incentive structures – and among funds that face little immediate risk of being closed. Overall, the combination of factors such as reporting performance to a database, high-water mark provisions, and low risk of fund closure appear to make poorly performing funds more conservative with regard to risk shifting.

Keywords: Keywords: hedge funds; tournaments; risk-taking; backfilling; high-water marks.
JEL Codes: G11, G12

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Abstract

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Keywords: hedge funds, absolute performance, portfolio choice, high-water mark.

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I. Introduction

The explosive growth and success of the hedge fund industry in recent years has heightened interest in the management and structure of these funds.[1] In particular, the nature and size of the performance fees received by hedge fund managers has received substantial attention in both popular and academic writing. Hedge funds are often structured with asymmetric performance contracts in which the rewards are based on exceeding a 'high-water mark' (HWM).[2] A matter debated in the literature – and also a focus of this paper – is the potential impact of such asymmetric performance contracts on the investment and portfolio risk decisions of managers. Does the presence of these contracts, for instance, exacerbate risk shifting by managers or, to the contrary, mitigate such behavior? These issues are important to understanding the design of hedge fund contracts – and the possible benefits and risks that they pose for hedge fund investors and for financial markets more broadly.

In the paper, we investigate the issue of risk shifting, including "tournament behavior": the notion that funds that perform poorly by mid-year, relative to peer funds, tend to increase risk in the latter part of the year. In addition, we also study how managers' variance strategies are related to absolute performance, using the fund's high-water mark benchmark. It is rational for managers to increase risk if their rewards are asymmetric and gains from a good performance more than offset the costs of a poor outcome. Such risk shifting is likely to be detrimental to the interests of investors, however, and has been documented for mutual funds (Brown, Harlow, and Starks, 1996) and, subsequently, for hedge funds (Brown, Goetzmann and Park, 2001). In this paper we re-examine hedge fund risk-shifting behavior. In relation to existing work, our sample is more extensive and allows us to identify backfilled periods that may correspond to

[1] The assets managed by the hedge fund industry have ballooned from a few billion dollars in the early 1990s to over a trillion dollars in 2005 (see e.g., The Hedge Fund Reader, August 2005, http://www.hedgefundreader.com/2005/08/hedge_funds_cha.html).

[2] This is unlike the symmetric incentive contracts associated with mutual funds. Mutual funds are subject to the Investment Company Act (1940) and must offer symmetric performance contracts. A ruling to this effect was made by the SEC in 1971 based on its regulatory authority under the Investment Company Act, 1940 (see Starks, 1987).

funds being at an incubation stage, with very different incentives to shift risk.[3] We also have more details on the manager's compensation contract and identify funds that use HWMs and those that do not. In our analysis we control for backfilling and draw on certain theoretical arguments to investigate the role of HWMs and anticipated horizon on risk shifting by funds.

The literature offers ambiguous predictions with regard to hedge fund risk-shifting behavior. On the one hand, asymmetric incentive contracts, such as those present in hedge funds, can promote risk taking. The theoretical literature suggests that, in a finite horizon setting, incentive contracts with convex payoffs can induce managers to increase the risk of their investment portfolios – beyond what might be desired by fund investors (e.g., Starks (1987), Carpenter (2000)). Risk shifting can also occur on account of tournament behavior, if funds are concerned about their performance relative to that of other funds. In the case of mutual funds, it has been argued that the convex relation between investor flows and relative fund performance gives fund managers an incentive to increase risk, if their mid-year relative performance is poor (Brown, Harlow, and Starks (1996)).

On the other hand, some recent theoretical work highlights the possibility that HWMs, coupled with a relatively long fund horizon, may discourage excessive risk taking by fund managers. Panageas and Westerfield (2007), for instance, show that if a fund's horizon is indefinitely long, HWMs will constrain risk taking, even by risk neutral managers. The intuition is that a hedge fund manager, depending on horizon, can be regarded as facing a sequence of options. While a riskier portfolio can increase the probability of crossing the current high-water mark, it also increases the probability that the assets will be worth less – and the future options more out of the money. In a related paper, Hodder and Jackwerth (2006) use simulations and show that fund horizon affects the incentive of funds to increase risk: the incentives are particularly strong when horizon is short and funds are below their HWMs. In addition, hedge fund managers may be dissuaded from increasing risk on account of risk-aversion and the fact that they often have a significant ownership stake in the fund. Fund managers may also be averse to the possibility of the fund being forced to shut down, with significant damage to their reputation (Brown,

[3] Backfilled data refers to fund data from periods prior to a hedge fund's inclusion in the database. Hedge funds usually provide data on their past performance, assets etc., when they being reporting to a database.

Goetzmann and Park (2001)).

Despite the theoretical interest in asymmetric incentive contracts and HWMs, there are few empirical studies of risk-shifting behavior by hedge funds. A well-known paper that investigates risk shifting by CTA and off-shore hedge fund managers is Brown, Goetzmann and Park (2001), henceforth BGP. The paper examines whether the relative performance of a hedge fund in the first half of a year is followed by changes in return volatility in the latter part of the year. The paper finds evidence of tournament behavior, similar to findings for mutual funds in Brown, Harlow, and Starks (1996), henceforth BHS. At the same time, a hedge fund's absolute performance, specifically whether it is estimated to be above or below its HWM at mid-year, does not appear to be related to subsequent volatility. BGP suggest that funds may be avoiding risk shifting in response to absolute performance on account of reputation and risk-aversion considerations since, as shown in the paper, poorly performing funds face significant risk of being shut down.

In this paper we investigate risk-shifting by hedge fund managers, as in BGP, by analyzing the impact of mid-year performance, relative as well as absolute, on subsequent fund volatility. However, our study differs from BGP along certain critical dimensions. We make use of a broader sample of hedge funds over a longer time period and have more detailed information about their incentive contracts and when the funds join the database. Hence, we differ from BGP in being able to investigate and control for the impact of backfilled data in our analysis of tournament behavior. This is important since, as noted earlier, backfilled data may correspond to an incubation stage, when fund managers have very different risk shifting incentives, compared to established fund managers. We would expect funds in incubation to be more willing to increase risk after a poor performance: the reason being that strong performers will likely be launched – while those that do poorly will presumably be closed quietly, without significant reputation or wealth repercussions for fund managers. Another advantage of our data is that it allows us to distinguish between hedge funds that employ HWMs and those that do not (about one third of sample funds) – unlike BGP in which all funds are assumed to use HWMs. In our analysis, funds without HWMs serve as a control group that helps us identify the effect of HWMs on risk choice.

Our paper also differs from BGP in that we investigate the likelihood of fund closure on risk shifting. The theoretical literature, as noted above, suggests that risk shifting incentives may be exacerbated when the horizon is short (e.g., Hodder and Jackwerth (2006)). Offsetting this, as argued in BGP, risk-averse managers facing a substantial risk of fund closure and loss of reputation will cut back on portfolio risk. In our analysis we estimate the likelihood of a fund being shut down in the coming year and use this ex-ante probability as a conditioning variable to investigate risk shifting by hedge funds.

Our main source of data is the Lipper/TASS data set over the sample period January 1989 through December 2007. For our empirical analysis of risk shifting we rely on both the contingent table tests used in BGP and BHS, as well as a multivariate regression approach. We find evidence of a substantial bias on account of backfilled data. When the full sample of hedge fund returns is used, our findings are consistent with BGP's conclusions that hedge funds exhibit tournament behavior. However, the evidence on tournament behavior is far weaker in the subsample that excludes backfilled observations. In fact, the contingency table tests indicate that mid-year relative performance bears no significant relation with the propensity to change fund risk. This is consistent with the pre-reporting period being one in which funds are being incubated for subsequent launch and when funds are apparently more willing to engage in risk shifting. Similar evidence emerges when we consider absolute performance and analyze the risk shifting behavior of funds that are above and below their HWMs at mid-year. Funds that are underwater in the backfilled period reveal a tendency to increase risk. However, for non-backfilled observations, the evidence on underwater funds increasing risk is far weaker. Hence, the evidence suggests that inferences about risk-shifting and tournament behavior among hedge funds are sensitive to the presence of backfilled observations. Further, for the overall sample, our regression results indicate that changes in fund risk depend more on mid-year absolute performance rather than performance relative to other funds.

We next investigate the role of HWMs on risk shifting in the non-backfilled sample. As noted, high-water marks may offset fund managers' propensity to increase risk following poor performance. About 65% of the funds in the sample have HWMs and our results indicate that these funds exhibit a significantly lower tendency to increase risk following a poor relative or absolute performance. Hence, we find support for theoretical models that have argued that HWMs can induce a form of risk-aversion in certain settings. Our findings suggest that fund investors may have a reason to prefer HWMs, since they seem to curb risk shifting by hedge fund managers.

To investigate the role of fund horizon, we follow a two-step procedure. In the first step, we estimate a probit model of whether the fund disappears from the database at year-end, where we make the assumption that funds disappear because they have decided to liquidate fund assets. Following BGP, we include fund specific variables to determine fund disappearance, including fund age, size, and lagged returns. We also include the extent to which the fund is underwater at the start of the year. Using the model we estimate the probability of fund disappearance for each fund and year given fund characteristics at the previous year-end – where funds with low probabilities of disappearance are interpreted as having the longest horizons. We then repeat our risk shifting tests on subsamples depending on high-water mark and the predicted probability of disappearance. Our results indicate that fund horizon matters: funds that face a higher risk of closure, i.e., effectively have a shorter horizon, have a greater tendency to increase risk following poor mid-year performance. While funds with HWMs have a lower tendency to increase risk, the sensitivity of risk change to investment horizon is similar across funds with and without HWMs.

Overall, the results of the paper indicate that the type of risk-shifting behavior documented for mutual funds is far weaker or non-existent for hedge funds – other than in backfilled data, when the funds are likely to have been in the incubation stage. HWMs and low risk of fund closure appear to make poorly performing funds quite conservative with regard to risk.

II Literature Review

Our paper is related to the substantial literature on mutual funds that examines the impact of incentive contracts on the portfolio and risk choices of fund managers.[4] It is well recognized, for instance, that convex payoffs – whether on account of incentive contracts or an asymmetry in the investor flow in response to fund performance (Sirri and Tufano (1992)) – can induce fund managers to increase portfolio risk. Theoretical arguments have, however, been advanced in papers such as Starks (1987) and Carpenter (2000) that, in a finite-horizon setting, this tendency will be curbed by factors such as managerial risk-aversion, managerial stake and reputational concerns.

The impact of HWMs and other factors on the risk choices of hedge fund managers has been analyzed in some recent papers. Of these, Hodder and Jackwerth (2006) uses simulation techniques to examine the effect incentive fees, high-water mark and managerial ownership of shares. They show that in some portions of the state space – especially when horizon is short and the fund is below its HWM, the manager takes extreme risks. At performance levels modestly above the high-water mark she reverses that strategy and opts for low risk positions to "lock in" the option payoff. In our analysis we condition our analysis of risk shifting by funds on the estimated likelihood of the fund's survival.

Another recent paper, Panageas and Westerfield (2007) studies the optimal portfolio choice of hedge fund managers who are compensated by high-water mark contracts. They show that if the horizon is long and/or uncertain, even risk-neutral managers will not take large risks – despite the option type features of the contract. The intuition is that hedge fund contracts represent a sequence of options with changing strike prices: while a riskier portfolio increases the probability of crossing the current high-water mark, it also increases the probability that the assets will be lower next period – and the future options more out of the money. Our findings are generally consistent with some of the model's predictions – when the horizon is relatively

[4] See, e.g., Admati and Pfleiderer (1997), Kritzman (1987), Ferguson and Leistikow (1997), Starks (1987), Grinblatt and Titman (1989), Carpenter (2000), and Basak, Pavlova, and Shapiro (2007). For empirical work, see Grinold and Rudd (1987), Brown, Harlow, and Starks (1996), Chevalier and Ellison (1997), Orphanides (1996), Elton, Gruber, and Blake (2003), Golec and Starks (2004), Koski and Pontiff (1999), Busse (2001), and Kempf and Ruenzi (2008).

long, poor performance tends to induce funds to reduce risk, while the opposite happens when these funds perform well. Goetzmann, Ingersoll and Ross (2003) is another paper that focuses on hedge funds contracts. They estimate the implied market value of hedge fund management fees for a given portfolio and analyze the effect of some limited managerial control of fund risk. Also, Aragon and Qian (2008) argue that the HWMs in hedge fund contracts can provide a certification role when information is asymmetric about manager ability. In contrast, we study how HWMs are related to managerial incentives to shift risk in response to past performance.

There is little empirical work on risk shifting by hedge fund managers. One well known paper is Brown, Goetzmann and Park (2001) that studies the volatility of off-shore hedge funds and CTAs in light of managerial career concerns. The paper uses the approach developed in Brown, Harlow, and Starks (1996) to study mutual funds and investigates whether mid-year performance affects the volatility of fund returns in the rest of the year. They find no significant evidence that absolute performance, that results in the fund being above or below its estimated HWM, affects risk taking behavior. However, they find an association between past performance relative to other hedge funds and risk levels (i.e., tournament behavior) consistent with previous findings for mutual fund managers: namely, below-the-median performing funds exhibit a greater propensity to increase portfolio risk. Agarwal, Daniel, and Naik (2002) also report this finding for hedge funds using a contingency table test. In our paper we rely, for some of our tests, on an approach similar to that in BGP, though we investigate risk shifting conditional on backfilling and the use of HWMs by funds. The conditional analysis allows us to detect the patterns of risk shifting by hedge funds – that tend to get obscured in an unconditional sample.

Finally, several authors have empirically examined the survival rates of hedge funds. For example, BGP find a positive (negative) relation between fund disappearance and lagged risk (returns). Fung and Hsieh (2000, 2002), Liang (2000), and Getmansky (2004) document a significant relation between fund survival and fund characteristics including investment style, assets, and performance.[5] To our knowledge, our analysis is the first to integrate the estimated fund survival rates into an empirical model of risk-shifting, thereby addressing the theoretical

[5]See, also, Brown, Goetzmann, and Ibbotson (1999), Gregoriou (2002), Getmansky, Lo, and Mei (2004), Baquero, Horst, and Verbeek (2005), and Grecu, Malkiel, and Saha (2006).

predictions about how a manager's propensity to shift risk in response to past performance might interact with his investment horizon.

III Available Fund Data and Summary Statistics

We describe the data used in our analysis in this section, followed by a discussion of our measures of variance change and sample summary statistics.

III.A Data

The main database used in our empirical analysis is supplied by Lipper/TASS, a major hedge fund data vendor. Our sample period covers January 1989 through December 2007. Our final sample contains the 45,816 fund-year observations of 7,658 individual funds, of which 3,167 are 'live' as of August 2, 2008. The remaining funds have ceased reporting to TASS and are considered 'defunct'. For each fund we observe monthly net-of-fees returns and total assets, and also a single, updated snapshot of organizational characteristics, including the parameters of the fund's compensation contract. We also observe the date the fund was added to the TASS database and use this information to directly test whether risk-shifting incentives are different in the fund's backfilling period.

BGP also use data from TASS in their study. Our sample is, however, expanded along three important dimensions: First, our sample period is 1989-2007, while BGP consider the 1989-1998 period. This is important because, as noted by BGP, data prior to 1994 are subject to survivorship bias, since data on disappearing funds were not recorded until 1994. For example, in the final year of BGP sample period (1998), approximately 13.5% of the funds are defunct. In contrast, 58% of the funds in the final year of our sample are in the TASS graveyard. Second, our data allow us to explicitly account for a potential backfilling bias. Backfilled observations precede the date a fund was added to the database. In our sample, 50% of the median fund's return observations are backfilled. An indication that the backfilled data is subject to self-selection problems is provided by Posthuma and van der Sluis (2003) who show that these data have higher average returns as compared to non-backfilled sample. A possible explanation for this pattern is fund incubation, in which the manager of several funds decides to report only those funds with a sufficiently strong performance. In the case of mutual funds, for instance, Evans (2004) provides evidence of such incubation behavior. As we show in our analysis, backfilling affects inferences regarding risk-shifting in hedge funds – with risk-shifting being evident primarily in the backfilled data.

Third, BGP implicitly assume that all funds have a high-water mark. In contrast, we account for variation across funds in the decision to include a high-water mark in the compensation by using the data contained in reported fund characteristics. In fact, high-water marks are present in the compensation contract in only 65% of the funds. Consequently, we construct a control group for the analysis of how high-water marks interact with risk-shifting behavior in hedge funds.

III.B Summary Statistics

A key variable of interest here is the extent to which fund investors' assets are below the high-water mark. This variable is not directly observable from the dataset, but can be indirectly measured using observable data on net-of-fees fund returns. Specifically, we assume the fund is initially at its high-water mark and solve recursively for the high-water mark of fund i in year y as follows, where $H_{i,y}$ and $A_{i,y}$ denote the fund's HWM and asset level, respectively:

$$\begin{aligned} A_{i,y} &= \; A_{i,y-1} \times (1 + r_{i,y}) \\ H_{i,y} &= \; \max\{H_{i,y-1}, A_{i,y}\}. \end{aligned} \tag{1}$$

The first expression is intended to capture the asset growth of a representative investor in the fund. This is affected each year by the annual net-of-fees return (r_{iy}). The second expression reflects the growth in the historical maximum asset level obtained by the fund at the end of each year. An advantage of this approach is that it follows BGP's method of calculating the high-water mark benchmark, thereby allowing more direct comparisons with the present analysis. Also, the actual assets of the fund are not necessary for the calculation (we assume $A_{i0} = H_{i0} = 1$). This allows us to avoid dropping observations for which asset level observations in TASS are missing (about 15% of the sample).

Of course, it is impossible to exactly measure the high-water mark due to differences in investor flows, hurdle rates, and frequency at which the high-water mark is reset. In reality, the fund manager usually faces a multiplicity of high-water mark levels, each of which corresponds to a distinct investor clientele. However, our main findings are qualitatively similar when we use the procedure used by Agarwal, Daniel, and Naik (2006) to track a fund's high-water mark.

We note that in analyzing the role of HWMs, we calculate a 'high-water mark' for funds without HWMs as we do for funds with HWMs. Basically, we track the extent to which a fund is underwater according to Eq. (1) for all funds, and then test whether the risk-shifting activities of underwater funds are different depending on whether the compensation contract actually includes a high-water mark provision.

Table I presents summary statistics for the full sample of funds. The average annual return is 9% and the average standard deviation of monthly returns is 4%. The variable UnderEnd measures the percentage difference between a fund's asset level and the fund's high-water mark at year-end (i.e., H_{iy}/A_{iy}-1). By construction, this variable cannot take negative values and is positively skewed. The median fund is not below-water at year-end, while the average fund is 6% below-water at year-end. UnderJune measures the mid-year percentage difference between a fund's asset level and the fund's high-water mark. Specifically,

$$\text{UnderJune}_{iy} = \frac{H_{i,y-1}}{A_{i,y-1} \times (1 + rJUN_{i,y})} - 1 \tag{2}$$

where $rJUN_{i,y}$ is the return on fund i over the first six months in year y. Unlike UnderEnd, this variable can be negative, in which case the fund is "above water" at mid-year. This distinction allows us to later test how fund risk is related to the high-water mark. The median fund is above water at mid-year by 3%. This is consistent with the overall positive average returns in our sample. However, the average fund is below their water mark by 6%.

The table also summarizes the age and reported assets for both the individual fund and the associated fund family. The variables are average of individual fund medians. The age variable is defined as the number of monthly return observations reported to TASS. The median fund in our sample has a median age and size of 30 months and $25.82 million, respectively. At the fund family level, the median age and size are 55 months and \$117.03 million, respectively.[6] Twenty-six percent of the funds in the sample have a lockup provision and the median redemption notice period is 30 days. This is in line with the numbers reported in Aragon (2007). Approximately 32% of the managers in our sample invest their personal capital into the fund's underlying portfolio. Finally, 50% of the median fund's reported history is generated prior to being added to the database, and 35% of funds do not use high-water marks. This suggests that backfilling and high-water marks can potentially affect inferences made from the full sample of observations.

IV Risk-taking and mid-year performance

In this section we discuss the methodology and findings from our analysis of risk-shifting incentives in hedge funds. Our focus is on how changes in fund risk between the first and second halves of the year are related to mid-year performance – and how these patterns interact with a fund's decision to advertise to a database, the presence of high-water marks in the compensation contract, and the risk of fund closure. We report results using two distinct approaches. First, a series of contingency table tests that allows for direct comparison with earlier findings of BHS and BGP; and second, a regression approach that tests hypotheses in a multivariate setting that controls for other factors that might affect risk-shifting.

IV.A Contingency Table Tests

BHS and BGP show how a 2x2 contingency table can be used to examine risk-shifting in fund management. The logic behind the test is that, if the propensity to change risk is unrelated to mid-year performance, then mid-year losers will be equally likely to show high and low changes in fund risk; and likewise for mid-year winners. Of course, changes in fund risk are unobservable and need to be estimated. Therefore, we follow BHS and BGP and estimate risk adjustment ratio's (RAR) for each fund-year observation. The RAR is defined as

$$RAR_{i,y} = \frac{\sigma_{i,y,2}}{\sigma_{i,y,1}}$$

[6]These variables are measured at the mid-life of each fund and then averaged across funds.

where $\sigma_{i,y,2}$ is the sample standard deviation of fund i's monthly returns during the second semi-annual period of year y, and $\sigma_{i,y,1}$ is defined similarly for the first semi-annual period. We also require each fund-year observation to have the full set of monthly returns available to calculate $RAR_{i,y}$. In the analysis, we classify funds as high (low) risk-shifters depending on whether the RAR is above (below) the median RAR.

We follow BGP and consider two methods of classifying funds as mid-year losers. First, we use a relative benchmark and classify losing funds as those for which the cumulative monthly raw return over January to June is below the median return of funds over the same period. By construction, therefore, there are an equal number of mid-year losers and winners with respect to the relative benchmark. In this case, the null hypothesis of no risk-shifting is also a hypothesis of no tournament behavior; specifically, whether the mid-year (relative) losers are equally distributed into high and low RAR categories. Second, we use an absolute benchmark where mid-year losers are those for which UnderJune is greater than zero (i.e., 'under-water') at mid-year. In general, there will not be an equal number of funds classified as losers and winners for the absolute benchmark. In this case, the null hypothesis of no risk shifting is a joint test of whether both the mid-year losers and mid-year winners are equally distributed into high and low RAR categories. Tests of the null hypothesis for both relative and absolute benchmarks involve a Chi-square statistic with one degree of freedom.

Table II presents results for contingency table tests where performance is measured relative to the median return across funds by year. Specifically, in each year we identify funds that are below the median mid-year return, and examine the frequency with which they are above the median RAR and below. By definition of relative performance, the results for mid-year winners are a mirror image of mid-year losers and are not reported. For the full sample (includes backfilled and non-backfilled data), we find that a greater proportion of mid-year losers have high RAR's as compared to low RAR's. For example, over the 1989-2007 period, 51.52% of mid-year losers have above-the-median RARs, as compared to only 48.48% with below-the-median RARs. The Chi-square test statistic of 31.65 leads us to reject at the 1% significance level the null hypothesis of an equal proportion of losers in the RAR groups. This pattern holds in 14 out of 19 years of the full sample. Tournament behavior is also evident using all observations over the 1989-1998 sample period analyzed in BGP, and therefore consistent with their findings.

Panel B shows that similar conclusions are reached for the subsample of backfilled observations. Evidence of tournament behavior is actually stronger in the sense that, compared to the full sample, a greater proportion (52.84% vs. 51.52%) of mid-year losers have above-the-median RARs. We again reject the null hypothesis of no tournament behavior at the 1% significance level (Chi-square is 37.57). However, Panel C presents strikingly different results for the subsample that excludes backfilled observations. Specifically, mid-year losers do not exhibit a strong tendency to have above-the-median RARs. This is evident in a roughly equal split of mid-year losers among low and high RAR categories, and an insignificant Chi-square statistic of 0.24. We conclude that tournament behavior in hedge funds is largely concentrated during the period in which the fund has not yet decided to report to the database. As we have discussed, such a pattern is consistent with backfilled data including an initial period of fund incubation, when fund managers may have far greater incentive to engage in tournament type behavior.

We next consider the impact of absolute, rather than relative, mid-year performance. Table III presents results for contingency table tests where mid-year performance is measured as being above or below the fund's high-water mark. Panel A reports results for the full sample. The point estimates suggest that – contrary to the findings for tournament type behavior – underwater funds have a lower propensity to fall into the high RAR category as compared to the low RAR category For example, the fraction is 49.11% over the 1989-2007 period. In addition, we can reject the null hypothesis of no risk-shifting at the 5% level for the 1989-2007 period. We note, however, that for the 1989-1998 period considered by BGP, we do not any significant evidence of risk-shifting, consistent with their findings.

In Panel B we report our findings for the subsample of backfilled observations. Consistent with risk-shifting behavior, the majority (51.45%) of mid-year losers are in the high RAR category. However, we cannot reject the null hypothesis of equal allocation of mid-year losers into RAR categories at standard levels of significance. A comparison of Panels B and C again reveals striking differences between the backfilled and non-backfilled samples. Specifically, for the non-backfilled sample (Panel C), we reject the hypothesis at the 1% significance level that mid-year losers are equally likely to be classified as low and high RAR funds (Chi-square is 11.73). Moreover, the pattern is contrary to tournament behavior: Underwater funds have a lower propensity (48%) to increase fund risk as compared to funds that are above their high-water mark at mid-year.

The above results indicate that underwater funds, at least those reporting to a database, are more likely to adopt a conservative approach to risk-taking. A possible explanation may be that a majority of funds compensate managers on the basis of HWMs. As discussed earlier, these funds may be unwilling to increase their level of risk: this is since an increase in risk also increases the likelihood that the fund is underwater in future periods, thereby reducing expected compensation. If HWMs affect the risk choice of managers and induce the conservative behavior, we would expect such behavior to be stronger among funds for which compensation is actually tied to the high-water mark. We now proceed to test this prediction.

Table IV repeats contingency table tests for the non-backfilled sample, with the sample split into two groups depending on whether or not a high-water mark is used to calculate performance compensation. Panel A corresponds to the subsample of funds that do not use a high-water mark. As indicated, there is no significant evidence that being above or below the HWM affects risk-shifting. The picture is quite different for funds with HWMs, as indicated in Panel B. We find that the anti-tournamemt behavior found for the full sample is apparently concentrated in the subsample of funds that actually have high-water marks.

Overall, the evidence here is consistent with the findings of BGP in the sense that, for the full sample of observations, risk-shifting is evident with respect to relative performance, but not absolute performance. However, our analysis highlights the sensitivity of inferences about hedge fund risk-shifting to backfilled data and the presence of high-water mark provisions in fund compensation contracts. Apparently, fund managers exhibit a greater propensity to increase risk following poor performance if they have not already decided to voluntarily report their returns to the database. Perhaps, the threat of liquidation by fund investors is more credible when manager behavior is made more transparent, and this threat curbs risk-shifting behavior.

In addition, the evidence in Table IV suggests that the presence of a high-water mark in the compensation contract dampens fund managers' incentives to increase fund risk when they are below their water mark at mid-year. A possible explanation is that, because funds with high-water marks do not renew their performance option at the start of each year, higher levels of risk increase the likelihood that the fund is underwater in future periods, thereby reducing expected compensation.

IV.B Multivariate Regressions

Our use of a contingency table test methodology is motivated both by its intuitive appeal and because it allows direct comparison with previous findings. However, one limitation is the inability to study risk-shifting incentives in a multi-variate setting that controls for other variables that might influence fund risk-taking. The following analysis reports results from multivariate regression of changes in fund risk on mid-year fund performance and other characteristics such as investor flows and lagged volatility. To test the relation between prior fund performance and backfilling to alter fund risk characteristics, we estimate the following pooled cross-sectional regression

$$\Delta Risk = \alpha + \beta_1 A + \beta_2 PERF + \beta_3 A * PERF + \beta_4 LagRisk + \beta_5 Flow + \Sigma_j \beta_j Dummy_j, \quad (3)$$

where $\Delta Risk$ is the difference between the sample standard deviations of monthly returns in the second (σ_{iy2}) and first halves (σ_{iy1})of the year, A is a dummy variable equal to one if the observation falls after the fund has been added to the database, $PERF$ is the performance measure for the first six months of the year, $LagRISK$ is the value of the risk variable during the first six months, and Flow is the percentage net flow during the second half of the year.[7]

For performance ($PERF$) we use relative and absolute performance measures: $RelRnk$, $AbsWin$, or $AbsRnk$. Here $RelRnk$ is the rank of the fund's raw return over the first six months relative to other funds during the same period. A negative coefficient on $RelRnk$ indicates a propensity

[7]Koski and Pontiff (1999) and Kempf and Ruenzi (2008) also use $\Delta Risk$. However, we also use as dependent variables the natural logarithm of the risk adjustment ration (RAR) and the difference of the risk ratios $(\sigma_{iy2}/\sigma_{my2}) - (\sigma_{iy1}/\sigma_{my1})$, where σ_{mys} is the median sample standard deviation of monthly returns across funds in semi-annual period s of year y. The results are very similar to those reported.

to increase risk following poor performance relative the manager's peers, and therefore indicative of tournament behavior. *AbsRnk* is the rank of the fund's percentage distance between the fund's level of assets at mid-year from the fund's high-water mark (i.e., the negative of the UnderJune variable), relative to the full sample of return observations; and *AbsWin* is an indicator variable that equals one if the fund is above its water-mark at mid-year. A negative coefficient on *AbsRnk* or *AbsWin* indicates how a manager's risk-shifting behavior is related to fund's mid-year position relative to its high-water mark benchmark. We include dummy independent variables for the year and interactions between A and the $LagRisk$, $Flow$, and the year dummies. Standard errors allow for clustering by fund family.

From this regression we can infer the relation between past performance and change in risk during the backfilled period from $PERF$. From $A * PERF$, we can infer the incremental effect that being added to the database has on this relation. We also include lagged risk in our specification to control for mean reversion in risk changes that may be caused by mismeasurement (e.g., Koski and Pontiff (1999), Daniel and Wermers (2000), and Kempf and Ruenzi (2008)). For example, in periods in which measured risk is high, we might expect lower risk in the next period due to mean reversion in the noise component of our estimate. We also include second period net flows into the fund because we expect this variable to capture a spurious relation between mid-year performance and changes in fund risk (e.g., Ferson and Warther (1996) and Koski and Pontiff (1999)). For example, in periods in which managers employ a buy-and-hold strategy (and therefore do not actively shift risk), investor net flows into the fund can affect fund risk to the extent that the manager takes time to re-deploy new capital.

Table V reports the results from estimating Eq. (3) for the full sample of observations. The results for Models 1a-3b indicate that, for each of the three measures of performance, the coefficient is significantly negative; while the interaction between $PERF$ and the indicator for the non-backfilled period ($A * PERF$) is significantly positive in Models 1b, 2b and 3b. Therefore, consistent with poor performers increasing risk, changes in fund risk are negatively associated with mid-year performance during the backfilling period. However, this relation is significantly weaker once funds are added to the database. For example, an increase in relative performance rank from 0 to 100 is associated with a 0.63% decrease in monthly return standard deviation during the backfilling period, as compared to only 0.30% in the non-backfilled sample. Meanwhile, the difference in fund risk changes between funds that are above and below water is -0.76% during the backfilled period, as compared to only -0.43% if the fund is added to the database. Therefore, despite the additional controls and difference in methodology, the message from these regression results is qualitatively similar to that from the contingency table tests: hedge funds engage in risk-shifting behavior, though the evidence is far weaker in the non-backfilled part of the sample.

Regarding other variables we find, consistent with mean reversion in fund risk, that the coefficient on LagRisk is negative and significant for all specifications. Also, the coefficient on Flow is negative across models and therefore consistent with the flow hypothesis. However, the estimates are not statistically significant.

The results in Model 1a-3b indicate that poor mid-year performance, whether relative or absolute, tends to be associated with an increase in fund risk. There are, however, somewhat different interpretations for relative and absolute performance. For instance, in a bear market, it is possible for some funds to achieve high relative performance while falling below their high-water mark. As proposed in BHS, the driver for tournament behavior is competition between funds and, hence, relative performance is the appropriate measure – while the evidence on absolute performance is interpretable in terms of the usual moral hazard motives for risk-shifting. In Models 4a-5b we, therefore, attempt to disentangle the marginal effects of relative and absolute performance on risk-taking. Interestingly, the results for Models 4a-5b suggest that the negative relation between changes in fund risk and performance is driven by absolute, not relative performance. For example, an increase in the relative performance rank from 0 to 100 is associated with an insignificant 0.15% (0.13%) increase in fund risk for the backfilled (non-backfilled) period. Meanwhile, holding relative performance constant, the differential change in fund risk between funds that are above and below water is a significant -0.82% (-0.48%) for the backfilled (non-backfilled) period. In fact, Model 5a and 5b indicate a positive relation between changes in risk and relative performance, after taking account of the absolute performance. Hence, at least on the basis of these results, it appears that the risk-shifting in hedge funds may not be driven primarily by considerations of relative performance.

We next use the regression approach to investigate whether high-water marks – as suggested by the contingency table results – tend to curb the extent of risk-shifting by funds in response to mid-year performance. We estimate the following pooled cross-sectional regression

$$\Delta Risk = \alpha + \beta_1 H + \beta_2 PERF + \beta_3 H * PERF + \beta_4 LagRisk + \beta_5 Flow + \Sigma_j \beta_j Dummy_j, \quad (4)$$

where H is a dummy variable equal to one if the observation corresponds to a fund that uses a high-water mark to calculate performance fees. We include dummy independent variables for year and interactions between H and the LagRisk, Flow, and the year dummies. From this regression we can infer the relation between past performance and risk for funds that do not use high-water marks in the compensation contract from $PERF$. From $H * PERF$, we can infer the incremental effect that a high-water mark provision has on this relation.

Table VI reports the results from estimating Eq. (4) for the subsample of non-backfilled observations. The results for Models 1a-3b indicate that, as before, the coefficient is significantly negative for each of the three measures of performance. The interaction term $H * PERF$ is, however, significantly positive in each case in Models 1b, 2b and 3b. Therefore, changes in fund risk are negatively associated with mid-year performance even after the backfilling period. However, this relation is significantly weaker among funds that use high-water marks to calculate performance fees. This result holds for all performance variables. For example, an increase in relative performance rank from 0 to 100 is associated with a 0.60% decrease in monthly return standard deviation for funds without high-water marks, as compared to only 0.05% when managers are subject to high-water marks. Meanwhile, the difference in fund risk changes between funds that are above and below water is -0.55% when high-water marks are absent, as compared to only -0.32% if the fund has a high-water mark.

Overall, the results of our regression analysis confirm and extend our initial findings from contingency table tests: Fund managers' incentives to increase risk following poor performance are significantly weaker among funds that advertise to a database and funds that tie the manager's performance pay to the fund's high-water mark asset level. Fund managers apparently increase risk in response to poor mid-year absolute performance, and not relative performance. In the following, we examine how risk-shifting incentives are related to the expected horizon of the fund manager.

IV.C Sorting by Expected Survival Rate

Panageas and Westerfield (2007) show that managerial horizon interacts importantly with the manager's portfolio choice. In this section we examine the extent to which investment horizon interacts with the relation between mid-year performance and changes in fund risk. In the first step, we estimate a probit model of whether the fund disappears from the database at year-end. A fund will disappear from the database for many reasons, including not wanting to advertise following good performance. However, we assume that the fund disappears because it has decided to liquidate fund assets. Following BGP, we include fund specific variables to determine fund disappearance, including fund age, size, and lagged returns. We also include the extent to which the fund is underwater at the start of the year. Consistent with fund disappearance from the database being associated with liquidation, we find that poor performance is a significant predictor of fund disappearance.

Table VII presents results from estimating the probit model. Several variables relate significantly to fund disappearance. Lagged style-adjusted return is significantly negatively related to fund disappearance. For example, funds without high-water marks experience a 3.39% lower likelihood in fund disappearance for every one standard deviation increase in style-adjusted returns. The estimated effect is lower (1.63%) and insignificant for the sample of funds with high-water marks. Fund age and fund size are both negatively related with fund disappearance. Fund disappearance is significantly related to the position of a fund's assets relative to the high-water mark at the previous year-end. Underwater funds with high-water marks are 12.39% more likely to disappear from the database as compared to funds that are not below-water. We estimate a weaker (4.55%) but still significant relation for funds without high-water marks. Raw returns during the first half of the year are negatively related to fund disappearance during the same year. Also, the distance between the fund's assets and its high-water mark is a significant predictor of fund disappearance. Specifically, for funds with high-water marks, a one standard deviation shift away from the fund's high-water mark is associated with a 24.45% increase in the likelihood of fund disappearance. Meanwhile, the relation between JuneUnder and fund disappearance is not significant for funds that do not use high-water marks.

A one standard deviation increase in our fund size reduces the probability of disappearance by 9.10 and 14.07 percent for funds with and without high-water marks, respectively. A negative relation is also found for family age, size, and complexity variables. Table VII also reports a negative relation between fund disappearance and restrictions that limit the liquidity of fund investors. For example, the likelihood of disappearance drops by 5.26 percent per one standard deviation increase in redemption notice period for funds without high-water marks. This pattern is also significant for funds that use high-water marks.

Our probit model can explain a significant amount of the variation in fund disappearance. The probability of fund disappearance estimated by our model might therefore provide a suitable proxy for the expected horizon of fund manager. We estimate the probability of fund disappearance for each fund and year given fund characteristics at the previous year-end. We then repeat our regression tests on subsamples depending on high-water mark and using the predicted probability of disappearance. We interpret funds with low probabilities of disappearance as the ones that have the longest horizon.

To test the relation between prior fund performance and fund distress to alter fund risk characteristics, we estimate the following pooled cross-sectional regression

$$\Delta Risk = \alpha + \beta_1 \text{PFin} + \beta_2 PERF + \beta_3 \text{PFin} * PERF + \beta_4 LagRisk + \beta_5 Flow + \Sigma_j \beta_j Dummy_j, \quad (5)$$

where PFin is the fractional rank of the estimated probability of fund disappearance relative to other funds and measured at the end of first six months of the year. The predicted probability of fund disappearance is obtained from the estimated coefficients of probit models 1b and 2b in Table VII. We include dummy independent variables for year. From this regression we can infer the relation between past performance and risk for funds with the lowest probability of disappearance from $PERF$. From $\text{PFin} * PERF$, we can infer the incremental effect that fund distress, as proxied by a jump from the lowest to the highest probability of fund disappearance, has on this relation. Finally, we can infer the relation between the probability of fund disappearance and changes in fund risk from parameter PFin.

Panel A of Table VIII reports the results from estimating Eq. (5) for the subsample of non-backfilled observations and funds that do not use high-water marks to calculate performance fees. The results for Models 1a-3b indicate that the coefficient $\beta_1 > 0$ and $\beta_3 < 0$. Therefore, changes in fund risk are positively related to the fund's probability of termination, and the propensity for mid-year losers to increase risk is stronger among funds that are more likely to disappear from the database. For Model 1a, for example, an increase in relative performance rank from 0 to 100 is associated with an insignificant 0.23% increase in fund risk for funds with the lowest predicted probability of disappearance. Meanwhile, this figure decreases to a significant 1.15% for funds with the highest likelihood of disappearance. This result holds for all performance variables. Therefore, longer expected manager tenure apparently curbs risk-shifting incentives.

Panel B of Table VIII reports the results from estimating Eq. (5) for the subsample of non-backfilled observations and funds that use high-water marks to calculate performance fees. Our findings from Table VI indicate that the propensity for mid-year losers to increase risk is lower among funds with high-water marks. However, consistent with our findings in Panel A, the results for Models 1a-3b indicate that $\beta_1 > 0$ and $\beta_3 < 0$. For Model 2, for example, an increase in relative performance rank from 0 to 100 is associated with an significant 0.68% increase in fund risk for funds with the lowest predicted probability of disappearance. Meanwhile, this figure decreases to a significantly negative 0.98% for funds with the highest likelihood of disappearance. Therefore, although the propensity for mid-year losers to increase risk is weaker among funds that use high-water marks, the sensitivity of this behavior to investment horizon is apparently similar across the two groups. We interpret this evidence as supportive of the notion in Panageas and Westerfield (2007) that there is an interaction between horizon and the ability of high-water marks to curb risk-taking behavior. Standard risk-shifting problems might not result in hedge funds because managers face a trade-off between current and future payoffs. This logic would seem to apply more to managers with longer expected tenures, and this is confirmed in Table VIII.

V Conclusions

Previous studies report a negative relation between changes in fund risk and mid-year relative fund performance. We find that such "tournament" behavior in hedge funds is far more evident in the backfilled period, before the fund voluntarily reports to a database. In fact, variance shifts depend on absolute rather than relative fund performance after removing the backfilled data. Managers of hedge funds that are below their high-water mark at mid-year are more likely to increase fund risk as compared to mid-year winners. However, this behavior is significantly more pronounced among funds that do not use high-water mark provisions to calculate performance fees, and also among funds that are more likely to disappear from the database. These findings suggest that fund investors may favor the use of HWMs, since they appear to curb risk shifting by hedge fund managers.

Overall, the results of the paper indicate that the type of tournament behavior documented for mutual funds is less evident for hedge funds, other than when the funds are in the incubation stage. Hedge fund risk incentives depend on absolute, rather than relative performance. In addition, the combination of factors such as HWMs, the decision to report to a database, and longer managerial horizons appear to make poorly performing funds quite conservative with regard to risk.

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Table I

Summary Statistics

This table reports summary statistics of key variables calculated from the raw sample of 7,658 hedge funds over the 1989-2007 period. Annual Return is the average net-of-fees compounded monthly return over each available year in a fund's sample period. Standard Deviation is the average standard deviation of monthly fund returns. UnderEnd is the average year-end percentage difference between a fund's asset level and its high-water mark. UnderJune is the average mid-year percentage difference between a fund's asset level and its high-water mark at the previous year-end. UnderEnd and UnderJune are winsorized at the 1st and 99th percentiles. Fund Age and Fund Size are the median observation of a fund's track record length and total assets under management, respectively. Family age is the median number of months between the fund's inception date, and the earliest inception date across all funds under the same fund family. Family size is the median total net assets (in millions of dollars) under management, across all funds under the same management firm. Family complexity is the median number of individual funds under management by the same family. Lockup is an indicator that equals one if the fund has a lockup provision. Redemption notice is the fund's redemption notice period in days. PersCap is an indicator variable that equals one if the fund manager invest personal capital into the fund. Live is an indicator variable that equals one if the fund is not defunct as of August 2, 2008. Backfilled Freq is the proportion of a fund's monthly return observations that precede the date the fund was added to the database. High-water mark is an indicator variable that equals one if the fund is required to recover losses.

Characteristic	N	Mean	StDev	Median	Min	Max
Annual Return	7658	0.09	0.12	0.08	-0.74	5.23
Standard Deviation	7656	0.04	0.03	0.03	0.00	0.74
UnderEnd	7658	0.03	0.09	0.00	0.00	0.58
UnderJune	7646	0.00	0.13	-0.03	-0.17	0.83
Fund Age	7658	37.43	25.29	30.00	1.00	263.00
Fund Size	6817	197.18	1998.85	25.82	0.00	70600.00
Family Age	7593	68.60	49.09	55.00	1.00	332.00
Family Size	7289	1124.40	6560.62	117.03	0.00	158000.00
Family Complexity	7593	5.98	8.74	3.00	1.00	57.00
Lockup Period	7658	0.26	0.44	0.00	0.00	1.00
Redemption Notice	7658	34.91	29.45	30.00	0.00	365.00
Personal Capital?	7658	0.32	0.47	0.00	0.00	1.00
Live?	7658	0.41	0.49	0.00	0.00	1.00
Backfilled Freq	7658	0.57	0.26	0.50	0.00	1.00
High-water Mark?	7655	0.65	0.48	1.00	0.00	1.00

Table II

Below Median Mid-Year Performance and Subsequent Volatility Change

The table reports the number of funds falling in each risk-adjustment ratio (RAR) classification for funds with returns that fall below the median return over January to June in a given year. Panels A, B and C correspond to the full sample, the sub-sample of backfilled observations, and the sub-sample that excludes backfilled observations, respectively. January to June return is defined as the total fund return measured over the first six month of each each year, and is measured relative to a benchmark of the median fund return over that six-month period. RAR is calculated each year as the ratio of the standard deviation of monthly fund returns over the second six-month period to the standard deviation of monthly fund returns over the first six-month period. RAR Low corresponds to observations less than the median for all funds in the calendar year, and RAR High corresponds to observations greater than or equal to the median. The Chi-square numbers represent the $\chi^2(1)$ statistics from the 2x2 contingency table. * and ** indicate rejections of a two-sided test of the null hypothesis of an equal number of funds within each group at 5% and 1% significance levels, respectively.

	Panel A: Full Sample			Panel B: Backfilled			Panel C: Backfill-Free		
Year	RAR Low	RAR High	Chi-Square	RAR Low	RAR High	Chi-Square	RAR Low	RAR High	Chi-Square
1989	45.71	54.29	0.86	45.71	54.29	0.86			
1990	47.12	52.88	0.48	47.12	52.88	0.48			
1991	41.67	58.33	7.97**	41.03	58.97	9.67			
1992	42.38	57.62	9.43**	41.83	58.17	10.42**			
1993	49.17	50.83	0.11	49.16	50.84	0.11	0.00	100.00	0.44
1994	52.03	47.97	1.54	52.93	47.07	3.04			.
1995	51.22	48.78	0.74	51.92	48.08	1.39	33.33	66.67	0.74
1996	45.21	54.79	11.10**	46.04	53.96	4.91*	43.10	56.90	4.13*
1997	47.73	52.27	2.99	45.24	54.76	7.41**	51.53	48.47	0.56
1998	48.24	51.76	2.04	48.00	52.00	1.28	47.77	52.23	1.07
1999	46.57	53.43	8.78**	46.03	53.97	6.03*	47.86	52.14	1.28
2000	44.03	55.97	30.54**	42.81	57.19	24.71**	46.87	53.13	2.88
2001	47.69	52.31	4.98*	45.75	54.25	5.60*	51.76	48.24	1.20
2002	48.75	51.25	1.70	51.05	48.95	0.51	47.62	52.38	3.14
2003	41.16	58.84	100.06**	40.12	59.88	37.09**	41.70	58.30	47.81**
2004	48.88	51.12	1.79	48.42	51.58	0.88	49.91	50.09	0.00
2005	55.35	44.65	46.42**	54.52	45.48	5.23*	56.87	43.13	48.09**
2006	49.43	50.57	0.50	51.88	48.12	0.45	48.62	51.38	2.26
2007	51.15	48.85	1.93			.	51.77	48.23	4.11*
1989-98	47.90	52.10	12.87**	47.80	52.20	9.99**	48.06	51.94	1.18
1989-07	48.48	51.52	31.65**	47.16	52.84	37.57**	49.75	50.25	0.24

Table III

Above/Below High Water Mark at Mid-Year and Subsequent Volatility Change

The table reports the number of funds falling in each risk-adjustment ratio (RAR) classification for funds with returns that fall above or below the fund's high-water mark over January to June in a given year. Panels A, B and C correspond to the full sample, the sub-sample of backfilled observations, and the sub-sample that excludes backfilled observations, respectively. The sample excludes all backfilled observations. Panels A and B correspond to funds without and with high-water marks, respectively. RAR is calculated each year as the ratio of the standard deviation of monthly fund returns over the second six-month period to the standard deviation of monthly fund returns over the first six-month period. RAR Low corresponds to observations less than the median for all funds in the calendar year, and RAR High corresponds to observations greater than or equal to the median. The p-values correspond two-sided contingency test that the null hypothesis of an equal number of funds within each group. The Chi-square numbers represent the $\chi^2(1)$ statistics from the 2x2 contingency table. * and ** indicate rejections of a two-sided test of the null hypothesis of an equal number of funds within each group at 5% and 1% significance levels, respectively.

Panel A: Full Sample

	Funds with January to June Assets Less Than High-water mark			Funds with January to June Assets Greater Than High-water mark			
Year	RAR Low	RAR High	p-value	RAR Low	RAR High	p-value	Chi-square
1989	45.83	54.17	0.69	50.43	49.57	0.93	0.17
1990	29.41	70.59	0.01	53.41	46.59	0.37	6.56*
1991	46.15	53.85	0.47	51.12	48.88	0.74	0.64
1992	47.65	52.35	0.54	51.39	48.61	0.66	0.57
1993	50.00	50.00	1.00	49.81	50.19	0.93	0.00
1994	49.90	50.10	0.96	49.86	50.14	0.96	0.00
1995	54.61	45.39	0.05	46.67	53.33	0.09	6.48*
1996	49.48	50.52	0.86	50.05	49.95	0.97	0.03
1997	49.81	50.19	0.95	50.00	50.00	1.00	0.00
1998	55.33	44.67	0.02	48.05	51.95	0.17	7.03**
1999	50.20	49.80	0.93	49.86	50.14	0.92	0.02
2000	41.04	58.96	0.00	53.99	46.01	0.00	30.98**
2001	48.96	51.04	0.55	50.51	49.49	0.69	0.52
2002	52.73	47.27	0.07	48.16	51.84	0.13	5.61*
2003	47.90	52.10	0.21	50.77	49.23	0.46	2.11
2004	49.57	50.43	0.77	50.18	49.82	0.86	0.12
2005	59.36	40.64	0.00	45.25	54.75	0.00	71.31**
2006	40.12	59.88	0.00	51.98	48.02	0.02	31.74**
2007	68.62	31.38	0.00	48.02	51.98	0.02	52.38**
1989-98	51.12	48.88	0.28	49.41	50.59	0.37	1.94
1989-07	50.89	49.11	0.08	49.62	50.38	0.21	4.71*

Table III

(cont.)

Panel B: Backfilled Sample

Year	Funds with January to June Assets Less Than High-water mark			Funds with January to June Assets Greater Than High-water mark			
	RAR Low	RAR High	p-value	RAR Low	RAR High	p-value	Chi-square
1989	45.83	54.17	0.69	50.43	49.57	0.93	0.17
1990	29.41	70.59	0.01	53.41	46.59	0.37	6.56*
1991	45.56	54.44	0.40	51.57	48.43	0.64	0.93
1992	47.65	52.35	0.54	51.21	48.79	0.70	0.51
1993	50.00	50.00	1.00	49.80	50.20	0.93	0.00
1994	50.11	49.89	0.96	49.58	50.42	0.87	0.02
1995	54.91	45.09	0.08	46.65	53.35	0.13	5.41*
1996	50.29	49.71	0.94	49.84	50.16	0.94	0.01
1997	48.59	51.41	0.74	50.14	49.86	0.94	0.11
1998	52.29	47.71	0.50	49.12	50.88	0.65	0.66
1999	47.95	52.05	0.54	50.52	49.48	0.77	0.45
2000	35.83	64.17	0.00	55.93	44.07	0.00	40.89**
2001	46.95	53.05	0.37	51.02	48.98	0.62	1.04
2002	54.67	45.33	0.11	47.69	52.31	0.24	3.99*
2003	42.62	57.38	0.05	51.67	48.33	0.35	4.85*
2004	47.92	52.08	0.52	50.63	49.37	0.74	0.53
2005	58.52	41.48	0.02	46.23	53.77	0.12	7.52**
2006	42.86	57.14	0.41	50.86	49.14	0.79	0.78
1989-98	50.23	49.77	0.85	49.70	50.30	0.70	0.14
1989-07	48.55	51.45	0.09	50.40	49.60	0.45	3.41

Table III

(cont.)

Panel C: Backfill-Free Sample

Year	Funds with January to June Assets Less Than High-water mark RAR Low	RAR High	p-value	Funds with January to June Assets Greater Than High-water mark RAR Low	RAR High	p-value	Chi-square
1995	37.50	62.50	0.52	60.00	40.00	0.70	0.63
1996	40.35	59.65	0.15	52.84	47.16	0.45	2.69
1997	53.49	46.51	0.52	48.93	51.07	0.68	0.58
1998	57.79	42.21	0.03	45.83	54.17	0.10	7.49**
1999	51.04	48.96	0.75	49.41	50.59	0.79	0.17
2000	47.97	52.03	0.51	50.85	49.15	0.70	0.59
2001	50.60	49.40	0.83	49.43	50.57	0.79	0.11
2002	51.03	48.97	0.59	48.99	51.01	0.57	0.61
2003	48.38	51.62	0.45	50.71	49.29	0.62	0.82
2004	51.96	48.04	0.28	48.82	51.18	0.39	1.93
2005	59.01	40.99	0.00	44.96	55.04	0.00	45.88**
2006	37.59	62.41	0.00	52.50	47.50	0.01	39.26**
2007	69.84	30.16	0.00	47.90	52.10	0.02	53.12**
1989-98	53.13	46.88	0.24	48.25	51.75	0.28	2.43
1989-07	52.00	48.00	0.00	49.14	50.86	0.05	11.73**

Table IV

High-Water Mark Usage and Volatility Change Following Above/Below Water Mark

The table reports the number of funds falling in each risk-adjustment ratio (RAR) classification for funds with returns that fall above or below the funds high-water mark over January to June in a given year. Panels A and B correspond to the sub-samples of funds without and with a high-water mark, respectively. Both samples exclude backfilled observations. January to June return is defined as the total fund return measured over the first six month of each each year, and is measured relative to a benchmark of the median fund return over that six-month period. RAR is defined as the ratio of standard deviation of return for the second six-month period to the standard deviation of the first six-month return. RAR Low corresponds to observations less than the median for all funds in the calendar year, and RAR High corresponds to observations greater than or equal to the median. The Chi-square numbers represent the $\chi^2(1)$ statistics from the 2x2 contingency table. * and ** indicate rejections of a two-sided test of the null hypothesis of an equal number of funds within each group at 5% and 1% significance levels, respectively.

Panel A: Funds without High water marks

	Funds with January to June Assets Less Than High-water mark			Funds with January to June Assets Greater Than High-water mark			
	RAR Low	RAR High	p-val	RAR Low	RAR High	p-val	Chi-square
1995	37.50	62.50	0.52	60.00	40.00	0.70	0.63
1996	36.36	63.64	0.04	54.32	45.68	0.27	5.30*
1997	55.00	45.00	0.37	48.50	51.50	0.59	1.09
1998	57.92	42.08	0.03	44.98	55.02	0.08	7.70**
1999	52.86	47.14	0.41	48.22	51.78	0.48	1.18
2000	47.77	52.23	0.51	51.06	48.94	0.68	0.61
2001	50.21	49.79	0.95	49.49	50.51	0.86	0.03
2002	48.37	51.63	0.55	51.25	48.75	0.64	0.58
2003	49.80	50.20	0.95	49.89	50.11	0.96	0.00
2004	51.06	48.94	0.72	49.10	50.90	0.70	0.27
2005	63.71	36.29	0.00	42.56	57.44	0.00	30.17**
2006	25.86	74.14	0.00	54.11	45.89	0.03	31.55**
2007	76.47	23.53	0.00	48.04	51.96	0.30	15.39**
1989-98	52.74	47.26	0.32	48.16	51.84	0.29	1.97
1989-07	51.25	48.75	0.23	49.16	50.84	0.23	2.74

Table IV

(cont.)

Panel B: Funds with High water marks

	Funds with January to June Assets Less Than High-water mark			Funds with January to June Assets Greater Than High-water mark			
	RAR Low	RAR High	p-val	RAR Low	RAR High	p-val	Chi-square
1996	0.00	100.00	.	50.00	50.00	1.00	1.78
1997	33.33	66.67	0.47	50.00	50.00	1.00	0.58
1998	62.50	37.50	0.33	46.67	53.33	0.57	1.32
1999	41.94	58.06	0.38	51.75	48.25	0.71	0.94
2000	48.94	51.06	0.89	49.67	50.33	0.94	0.01
2001	49.50	50.50	0.92	49.78	50.22	0.95	0.00
2002	53.37	46.63	0.21	47.11	52.89	0.23	2.99
2003	45.34	54.66	0.10	51.86	48.14	0.31	3.74
2004	52.48	47.52	0.28	48.57	51.43	0.39	1.93
2005	56.81	43.19	0.00	46.07	53.93	0.01	19.07**
2006	41.35	58.65	0.00	51.84	48.16	0.11	15.08**
2007	68.50	31.50	0.00	47.81	52.19	0.04	38.99**
1989-98	50.00	50.00	1.00	48.06	51.94	0.66	0.03
1989-07	52.28	47.72	0.02	49.12	50.88	0.11	7.97**

Table V

Regressions of Change in Risk on Past Performance

in the Same Calendar Year by Backfilling

Results of regression analyses testing the relation between the change in risk variable between the first six months and the second six months of the year, and hedge fund performance during the first six months of the year. The dependent variable is the change in risk variable between the first six months and the second six months of the year. Risk is measured as the sample standard deviation of the monthly raw return. Independent variables include a dummy variable equal to one if the observation falls before the fund was added to the database (B) and a dummy variable equal to one if the fund's assets at mid-year are below their high-water mark (AbsWin). RelRnk is the fractional rank of the fund's raw return in the first six months relative to that of all other funds. AbsRnk is the fractional rank of the distance of a fund's net assets at mid-year to its high-water mark measured at the end of the previous year. Flow is the percentage net flow in the second half of the year. LagRisk is the value of the risk variable during the first six months. Each regression also includes dummy independent variables (not reported) for year and year interacted with A. Dependent variables are windsorized at the 1% level. t-statistics for tests of the null hypothesis that the coefficient equals zero are reported. Standard errors allow for clustering at the level of the fund company.

	1a	1b	2a	2b	3a	3b	4a	4c	5a	5c
RelRNK	-0.0059	-0.0063					0.0008	0.0015	0.005	0.0052
	5.59**	4.93**					0.7	1.06	3.00**	2.75**
RelRNK*A	0.0031	0.0033					0.0006	-0.0002	-0.0012	-0.0018
	2.51*	2.33*					0.45	0.12	0.6	0.81
AbsWin			-0.0068	-0.0076			-0.0071	-0.0082		
			10.63**	10.58**			10.31**	10.82**		
AbsWin*A			0.0024	0.0033			0.0022	0.0034		
			3.20**	3.93**			2.53*	3.71**		
AbsRNK					-0.0087	-0.0094			-0.0129	-0.0135
					8.12**	7.31**			7.49**	6.99**
AbsRNK*A					0.0031	0.0036			0.0037	0.0047
					2.34*	2.42*			1.7	2.03*
LagRISK	-0.2146	-0.2158	-0.2399	-0.2427	-0.2242	-0.2258	-0.2418	-0.246	-0.2312	-0.233
	13.66**	12.11**	15.55**	14.07**	14.69**	13.14**	15.05**	13.71**	14.88**	13.41**
LagRISK*A	0.0037	0.0088	0.01	0.0169	0.0076	0.0129	0.0087	0.0173	0.0099	0.0159
	0.18	0.41	0.49	0.79	0.38	0.62	0.41	0.78	0.49	0.75
Flow		-0.0006		-0.0003		-0.0002		-0.0004		-0.0003
		1.71		0.97		0.58		1.14		0.73
Flow*A		-0.0004		-0.0004		-0.0005		-0.0005		-0.0005
		0.89		1		1.1		1.02		1.12
A	0.0016	-0.0104	0.0012	-0.0162	0.0002	-0.0149	0.0005	-0.0173	-0.0016	-0.0178
	1.13	3.78**	0.88	6.01**	0.13	5.48**	0.34	6.07**	1.09	6.13**
Intercept	0.0111	0.0126	0.0151	0.0171	0.0146	0.0164	0.015	0.0171	0.0153	0.017
	4.51**	4.58**	6.12**	5.99**	5.75**	5.69**	6.11**	5.92**	6.08**	5.88**
Observations	30364	25532	30369	25537	30364	25532	30364	25532	30364	25532
R-squared	0.23	0.23	0.23	0.24	0.23	0.23	0.23	0.24	0.23	0.23

* significant at 5% level; ** significant at 1% level

Table VI

Regressions of Change in Risk on Past Performance in the Same Calendar Year by High-water Mark

Results of regression analyses testing the relation between the change in risk variable between the first six months and the second six months of the year, and hedge fund performance during the first six months of the year. The dependent variable is the change in risk variable between the first six months and the second six months of the year. Risk is measured as the sample standard deviation of the monthly raw return. Independent variables include a dummy variable equal to one if the fund has a high-water mark (H) and a dummy variable equal to one if the fund's assets at mid-year are below their high-water mark (AbsWin). RelRnk is the fractional rank of the fund's raw return in the first six months relative to that of all other funds. AbsRnk is the fractional rank of the distance of a fund's net assets at mid-year to its high-water mark measured at the end of the previous year. Flow is the percentage net flow in the second half of the year. LagRisk is the value of the risk variable during the first six months. Each regression also includes dummy independent variables (not reported) for year and year interacted with H. Dependent variables are windsorized at the 1% level. t-statistics for tests of the null hypothesis that the coefficient equals zero are reported. Standard errors allow for clustering at the level of the fund company.

	1a	1b	2a	2b	3a	3b
RelRNK	-0.0028	-0.006				
	3.89**	4.77**				
RelRNK*H		0.0055				
		3.76**				
AbsWin			-0.0042	-0.0055		
			8.80**	7.46**		
AbsWin*H				0.0023		
				2.58**		
AbsRNK					-0.0053	-0.0077
					6.40**	6.04**
AbsRNK*H						0.0046
						2.92**
LagRISK	-0.2044	-0.195	-0.2226	-0.2172	-0.2106	-0.2048
	14.34**	9.58**	15.22**	10.54**	14.88**	10.22**
LagRISK*H		-0.0199		-0.0128		-0.0132
		0.76		0.48		0.51
Flow	-0.001	-0.0014	-0.0008	-0.0013	-0.0007	-0.0011
	3.41**	2.58**	2.66**	2.43*	2.35*	2.09*
Flow*H		0.0005		0.0007		0.0005
		0.72		1.09		0.75
H		-0.0038		-0.0033		-0.0042
		1.09		0.92		1.14
Constant	0.0079	0.0109	0.0144	0.0156	0.0126	0.0138
	10.11**	8.18**	26.90**	19.26**	29.51**	21.07**
Observations	16277	16277	16281	16281	16277	16277
R-squared	0.25	0.25	0.25	0.25	0.25	0.25

* significant at 5% level; ** significant at 1% level

Table VII

Fund Disappearance and Fund Return, Risk, and Other Characteristics

This table reports the output from a standard Probit regression that examines the relation between fund disappearance in a given year and lagged observations of fund characteristics. LagRawRet and LagStyleRet refers to the lagged annual raw return and return in excess of the annual return of a value-weighted portfolio of funds of the same style. LagUnder is an indicator variable that takes the value of one if the funds assets are below the funds highwater mark. JuneUnder is the percentage distance between the fund's high-water mark and the assets. LagStnDev is the standard deviation of the funds return. JuneSize and JuneAge are the natural logarithms of the funds estimated asset value (in millions of dollars) and number of monthly return observations reported by a fund since the date of the first return observation, respectively. LagFamSize and LagFamAge are the natural logarithms of the fund familys estimated asset value (in millions of dollars) and number of monthly return observations reported by the fund family since the date of the first return observation, respectively. LagFamNum is the natural logarithm of the number of funds managed by the same fund family. Lag variables are measured at the end of the previous year. June variables are measured at the end of the first semi-annual period of the current year. Lockup is an indicator variable that takes the value of one if the fund has lockup; RedNotice is the funds redemption notice period (in days); and PersCap is an indicator variable that equals one if the fund manager invests personal capital into the fund. These variables are standardized to have a zero mean and variance of one across funds. Models 1 and 2 correspond to funds without and with high-water marks, respectively. Models 1b and 2b include fund style fixed effects (Models 1a and 2a do not). Marginal effects are reported for each variable. For the indicator variable Lockup, discrete marginal effects are reported. The sample excludes backfilled observations. Heteroskedasticity-consistent t-statistics are reported below marginal effects. * and ** indicate significance at 5% and 1% levels, respectively, of a two-tailed test that the coefficient equals zero.

Table VII

cont.

Lagged Fund Variables	Funds without high-water mark 1a	Funds without high-water mark 1b	Funds with high-water mark 2a	Funds with high-water mark 2b
LagRawRet	0.0243	0.0221	-0.0064	0.0033
	2.11*	1.91*	0.38	0.19
LagStyleRet	-0.0374	-0.0339	-0.0021	-0.0163
	3.30**	2.99**	0.11	0.84
LagUnder	0.0511	0.0455	0.1387	0.1239
	2.69**	2.35**	7.66**	6.70**
JuneRawRet	-0.0272	-0.0279	-0.059	-0.0591
	3.73**	3.72**	5.73**	5.41**
JuneUnder	0.0914	0.0782	0.2123	0.2445
	1.52	1.31	2.85**	3.08**
LagStnDev	0.042	0.0472	-0.0257	-0.0134
	4.73**	4.94**	2.52**	1.22
JuneAge	-0.0825	-0.0683	-0.0609	-0.0628
	5.90**	4.83**	4.91**	4.93**
JuneSize	-0.1234	-0.1407	-0.0786	-0.091
	10.37**	11.45**	7.20**	8.13**
LagFamAge	-0.0368	-0.0457	-0.0298	-0.0184
	1.65*	2.02*	1.69*	1.01
LagFamSize	-0.021	-0.0245	-0.0144	-0.0169
	1.43	1.64	1.1	1.27
LagFamNum	-0.1072	-0.0829	-0.0574	-0.0516
	9.54**	7.06**	5.21**	4.54**
Lockup	-0.1484	-0.1706	-0.0149	-0.0369
	6.26**	7.01**	1.08	2.57**
RedNotice	-0.0387	-0.0526	-0.0149	-0.0111
	4.81**	6.07**	2.12*	1.48
PersCap	0.0385	0.0134	-0.0655	-0.0731
	2.68**	0.89	4.79**	5.25**
Pseudo-R2	0.1776	0.2073	0.0795	0.1079
Observations	5932	5932	6582	6582
Style fixed effects?	no	yes	no	yes

* significant at 5% level; ** significant at 1% level

Table VIII

Regressions of Change in Risk on Past Performance in the Same Calendar Year by Fund Horizon

Results of regression analyses testing the relation between the change in risk variable between the first six months and the second six months of the year, and hedge fund performance during the first six months of the year. The dependent variable is the change in risk variable between the first six months and the second six months of the year. Risk is measured as the sample standard deviation of the monthly raw return. Independent variables include PFin-the fractional rank of the estimated probability of fund disappearance relative to other funds and measured at the end of first six months of the year. The predicted probability of fund disappearance is obtained from the estimated coefficients of probit models 1b and 2b in Table VII. Other variables include a dummy variable equal to one if the fund's assets at mid-year are below their high-water mark (AbsWin). RelRnk is the fractional rank of the fund's raw return in the first six months relative to that of all other funds. AbsRnk is the fractional rank of the distance of a fund's net assets at mid-year to its high-water mark measured at the end of the previous year. Flow is the percentage net flow in the second half of the year. LagRisk is the value of the risk variable during the first six months. Each regression also includes dummy independent variables (not reported) for year. Dependent variables are windsorized at the 1% level. t-statistics for tests of the null hypothesis that the coefficient equals zero are reported. Standard errors allow for clustering at the level of the fund company.

Panel A: Funds without high-water marks

	1	2	3	4	5	6
RelRNK	-0.0061	0.0023				
	4.81**	0.99				
RelRNK*PFin		-0.0138				
		3.02**				
AbsWin			-0.0058	-0.0003		
			7.60**	0.18		
AbsWin*PFin				-0.0077		
				2.81**		
AbsRNK					-0.0092	0.0009
					6.41**	0.31
AbsRNK*PFin						-0.0166
						3.26**
LagRisk	-0.2015	-0.2276	-0.2243	-0.242	-0.2126	-0.2374
	9.09**	9.28**	9.99**	9.85**	9.75**	9.85**
Flow	-0.0015	-0.0017	-0.0013	-0.0017	-0.0011	-0.0012
	2.55*	2.30*	2.37*	2.38*	1.92	1.68
PFin		0.014		0.0112		0.0137
		5.28**		4.40**		4.82**
Constant	0.0112	0.0024	0.0057	0.0053	0.0148	0.005
	8.19**	0.87	9.21**	1.84	19.31**	1.67
Observations	6834	5084	6836	5084	6834	5084
R-squared	0.25	0.25	0.25	0.25	0.25	0.25

* significant at 5% level; ** significant at 1% level

Table VIII

cont.

Panel B: Funds with high-water marks

	1	2	3	4	5	6
RelRNK	-0.0002	0.0068				
	0.32	3.75**				
RelRNK*PFin		-0.0166				
		5.41**				
AbsWin			-0.003	0		
			5.44**	0.02		
AbsWin*PFin				-0.0063		
				2.97**		
AbsRNK					-0.0026	0.0039
					2.89**	1.88
AbsRNK*PFin						-0.0173
						5.26**
LagRisk	-0.2038	-0.2435	-0.2176	-0.252	-0.2061	-0.2502
	12.19**	13.96**	12.69**	14.26**	12.49**	14.43**
Flow	-0.0009	-0.0011	-0.0006	-0.0008	-0.0007	-0.0006
	2.90**	2.24*	1.8	1.69	1.92	1.19
PFin		0.011		0.0058		0.0092
		6.19**		2.92**		5.11**
Constant	0.0166	0.0049	0.0146	0.0098	0.0182	0.009
	5.49**	1.12	3.54**	2.38*	5.95**	2.05*
Observations	9443	5858	9445	5858	9443	5858
R-squared	0.25	0.22	0.25	0.23	0.25	0.23

* significant at 5% level; ** significant at 1% level