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Compensation Options, Managerial Incentives, and Risk Taking in Hedge Funds

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Abstract

Hedge fund managers with asymmetric performance-based compensation packages have the incentive to increase the risk exposure of their funds in response to poor performance. Based on regression analysis of data from a panel of dollar-based hedge funds from 1994-2008, we find evidence that they do just that. A fund with net asset value (NAV) below its previous high-water mark (out of the money) tends to increase its exposure to risk. The result is robust for relatively small hedge funds, somewhat less so for large hedge funds. A hedge fund with NAV above its high-water mark (in the money) tends to decrease its exposure to risk. Furthermore, a hedge fund tends to increase exposure to risk following a period of negative returns (regardless of whether the fund is in, at, or out of the money). The result is robust for hedge funds that earn below-normal performance fees, somewhat less so for hedge funds that pay normal or above-normal performance fees.

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I. Introduction

The increasing economic significance of hedge funds has drawn attention to the risk-taking behavior of hedge fund managers. Hedge funds are largely unregulated, and managers receive both management fees and performance fees which usually amount to 20% of the value they "created" during the time period. Managers are awarded performance fees on a certain amount of capital if the fund's return surpasses a hurdle rate, say LIBOR, *and* the net asset value (NAV) of the capital surpasses its past high-water mark. The high-water mark represents the highest past value achieved for a certain amount of capital inflow. The compensation structure is asymmetric, however, in that hedge funds managers usually do not get penalized if they do not create value for their investors.

Past literature suggests that hedge fund managers paid with asymmetric performance-based compensation have the incentive to adjust the risk exposure of their funds in the hope of improving performance. In essence, the compensation structure provides managers with a long option on the fund's assets. By increasing holdings of risky assets, they increase the value of the option. For example, Carpenter (2000) shows analytically that the optimal strategy for out-of-the-money managers is likely to result in payoffs that are either well into the money or far out of the money -- that is, more risky strategies. Elton, Gruber, and Blake (2003) studied a group of mutual fund managers who are paid like hedge fund managers and report that they tend to increase exposure to risk in response to poor previous performance. [1]

On the other hand, a number of factors may reduce the incentive to adjust risk-taking. These factors include:

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[1] It is quite rare for mutual fund managers to receive performance fees. Elton, Gruber, and Blake (2003) studied a sample of about 100 managers.

- long horizons for managers (Hodder and Jackwerth (2007), Panageas and Westerfield (2009))
- fear of termination if the fund value falls too far (Brown, Goetzmann, and Park (2001), Panageas and Westerfield (2009))
- investment of a substantial amount of the manager's own money in the hedge fund (Kouwenberg and Ziemba, (2007))
- reputational concerns or contractual constraints (Fung and Hsieh (1997)).

Empirical evidence on risk-taking for hedge funds is scant. Brown, Goetzmann, and Park (2001) find no evidence of significant changes in risk exposure for hedge funds holding an in- or out-of-money compensation option, but do find that funds that perform poorly *relative* to the median performance of all hedge funds tend to increase risk. Clare and Motson (2009) present a similar finding. Aragon and Nanda (2009) find that hedge fund managers increase risk in response to poor absolute performance, though not relative performance. Of these studies, only Aragon and Nanda use regression analysis as we do.

In this paper, we seek to answer the questions: Do hedge fund managers shift their risk taking in response to previous performance (absolute or relative), and how do fund characteristics like size, liquidity, and level of performance fee affect risk taking? To achieve our goal, we assume one-year evaluation periods for a manager's performance and consider changes to the riskiness of the hedge fund's portfolio at mid-year over the period 1994-2008. We consider four major possibilities that have not been considered by previous researchers: (1) managers could respond differently with regard to risk taking to positive or negative returns in the first half year of the evaluation period, (2) performance could matter for risk taking on more than one dimension – e.g., the effect of a fund experiencing a positive return might depend on whether the fund is in, at, or out of the money, (3) characteristics of the hedge fund such as size, liquidity, and level of performance fee could impact the response of risk taking to previous performance, and (4) characteristics of the hedge fund could matter for risk taking on more than one dimension – e.g., the effect of being a larger firm might depend on whether it has a liquid or illiquid portfolio.

The major findings are

1. Hedge funds that are out of the money tend to display greater volatility (which we take to reflect greater risk taking) than funds that are at the money. The finding is robust for relatively small hedge funds, somewhat less so for relatively large hedge funds.
2. Hedge funds that are in the money tend to display less volatility than funds that are at the money.
3. The more negative is the return on a hedge fund's portfolio in the first half of the year, the greater the increase in volatility of returns in the second half of the year. The finding is robust for hedge funds that pay below-normal performance fees, less so for funds that pay normal or above-normal performance fees.
4. Funds that have returns below the median of all hedge funds in the first half of the year do not tend to display greater volatility in the second half of the year.
5. The size of a hedge fund has significant interactions with other fund characteristics, with the greatest volatility being for a small fund that is relatively liquid, earned above-normal performance fees, and did not survive to the end of the sample period.

The paper proceeds next with a discussion of research design and data, then moves on to the results, robustness checks, and a conclusion**.**

2. Research Design and Data

The data for this study come from the CISDM Hedge Fund Database, a major data vendor which provides information on performance and various characteristics of thousands of hedge funds, funds of hedge funds, and CTAs.[2] For each fund we observe monthly net-of-fees returns, net asset value (NAV), fund's survivorship as of the reporting month, major trading strategy claimed by the fund, whether the fund is listed on an exchange, and the regulation agency for the fund. For most funds, we are also able to get information on their assets under management, level of performance fees, and initiation month of the fund. The oldest fund in the database dates from 1976. We examine monthly data from January 1994 to December 2008 and include both live and defunct funds to minimize survivorship bias (prior to 1994, like other major vendors, CISDM does not keep track of funds that later became defunct). We focus on the decision-making of individual hedge fund managers and exclude funds of hedge funds and CTAs. Altogether there are 6419 individual performance-characteristics observations with return history from January 1994 to December 2008, all US dollar funds. Our sample contains considerably more funds than the samples used by Brown, Goetzmann, and Park (2001) who examine hundreds of hedge funds and CTAs or Elton, Gruber, and Blake (2003) who examine about 100 mutual funds. It is comparable to that of Aragon and Nanda (2009), but with one more year of coverage.

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

An empirical study related to management compensation options requires a proxy for the high-water mark of management compensation. The high-water mark represents the highest past value achieved for a certain amount of capital inflow. There is no single high-water mark, however, even for the same investor in a fund, as it differs for individual cash flows. Managers earn performance fees on a certain amount of capital if the fund's return surpasses a hurdle rate, say LIBOR, *and* the NAV of the capital surpasses its past high-water mark. Hedge funds report their total assets under management (AUM) to databases on a monthly basis but do not disclose the individual money flow. That makes it difficult to track the high-water mark for each capital inflow.

To address this challenge, Brown, Goetzmann, and Park (2001) use zero annual return as the proxy for the representative high-water mark for a hedge fund. Specifically, if the fund has a positive annual return, they assume it has surpassed the high-water mark, in which case the manager will be awarded performance fees. If the fund has a negative annual return, they assume it has not surpassed the high-water mark, in which case the manager receives only a management fee. They find no evidence that managers shift risk-taking in response to compensation options that are out of the money.

We use a different proxy for the high-water mark used to trigger performance fees for the hedge fund manager. It is based on, but not exactly equal to, the highest previously-reached NAV for the fund. First, we consider only the most recent three years, rather than the entire history of the fund, and identify the highest NAV for that period. We then assume the representative high-water mark is some proportion, η, of the highest NAV for the three-year window, where $0 < \eta \leq 1$. Therefore, we can write the relationship between the representative high-water mark and highest NAV for fund i in jth three-year evaluation window as:

$HWM_{i,j} = \eta * MaxNAV_{i,j}$ where $0 < \eta < 1$

We then assume the manager judges his/her compensation option to be in, at, or out of the money by the following rule:

$$NAV_{i,k} \geq MaxNAV_{i,j}: in - the - money\ compensation\ option$$

$$NAV_{i,k} < HWM_{i,j}: out - of - the - money\ compensation\ option$$

$$HWM_{i,j} \leq NAV_{i,k} < MaxNAV_{i,j}: at - the - money\ compensation\ option$$

Where $NAV_{i,k}$ *is the NAV of fund i during the kth decision year.*

As our measure of hedge-fund risk, we use the volatility of excess returns for a hedge fund. We assume the hedge fund manager receives performance fees, if applicable, at the end of the calendar year. Our interest is mid-year changes in volatility as a result of early-in-the-year performance, so we focus on the relationship between volatility in the second half of the year and volatility in the first half of the year. Although volatility is not a perfect measure of risk and there are many alternatives – including semi-deviation, expected shortfall, and VaR – we believe volatility is a good choice for comparing risk taking for different periods of time. In addition, it is clear that hedge fund managers have the ability to manipulate volatility as shown by Goetzmann, Ingersoll, Spiegel, and Welch (2006), Getmansky, Lo, and Markarov (2004), and Bollen and Poll (2008). Volatility is also the measure of risk used by Brown, Goetzmann, and Park (2001) and Aragon and Nanda (2009).

We estimate the following regression equation in linear form for the pooled sample of hedge funds over the 1994 to 2008 period. We use data from 1991-93 to calculate HWM for the first three years of our sample period, 1994-96. We then pool the fund-return observations for all U.S. dollar-based hedge funds, providing a sample of 6419 observations for which all of the data required to estimate the regression model are available.

$$(1)\ StdRatio_i - PastStdRatio_i = f(PastStdRatio_i, PrevPerformance_i, FundCharacteristics_i, InteractionTerms_i, StyleEffects, FixedEffects, \varepsilon)$$

where *i* indexes an individual hedge fund for a given year and ε is an error term.

StdRatio is the average monthly volatility of a hedge fund's return for the second half of the year divided by the average monthly volatility of returns for the Standard & Poor's 500 stock market index. Although we recognize that the manager can alter the fund's riskiness at any time during the year, we assume for tractability that changes are made to the fund's asset mix only at mid-year (July 1).

PastStdRatio is the same variable calculated for the first half of the year. Engle and Mustafa (1992) and Lamoureux and Lastrapes (1993) find that volatility of hedge fund returns is highly persistent but stationary over time. We're interested in changes in volatility during the year, so we use the difference between *StdRatio* and *PastStdRatio* as the dependent variable. We also include *PastStdRatio* as a regressor and expect the coefficient to be between 0 and -1 reflecting persistent but stationary volatility. The degree of persistence in volatility movements will therefore be 1 + the coefficient for *PastStdRatio*.[3]

PrevPerformance is a vector of variables relating to previous performance of the hedge fund. We estimate a number of different specifications with the variables sometimes included by

[3] Because we compare volatilities within a single calendar year (second half compared to first half), we do not consider the possibility that volatility movements persist from one year to another. We expect they would, however.

themselves or in sets and sometimes in combination with other performance variables or sets of variables.

One set is *InMoney, AtMoney, and OutMoney*. *InMoney* equals 1 if NAV is greater than its previous maximum for the three-year evaluation period (*MaxNAV*) and zero otherwise. In this case, we consider the manager's compensation option to be in the money. We expect the coefficient to be negative. *OutMoney* equals 1 if NAV is less than 90% of *MaxNAV* and zero otherwise. In this case, we consider the manager's compensation option to be out of the money. In other words, we set the value of η (the threshold value) at .90. We expect the coefficient to be positive. Thus, the excluded dummy variable will be *AtMoney* which equals 1 if NAV is between 90% and 100% of *MaxNAV* and zero otherwise. In this case, we're not sure whether the manager's compensation option is in or out of the money, but we think of it as "at the money."

Another set is *PosAvgRet* and *NegAvgRet*. *PosAvgRet* is the maximum of the average monthly return for the first half of the year and zero. *NegAvgRet* is the minimum of the average monthly return for the first half of the year and zero. With these two variables, we allow for the possibility that managers react differently to positive and negative first-half performance. We expect the coefficient for *PosAvgRet* to be negative if higher early-in-the-year returns induce managers to take on less risk later in the year. We expect the coefficient for *NegAvgRet* to also be negative if larger negative returns lead to increased risk later in the year.

A third set is *BelowMedian* and *AboveMedian*. *BelowMedian* = 1 if the hedge fund return is below the median for all hedge fund returns and 0 otherwise. *AboveMedian* is the opposite and will be the excluded dummy variable. If managing a hedge fund can be regarded as a "tournament" as in Brown, Starks, and Harlow's (1996) analysis of mutual fund managers, then "losing" firms might increase risk mid-year to increase the probability of emerging as a "winner" at the end of the year. Assuming that hedge fund managers behave in a manner similar to their mutual fund peers, we would expect the coefficient to be negative[4].

FundCharacteristics is a vector of variables representing characteristics of the hedge funds. These include *Illiquid*, *Survival*, *HighFee*, *LowFee*, and *Size*. All of these are dummy variables, and their counterparts are excluded from the estimated equations as appropriate.

Illiquid =1 if the first-order autocorrelation coefficient for the monthly returns of the hedge fund for the previous three years is above the median for all hedge funds and 0 otherwise. Asness, Krail and Liew (2001) and Getmansky, Lo, and Markarov (2004) use the first-order autocorrelation coefficient for returns as a proxy for the liquidity of asset holdings, with high autocorrelation indicating illiquidity. A hedge fund that holds relatively illiquid assets may compensate for a high level of liquidity risk by holding assets with less volatile returns. It may also be constrained in shifting its risk taking. We expect the coefficient to be negative.

Survival = 1 if the hedge fund remains in the database at the end of the sample period (December 2007) and 0 otherwise. Liang (1999), Brown, Ibbotson and Goetzmann (1999), Fung and Hsieh (2000), and Liang and Park (2007), among others, provide evidence that hedge funds that have since gone defunct displayed more volatile returns especially as their "deaths" grew near. We therefore expect the coefficient to be negative.

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[4] Brown, Harlow and Starks (1996) find evidence of a "tournament effect" in mutual funds, which are ranked in mid-year. As in a sports tournament, mid-year winning mutual funds reduce their risk-taking in the second half year in an attempt to secure existing performance while mid-year losing mutual funds increase their risk-taking in the second half year in in an attempt to improve full-year performance.

HighFee =1 if the performance fee for the hedge fund manager exceeds the industry standard of 20% and 0 otherwise. Kouwenberg and Ziemba (2007) find for a sample of funds of hedge funds that those offering higher incentive fees for managers tend to have higher returns and greater risk. We expect funds earning higher incentive fees to be more sensitive to the "moneyness" of their compensation and therefore expect the coefficient to be positive.

LowFee = 1 if the performance fee for the hedge fund manager is below the industry standard of 20% and 0 otherwise. Hedge funds with lower incentive fees are expected to be less sensitive in adjusting risk-taking in response to a change in the "moneyness" of their compensation option.

Size = 1 if a fund has above-median size and 0 otherwise. Fund size refers to the amount of assets under management, which is also the base for management fees charged. Compared to performance fees, management fees are a more steady income stream and an important source of compensation for managers, especially when managers are not able to earn performance fees. Hedge funds are usually smaller than mutual funds which means that performance fees tend to dominate managerial compensation for hedge funds. As a hedge fund grows, however, management fees become more important and may mitigate the desire to take extra risks in pursuit of performance fees. Akermann et al (1999) and Liang (2000), among others, find evidence of such an effect. Larger funds tend to take on less risk, so we expect a negative coefficient for size.

InteractionTerms allow us to test for interaction effects between the variables included in the model. We include every interaction term that makes sense. That is, we do not include interactions that do not make sense such as between *InMoney* and *OutMoney*. The interaction terms allow us to consider three major possibilities:

(1) performance could matter for risk taking on more than one dimension – e.g., the effect of a fund experiencing a positive return might depend on whether the fund is in, at, or out of the money,

(2) characteristics of the hedge fund -- size, liquidity, survival status, and level of performance fee could impact the response of risk taking to previous performance,

(3) characteristics of the hedge fund could matter for risk taking on more than one dimension – e.g., the effect of being a larger firm might depend on whether it has a liquid or illiquid portfolio.

StyleEffects are dummy variables that represent the different "styles" of hedge funds that are recognized in the market[5]. If a fund belongs to a certain style "XX", then dummy styleXX is set to 1. The base case used in our regression is equity hedge.

FixedEffects are dummy variables that represent each decision year in the sample period.

3. Empirical Results

3.1 Summary Statistics

The summary statistics for our sample of hedge funds are reported in Table 1. To enter our sample, each hedge fund is required to have full 48-month return history, together with key

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[5] Even though hedge funds share a common name, they are very heterogeneous in terms of trading strategies and exhibit quite different risk profiles. They are categorized into various styles to reflect this fact. For our sample, there are 21 styles: capital structure arbitrage, convertible arbitrage, distressed securities, emerging markets, equity hedge, equity long, equity market neutral, event driven, fixed income, fixed income – mortgage based, fixed income arbitrage, global macro, market timing, merger arbitrage, multi-strategies, other relative value, RegulationD, relative value-multi-strategy, sector, short-biased, and single strategy.

characteristic information, including fund size (AUM), strategy followed by manager (style). We only include US dollar funds. After applying the above filters, there are 6419 individual fund performance-characteristic observations appearing in the database at some point between January 1994 and December 2008 with the number increasing every year steadily before declining somewhat in 2008. Not all funds in the database have data on assets under management (AUM) and the ones that do not are excluded from the regression analysis. The mean level of AUM increased from $137 million in 1994 to $237 million in 2008while the median increased from $42 million to $67 million. A performance fee of 20% is the industry standard, with 77.5% of funds paying 20% in 2008.

We report in Table 2 the summary statistics of our constructed proxy for the compensation option when the threshold value is selected to be 0.9. That is, funds with NAV less than 90% of its maximum value over the previous three years are considered to have compensation options for managers that are out of the money.On average over the period 1994-2008, 52% of the hedge funds held an "in-the-money" compensation option, 21% were "at the money" and 27% "out of the money." However, the most recent year of 2008 shows 56% out of the money, reflecting the collapse in asset values resulting from the subprime mortgage crisis.

3.2 Regression Results

We present in Table 3 the results of estimating five versions of Equation 1 and summarize below. Only interaction terms with statistically significant coefficients at the 5% level are included in the reported estimates. Standard errors are adjusted for heteroskedasticity using the Eicker-White method. We do not present the detailed results for either the style effects or the fixed effects. Interested persons may contact the authors for the detailed results.

PastStdRatio: The estimated coefficient for the lagged dependent variable, *PastStdRatio*, varies from -0.42 to -0.47 across the five different specifications and is always statistically significant. The estimates indicate that volatility is persistent but stationary as expected (recall that the dependent variable is *StdRatio – PastStdRatio*). In this specification, the degree of persistence in volatility movements (ρ) is equal to 1 + the coefficient for PastStdRatio, so estimates of ρ range from 0.53 to 0.58.

PrevPerformance: With the exception of *BelowMedian*, variables relating to previous performance generally have statistically significant effects on volatility when included in the equation as a set with no other performance variables. When included along with other performance variables in estimated regressions, however, the results are somewhat mixed. But in every specification being out of the money significantly increases volatility at least for funds of below-median size, and being in the money significantly reduces volatility (relative to being at the money). A large negative average return always increases volatility at least for funds that pay below-normal performance fees.

In column 1 the only performance variables included are *InMoney* and *OutMoney*. The coefficient for *InMoney* is negative as expected, and the coefficient for *OutMoney* is positive as expected. Both effects are statistically significant. However, the effect of *OutMoney* for a fund above median size (the sum of the coefficients for *OutMoney* and *Size*OutMoney*), is not statistically significant though is still positive. A fund that is in the money reduces volatility on average by 4.8% of its standard deviation compared to an at-the-money fund. A relatively small fund that is out of the money increases volatility onv average by 6.4% of its standard deviation compared to an at-the-money fund.[6]

In column 2 the only performance variables included are *PosAvgRet* and *NegAvgRet*. The coefficient for *NegAvgRet* is negative and statistically significant and for *PosAvgRet* is positive but not significant. That is, smaller negative returns reduce volatility and larger negative returns increase volaitility as expected.There are no significant interactions with fund characteristics. A one-standard-deviation increase in *NegAvgRet* reduces volatility by 7.5% of its standard deviation.

In column 3 the only performance variable included is *BelowMedian*. The effect on volatility of a return that is below the median for all hedge funds is essentially zero – i.e., far from statistical significance. There are no significant interactions with fund characteristics.

In Column 4 *PosAvgRet*, *NegAvgRet*, *InMoney*, and *OutMoney* are included without *BelowMedian*. The effect of *InMoney* is negative and significant, and the effect of *OutMoney* is positive and significant. A fund that is in the money reduces volatility on average by 6% of its standard deviation compared to an at-the-money fund. A fund that is out of the money increases volatility on average by 2.7% of its standard deviation compared to an at-the-money fund. Note that in this specification, there is no significant interaction with size of the fund. The effect of *PosAvgRet* is positive and now statistically significant for the first time, suggesting the possibility that larger positive returns increase volatility relative to returns close to zero. Perhaps fund managers gain confidence when returns are higher. A one-standard-deviation increase in PosAvgRet increases volatility by 5.2% of its standard deviation. The effect of *NegAvgRet*,

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[6] If the current year's volatility affects next year's volatility, then the effect of a change in the value of any regressor would extend beyond the current year. We ignore this possibility.

though still negative, falls short of statistical significance at the 5% level (the level is 9%). However, it is significant for funds that pay below-normal performance fees (the sum of the coefficients for *NegAvgRet* and *NegR*LowFee* is -14.98). A one-standard-deviation increase in *NegAvgRet* for a fund that pays less than 20% performance fees reduces volatility by 12.3% of its standard deviation.

Finally, in column 5 all of the previous performance variables are included in the equation. In this case, *InMoney* and *OutMoney* retain statistical significance. The magnitude of the coefficient for *InMoney* is two-thirds of its magnitude in column 4; for *OutMoney* the coefficient is slightly higher than in Column 4. The coefficients for *PosAvgRet* and *NegAvgRet* are not significant, but as in column 4 there is significant interaction between *NegAvgRet* and LowFee: a large negative average return significantly increases volatility for funds that pay below-normal performance fees. The size of the effect is about the same as in Column 4. The coefficient for *BelowMedian* is essentially zero as in column 3, but it has significant interactions with both *InMoney* and *LowFee*. A fund with returns in the first half of the year that are below the median for all hedge funds tends to reduce volatility if it is also in the money (which means the return must have been positive) or if it pays below-normal performance fees. Neither of these results is consistent with the hypothesis that "tournament losers" tend to increase risk taking.

FundCharacteristics: The estimated effects of fund characteristics are robust across all five specifications presented in Table 3. The fund characteristics are all specified as dummy variables and interactions between dummy variables. Given the number of significant interaction terms, there are 24 separate cases which define the various combinations of coefficients to be summed to get the overall effects. Table 4 lists the cases along with the equations used to calculate how each case impacts volatility based on Column 5 in Table 3. We list these from highest to lowest volatility and separate them into five categories: highest volatility, high volatility, moderate volatility, low volatility, and lowest volatility. The highest volatility and lowest volatility categories each include only one case.

To summarize the results,

1. The greatest volatility is for a relatively small, liquid, non-surviving fund with above-normal fees. The least volatility is for a relatively small, illiquid, surviving fund with below-normal fees.

2. The four highest volatility cases are for relatively small funds, but four of the eight lowest volatility cases are also for small funds. On average, however, volatility is greater for small funds than for large funds. However, the impact of size on volatility is generally less for funds that are relatively illiquid and for funds that survived to the end of the sample period. It disappears altogether for funds that earn below-normal performance fees.

3. Three of the four highest volatility cases include funds that earn above-normal performance fees. None of the eight lowest volatility cases include funds that earn above-normal performance fees. None of the four highest volatility cases include funds that earn below-normal performance fees. Three of the eight lowest volatility cases include funds that earn below-normal performance fees. On average, volatility is greater for funds that earn above-normal performance fees than for funds that earn either normal or below-normal fees.

4. Three of the four highest volatility cases are for relatively liquid funds. Five of the eight lowest volatility cases are for relatively illiquid funds. On average, volatility is greater for relatively liquid funds.

5. Funds that survived to the end of the sample period display less volatility on average than funds that did not survive. This is primarily the result of the highest volatility case being for a non-surviving fund and the lowest volatility case being for a surviving fund.

Significant interactions between fund characteristics and previous performance of the fund are discussed in the section above on the effects of previous performance.

3.3 Robustness

Recall that for the above estimates, a fund with NAV less than 90% of its maximum value over the previous three years (the threshold value) is considered to be out of the money. We re-estimate the regressions with threshold values of 95%and 80%, and the results are very similar to the results for 90% (details are available from the authors). The one exception is that for a 95% threshold the effect of being out of the money is not robust. It falls below statistical significance in estimates that also include other performance variables.

Aragon and Nandes (2009) point out that the risk shifting due to tournament behavior in hedge funds is mainly for the back-filled sample. Back-filling bias arises when hedge funds back-fill their historical return records after a successful incubation. In order to minimize the possible impact on our results due to back-filling bias, we exclude the returns for a hedge fund during its incubation period, removing the first 24 months of returns for each fund, and re-estimate the regression equations. The results are reported in Table 5 and are similar to the full-sample results. In particular, (1) being out of the money tends to increase volatility unless the hedge fund is large, (2) being in the money tends to reduce volatility, (3) a negative return tends to increase volatility (significantly or very nearly so), and (4) there is no positive effect on volatility of having returns that are below the median. The effects of fund characteristics are also essentially the same as in the full-sample estimates except there is no significant interaction between size and illiquidity.

4. Conclusion

We have attempted in this paper to discover the determinants of risk exposure in hedge fund returns. The findings suggest that poor performance leads to greater risk exposure, especially for smaller hedge funds. A fund with net asset value (NAV) below its previous high-water mark (out of the money) tends to increase its exposure to risk. The result is robust for relatively small hedge funds, somewhat less so for large hedge funds. A hedge fund with NAV above its high-water mark (in the money) tends to decrease its exposure to risk. Furthermore, a hedge fund tends to increase exposure to risk following a period of negative returns (regardless of whether the fund is in, at, or out of the money). The result is robust for hedge funds that earn below-normal performance fees, somewhat less so for hedge funds that pay normal or above-normal performance fees. Holding fund performance constant, the greatest volatility is for a relatively small fund that is also relatively liquid, earned above-normal performance fees, and did not survive to the end of the sample period.

Our findings suggest that investors should be alert to the possibility of increases in risk taking for a hedge fund that has been performing poorly, especially a relatively small hedge fund. One might ask, however, whether the changes are likely to be large enough to be of major concern. Unfortunately, we are not able to definitively answer that question based on our analysis. We can say only that there is evidence that changes in risk taking do occur as a result of previous performance.

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Table 1 Summary Statistics of Hedge Funds Sample, 1994 - 2008

Summary statistics are reported for the hedge funds sample from the CISDM database. We include only funds that have returns in CISDM after January 1994 to minimize survivorship bias. To be included in the sample, each fund must have at least three years of return history, as well as returns for the entire year .

Year	Number of Hedge Funds	AUM in Millions					Performance Fee Dist. In %		
		# Obs	Mean	Median	Min	Max	<20%	=20%	>20%
1994	45	34	137.5	42.5	3.7	845.8	7	37	1
1995	60	47	133.0	68.8	3.8	723.4	12	44	4
1996	85	74	119.9	49.3	1.5	1110.3	20	61	4
1997	119	105	146.3	56.5	2.9	1369.4	24	88	7
1998	179	152	169.9	56.1	0.9	2013.6	40	126	13
1999	237	199	138.9	57.2	0.5	2292.8	53	169	15
2000	330	273	143.9	60.7	0.3	2953.8	67	247	16
2001	401	345	137.7	53.0	0.1	3097.8	78	303	20
2002	515	418	139.0	54.2	0.2	2026.4	87	401	27
2003	649	542	143.7	56.4	0.1	1959.0	111	508	30
2004	812	670	201.6	70.9	0.0	4159.3	145	626	41
2005	999	794	210.5	72.5	0.0	4569.0	173	780	46
2006	1142	907	292.5	71.9	0.3	5800.0	197	895	50
2007	1194	992	325.0	81.4	0.0	5200.0	208	936	50
2008	1022	867	373.0	76.6	0.3	9200.0	181	792	49
1991-2008	7789	6419	237.5	67.0	0.0	9200.0	1071	6407	311

Table 2 Summary Statistics of Compensation Option Proxy

Year	Moneyness Distribution In % Based on Threshold Value of 0.9		
	Out-of-the -Money	At-the-money	In-the-money
1994	0.02	0.64	0.33
1995	0.47	0.38	0.15
1996	0.14	0.18	0.68
1997	0.11	0.13	0.76
1998	0.25	0.37	0.38
1999	0.41	0.20	0.39
2000	0.30	0.22	0.48
2001	0.35	0.22	0.43
2002	0.31	0.26	0.43
2003	0.49	0.16	0.35
2004	0.15	0.12	0.73
2005	0.21	0.37	0.42
2006	0.10	0.10	0.80
2007	0.15	0.19	0.66
2008	0.56	0.23	0.21
1994-2008	0.27	0.21	0.52

Table 3 Results from Regressions

This table reports the empirical results from a cross-sectional regression on shift of risk-taking in hedge funds in the decision period (2nd half year). P-values are in parentheses.

	(1)	(2)	(3)	(4)	(3)
Variables	Estimates	Estimates	Estimates	Estimates	Estimates
Intercept	0.53	0.49	0.525	0.54	0.52
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
PastStdRatio	-0.44	-0.45	-0.42	-0.47	-0.46
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
InMoney	-0.12			-0.15	-0.10
	[0.00]			[0.00]	[0.04]
OutMoney	0.21			0.09	0.10
	[0.00]			[0.04]	[0.03]
PosAvgRet		2.46		4.29	2.46
		[0.23]		[0.05]	[0.35]
NegAvgRet		-9.12		-4.10	-3.59
		[0.00]		[0.09]	[0.17]
BelowMedian			-.002		0.01
			[0.93]		[0.85]
Illiquid	-0.15	-0.16	-0.15	-0.16	-0.15
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Survival	-0.12	-0.12	-0.13	-0.13	-0.12
	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
HighFee	0.11	0.12	0.12	0.11	0.11
	[0.02]	[0.02]	[0.02]	[0.03]	[0.03]
LowFee	-0.16	-0.15	-0.16	-0.19	-0.13
	[0.00]	[0.00]	[0.00]	[0.00]	[0.06]
Size	-0.22	-0.26	-0.26	-0.25	-0.25
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Size*Illiquid	0.11	0.13	0.12	0.13	0.12
	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
Size*LowFee	0.22	0.22	0.23	0.23	0.23
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Size*Survival	0.13	0.13	0.13	0.12	0.13
	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
Size*OutMoney	-0.15				
	[0.03]				
NegR*LowFee				-10.88	-12.98
				[0.04]	[0.02]
BelowMedian*InMoney					-0.13
					[0.02]
BelowMedian*LowFee					-0.13
					[0.04]
# of Observations	6419	6419	6419	6419	6419
Adjusted R-squared	0.34	0.35	0.34	0.35	0.35

PosAvgRet = 1 if actual fund return is positive, and 0 otherwise.
NegAvgRet = 1 if actual fund return is negative, and 0 otherwise.
InMoney = 1 if the NAV is above *MaxNAV*, highest NAV in the 42-month evaluation window, and 0 otherwise.
OutMoney = 1 if the NAV is between the threshold* *MaxNAV* and *MaxNAV*, the highest NAV in the 42-month evaluation window, and 0 otherwise.
BelowMedian = 1 if a fund's performance over the first half of the evaluation year is below median, and 0 otherwise.
Illiquidity = 1 if a fund has above-median first-order autocorrelation for the three-year window of historical returns, or 0 otherwise.
HighFee = 1 if a fund charges performance fees at a level higher than industry standard (20%), and 0 otherwise.
LowFee = 1 if a fund charges performance fees at a level lower than industry standard (20%), and 0 otherwise.
SizeRank = 1 if a fund's asset under management is above median among all funds, and 0 otherwise.

Table 4 Coefficient Estimates for Twenty-Four "Cases" of Fund Characteristic

Based on individual coefficient estimates from Column 5 of Table 3

Highest volatility

Liquid, non-survivor, high-fee, small: 0.52 + 0.11 = 0.63

High volatility

Liquid, non-survivor, normal-fee, small: 0.52 (base case)

Liquid, survivor, high-fee, small: 0.52 - 0.12 + 0.11 = 0.51

Illiquid, non-survivor, high-fee, small: 0.52 - 0.15 + 0.11 = 0.48

Moderate volatility

Liquid, survivor, normal-fee, small: 0.52 -0.12 = 0.40

Liquid, non-survivor, low-fee, small: 0.52 - 0.13 = 0.39

Liquid, survivor, high-fee, large: 0.52 - 0.12 + 0.11 - 0.25 + 0.13 = 0.39

Liquid, survivor, low-fee, large: 0.52 - 0.12 - 0.13 - 0.25 + 0.23 + 0.13 = 0.38

Liquid, non-survivor, high-fee, large: 0.52 + 0.11-0.25 = 0.38

Liquid, non-survivor, low-fee, large: 0.52 - 0.13 - 0.25 + 0.23 = 0.37

Illiquid, non-survivor, normal-fee, small: 0.52 - 0.15 = 0.37

Illiquid, survivor, high-fee, small: 0.52 - 0.15 - 0.12 + 0.11 = 0.36

Illiquid, survivor, high-fee, large: 0.52 - 0.15 - 0.12 + 0.11 - 0.25 + 0.12 + 0.13 = 0.36

Illiquid, survivor, low-fee, large: 0.52 - 0.15 - 0.12 - 0.13 - 0.25 + 0.12 + 0.23 + 0.13 = 0.35

Illiquid, non-survivor, high-fee, large: 0.52 - 0.15 + 0.11 - 0.25 + 0.12 = 0.35

Illiquid, non-survivor, low-fee, large: 0.52 - 0.15 - 0.13 - 0.25 + 0.12 + 0.23 = 0.34

Table 4 continued

Low volatility

Liquid, survivor, normal-fee, large: 0.52 - 0.12 - 0.25 + 0.13 = 0.28

Liquid, non-survivor, normal-fee, large: 0.52 - 0.25 = 0.27

Liquid, survivor, low-fee, small: 0.52 - 0.12 - 0.13 = 0.27

Illiquid, survivor, normal-fee, small: 0.52 - 0.15 - 0.12 = 0.25

Illiquid, survivor, normal-fee, large: 0.52 - 0.15 - 0.12 - 0.25 + 0.12 + 0.13 = 0.25

Illiquid, non-survivor, low-fee, small: 0.52 - 0.15 - 0.13 = 0.24

Illiquid, non-survivor, high-fee, large: 0.52 - 0.15 - 0.25 + 0.12 = 0.24

Lowest volatility

Illiquid, survivor, low-fee, small: 0.52 - 0.15 - 0.12 - 0.13 = 0.12

Table 5 Results from Regressions Without Back-filled Return Data

This table reports the empirical results from a cross-sectional regression on shift of risk-taking in hedge funds in the decision period (2nd half year) after removing the first 24 months of returns to minimize the possible impact from back filling bias. P-values are in parentheses. The threshold value is 90%.

Variables	(1) Estimates	(2) Estimates	(3) Estimates	(4) Estimates	(5) Estimates
Intercept	0.41	0.46	0.41	0.43	0.51
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
PastStdRatio	-0.33	-0.33	-0.33	-0.34	-0.34
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
InMoney		-0.10		-0.08	-0.12
		[0.00]		[0.04]	[0.00]
OutMoney		0.22		0.14	0.14
		[0.00]		[0.04]	[0.04]
PosAvgRet	-0.97			0.17	-2.34
	[0.73]			[0.95]	[0.56]
NegAvgRet	-8.98			-6.49	-7.61
	[0.00]			[0.06]	[0.03]
BelowMedian			0.05		-0.13
			[0.13]		[0.04]
Illiquid	-0.06	-0.06	-0.06	-0.06	-0.06
	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]
Survival	-0.14	-0.14	-0.14	-0.14	-0.14
	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
HighFee	0.15	0.13	0.13	0.14	0.14
	[0.02]	[0.03]	[0.04]	[0.03]	[0.02]
LowFee	-0.13	-0.13	-0.13	-0.12	-0.12
	[0.06]	[0.06]	[0.07]	[0.07]	[0.08]
Size	-0.19	-0.15	-0.19	-0.15	-0.15
	[0.00]	[0.01]	[0.00]	[0.01]	[0.01]
Size*LowFee	0.18	0.18	0.18	0.18	0.18
	[0.02]	[0.02]	[0.02]	[0.02]	[0.02]
Size*Survival	0.14	0.14	0.14	0.14	0.14
	[0.02]	[0.03]	[0.02]	[0.02]	[0.02]
Size*OutMoney		-0.18		-0.18	-0.18
		[0.02]		[0.02]	[0.03]
BelowMedian*InMoney			-0.19		
			[0.00]		
BelowMedian*OutMoney			0.15		
			[0.02]		
# of Observations	4119	4119	4119	4119	4119

Adjusted R-squared	0.25	0.25	0.25	0.25	0.26

PosAvgRet = 1 if actual fund return is positive, and 0 otherwise.
NegAvgRet = 1 if actual fund return is negative, and 0 otherwise.
InMoney = 1 if the NAV is above *MaxNAV*, highest NAV in the 42-month evaluation window, and 0 otherwise.
OutMoney = 1 if the NAV is between the threshold* *MaxNAV* and *MaxNAV*, the highest NAV in the 42-month evaluation window, and 0 otherwise.
BelowMedian = 1 if a fund's performance over the first half of the evaluation year is below median, and 0 otherwise.
Illiquidity = 1 if a fund has above-median first-order autocorrelation for the three-year window of historical returns, or 0 otherwise.
HighFee = 1 if a fund charges performance fees at a level higher than industry standard (20%), and 0 otherwise.
LowFee = 1 if a fund charges performance fees at a level lower than industry standard (20%), and 0 otherwise.
SizeRank = 1 if a fund's asset under management is above median among all funds, and 0 otherwise.