The Cass Centre for Asset Management Research

Locking in the profits or putting it all on black? An empirical investigation into the risk-taking behaviour of hedge fund managers

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Abstract

In this paper we investigate the influence of two factors on the risk taking behaviour of hedge fund managers. The first factor is the past performance of the fund relative to the performance of each fund's peer. The second is the option-like features of the typical hedge fund manager's compensation structure. We aim to answer questions of the following kind: do those funds that find that their incentive option is out of the money increase risk or vice-versa? We then attempt to reconcile these results with the theoretical frameworks proposed. We believe these questions to be of critical importance given the recent performance of the hedge fund industry. Based upon performance to end of October 2008, it is clear that many funds will find themselves considerably below their high water marks and with significantly less assets under management. Our work here may help to throw some light on the likely response of hedge fund managers to this current crisis.

Keywords: hedge fund, risk, return, fees, performance, high-water mark, agency conflicts, benchmarking, portfolio choice

JEL Classifications: G1, G2

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1. Introduction

The ideal fee structure aligns the incentives of the investor with those of the fund manager. Investors will normally be looking to maximise their risk-adjusted return while fund managers will seek to maximise their fees. Mutual funds typically only charge a management fee which is a proportion of the funds under management. This traditional fee structure can only align fund manager and investor objectives to a limited degree: if the investor is unsatisfied with the performance of the manager they can usually withdraw their funds thus reducing the fee to zero. Hedge funds on the other hand generally charge both a management fee and an incentive fee which is a fraction of the fund's return each year in excess of a high-water mark. It is clear that this structure aligns the objectives of these two parties more closely since they both stand to benefit from incrementally better performance.

However hedge fund incentive fees are a contentious issue for two important reasons. First the fees can be very large as a proportion of the fund and can therefore be a drag on the performance of the fund[3]. Depending upon the variance of returns Goetzmann *et al* (2003) estimate that the performance fee effectively costs investors between 10 and 20 percent of the portfolio. Clearly investing in a hedge fund would only be rational if they provide a large, positive risk-adjusted return which compensates for these fees.

The second and perhaps more interesting issue is whether the incentive fees provide the manager with the right incentives anyway. On the one hand Anson (2001), who describes incentive fees as a "free option", argues that the option-like nature of the incentive fee will lead the manager to increase the volatility of returns in order to maximise the value of this option. This is a view that is partially supported by Goetzmann *et al* (2003) who state that "*the manager has the incentive to increase risk provided other non modelled considerations are not overriding*". An opposing view is presented by L'Habitant (2007) who considers the incentive fee as an option premium paid to the hedge fund manager by the investor. This premium ensures that the manager will optimise the size of the fund to keep returns high because the incentives for superior performance can be greater than for asset growth. He argues that the absence of incentive fees (for example in mutual funds) leads the manager to maximise funds under management, which is not necessarily in the interests of the investor who is seeking to maximise risk-adjusted returns.

[3] For the period from 1994 to 2006 Brooks, Clare and Motson (2007) found fees cost on average 5.15% pa.

Several recent papers have examined the effect that incentive fees have upon the optimal dynamic investment strategies of fund managers within a theoretical framework. Typically these papers present a framework with one risky and one riskless asset and then examine the allocation the manager would make to each asset under various scenarios. The theoretical results provide a range of possible behaviour depending upon: the assumptions made about manager preferences'; the possibility of fund liquidation; and the assumed level of the management's stake in the fund. Thus the models illustrate the importance of what Goetzmann *et al* (2003) describe as *"non-modelled considerations"*, or what could also be described as implicit rather than explicit contract terms.

The explicit terms of the compensation contract are that investors agree to pay the manager a fixed percentage of positive returns while accepting all of the downside, if the contract was this simple then the manager would, as Anson (2001) describes, simply possess a call option on the future performance of the fund which would provide the manager with an incentive to increase risk. However, there are also many implicit terms to the contract that are more difficult to model, some of which will mitigate this problem and others that may exacerbate it. For example, investors will expect the hedge fund manger to invest a substantial percentage of their own net worth in the fund and penalise them for poor performance (or for excessive risk taking) by withdrawing their funds (just as a mutual fund client would). This will mitigate some of this risk taking. However, risk taking might be exacerbated if as has been illustrated using mutual fund flow data, fund flows are a convex function of past performance where good performance leads to significant fund inflows, but where poor performance leads to smaller net outflows. This results in manager compensation having a call option-like feature that can induce the manager to indulge in excessive risk-taking.

In this paper we present empirical evidence of the influence of the hedge fund industry's typical fee structure on the risk taking behaviour of hedge fund managers. Our analysis takes explicit account of the option-like features of the compensation structure. We also analyse the various hedge fund strategies separately rather than assuming that manager behaviour is effectively unaffected by their strategies, which is often the implicit assumption of other work in this area. Amongst other things, our results enable us to distinguish between and to say something about the competing theoretical models that seek to identify the relationship between incentives and hedge fund manager behaviour. To do this we use a large database of hedge fund returns and identify each fund's position relative to its peer group and to its high-water mark. After identifying the position of each fund in each of these two ways we can then examine whether hedge fund managers adjust the volatility of their fund in response to their performance relative to other hedge funds or the “moneyness” of the performance option.

We aim to answer questions of the following kind: do those funds that find that their incentive option is out of the money “*put it all on black*” and increase risk; do they maintain risk levels; or do they reduce them? We then attempt to reconcile these results with the theoretical frameworks proposed.

We believe these questions to be of critical importance given the recent performance of the hedge fund industry. Based upon performance to end of October 2008 it is clear that many funds will find themselves considerably below their high water marks and with significantly less assets under management as we move in to 2009. According to the CSFB Tremont hedge fund indices, the year-to-end of October performance of the average hedge fund has been -15.5%. And of the twelve strategies for which they compile performance only two – Dedicated Short Bias and Managed Futures – have produced a positive average return over this period. Our work here, may help to throw some light on the likely response of hedge fund managers to this current crisis.

The rest of the paper is organised as follows: Section 2 reviews the existing literature related to our analysis, Section 3 outlines the data and construction methodology, Section 4 presents the results, Section 5 compares the results with the literature and Section 6 concludes.

2. Literature Review

The conflicting results of theoretical models of fund manager behaviour in the presence of incentive fees and the importance of the implicit terms is clearly illustrated by contrasting the findings of Carpenter (2000), Goetzmann et al (2003) and Panageas and Westerfield (2008). Carpenter (2000) examined the optimal risk taking behaviour of a risk-averse mutual fund manager who is paid with a call option on the assets they control (similar to hedge fund incentive fees). She found that a manager paid with an incentive fee increases the risk of the fund’s investment strategy if the fund’s return is below the hurdle rate and decreases the risk if the fund is above the hurdle rate. Carpenter’s analysis is for a single evaluation period and does not consider the possibility of the fund being liquidated unless the value goes to zero. Goetzmann et al (2003) provide a closed-form solution to the cost of hedge fund fee contracts subject to a number of assumptions in a continuous time framework. They model incentive fees as an option and find that the cost of the contract rises as the portfolio’s variance rises and hence conclude that the manager has the incentive to increase risk "provided other non modelled considerations are not overriding". The authors include the possibility that the fund can be liquidated if its value falls below a specified boundary and show that as the fund's value approaches this boundary the manager will reduce risk. So whereas Carpenter's theoretical manager would increase (decrease) risk as the fund value falls (rises) Goetzmann et al's would decrease (increase) risk as it falls (rises). Panageas and Westerfield (2008) find that a manager compensated with an incentive fee and a high-water mark will place a constant fraction in the risky asset if they are operating in an infinite horizon setting. The intuition behind this is that the manager does not optimise just one option but an infinite time series of options, a manager who is below the high-water mark could increase the value of the current option by taking excessive risk today. However this will decrease the value of future options because it will also increase the probability of negative returns while the high-watermark is still fixed.

Hodder and Jackwerth (2007) consider the optimal risk-taking behaviour of an expected-utility maximising manager of a hedge fund who is compensated by both a management fee and an incentive fee. The authors also examine the effect of several implicit terms including the manager's own investment in the fund, a liquidation barrier where the fund is shut down due to poor performance and the ability of the manager to voluntarily shut down the fund as well as to enhance the fund's Sharpe Ratio through additional effort. Using a numerical approach they find that seemingly slight adjustments to the compensation structure can have dramatic effects on managerial risk taking behaviour. Specifically, they find that the existence of a liquidation barrier and an assumption that the managers own a percentage of the fund inhibits excessive risk taking as the fund value falls.

In Figure 1 we present a stylised summary of the differences between Carpenter's (2000) Goetzmann et al's (2003), Panageas and Westerfield's (2008) and Hodder and Jackwerth's (2007) models of fund manager behaviour in the presence of incentive fees.

Figure 1 here

Figure 1 clearly illustrates the striking difference between Carpenter's and Goetzmann *et al*'s models of behaviour. Carpenter assumes that the fund will only be liquidated if the fund value goes to zero hence as the value of the fund falls the manager increases risk to increase the chance of collecting incentive fees without fearing liquidation. On the other hand, Goetzmann *et al* have a fixed liquidation boundary, thus as the fund value approaches this boundary the manager decreases risk in order to reduce the probability of liquidation. In the model of

Panageas and Westerfield the manager holds a constant level of risk. Hodder and Jackwerth's model lies somewhere between the other three.

However, even in the absence of incentive fees there are implicit terms to the compensation contract that could encourage excessive risk taking. Chevalier and Ellison (1997) showed that if fund flows are a convex function of past performance, that is to say that more money flows into strong performers than out of weak performers, because the management fees are a fixed percentage of assets under management they will display call option like features. This in turn creates incentives for fund managers to increase or decrease the risk of the fund that are dependent on the fund's year-to-date return. Sirri and Tufano (1998) and others have confirmed that flows in and out of mutual funds do exhibit this convexity, superior relative performance leads to the growth of assets under management while there is no substantial outflow in response to poor relative performance. This flow/performance relationship was investigated for hedge funds by Agarwal, Daniel and Naik (2004) who find that funds in the top quintile of performers exhibit an inflow of 63%, while the bottom quintile exhibits an outflow of only 3%.

An empirical investigation of the risk taking behaviour of mutual funds for the 16 year period from 1976 to 1991 was undertaken by Brown, Harlow and Starks (1996). Using a contingency table approach they showed that mutual fund managers undertake what they termed as "tournament behaviour", with funds whose mid-year returns were below the median (losers) increasing volatility in the latter part of the year by more than those funds whose mid-year returns were above the median (winners). The authors concluded that this behaviour was a direct consequence of the adverse incentives described above. Managers who have performed poorly by mid-year have incentives to increase their risk level to try and improve their ranking by the year-end; whereas managers with strong mid-year performance appeared to reduce risk in order to maintain their ranking.

The empirical relationship between risk taking and incentives in hedge funds has been examined by Ackermann, McEnally and Ravenscraft (1999) and Brown, Goetzmann and Park (2001) and many others. Using a regression approach Ackerman *et al* (1999) found a positive and significant relationship between the Sharpe ratio and the level of incentive fees but no statistically significant relationship between the level of risk (as measured by the standard deviation of returns) and the level of incentive fees. The authors concluded that this was evidence that the incentive structure was effective because it attracted top managers while not increasing their propensity to take on risk. Using a sample of hedge funds and commodity trading advisors (CTAs) from the TASS database Brown, Goetzmann, and Park

(2001) showed that survival probability depends on absolute and relative performance, excess volatility, and on fund age. Perhaps not surprisingly the authors found that excess risk and poor relative performance substantially increased the probability of termination which they argue is a cost sufficient to offset the adverse incentive of excessive risk taking provided by the fee contract. Using a contingency table approach similar to Brown, Harlow and Starks (1996) they found that funds tend to increase (decrease) their risk in response to poor (strong) relative performance but not in response to their absolute performance.

3. Data and Methodology

3.1 Data

A major limitation of earlier studies is that they implicitly assume that hedge funds are a homogenous asset class. In practice however, the term "hedge fund" refers to the structure of the investment vehicle rather than the investment strategy being followed. Different strategies have varying levels of risk and historic return which makes a strategy level comparison essential if the results are to be meaningful. The data that we use in this study have been extracted from the TASS live and graveyard databases from January 1994 through to December 2007. More specifically, we extract monthly Net Asset Values (NAV), strategy details and inception dates for all hedge funds that are denominated in US Dollars, that report monthly and that have reported for at least one full calendar year over this sample period. These criteria result in a total sample of 4,990 funds of which 2,449 are currently reporting and 2,541 are no longer reporting. The data are summarised in Table 1. The total number of funds has increased rapidly over time from just over 500 in 1994 to approximately 2,500 in 2007, of which the long/short equity category comprised 950. The mean and median fund sizes have also increased over time, the difference between these two statistics indicate that the sample is dominated by smaller funds. There is a similar but less pronounced pattern in the fund age.

Table 1 here

Using the net asset values (NAVs) of each fund as reported in the TASS database we calculate the monthly gross returns of each hedge fund over time using the a slightly modified[4] version of the procedure outlined in Brooks *et al* (2007) which is described in detail in the Appendix. We use gross rather than net returns in order to isolate changes in risk that are a result of manager behaviour rather than being due to the mechanics of the incentive contract since incentive fees can have the effect of lowering the standard deviation of

[4] The procedure was slightly modified to incorporate comments in Hodder *et al* (2008) regarding the timing of the management fee payments.

observed net returns when a fund is above its high-water mark which could clearly bias the results (see Brooks *et al* (2007)).

Calculation of the exact delta of the fee option is problematic because we do not have an appropriate model or a true estimate of the implied volatility, so instead we use the "moneyness" of the option as a proxy for delta. Moneyness is defined as:

$$Moneyness_{fMy} = \frac{NAV_{fMy}}{HighWaterMark_{fMy}} \quad (1)$$

where Moneyness_{fMy} defines fund f's value after M months of the year relative to its previous maximum value as represented by its high water mark at time, $\text{HighWaterMark}_{fMy}$

3.2. Methodology

One has to be extremely careful when interpreting the relationship between the risk choices of a fund manager in response to returns because the two are inherently linked. Figure 2 (taken from Brooks *et al* (2007)) shows the distribution of hedge fund returns conditional upon the moneyness of the incentive option for three sub-samples defined as "at the money" (ATM), "in the money" (ITM) and "out of the money" (OTM) using the data described in section 3.1 of this paper. The standard deviation of both the OTM and the ITM samples are statistically larger than for the ATM sample, which could support the hypothesis that hedge funds increase their risk when they are significantly below or above their high-water mark as defined in expression (1).

Figure 2 here

However there is an alternative explanation for the above result: funds that produce high return volatility are more likely to have extremely positive (or negative) performance and hence more likely to be classified as in (or out) of the money. Whereas funds with low return volatility are less likely to have had extreme return outcomes and hence are more likely to be classified as at the money. In order to investigate this we calculate the annualised standard deviation of gross returns for the funds in our sample for each calendar year as well as the moneyness of the incentive option at the end of the year. We then split the sample into 12 sub-samples based on levels of moneyness between 0.70 and 1.30 and calculate the median standard deviation for each sub sample. The results are presented in Figure 3.

Figure 3 here

The "V" shape of figure 3 illustrates that the alternative explanation of our earlier results is extremely possible. Those funds with historically lower standard deviation are more likely to be closer to "at the money" whereas those with higher standard deviation are more likely to be significantly in or out of the money.

In order to examine whether funds adjust the risk of their portfolios in response to their performance we need to examine the standard deviation of returns before and after a specific assessment point in time.

Using gross monthly hedge fund returns we calculate the annualised performance of fund f between January and month M. Specifically, for each fund *f* in a given year *y*, we calculate the M-month cumulative return as follows:

$$\text{Return}_{fMy} = \left[\left(1+r_{f1y}\right)+\left(1+r_{f2y}\right)+.....\left(1+r_{fMy}\right)\right]^{\frac{12}{M}}-1 \tag{2}$$

where r_f is the monthly gross return for hedge fund f. In our initial analysis we set M to 6 (June), but we also allow month M to vary between April and August so that the return is measured over periods ranging from four to eight months. We refer to this period as the "assessment period", that is, the period over which we assess the performance of each fund.

In order to analyse whether hedge funds adjust the risk of their portfolios in the post assessment period, that is from month M to December, we follow Brown *et al* (1996) and calculate the Risk Adjustment Ratio (RAR) using the following expression:

$$RAR_{fy} = \frac{\sqrt{\left(\frac{\sum_{m=M+1}^{12}\left(r_{fmy}-\bar{r}_{f(12-M)y}\right)^2}{(12-M)-1}\right)}}{\sqrt{\left(\frac{\sum_{M=1}^{M}\left(r_{fmy}-\bar{r}_{fMy}\right)^2}{M-1}\right)}} \tag{3}$$

where RAR_{fy} represents the RAR of fund f in year y. Expression (3) is simply the ratio of the standard deviation of returns for the post assessment period to the standard deviation of returns over the assessment period. In our base case the assessment period is from January to June (M=6). This analysis is conducted using non-overlapping assessment and post assessment periods.

As well as assessing the performance of the fund from January to month M, we also calculate the moneyness of the incentive fee option at the end of month M. The performance of any fund over the assessment period might be above the median return for its strategy, but still may not be sufficient to lift the fund's performance above its high water mark and therefore may not be enough for the manger to be able to claim a performance fee. By using moneyness as a way of categorising the position of the fund and therefore the fund manager's attitude to risk, we can assess the influence not only of relative performance, but also the value of the incentive option on manager behaviour.

We analyse the post-assessment performance of the fund f relative to the performance of the hedge fund strategy to which it belongs. We therefore ask whether the funds adjust their behaviour relative to their peer group. We normalise the post assessment return and the RAR by using the following expressions:

$$Normalised\ \mathrm{Re}turn_{fMy} = \mathrm{Re}turn_{fMy} - Median\left[\mathrm{Re}turn_{sMy}\right] \quad (5)$$

$$Normalised\ RAR_{fMy} = RAR_{fMy} - Median\left[RAR_{sMy}\right] \quad (6)$$

where *s* is one of the ten individual strategies being considered such that *Normalised Return* and *Normalised RAR* are measures of how fund f either performed or changed risk relative to other funds following the same strategy for a particular period. A value greater (less) than one for each expressions (5) and (6) should therefore be taken to indicate that the fund in question has either outperformed (underperformed) its peer group, or increased (decreased) its risk by more (less) than its peer group for the particular period in question.

Using the variables calculated above we construct 2x2 contingency tables in order to test whether hedge funds adjust their risk in response to either their relative performance or the moneyness of their incentive option. Specifically we construct two 2x2 tables where we split the funds into those with high (Normalised RAR>0) or low (Normalised RAR<0) Risk Adjustment Ratios conditioned upon either past performance or moneyness. The null hypothesis in each case is that the percentage of the sample population falling into each of the high or low RAR categories is independent of either the return or the moneyness. The statistical significance of these frequencies is tested in 2 ways:

i) a chi-square test having one degree of freedom (though this might be mis-specified as it assumes the cell counts are independent); and

ii) the log odds ratio, which is robust to the misspecification of the chi-square test and also provides additional information regarding the direction and level of dependence.

Although the contingency table approach will identify whether there is any directional relationship between the Risk Adjustment Ratio and either past performance or the moneyness of the incentive option, this approach assumes that the relationship is linear. In order to examine further this relationship we construct tables where Normalised RAR is conditioned upon either:

i) 12 levels of moneyness between 0.70 and 1.30, and

ii) 10 Deciles of relative performance

For each of these sub-samples we then test whether the median Normalised RAR is significantly different from zero using the Wilcoxon Signed Rank test.

4. Results

In panel A of Table 2 we present summary statistics of the median annualised return for each strategy and for all funds on an annual basis using a 6 month assessment period; in Panel B we present the median moneyness for the same break down of funds over the assessment period; while in Panel C we present the RAR for the assessment period for the same stratification.

Table 2 here

These results clearly illustrate the heterogeneous nature of the ten hedge fund strategies being examined. For example consider a global macro hedge fund in 1994 that produced an annualised return of 1% in the first half of the year and had a RAR of 0.80. Treating hedge funds as one homogenous group would classify this as being below the 1.5% median return and below the 0.85 median RAR, yet it is considerably above the median return of -8.3% and above the median RAR of 0.74 for funds following the same strategy, namely global macro. Additionally market conditions at particular points in time can affect different strategies in different ways, for example the median RAR for fixed income arbitrage funds during the 1998

LTCM/Russian debt crisis was 2.93, but it was only 1.33 for global macro funds and 1.84 for all hedge funds.

Although we do calculate the performance statistics described in Section 3 above treating all hedge funds as one group, we believe that the results are more meaningful when they are considered by strategy.

4.1. Contingency Tables

Table 3 shows the contingency table results using the period from January to the end of June in each full year as the assessment period (M=6) categorised by their returns over the assessment period (Panel A) and by moneyness at the end of June (Panel B), and therefore the period from July to December as the post assessment period.

Table 3 here

Panel A shows that over the full sample period we can reject the null hypothesis of independence between the relative return and RAR. More specifically, the Low Return/High RAR and High Return/Low RAR cells have statistically significantly larger frequencies than the other two outcomes. This result is in line with the findings of Brown *et al* (1996) for mutual funds: those funds that have generated returns that are below the median for their strategy over the first six months of the year are likely to increase risk more than the median fund possibly in order to try and improve their whole-of-year ranking; while those funds that have achieved above median returns for their strategy are more likely to decrease risk, possibly in order to protect their returns and relative performance rankings. Taking each year individually, the log odds ratio shows that the relationship is in the same direction for 12 out of the 14 years in the sample and is statistically significant for ten of these years.

Panel B shows that for the full 14 year sample period we can reject the null hypothesis of independence between moneyness and the subsequent RAR with the Below HW Mark/High RAR and Above HW Mark/Low RAR cells having statistically significant and larger frequencies than the other two outcomes implying that those funds that find themselves below their high-water marks after six months increase risk relative to the median risk during the post assessment period, and those funds above it decrease risk. When we look at individual years, the log odds ratio shows that the relationship is only in the same direction for 10 out of the 14 years in the sample and significant for 8 of them. In fact in 2005 and 2007 the relationship is statistically significant and in the opposite direction – implying that in these years funds that were below their high water mark after 6 months reduced their risk relative to the median risk during the post assessment period.

These results imply that although hedge fund managers adjust their risk in response to both their relative returns and according to the moneyness of the incentive option the effect is more pronounced in the former rather than the latter case. This is borne out by the fact that the log odds ratio of 0.2708 is greater overall when performance is benchmarked against the median performance (last row, column (7) of Table 3, Panel A) compared with a logs odds ratio of 0.09011 when performance is assessed as a function of the moneyness of the fund at the start of the post assessment period (last row, column (7) of Table 3, Panel B).

After considering the case of M=6 we now consider other assessment and post assessment periods. Our original choice of M=6 was a relatively arbitrary one. It may be that funds change their risk exposures in response to their performance relative to their peers, or because of the moneyness of the incentive option earlier, or later in the year. In Table 4 we present results analogous to those in Table 3 but with M=4, 5, 6, 7 and 8. Our assessment periods are therefore either from January to April (M=4) or from January to May (M=5) etc; and we calculate the moneyness of the fund at the end of April (M=4) or at the end of May (M=5) etc. The results are all for the full 14 year sample rather than for individual years[5].

Table 4 here

Panel A in Table 4 shows that for all assessment periods the effect of relative return on normalised RAR is statistically significant but at a declining rate, as evidenced by the declining value of the log odds ratio that falls from 0.2401 to 0.1597. This result suggests that fund managers are more likely to change their risk taking behaviour earlier on in the year rather than later in the year – and most likely halfway through the year. The effect of moneyness appears to be only significant from M=6 upwards and at an increasing rate – here the log odds ratio increases from 0.0243 to 0.1180. This result is extremely interesting since it can be taken to imply that hedge fund managers care more about relative return early in the year but more about the value of their incentive option (absolute return) later on in the year. One possible explanation for this is that as the year moves towards its end managers have less chance or opportunity of increasing their ranking but can attempt to maximise the fees they will receive by increasing risk, though the data does not support this. The proportion of funds that are below their high-water mark that increase risk actually falls from

[5]We repeat the results for M=6 here for completeness. Yearly results for each value of M are available on request.

15.68% over the (4,8) assessment period to 15.25% over the (8,4) assessment period. Rather the result appears to be driven by the proportion of funds that are above their high-water mark who reduce risk which increases from 34.63% to 36.05%.

4.2. Disaggregated analysis

Having ascertained that there appears to be a relationship between the risk taking decisions of hedge fund managers and both their relative performance and the value of their incentive option using 2x2 contingency tables we now examine the relationship across a broader cross-section of relative returns and moneyness.

Table 5 presents the results for the effect of relative performance on Normalised RAR for M=6. These results are shown in Figure 4 too. Although the funds in the top four performance deciles reduce risk this reduction is only statistically significant for the first and fourth deciles. Meanwhile there is a statistically significant increase in risk for the fifth to the ninth performance deciles. This confirms our previous results and is consistent with the mutual fund literature that shows that fund managers react to their implicit incentives to increase (decrease) risk in order to improve (maintain) their ranking by year end.

Table 5, Figure 4 here

Table 6 presents the results for the effect of the moneyness of the incentive option (absolute performance) on subsequent Normalised RAR for M=6. These results are shown in Figure 5 too. Here we see that there is evidence of a statistically significant change in risk behaviour across the moneyness categories. For moneyness above 1.15, that is for fund's that are 15% above the high-water mark half way through the year, there appears to be a statistically significant risk reduction, this is in line with the theoretical models presented by Carpenter (2000) and Hodder and Jackwerth (2007) who describe this as "locking in" behaviour. However for moneyness between 1.05 and 0.85 that is 5% above to 15% below the high - water mark after six months there is a statistically significant increase in risk. More interestingly we can see that for funds that are 15% below their high water mark after the first half of the year there is a reduction in risk taking behaviour. However, since this reduction in risk is not found to be statistically significant we cannot reject the null hypothesis of a Normalised RAR of zero, a result that does not support Carpenter's model (2000) but which does support the model of Hodder and Jackwerth (2007).

Table 6, Figure 5 here

4.3. Varying the Assessment Period

Table 7 presents the results for the effect of relative performance on Normalised RAR for a assessment periods ranging from (4,8) to (8,4). The results are broadly consistent across all assessment periods with a large negative and significant normalised RAR for the top performing decile and smaller positive normalised RAR for lower deciles.

Table 7 here

Table 8 presents the results for the effect of moneyness on Normalised RAR for a assessment periods ranging from (4,8) to (8,4). In contrast to the results for the response to relative performance, here we find significant changes in response as we vary the assessment period. As the assessment period increases from M=4 to M=8, although the results for above 1.05 moneyness are broadly consistent, with a normalised RAR significantly below zero, managers that are below their high-water mark appear to change their behaviour. In the early part of the year normalised RAR is not significantly different from zero below 0.90 moneyness, however as we move towards August (8,4) there is a significant increase in risk, in fact for the (8,4) assessment period the median normalised RAR is significantly above zero for all levels of moneyness below 1.10.

Table 8 here

4.4. Size & Age Effects

The previous analysis has shown that managers do appear to change their risk taking behaviour according to both relative performance and as a function of the value of their incentive option, with the former having the largest impact. As suggested by the theoretical literature on this topic, the implicit terms of the compensation contract do appear to inhibit excessive risk taking by fund managers who find themselves substantially below their high-water mark.

In the next section of the paper we examine whether fund characteristics such as size and age have any impact on risk taking behaviour.

4.4.1. Size

Using a Probit regression Liang (2000) shows that fund size is an important factor in determining fund survival with smaller funds more likely to liquidate. With this in mind we now examine whether small and large funds differ in their risk taking behaviour in response to relative performance and dependent upon the moneyness of their incentive option. Using the fund size data reported in Table 1, we split the sample by defining large funds as those which are either larger than or equal to the median size and small funds as those that are smaller than the median size. We then carry out the same contingency analysis as in the previous section on these sub-samples.

Table 9 here

Table 9 presents the results for 2x2 contingency table tests. Panels A and B show that there is a statistically significant change in risk levels whether funds are categorised by their performance relative to other funds in the assessment period or by the moneyness of both large and small funds in the same direction. It would appear that the response to relative returns is greater for small than for large funds while the response to the moneyness of the incentive option is smaller. These results are consistent with the findings of Brown et al. (1996) for mutual funds and also with the theoretical model of behaviour presented by Hodder and Jackwerth (2007). Small funds who wish to attract assets will need to ensure that their relative performance is strong, thus if they are below (above) the median return at the half year assessment date they are more likely to increase (decrease) risk in order to try and improve (maintain) their ranking. However if small funds face a greater chance of liquidation than large funds, they are less likely to increase their risk if they are below their high-water marks.

In Table 10 and Figure 6 we present the results for the effect of relative performance on Normalised RAR for both large and small funds. Though the median normalised RAR for the first decile is more negative for the small fund sample, which suggests that smaller funds are more susceptible to "locking in" behaviour, the difference is not statistically significant. It is a similar story for the lower deciles, for the fifth, sixth, seventh and ninth deciles the median normalised RAR for the small firm sample is more positive, which suggests that smaller funds are more likely to increase risk, but once again the difference is not statistically significant.

Table 10, Figure 6 here

In Table 11 and in Figure 4 we present the results for the effect that the moneyness of the incentive option has on Normalised RAR for both large and small funds. For the funds that are significantly above their high-water mark, the median normalised RAR is more negative for the small fund sample (and in 1 case statistically significantly so) suggesting smaller funds are more susceptible to “locking in” behaviour. However for those funds that are at or below their high-water marks the median normalised RAR for the small sample is less positive than for large funds. This result would appear to be consistent with the literature because it could be the possibility of liquidation that prevents small funds from increasing risk.

Table 11 and Figure 7

4.4.2. Fund age

Both Liang (2000) and Brown, Goetzmann, and Park (2001) identify age as an important factor in determining fund survival with younger funds more likely to liquidate. With this in mind we now examine whether young and old funds differ in their risk taking behaviour in response to relative and absolute returns. Using the fund age data reported in Table 11, we split the sample by defining old funds as those which are either older or equal to the median age and young funds as those that are younger than the median size. We then carry out the same analysis as in the previous section on these sub-samples.

Table 12 presents the results for the simple 2x2 contingency table tests. Panels A and B show that there is a statistically significant response in risk to both relative performance and moneyness for both young and old funds in the same direction as previously reported. It would appear that the response to relative returns is almost identical for both young and old funds, while the response to absolute returns is slightly larger for young funds. This result is somewhat surprising and contrasts with both the results for size and with the theoretical literature. One would expect that young funds who wish to attract assets will have to ensure that their relative performance is strong, thus if they are below (above) the median return at the half year assessment date they are more likely to increase (decrease) risk in order to try and improve (maintain) their ranking, at the same time if younger funds face a greater chance of liquidation than older funds, they are less likely to increase their risk if they are below their high-water mark, but this is not supported by the data.

Table 13 and Figure 8 present the results for the effect of relative performance on Normalised RAR for both young and old funds. As with the results for size, the median normalised RAR for the first decile is more negative for the young fund sample, suggesting that younger funds are more susceptible to “locking in” behaviour, but the difference is not statistically significant. Similarly, examining the lower deciles, for the fifth, sixth, eighth and ninth deciles the median normalised RAR for the old sample is more positive, suggesting that older funds are more susceptible to increasing risk, but once again the difference is not statistically significant.

Table 13 and Figure 8 here

Table 14 and Figure 9 present the results for the effect of the moneyness of the incentive option has on Normalised RAR for both young and old funds. For the funds that are significantly above their high-water mark, the only apparent (and statistically significant) difference is that for younger funds the median normalised RAR is more negative in the 1.1 to 1.15 range of moneyness, this suggests that younger funds are more susceptible to “locking in” behaviour. However for those funds that are below their high-water mark the median normalised RAR for the young sample is less positive (or in one case negative). Once again this result is consistent with the literature because if it is the threat of liquidation that is preventing excess increasing of risk, and younger funds have a higher probability of liquation, then they are less inclined to increase risk.

Table 14 and Figure 9 here

6.0 Conclusions

We find evidence to suggest that hedge fund managers adjust the risk profile of their funds in response to their relative performance with managers of relatively poor (strong) performing funds increasing (decreasing) the risk profile of their funds. The hedge fund industry has always sold itself on the basis that it targets and aims to produce absolute returns for investors. That is, returns that are not benchmarked against specific financial market indices, or against a peer group. Our results call in to question this idea and suggests at a minimum that hedge funds pay attention to the performance of their peers. This may well be a consequence of the actions of fund of fund managers and other investors who make their own investment decisions based upon the relative performances of the funds in which they seek to invest. It may well be an unintended consequence of the way in which investors choose to invest in a fund.

Our results with regard to how hedge fund managers adjust the risk profile of their fund given the moneyness of their incentive option are more complex. Managers whose incentive option is well in the money decrease risk. Relatively speaking these managers are protecting the value of this option towards the end of the year. For investors who wish their managers to take risks in a consistent manner regardless of the month of the year, this result may come as a disappointment. It suggests that there is an element of “locking in” behaviour particularly towards the end of the calendar year. Perhaps of more interest is the risk taking behaviour of those fund managers who find their incentive option to be well out of the money. We find that these managers do not “put it all on black” in order to “win” back earlier losses and to increase the value of their incentive option. This should be good news for hedge fund investors. This conservative behaviour may be due to the implicit terms of the manager’s contract. As Hodder and Jackwerth (2007) suggest, these implicit terms may include the risk of liquidation as investors withdraw funds and may also be due to the often substantial management stake in the fund that discourages the fund manager from “swinging the bat”.

Our results are of significance for the design of hedge fund manager compensation contracts. It would appear that the concern that incentive fees encourage excessive risk taking behaviour may be misplaced, however there does appear to be an incentive to “lock in” previous gains by reducing the risk profile of the fund. It is possible that this locking in behaviour could be reduced by introducing a rising scale of incentive fees.

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Table 1
Summary Statistics for Hedge Fund Sample 1994-2007

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Convertible Arbitrage	26	38	40	47	51	64	75	81	104	120	122	105	97	66
Dedicated Short Bias	11	13	12	14	17	17	22	18	18	19	20	19	20	15
Emerging Markets	46	72	101	120	132	149	155	149	144	144	166	190	219	228
Equity Market Neutral	12	20	31	41	55	77	106	116	148	170	175	188	194	163
Event Driven	63	80	104	134	162	174	194	215	233	273	314	341	319	284
Fixed Income Arbitrage	19	30	41	55	55	67	69	77	91	115	144	166	159	132
Global Macro	48	55	61	68	83	87	76	77	89	112	135	139	147	131
Long/Short Equity Hedge	175	225	278	375	468	554	659	762	840	899	968	1,015	1,055	950
Managed Futures	156	175	169	179	186	176	178	172	160	172	188	210	217	214
Multi-Strategy	20	25	36	51	62	73	85	101	119	153	176	192	238	266
Total	576	733	873	1,084	1,271	1,438	1,619	1,768	1,946	2,177	2,408	2,565	2,665	2,449
Median Fund Size ($m)	6.6	5.5	6.1	8.0	11.0	11.3	15.6	18.9	20.0	20.7	27.0	28.9	31.2	60.0
Mean Fund Size ($m)	56.4	46.4	51.4	62.2	79.2	64.2	69.8	79.9	86.3	93.3	127.6	143.3	169.5	250.8
Median Age (months)	24	27	29	30	33	36	39	41	41	42	41	43	45	52
Mean Age (months)	37	38	40	41	44	47	49	51	52	54	56	58	61	68

Notes: The table presents summary information for the sample of hedge funds collected from the TASS database. Only funds that are denominated in US Dollars, report monthly performance and that have a return history spanning at least one full calendar year are included. The statistics for fund size are based on funds that report this information and thus do not represent every fund in the sample. Fund age is calculated based on the reported inception date of the fund.

Table 2
Summary Statistics Return, Moneyness and Risk Adjustment Ratio (RAR) 1994-2007

Panel A: Median (Annualised) Gross Return

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Convertible Arbitrage	-5.4%	18.6%	24.9%	19.3%	14.4%	19.9%	28.2%	22.4%	11.3%	16.5%	1.4%	-7.3%	17.4%	12.5%
Dedicated Short Bias	57.1%	-8.7%	-4.7%	2.7%	-2.6%	-14.5%	-16.1%	7.2%	39.9%	-18.5%	-4.3%	7.8%	-0.3%	-8.1%
Emerging Markets	-5.0%	-0.8%	38.5%	51.5%	-19.2%	47.2%	8.4%	15.5%	20.7%	42.3%	7.3%	12.0%	17.3%	29.8%
Equity Market Neutral	6.9%	17.4%	23.0%	20.6%	14.5%	12.7%	20.5%	12.8%	6.9%	7.6%	5.1%	7.8%	14.5%	13.3%
Event Driven	9.7%	23.8%	25.5%	20.1%	17.8%	23.6%	21.6%	11.5%	4.2%	23.5%	10.3%	8.1%	17.7%	18.2%
Fixed Income Arbitrage	9.5%	17.6%	20.3%	21.2%	11.7%	19.6%	12.1%	15.8%	15.7%	12.8%	9.1%	7.7%	12.9%	11.9%
Global Macro	-8.3%	19.9%	13.5%	14.1%	8.5%	4.7%	6.3%	11.3%	11.9%	18.5%	1.0%	6.2%	7.6%	15.2%
Long/Short Equity Hedge	-0.3%	32.6%	35.6%	27.7%	24.5%	42.0%	20.2%	8.2%	2.5%	18.1%	6.8%	6.1%	14.2%	24.1%
Managed Futures	2.7%	22.1%	4.7%	16.4%	4.9%	7.4%	-3.0%	5.1%	13.0%	22.3%	-8.3%	-0.5%	15.8%	12.4%
Multi-Strategy	-2.5%	18.6%	20.5%	21.1%	16.7%	23.0%	28.1%	14.9%	6.6%	14.8%	6.2%	4.1%	14.5%	18.9%
All Funds	1.5%	21.6%	23.7%	22.5%	15.2%	24.3%	15.8%	11.3%	7.3%	17.5%	5.9%	6.3%	14.5%	18.9%

Panel B: Median Moneyness

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Convertible Arbitrage	0.97	1.04	1.07	1.05	1.05	1.06	1.08	1.07	1.03	1.06	1.01	0.94	1.04	1.04
Dedicated Short Bias	1.11	1.00	0.83	0.96	0.96	0.93	0.91	0.89	0.98	0.89	0.71	0.65	0.61	0.53
Emerging Markets	0.97	0.96	1.06	1.09	0.90	0.83	0.92	0.97	1.04	1.07	1.02	1.02	1.06	1.08
Equity Market Neutral	1.01	1.04	1.06	1.05	1.04	1.03	1.07	1.03	1.02	1.01	1.01	1.02	1.04	1.04
Event Driven	1.02	1.06	1.07	1.05	1.06	1.06	1.05	1.04	1.02	1.06	1.02	1.01	1.06	1.07
Fixed Income Arbitrage	1.03	1.05	1.05	1.06	1.03	1.04	1.02	1.04	1.04	1.03	1.02	1.02	1.04	1.04
Global Macro	0.92	1.00	1.05	1.03	1.03	0.99	1.00	1.02	1.01	1.04	1.00	0.99	1.02	1.03
Long/Short Equity Hedge	1.00	1.06	1.13	1.07	1.07	1.08	1.03	1.01	1.01	1.01	1.01	1.00	1.05	1.08
Managed Futures	0.98	1.03	1.00	1.03	1.00	0.99	0.97	1.01	0.97	1.10	0.98	0.96	1.04	1.02
Multi-Strategy	1.00	1.02	1.06	1.06	1.05	1.05	1.07	1.04	1.02	1.04	1.01	1.00	1.05	1.06
All Funds	1.00	1.04	1.07	1.05	1.04	1.04	1.03	1.03	1.02	1.03	1.01	1.00	1.05	1.06

Panel C: Median RAR

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Convertible Arbitrage	1.00	0.78	1.14	1.27	2.09	1.03	0.90	0.67	1.84	0.89	0.59	0.72	0.54	2.18
Dedicated Short Bias	0.92	1.09	1.59	0.92	2.06	1.24	1.01	1.19	1.39	0.84	1.50	1.18	0.88	1.34
Emerging Markets	0.89	0.59	0.72	1.65	1.75	1.02	0.74	1.29	0.94	0.86	0.70	1.18	0.51	1.68
Equity Market Neutral	0.96	1.25	0.96	0.97	1.65	0.87	0.75	0.80	1.44	1.01	0.99	1.05	0.83	1.40
Event Driven	0.85	0.97	0.97	1.02	2.58	0.93	0.70	1.09	1.20	0.77	1.10	1.08	0.85	1.62
Fixed Income Arbitrage	0.88	0.86	1.00	1.14	2.93	1.09	0.84	1.24	1.14	1.20	0.81	0.87	0.92	1.93
Global Macro	0.74	0.97	0.98	0.99	1.33	1.14	0.89	0.87	0.99	0.98	0.93	1.09	0.72	1.87
Long/Short Equity Hedge	0.87	1.31	1.15	1.08	1.78	1.02	0.66	0.92	1.25	0.88	1.09	1.06	0.65	1.68
Managed Futures	0.80	0.85	1.01	1.36	1.81	0.96	1.50	1.10	1.17	0.68	0.74	1.02	0.83	1.33
Multi-Strategy	0.82	1.07	0.85	1.33	1.97	1.07	0.79	0.86	1.35	0.90	0.89	1.14	0.66	2.13
All Funds	0.85	0.97	1.00	1.17	1.84	1.01	0.76	0.97	1.24	0.86	0.95	1.05	0.71	1.68

Notes: The table presents median values for various statistics for both individual strategies and for all funds in the sample using a 6 month assessment and post assessment period. Panel A presents the median annualised return for M=6 calculated from equation (2) in the text. Panel B presents the median moneyness for M=6 calculated from equation (4). Panel C presents the median risk adjustment ratio calculated from equation (3) for M=6.

Table 3
Contingency Tables of Relative Returns, Moneyness and Risk Adjustment Ratio

Panel A

		Below Median Return		Above Median Return		Log Odds	Std Error Log		
	Observations	Lower RAR	Higher RAR	Lower RAR	Higher RAR	Ratio	Odds	t-value	Chi-Square
1994	576	25.69%	23.96%	24.65%	25.69%	-0.1113	0.1667	-0.67	0.45
1995	733	21.96%	26.74%	28.38%	22.92%	0.4103	0.1486	2.76	7.65**
1996	873	20.39%	27.26%	29.90%	22.45%	0.5769	0.1369	4.21	17.87**
1997	1,084	21.86%	27.86%	28.41%	21.86%	0.5044	0.1225	4.12	17.06**
1998	1,271	23.92%	25.18%	26.28%	24.63%	0.1162	0.1123	1.04	1.07
1999	1,438	20.38%	27.96%	29.83%	21.84%	0.6283	0.1068	5.88	34.87**
2000	1,619	22.30%	26.25%	27.86%	23.59%	0.3293	0.0998	3.30	10.91**
2001	1,768	23.53%	25.57%	26.64%	24.26%	0.1764	0.0952	1.85	3.43
2002	1,946	22.51%	26.16%	27.60%	23.74%	0.3007	0.0910	3.31	10.95**
2003	2,177	20.26%	28.25%	29.86%	21.64%	0.6547	0.0869	7.53	57.24**
2004	2,408	22.84%	25.71%	27.20%	24.25%	0.2329	0.0817	2.85	8.14**
2005	2,565	25.03%	22.92%	25.07%	26.98%	-0.1613	0.0791	-2.04	4.16*
2006	2,665	22.78%	26.38%	27.35%	23.49%	0.2992	0.0777	3.85	14.85**
2007	2,449	23.23%	24.50%	26.87%	25.40%	0.1093	0.0809	1.35	1.82
1994-2007	23,572	22.68%	25.91%	27.47%	23.94%	0.2708	0.0261	10.37	107.61**

Notes: Proportions in the body of the table give the proportion of funds that fall into each classification. Each fund was required to have a complete return history for each calendar year. Above and below median measures are defined as Normalised Return or RAR greater or less than zero. The log odds ratio is the log of the ratio of the product of the second and third columns to the product of the first and fourth with standard error and the t-value measures the significance of this ratio. The chi-square number represent the statistics from the 2x2 contingency tables with 1 degree of freedom. Values significant at the 5% level are denoted with * and those significant at 1% by **.

Table 3 (cont)

Panel B

		Below High-Water Mark		Above High-Water Mark		Log Odds Ratio	Std Error Log Odds	t-value	Chi-Square
		Lower RAR	Higher RAR	Lower RAR	Higher RAR				
1994	576	28.13%	25.17%	22.22%	24.48%	-0.2076	0.1673	-1.24	1.54
1995	733	14.87%	18.96%	35.47%	30.70%	0.3877	0.1570	2.47	6.12*
1996	873	9.16%	11.80%	41.12%	37.92%	0.3339	0.1674	1.99	4.00*
1997	1,084	9.59%	10.33%	40.68%	39.39%	0.1064	0.1522	0.70	0.49
1998	1,271	14.87%	13.61%	35.33%	36.19%	-0.1127	0.1244	-0.91	0.82
1999	1,438	15.02%	18.01%	35.19%	31.78%	0.2834	0.1125	2.52	6.36*
2000	1,619	18.78%	20.63%	31.38%	29.22%	0.1655	0.1018	1.63	2.64
2001	1,768	17.48%	18.44%	32.69%	31.39%	0.0942	0.0992	0.95	0.90
2002	1,946	18.55%	19.01%	31.55%	30.88%	0.0460	0.0936	0.49	0.24
2003	2,177	13.60%	16.63%	36.52%	33.26%	0.2948	0.0937	3.15	9.93**
2004	2,408	16.61%	19.81%	33.43%	30.15%	0.2793	0.0849	3.29	10.84**
2005	2,565	24.44%	20.51%	25.65%	29.40%	-0.3118	0.0796	-3.92	15.36**
2006	2,665	5.93%	9.31%	44.20%	40.56%	0.5368	0.1102	4.87	24.10**
2007	2,449	6.98%	4.82%	43.12%	45.08%	-0.4154	0.1272	-3.27	10.78**
1994-2007	23,572	14.79%	15.66%	35.36%	34.19%	0.0911	0.0283	3.22	10.35**

Notes: Proportions in the body of the table give the proportion of funds falling into each classification. Each fund was required to have a complete return history for each calendar year. Above and below median measures are defined as Normalised Return or RAR greater or less than zero. The log odds ratio is the log of the ratio of the product of the second and third columns to the product of the first and fourth with standard error and the t-value measuring the significance of this. The chi-square number represents the statistics from the 2x2 contingency tables with 1 degree of freedom. Values significant at the 5% level are denoted with * and those significant at 1% by **.

Table 4
Contingency Tables of Relative Returns, Moneyness and Risk Adjustment Ratio Varying the Assessment Period

Panel A

Assessment Period	Obs	Below Median Return		Above Median Return		Log Odds Ratio	Std Error Log Odds	t-value	Chi-Square
		Lower RAR	Higher RAR	Lower RAR	Higher RAR				
(4,8)	23,574	22.82%	25.68%	27.32%	24.18%	0.2401	0.0261	9.20	84.65**
(5,7)		22.64%	25.88%	27.50%	23.98%	0.2704	0.0261	10.35	107.34**
(6,6)		22.68%	25.91%	27.47%	23.94%	0.2708	0.0261	10.37	107.61**
(7,5)		23.31%	25.44%	26.83%	24.42%	0.1819	0.0261	6.97	48.63**
(8,4)		23.56%	25.41%	26.59%	24.44%	0.1597	0.0261	6.13	37.54**

Panel B

Assessment Period	Obs	Below High-Water Mark		Above High-Water Mark		Log Odds Ratio	Std Error Log Odds	t-value	Chi-Square
		Lower RAR	Higher RAR	Lower RAR	Higher RAR				
(4,8)	23,574	15.51%	15.68%	34.63%	34.18%	0.0243	0.0281	0.87	0.75
(5,7)		15.85%	15.89%	34.29%	33.97%	0.0117	0.0280	0.42	0.18
(6,6)		14.79%	15.66%	35.36%	34.19%	0.0911	0.0283	3.22	10.35**
(7,5)		13.82%	14.82%	36.32%	35.04%	0.1050	0.0288	3.64	13.28**
(8,4)		14.10%	15.23%	36.05%	34.61%	0.1180	0.0286	4.12	16.99**

Notes: Proportions in the body of the table give the proportion of funds falling into each classification. Each fund was required to have a complete return history for each calendar year. Above and below median measures are defined as Normalised Return or RAR greater or less than zero. The log odds ratio is the log of the ratio of the product of the second and third columns to the product of the first and fourth with standard error and the t-value measuring the significance of this. The chi-square number represents the statistics from the 2x2 contingency tables with 1 degree of freedom. Values significant at the 5% level are denoted with * and those significant at 1% by **.

Table 5
Median Normalised Risk Adjustment Ratio by Performance Decile

Assessment Period	Performance Decile	10	9	8	7	6	5	4	3	2	1
(6,6)	Observations	2,132	2,275	2,304	2,378	2,363	2,427	2,397	2,438	2,432	2,426
	Median Normalised RAR	-0.0088**	0.0726**	0.0475**	0.0624**	0.0470**	0.0441**	-0.0036**	-0.0397	-0.0484	-0.1449**
	Wilcoxon Statistic	-2.9985	-10.3075	-9.2600	-10.6714	-9.5400	-8.6747	-5.2503	-0.6152	-0.3410	-8.1947
	p-Value	0.0027	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5384	0.7331	0.0000

Notes: The table presents the normalised risk adjustment ratio by performance decile as well as the test statistics for a Wilcoxon signed rank test of this median. Values significant at the 5% level are denoted with * and those significant at 1% by **.

Table 6
Median Normalised Risk Adjustment Ratio by Moneyness

Assessment Period	Moneyness	0.70-0.75	0.75-0.80	0.80-0.85	0.85-0.90	0.90-0.95	0.95-1.00	1.00-1.05	1.05-1.10	1.10-1.15	1.15-1.20	1.20-1.25	1.25-1.30
(6,6)	Observations	245	311	479	805	1,387	3,190	7,029	4,935	2,095	1,016	520	265
	Normalised RAR	-0.0586	-0.0270	-0.0152	0.0262**	0.0086**	0.0440**	0.0529**	-0.0046**	-0.0585	-0.0903**	-0.1158**	-0.1514**
	Wilcoxon Statistic	-0.8821	-0.4619	-1.6404	-2.8820	-4.6656	-9.6559	-16.9824	-7.3172	-1.5184	-2.6788	-3.0113	-4.2374
	p-Value	0.3777	0.6442	0.1009	0.0040	0.0000	0.0000	0.0000	0.0000	0.1289	0.0074	0.0026	0.0000

Notes: The table presents the normalised risk adjustment ratio by performance decile as well as the test statistics for a Wilcoxon signed rank test of this median. Values significant at the 5% level are denoted with * and those significant at 1% by **.

Table 7
Median Normalised Risk Adjustment Ratio by Performance Decile, Varying the Assessment Period

Assessment Period	Performance Decile	10	9	8	7	6	5	4	3	2	1
(4,8)	Observations	2112	2293	2303	2365	2361	2434	2403	2441	2417	2445
	Median Normalised RAR	-0.0163**	0.0259**	0.0425**	0.0593**	0.0571**	0.0463**	-0.0008**	-0.0156**	-0.0452	-0.1382**
	Wilcoxon Statistic	-4.3230	-8.8680	-10.1317	-11.3619	-11.3571	-11.2073	-7.1557	-4.7867	-1.6422	-7.1910
	p-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1006	0.0000
(5,7)	Observations	2117	2279	2321	2382	2338	2435	2416	2422	2434	2430
	Median Normalised RAR	-0.0173**	0.0470**	0.0603**	0.0492**	0.0402**	0.0397**	-0.0001**	-0.0253**	-0.0585	-0.1336**
	Wilcoxon Statistic	-3.2537	-9.9317	-10.8222	-10.7923	-9.2358	-9.6500	-5.4474	-2.8691	-0.0705	-7.5317
	p-Value	0.0011	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0041	0.9438	0.0000
(6,6)	Observations	2132	2275	2304	2378	2363	2427	2397	2438	2432	2426
	Median Normalised RAR	-0.0088**	0.0726**	0.0475**	0.0624**	0.0470**	0.0441**	-0.0036**	-0.0397	-0.0484	-0.1449**
	Wilcoxon Statistic	-2.9985	-10.3075	-9.2600	-10.6714	-9.5400	-8.6747	-5.2503	-0.6152	-0.3410	-8.1947
	p-Value	0.0027	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5384	0.7331	0.0000
(7,5)	Observations	2158	2288	2317	2371	2359	2428	2391	2427	2412	2423
	Median Normalised RAR	-0.0134**	0.0430**	0.0354**	0.0406**	0.0347**	0.0364**	-0.0011**	-0.0053**	-0.0412	-0.1496**
	Wilcoxon Statistic	-3.7883	-7.3760	-8.3569	-8.5266	-8.1039	-8.1704	-5.2824	-4.1589	-1.8652	-7.1575
	p-Value	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0622	0.0000
(8,4)	Observations	2199	2295	2328	2366	2355	2417	2376	2402	2423	2413
	Median Normalised RAR	0.0323**	0.0288**	0.0089**	0.0233**	0.0450**	0.0022**	0.0106**	0.0113**	-0.0420	-0.1461**
	Wilcoxon Statistic	-7.0864	-7.5212	-6.1737	-7.2004	-7.8144	-5.8398	-6.2301	-4.5616	-1.7225	-4.9008
	p-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0850	0.0000

Notes: The table presents the normalised risk adjustment ratio by performance decile as well as the test statistics for a Wilcoxon signed rank test of this median. Values significant at the 5% level are denoted with * and those significant at 1% by **.

Table 8
Median Normalised Risk Adjustment Ratio by Moneyness Varying the Assessment Period

Assessment Period	Moneyness	0.70-0.75	0.75-0.80	0.80-0.85	0.85-0.90	0.90-0.95	0.95-1.00	1.00-1.05	1.05-1.10	1.10-1.15	1.15-1.20	1.20-1.25	1.25-1.30
(4,8)	Observations	237	276	439	728	1429	3447	9758	3933	1306	535	288	149
	Median Normalised RAR	-0.0658	-0.0771	-0.0175	-0.0372	0.0181**	0.0368**	0.0522**	-0.0366**	-0.0660**	-0.1188**	-0.1495**	-0.1935**
	Wilcoxon Statistic	-0.34	-1.52	-1.24	-0.98	-4.95	-11.83	-22.96	-3.89	-2.90	-3.40	-5.39	-5.08
	p-Value	0.73	0.13	0.21	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(5,7)	Observations	209	310	498	795	1533	3347	7943	4528	1828	802	359	223
	Median Normalised RAR	-0.0006	-0.0998*	-0.0672	-0.0368	0.0006**	0.0357**	0.0600**	-0.0036**	-0.0688**	-0.0907**	-0.1604**	-0.1587**
	Wilcoxon Statistic	-1.83	-2.12	-0.42	-1.71	-3.67	-10.62	-20.61	-6.28	-2.86	-2.85	-4.77	-4.67
	p-Value	0.07	0.03	0.67	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(6,6)	Observations	245	311	479	805	1387	3190	7029	4935	2095	1016	520	265
	Median Normalised RAR	-0.0586	-0.0270	-0.0152	0.0262**	0.0086**	0.0440**	0.0529**	-0.0046**	-0.0585	-0.0903**	-0.1158**	-0.1514**
	Wilcoxon Statistic	-0.88	-0.46	-1.64	-2.88	-4.67	-9.66	-16.98	-7.32	-1.52	-2.68	-3.01	-4.24
	p-Value	0.38	0.64	0.10	0.00	0.00	0.00	0.00	0.00	0.13	0.01	0.00	0.00
(7,5)	Observations	245	300	460	810	1358	2796	6292	5140	2420	1197	691	342
	Median Normalised RAR	0.0445*	-0.0007	0.0302**	0.0244**	0.0161**	0.0224**	0.0463**	0.0109**	-0.0566	-0.0786	-0.1415**	-0.2187**
	Wilcoxon Statistic	-2.22	-1.02	-3.13	-3.35	-5.42	-8.15	-15.03	-8.43	-0.09	-1.32	-3.88	-3.79
	p-Value	0.03	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.93	0.19	0.00	0.00
(8,4)	Observations	261	361	528	828	1452	2637	5700	4976	2547	1314	780	421
	Median Normalised RAR	0.1091**	0.0478*	0.0517**	0.0488**	0.0032**	0.0203**	0.0253**	0.0100**	-0.0198**	-0.0480	-0.1334*	-0.0838
	Wilcoxon Statistic	-3.30	-2.15	-4.05	-4.57	-3.43	-6.89	-12.13	-8.81	-2.75	-0.23	-2.35	-1.57
	p-Value	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.82	0.02	0.12

Notes: The table presents the normalised risk adjustment ratio by performance decile as well as the test statistics for a Wilcoxon signed rank test of this median. Values significant at the 5% level are denoted with * and those significant at 1% by **.

Table 9
Contingency Tables of Relative Returns, Moneyness and Risk Adjustment Ratio Split By Size

Panel A

Assessment Period	Observations	Below Median Return		Above Median Return		Log Odds Ratio	Std Error Log Odds	t-value	Chi-Square
		Low RAR	High RAR	Low RAR	High RAR				
(6,6)	Large 11,673	22.00%	25.05%	28.22%	24.73%	0.2617	0.0372	7.04	49.65**
	Small 9,964	22.99%	26.76%	27.25%	23.00%	0.3210	0.0402	7.98	63.87**

Panel B

Assessment Period	Observations	Below High-Water Mark		Above High-Water Mark		Log Odds Ratio	Std Error Log Odds	t-value	Chi-Square
		Low RAR	High RAR	Low RAR	High RAR				
(6,6)	Large 11,673	12.88%	13.87%	37.34%	35.91%	0.1134	0.0418	2.71	7.35**
	Small 9,964	17.35%	18.36%	32.89%	31.40%	0.1024	0.0418	2.45	6.00*

Notes: Proportions in the body of the table give the proportion of funds falling into each classification. Each fund was required to have a complete return history for each calendar year. Above and below median measures are defined as Normalised Return or RAR greater or less than zero. The log odds ratio is the log of the ratio of the product of the second and third columns to the product of the first and fourth with standard error and the t-value measuring the significance of this. The chi-square number represents the statistics from the 2x2 contingency tables with 1 degree of freedom. Values significant at the 5% level are denoted with * and those significant at 1% by **.

Table 10
Median Normalised Risk Adjustment Ratio by Performance Decile and Size

	Performance Decile	10	9	8	7	6	5	4	3	2	1
Large	Observations	885	1087	1108	1161	1251	1297	1280	1288	1216	1100
	Median Normalised RAR	-0.0007**	0.0746**	0.0695**	0.0537**	0.0330**	0.0358**	0.0000**	-0.0434	-0.0495	-0.1437**
	Wilcoxon Statistic	-2.7960	-7.1615	-7.3106	-6.3182	-5.8055	-5.7403	-4.4383	-0.1988	-0.0123	-5.5264
	p-Value	0.0052	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.8424	0.9902	0.0000

	Performance Decile	10	9	8	7	6	5	4	3	2	1
Small	Observations	1085	1000	973	990	909	937	959	967	1012	1132
	Median Normalised RAR	-0.0186	0.0943**	0.0383**	0.0725**	0.0731**	0.0548**	-0.0264*	-0.0474	-0.0516	-0.1655**
	Wilcoxon Statistic	-1.4292	-7.3646	-5.6006	-7.7881	-7.0592	-6.1627	-2.3397	-0.3489	-0.3825	-5.8673
	p-Value	0.1529	0.0000	0.0000	0.0000	0.0000	0.0000	0.0193	0.7272	0.7021	0.0000

Wilcoxon Rank Sum Test for Equal Medians p-value	0.3309	0.8130	0.3603	0.1040	0.0911	0.3158	0.1363	0.5118	0.9566	0.4026

Notes: The table presents the normalised risk adjustment ratio by performance decile, the test statistics for a Wilcoxon signed rank test of this median as well as the p-values for the Wilcoxon Rank Sum test of equal medians between the two samples. Values significant at the 5% level are denoted with * and those significant at 1% by **.

Table 11
Median Normalised Risk Adjustment Ratio by Moneyness and Size

	Moneyness	0.70-0.75	0.75-0.80	0.80-0.85	0.85-0.90	0.90-0.95	0.95-1.00	1.00-1.05	1.05-1.10	1.10-1.15	1.15-1.20	1.20-1.25	1.25-1.30
Large	Observations	90	115	205	343	617	1515	3724	2572	1106	514	254	133
	Median Normalised RAR	-0.1017	-0.0650	-0.0234	-0.0078*	0.0184**	0.0664**	0.0621**	-0.0220**	-0.0623*	-0.0948*	-0.0573	-0.1448**
	Wilcoxon Statistic	-0.6740	-0.6223	-1.4250	-2.3332	-3.5962	-7.2072	-13.2476	-3.4548	-2.1270	-2.2219	-0.6949	-3.1812
	p-Value	0.5003	0.5337	0.1542	0.0196	0.0003	0.0000	0.0000	0.0006	0.0334	0.0263	0.4871	0.0015
	Moneyness	0.70-0.75	0.75-0.80	0.80-0.85	0.85-0.90	0.90-0.95	0.95-1.00	1.00-1.05	1.05-1.10	1.10-1.15	1.15-1.20	1.20-1.25	1.25-1.30
Small	Observations	133	173	241	418	686	1423	2614	1965	812	415	229	117
	Median Normalised RAR	0.0184	-0.0034	-0.0631	0.0235	0.0091**	0.0376**	0.0366**	0.0111**	-0.0502	-0.1002	-0.1655**	-0.2204**
	Wilcoxon Statistic	-1.2790	-0.8375	-0.1421	-1.6827	-3.1709	-6.8671	-9.3134	-6.1219	-0.0366	-1.4747	-3.6772	-2.7742
	p-Value	0.2009	0.4023	0.8870	0.0924	0.0015	0.0000	0.0000	0.0000	0.9708	0.1403	0.0002	0.0055
	Wilcoxon Rank Sum Test for Equal Medians p-value	0.2459	0.3670	0.1812	0.6092	0.7188	0.8828	0.1197	0.0480*	0.2197	0.9262	0.0138*	0.8989

Notes: The table presents the normalised risk adjustment ratio by performance decile, the test statistics for a Wilcoxon signed rank test of this median as well as the p-values for the Wilcoxon Rank Sum test of equal medians between the two samples. Values significant at the 5% level are denoted with * and those significant at 1% by **.

Table 12
Contingency Tables of Relative Returns, Moneyness and Risk Adjustment Ratio Split by Age

Panel A

Assessment Period	Observations	Below Median Return		Above Median Return		Log Odds Ratio	Std Error Log Odds	t-value	Chi-Square
		Low RAR	High RAR	Low RAR	High RAR				
(6,6)	Old 12,959	23.28%	27.26%	26.19%	23.27%	0.2757	0.0352	7.83	61.35**
	Young 9,964	21.94%	24.26%	29.04%	24.76%	0.2602	0.0390	6.67	44.52**

Panel B

Assessment Period	Observations	Below High-Water Mark		Above High-Water Mark		Log Odds Ratio	Std Error Log Odds	t-value	Chi-Square
		Low RAR	High RAR	Low RAR	High RAR				
(6,6)	Old 12,959	16.53%	17.75%	32.94%	32.78%	0.0761	0.0370	2.06	4.22*
	Young 9,964	12.66%	13.12%	38.31%	35.91%	0.0999	0.0444	2.25	5.06*

Notes: Proportions in the body of the table give the proportion of funds falling into each classification. Each fund was required to have a complete return history for each calendar year. Above and below median measures are defined as Normalised Return or RAR greater or less than zero. The log odds ratio is the log of the ratio of the product of the second and third columns to the product of the first and fourth with standard error and the t-value measuring the significance of this. The chi-square number represents the statistics from the 2x2 contingency tables with 1 degree of freedom. Values significant at the 5% level are denoted with * and those significant at 1% by **.

Table 13
Median Normalised Risk Adjustment Ratio by Performance Decile and Age

	Performance Decile	10	9	8	7	6	5	4	3	2	1
Old	Observations	1244	1315	1317	1347	1326	1325	1336	1365	1266	1118
	Median Normalised RAR	-0.0009*	0.0727**	0.0578**	0.0596**	0.0573**	0.0644**	-0.0145*	-0.0321	-0.0367	-0.1437**
	Wilcoxon Statistic	-2.4070	-7.5591	-7.5994	-7.6956	-7.4709	-7.1418	-2.5158	-0.5215	-0.8776	-6.2233
	p-Value	0.0161	0.0000	0.0000	0.0000	0.0000	0.0000	0.0119	0.6020	0.3802	0.0000

	Performance Decile	10	9	8	7	6	5	4	3	2	1
Young	Observations	888	960	987	1031	1037	1102	1061	1073	1166	1308
	Median Normalised RAR	-0.0161	0.0679**	0.0279**	0.0666**	0.0278**	0.0133**	0.0083**	-0.0491	-0.0561	-0.1478**
	Wilcoxon Statistic	-1.7669	-7.0539	-5.4152	-7.3944	-5.9956	-5.0752	-5.0162	-0.3707	-0.4040	-5.3969
	p-Value	0.0772	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7109	0.6862	0.0000

Wilcoxon Rank Sum Test for Equal Medians p-value	0.9024	0.5695	0.5694	0.5049	0.7690	0.3218	0.0373*	0.6090	0.2928	0.8653

Notes: The table presents the normalised risk adjustment ratio by performance decile, the test statistics for a Wilcoxon signed rank test of this median as well as the p-values for the Wilcoxon Rank Sum test of equal medians between the two samples. Values significant at the 5% level are denoted with * and those significant at 1% by **.

Table 14
Median Normalised Risk Adjustment Ratio by Moneyness and Age

	Moneyness	0.70-0.75	0.75-0.80	0.80-0.85	0.85-0.90	0.90-0.95	0.95-1.00	1.00-1.05	1.05-1.10	1.10-1.15	1.15-1.20	1.20-1.25	1.25-1.30
Old	Observations	179	210	308	533	850	1,766	3,705	2,607	1,091	523	250	121
	Median Normalised RAR	0.0645*	-0.0001	-0.0292	0.0557**	0.0092**	0.0479**	0.0496**	-0.0001**	-0.0290	-0.1084*	-0.0810*	-0.1568**
	Wilcoxon Statistic	-2.4156	-0.9785	-0.4998	-2.8802	-3.2322	-7.4290	-12.3825	-4.9302	-0.0844	-2.3733	-2.0520	-3.8288
	p-Value	0.0157	0.3278	0.6172	0.0040	0.0012	0.0000	0.0000	0.0000	0.9327	0.0176	0.0402	0.0001

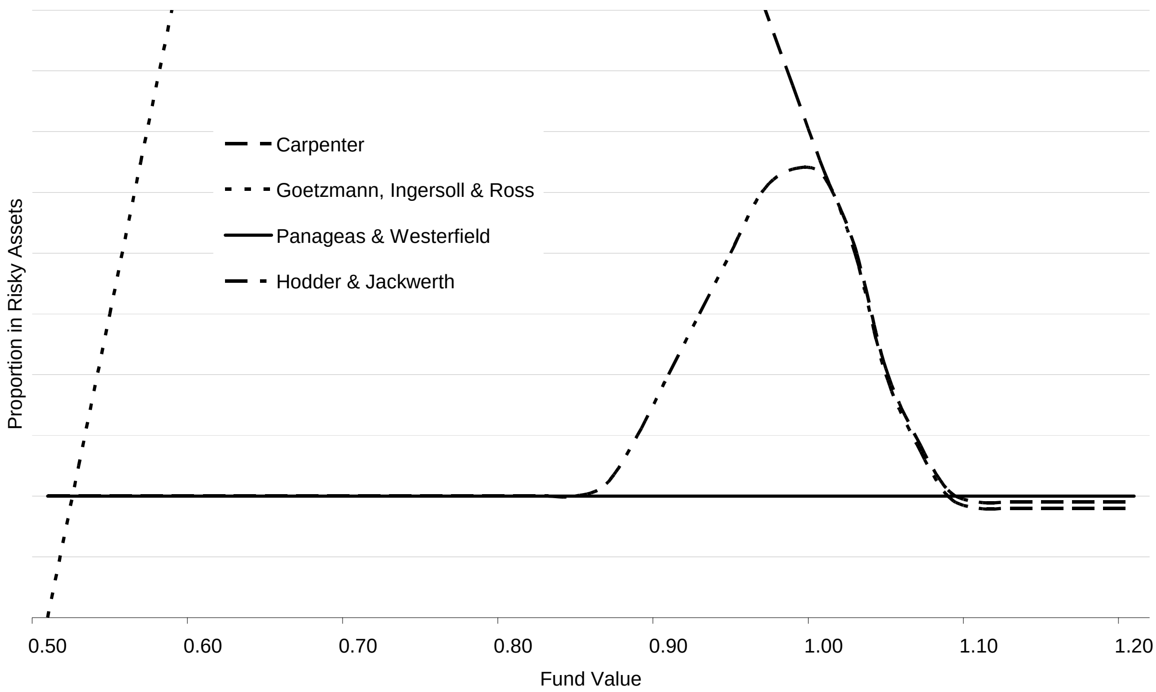
	Moneyness	0.70-0.75	0.75-0.80	0.80-0.85	0.85-0.90	0.90-0.95	0.95-1.00	1.00-1.05	1.05-1.10	1.10-1.15	1.15-1.20	1.20-1.25	1.25-1.30
Young	Observations	66	101	171	272	537	1,424	3,324	2,328	1,004	493	270	144
	Median Normalised RAR	-0.1621*	-0.0650	0.0102*	-0.0066	0.0086**	0.0334**	0.0569**	-0.0138**	-0.0910*	-0.0668	-0.1219*	-0.1423*
	Wilcoxon Statistic	-2.5329	-0.6521	-2.0827	-0.8515	-3.4286	-6.1877	-11.6489	-5.4583	-2.1187	-1.4029	-2.2526	-2.2915
	p-Value	0.0113	0.5143	0.0373	0.3945	0.0006	0.0000	0.0000	0.0000	0.0341	0.1606	0.0243	0.0219

Wilcoxon Rank Sum Test for Equal Medians p-value	0.0012**	0.1954	0.3279	0.3389	0.3956	0.9170	0.9576	0.7259	0.0326*	0.3819	0.8740	0.2366

The table presents the normalised risk adjustment ratio by performance decile, the test statistics for a Wilcoxon signed rank test of this median as well as the p-values for the Wilcoxon Rank Sum test of equal medians between the two samples. Values significant at the 5% level are denoted with * and those significant at 1% **

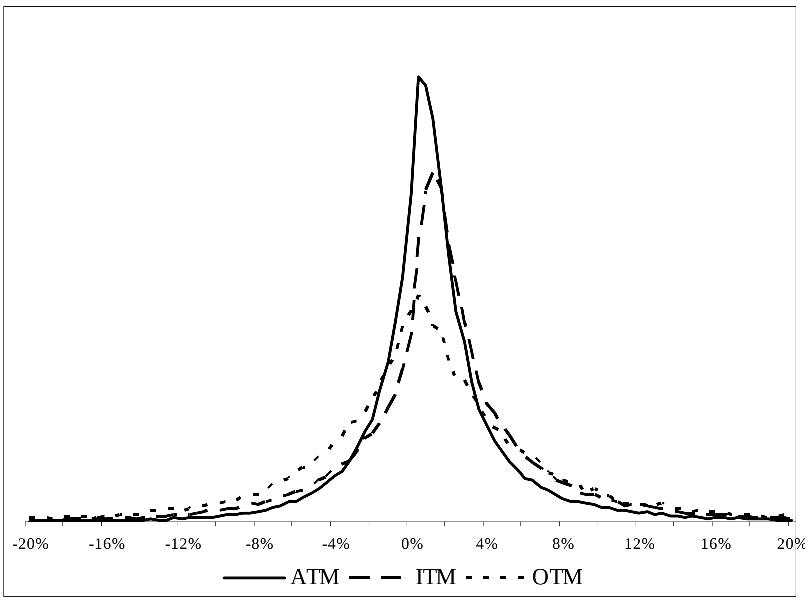
Figures

Figure 1
Comparison of Risk Choices Under Various Theoretical Models of Behaviour



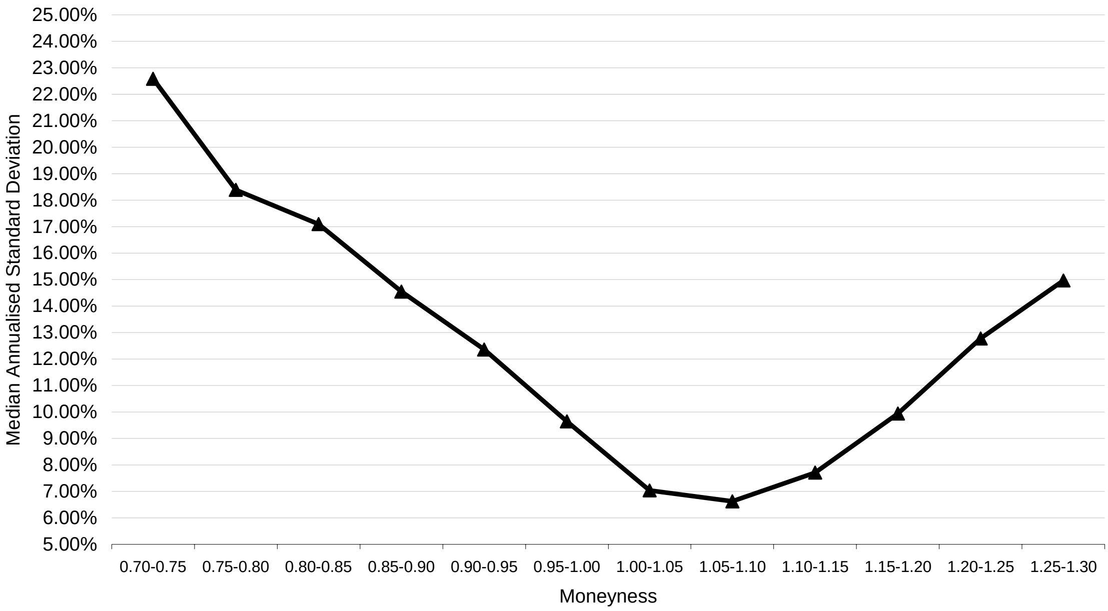
This figure shows how the optimal proportion of assets held in the risky asset varies with fund value under four different theoretical models of behaviour, Carpenter (2000), Goetzmann, Ingersoll and Ross (2003), Hodder and Jackwerth (2007) and Panageas and Westerfield (2008)

Figure 2
The Distribution of Hedge Fund Returns Conditional upon the Moneyness of The Incentive Option



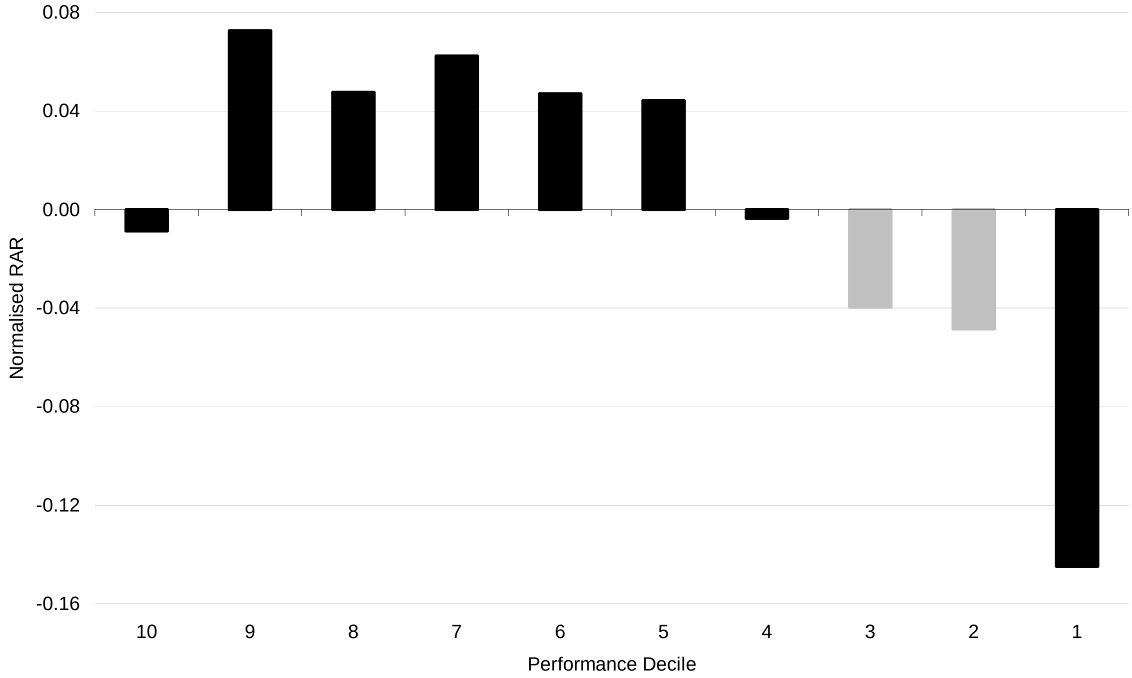
This figure taken from Brooks, Clare and Motson (2008) shows the distributions of return at time t+1 conditional upon the moneyness at time t. The three distributions are defined as: At the Money (ATM)

Figure 3
Median Annualised Standard Deviation by Moneyness of Incentive Option



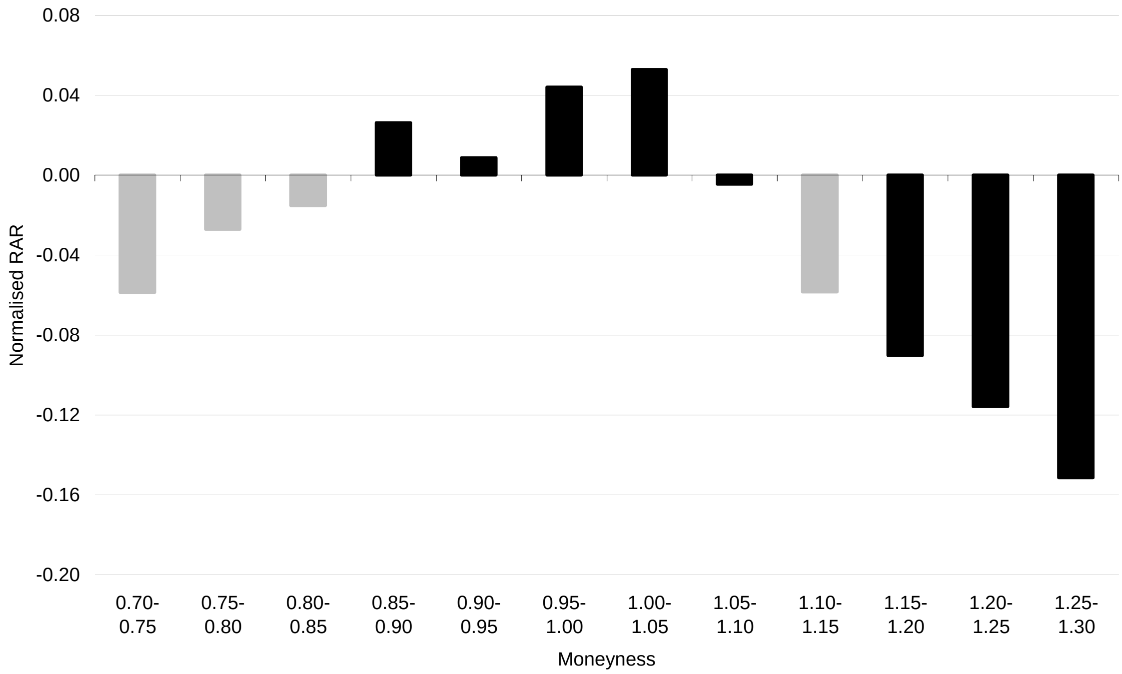
This figure shows the median historical annualised standard deviation of returns versus various levels of moneyness measured at the end of each calendar year.

Figure 4
Median Normalised Risk Adjustment Ratio by Performance Decile



This figure shows the median normalised risk adjustment ratio by performance decile with statistically significant values in black and others in grey

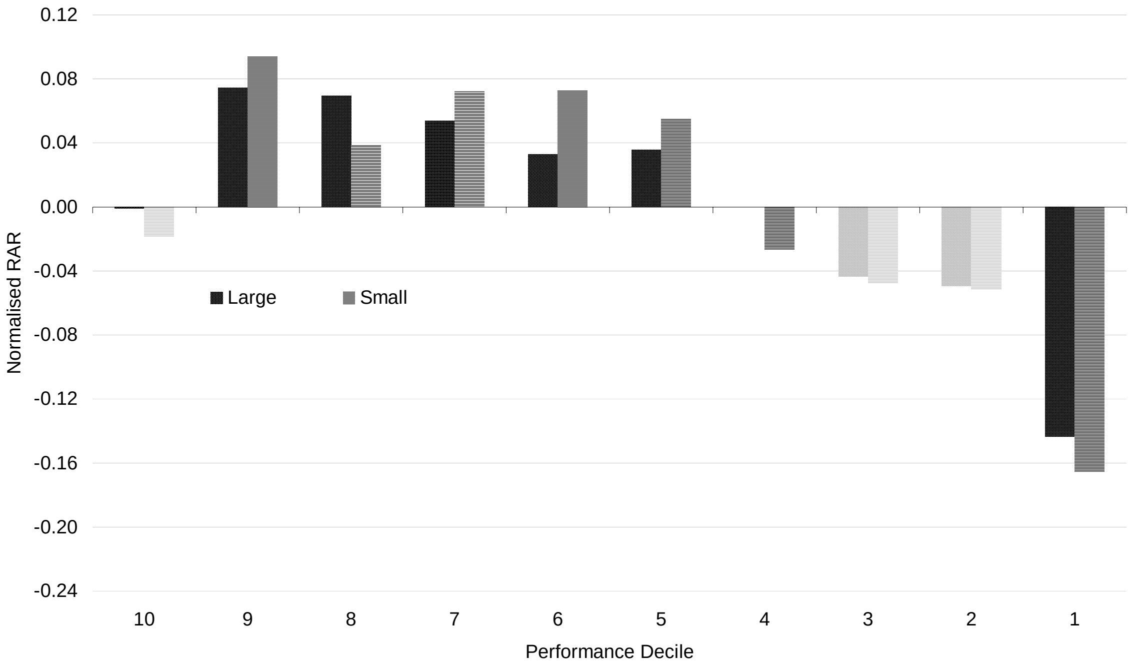
Figure 5
Median Normalised Risk Adjustment Ratio by Moneyness



This figure shows the median normalised risk adjustment ratio by level of moneyness with statistically significant values in black and others in grey

Figure 6

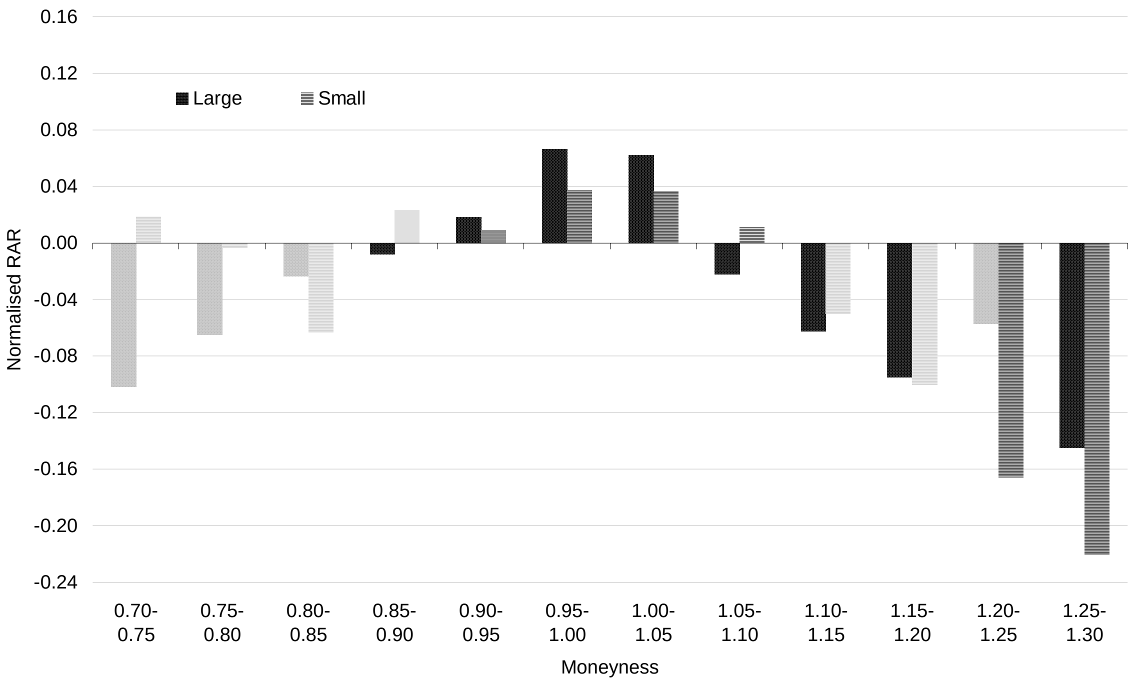
Median Normalised Risk Adjustment Ratio by Performance Decile and Size



This figure shows the normalised risk adjustment ratio by performance decile and size with statistically significant values in black and others in grey

Figure 7

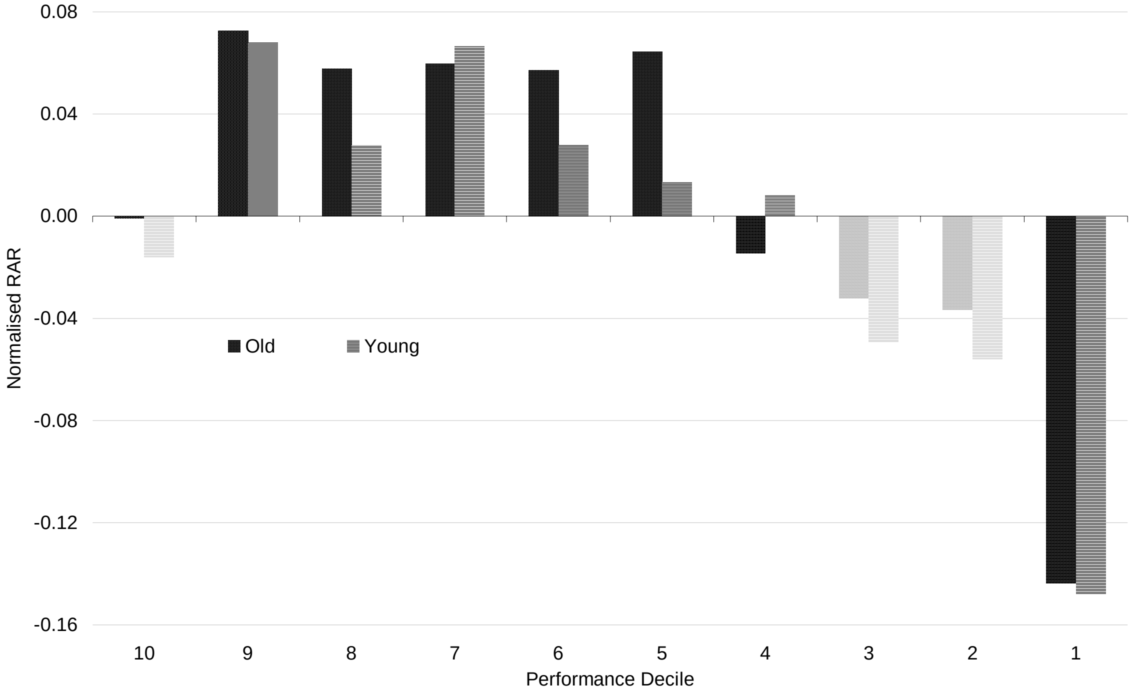
Median Normalised Risk Adjustment Ratio by Moneyness and Size



This figure shows the normalised risk adjustment ratio by level of moneyness and size with statistically significant values in black and others in grey

Figure 8

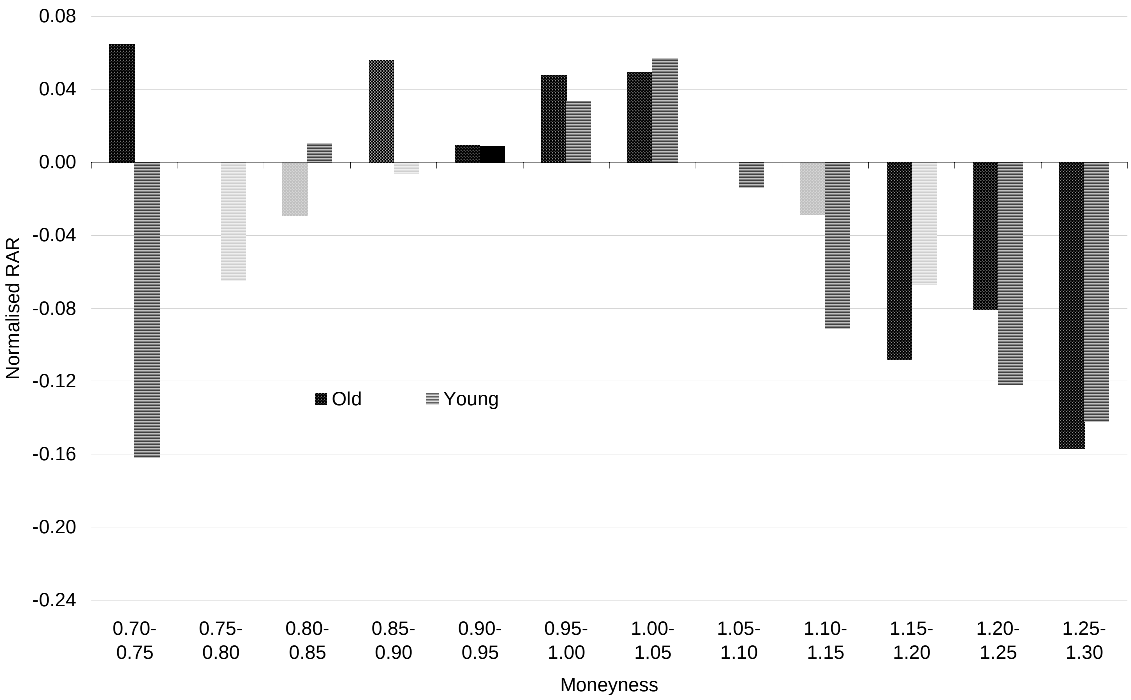
Median Normalised Risk Adjustment Ratio by Performance Decile and Age



This figure shows the normalised risk adjustment ratio by performance decile and size with statistically significant values in black and others in grey

Figure 9

Median Normalised Risk Adjustment Ratio by Moneyness and Age



This figure shows the normalised risk adjustment ratio by level of moneyness and age with statistically significant values in black and others in grey

Appendix

All hedge fund database providers (and indices) report monthly net, rather than gross, performance figures. However, all of these providers also report net asset values (NAVs) as well as net performance figures, and by using a number of realistic assumptions it is relatively straightforward to estimate gross returns from these NAV numbers. To do this, assumptions about the following issues are required. We assume that:

i) management fees are calculated and paid on a monthly basis;

ii) incentive fees are accrued on a monthly basis, but are only paid at the end of the calendar year;

iii) unless specified otherwise, the fund applies a high-water mark provision;

iv) the fund implements an 'Equalisation Credit/Contingent Redemption' approach to calculating the NAV such that it is the same for all investors (for a more thorough explanation see McDonnell [2003]).

The net hedge fund return for period *t* is calculated as follows:

$$R_{NET_t} = \frac{\left(NAV_t - NAV_{t-1}\right)}{NAV_{t-1}} \qquad \text{(A.1)}$$

The gross return for period *t* is calculated as follows:

$$R_{GROSS_t} = \frac{\left(NAV_t - NAV_{t-1}\right) + MgtFee_t + \left(AccruedIncentFee_t - AccruedIncentFee_{t-1}\right)}{\left(NAV_{t-1} + AccruedIncentFee_{t-1}\right)} \qquad \text{(A.2)}$$

where

$$MgtFee_t = NAV_t \times \left(\frac{1}{1 - \frac{MgmtFee\%}{12}} - 1 \right) \qquad \text{(A.3)}$$

and

$$AccruedIncentFee_t = \max\left\{0, NAV_t - HighWaterMark\right\} \times \left(\frac{1}{1 - IncentiveFee\%} - 1 \right) \qquad \text{(A.4)}$$

At the end of each year, the accrued incentive fee is reset to zero and if necessary, the high-watermark is moved upwards to reflect this.