The Gross Truth About Hedge Fund Performance and Risk: The Impact of Incentive Fees

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Abstract

Factor models are frequently applied to hedge fund returns in an attempt to separate the return from identified risk factors (beta) and from manager skill (alpha). More recently, these same techniques have been used to replicate the returns from hedge fund strategies with varying degrees of success. In this paper, we show that due to the particular nature of hedge fund incentive contracts, the use of net of fee returns can lead to considerably biased estimates of factor exposures which can distort the picture of fund manager performance. The solution we propose is to model the gross returns of hedge funds and the incentive fees independently, which gives a truer representation of the underlying return generating process. Using a large sample of hedge funds, we quantify the effect of this bias on both performance attribution and replication. We find that using net of fee returns understates the return attributable to beta by up to 58 basis points per annum. Following from this we find that some of the additional beta exposure can be captured by basing replication on gross rather than net returns. We also investigate the risk taking behaviour of fund managers conditional upon the delta of their incentive option and find that contrary to previous studies, there does appear to be evidence of increased risk taking for those managers who find themselves significantly below their high water mark.

Keywords: hedge fund, returns, alpha, beta, fees, performance

JEL Classifications: G1, G2

Introduction

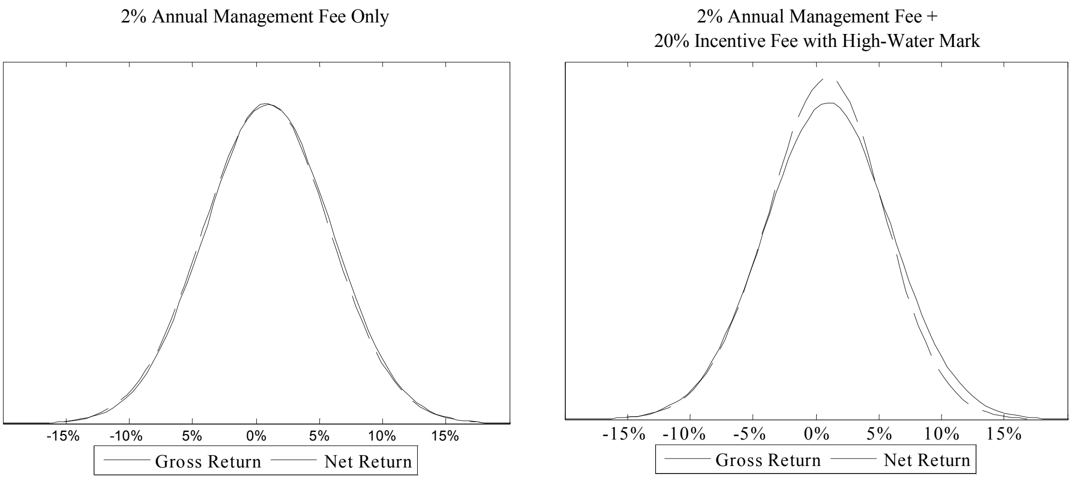
Investors in hedge funds are generally charged an annual management fee that can range anywhere from 1% to 3% of assets under management, and also an incentive fee which is typically between 10% and 30% of annual profits, based upon the fund's overall performance. It is argued that the annual management fee is designed to cover the fund's operating costs while the incentive fee "incentivizes" the manager to produce absolute returns.[1] This incentive fee is typically subject to two constraints: a "hurdle rate" and a "high-water mark". The hurdle rate is a benchmark return that must be exceeded before the performance incentive fees are payable. In practice, this hurdle rate is often set at zero, although benchmarks such as LIBOR are also common. The high-water mark means that each investor only pays performance fees when the value of their investment is greater than its previous highest value, which ensures that an investor only pays an incentive fee for positive performance once any previous underperformance has been recouped. The existence of such incentive fees and high-watermark provisions means that hedge fund fees are both time-varying and path-dependent, and therefore that the relationship between gross and net of fee returns is non-linear.

Figure 1 illustrates this via a Monte Carlo simulation of 5,000 funds over a 100 year history, assuming that the underlying gross returns are 1% per month with a 5% standard deviation (comparable to historical equity market returns). For funds that charge only an annual management fee (for example, mutual funds), the distribution is simply moved to the left by 0.17% per month with all other moments unchanged. However, introducing a 20% annual incentive fee that is accrued monthly and paid annually with a high-water mark provision, leads to a more significant change in the distribution. First, the mean net return is 0.70%, implying that the mean incentive fee payable is 0.13% per month, which is clearly less than 20% of the 0.83% return net of management fees because fees are only payable on positive returns above the high-water mark. Second, the standard deviation of net returns is 4.67%, which is lower than the 5% for gross returns. This is because the fees act to smooth returns over time. So if, for example, the returns net of management fees but before incentive fees for two consecutive months are +1% and -1%, the net returns will be +0.8% and -0.8%. Third, the net returns exhibit negative skew because incentive fees will be charged on positive but not on negative returns. Finally, net returns exhibit excess kurtosis since the incentive fees

[1] Kahn, Scanlan and Siegel [2006] provide an extensive discussion and analysis of hedge fund fees.

have the impact of pushing the distribution away from the shoulders into the centre, and the standard deviation is lower.

Figure 1
Monte-Carlo Simulation of the Effect of Incentive Fees



Summary Statistics

	Gross Return	Net Return
Mean	1.00%	0.83%
Standard Deviation	5.00%	5.00%
Skew	0.00	0.00
Kurtosis	3.00	3.00

Summary Statistics

	Gross Return	Net Return
Mean	1.00%	0.70%
Standard Deviation	5.00%	4.67%
Skew	0.00	-0.07
Kurtosis	3.00	3.08

Performance attribution and the effect of incentive fees on the risk exposures of an investor

Most of the empirical work on the effect of market or risk factors on hedge fund returns builds upon the work of Sharpe [1992]. His framework for the analysis of mutual funds involved the development of an asset class factor model to determine risk exposures of the form:

$$R_t = \alpha + \sum_{i=1}^{n} \beta_{i,t} F_{i,t} + \varepsilon_t \qquad (1)$$

where R_t represents the return on the fund at time t, $F_{i,t}$ represents the return on factor F_i at time t, $\beta_{i,t}$ represents the sensitivity of the fund to factor F_i at time t and α is the value added by the manager.

Sharpe regressed mutual fund returns against twelve asset class returns and interpreted the resulting betas as representing the mutual funds' historic exposures to the asset classes. Sharpe's results showed that only a limited number of major asset classes were required to successfully replicate the performance of the universe of U.S. mutual funds. Sharpe's model is the building block of most risk-return research in hedge funds. This approach was first used in the hedge fund arena by Fung and Hsieh [1997], who applied Sharpe's asset class factor model to a sample of hedge funds and mutual funds using eight asset classes. The results were strikingly different for hedge funds compared to mutual funds: 47% of the mutual fund regressions had R-squared values higher than 75%, and 92% had R-squared figures higher than 50%. For the hedge fund regressions, 48% had R-squared values below 25%.

Subsequent work by Fung and Hsieh and other authors has attempted to improve upon the explanatory power of the models using different sets of independent variables, sample periods and hedge fund databases. Most of this work has been conducted within Sharpe's general framework. Some have concentrated on the addition of non-linear factors such as options (Agarwal and Naik [2000]) while others have estimated time-varying betas using either rolling window regressions (Fung and Hsieh [2004]), or by using statistical techniques such as the Kalman filter (Gehin and Vaissie [2006]). However, all of this work has been undertaken using net of fee returns and linear regression techniques, where the resulting betas are interpreted as representing the exposure of the investor to a specific source of systematic risk.

For mutual funds, the only difference between net and gross returns is the management fees that are a fixed percentage of the assets under management. As equation (2) illustrates, in this case the beta is the same for both the investor and the fund because the fees are independent of the fund return, and so the fees affect only the fund's alpha.

$$R_{GROSS,t} - FEES_t = \alpha + \sum_{i=1}^{n} \beta_{i,t} F_{i,t} + \varepsilon_t \tag{2}$$

However, because hedge funds also charge incentive fees which are a fixed percentage of the profits above a certain threshold, the fees are not independent of the fund's return. For this reason, the beta of the fund and the beta of the investor can be different depending upon the performance of the fund, as shown by equation (3).

$$\beta_{Investor} = \beta_{Fund} - \beta_{IncentiveFee} \tag{3}$$

The incentive fee can be thought of as a call option on a percentage of the performance of the fund. The investor is short this option while the fund manager has the corresponding long position. Armed with this information, it is relatively simple to calculate $\beta_{IncentiveFee}$ from equation (4), where $\delta_{IncentiveOption}$ is the delta of the incentive option, $IncentiveFee\%$ is the percentage fee charged by the fund and β_{Fund} is the beta of the fund calculated by regressing the gross returns against the risk factor/factors.

$$\beta_{IncentiveFee} = \delta_{IncentiveOption} * IncentiveFee\% * \beta_{Fund} \tag{4}$$

If, for example, the fund charges a 20% incentive fee, then the boundary conditions are as follows:

i) *when the fund is a long way below the high-water mark* - all gains and losses from the fund will accrue to the investor with no incentive fees payable. $\delta_{IncentiveOption}$ will be close to zero and the exposures of the investor are the same as the exposures of the fund;

ii) *when the fund is a long way above the high-water mark* - all gains will result in further incentive fees being payable and losses will result in a reduction in the fees. $\delta_{IncentiveOption}$ will be close to 1, and hence the exposure of the investor will be 20% smaller than the exposure of the fund.

It is clear, then, that using net of fee returns to calculate betas will lead to biased estimates. The correct approach would be to model the gross returns of the fund and incentive fees separately. The possible consequences of modelling net rather than gross incentive fees is best illustrated with a stylised example.

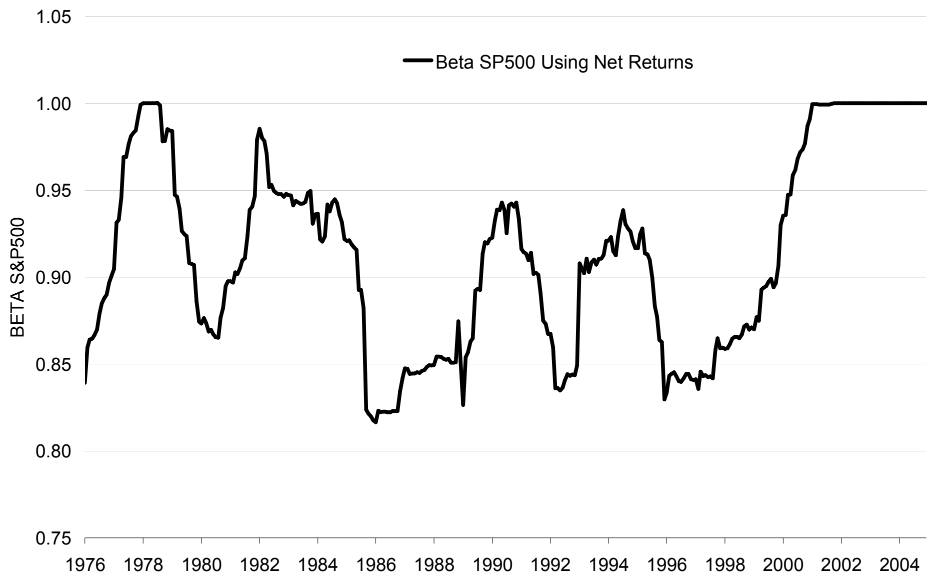
A stylised example of the problem: Beta Partners

Suppose that a hypothetical hedge fund called "Beta Partners" was established in January 1975, and unbeknown to its investors, the fund simply invested 100% of its assets on a passive basis in the S&P 500 index. Beta Partners charges the standard 2% management fee, a 20% performance fee with a hurdle rate of 0% and a high-water mark provision.

Applying the approach suggested by Ibbotson and Chen [2006] to separate the sources of return into alpha, beta and costs (or fees) by a static linear regression of the net returns from Beta Partners against the S&P500 index yields a slope coefficient of 0.91 and an alpha estimate of -0.23% per month. This implies that over the 31 year period, the compound annual returns of Beta Partners comprise an alpha of -2.67%, a beta of 11.95% and fees of 4.32%. However, in this stylized example we know that all of Beta Partners' returns are driven by beta and it is the incentive fees that distort the picture. The correct approach is to use the gross returns to calculate the alpha and beta estimates before subtracting the fees. This approach, as one would expect, yields an alpha estimate of zero and a slope coefficient of 1. Thus the compound annual returns comprise an alpha of 0%, a beta of 13.45% and fees of 4.03%.

Using returns net of fees understates both the alpha and beta components of the return of the fund. While it is clear that the investor does not receive all of these returns due to the fee structure, separating out the effect of fees from the fund returns gives the investor a far truer representation of the underlying return generating process of the fund and of the performance of the fund manager. If an investor were to follow the methodology of Fung and Hsieh [2004] in an attempt to analyse the exposure of Beta Partners to the S&P 500 using a 24-month rolling window regression on the net of fee returns, the results would be as shown in Figure 2.

Figure 2
Beta Partners – Rolling Window Regression

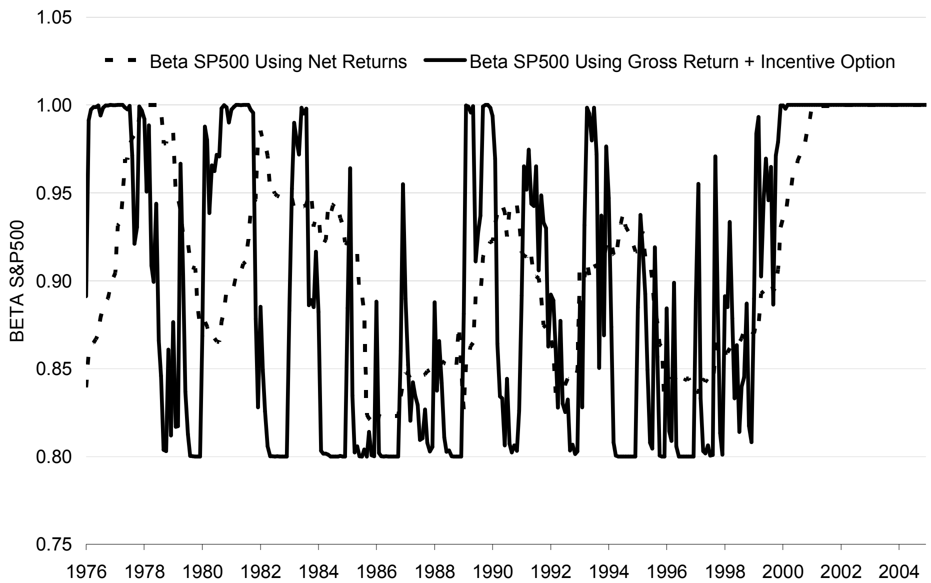


The rolling regression results show how the beta varies between a maximum of 1 and a minimum of 0.82 over the sample period. On the basis of this information an investor might conclude that Beta Partners is varying its exposure to the market over time but by construction, the actual beta of the fund is 1.0 at all times. All of the variation in exposure is actually coming from the change in the delta of the incentive fee option.

We know that the beta of the investor can easily be calculated from equations (3) and (4) once we have identified the delta of the incentive option. In this example, the incentive option is simply a 1-month call option on the S&P 500 with a strike set at the current high-water mark, and thus the delta can easily be calculated using the Black-Scholes equation. Figure 3 shows how the beta of the investor evolves over time.

As one would expect, the investor's beta is always between 0.8 and 1. When the incentive option has zero delta, the investor and fund betas are the same. When the incentive option has a 100% delta, then the investor beta is 20% lower than that of the fund. The evolution of the investor's exposure is far less smooth using this procedure compared to using net returns; part of the reason for this is the re-setting of the high-water mark each January after incentive fees are paid. In fact, using net returns simply results in a moving average of the true investor beta.

Figure 3
Beta Partners – Investor Beta



Empirical Analysis of Net and Gross Hedge Fund Returns

We now propose a technique for recovering gross of fee hedge fund returns and apply this to individual hedge fund performance data. The hedge fund return data are extracted from the TASS live and graveyard databases from January 1994 through to December 2006. More specifically, we extract monthly Net Asset Values (NAV) for all hedge funds that are denominated in US Dollars, that report monthly and that have at least 37 data points. This criterion results in a total sample of 2,837 funds of which 1,433 are currently reporting and 1,404 are no longer reporting. We recognise that this data will be subject to the various biases described by Fung and Hsieh [2002] and others, namely survivorship, instant history and selection bias. We minimise survivorship bias by using both the live and graveyard databases, and by using data only from January 1994 when TASS began collecting data on graveyard funds. Instant history bias has been estimated by Fung and Hsieh at approximately 1.4% pa. We estimate the size of the selection bias by comparing the return on the equally weighted return of our sample to the equally weighted return on all funds in the database. We estimate this to be 0.83%pa.

Using these NAVs we calculate monthly net and gross returns using the following procedure. All hedge fund database providers (and indices) report monthly net, rather than gross, performance figures. However, all of these providers also report 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:

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[2] such that it is the same for all investors.

[2] For a more thorough explanation see McDonnell [2003].

The net hedge fund return for period *t* is calculated using expression (5):

$$R_{NET_t} = \frac{\left(NAV_t - NAV_{t-1}\right)}{NAV_{t-1}} \tag{5}$$

The gross return calculation is calculated as follows:

$$R_{GROSS_t} = \frac{\left(NAV_t - NAV_{t-1}\right) + MgtFee_t + \left(AccruedIncentFee_t - AccruedIncentFee_{t-1}\right)}{\left(NAV_{t-1} + AccruedIncentFee_{t-1}\right)} \tag{6}$$

where

$$MgtFee_t = NAV_{t-1} \times \left(\frac{1}{1 - \frac{MgmtFee\%}{12}} - 1 \right) \tag{7}$$

and

$$AccruedIncentFee_t = \max\left\{0, NAV_t - HighWaterMark\right\} \times \left(\frac{1}{1 - IncentiveFee\%} - 1 \right) \tag{8}$$

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

By applying this technique to the data, we can construct equally weighted indices for the ten strategies reported in the TASS database as well as a broad index of all hedge funds in our sample.

The Statistical Properties of Net and Gross Returns

Table 1 contains the summary statistics for the net and gross returns in the sample. Clearly, by construction, the compound annual, gross returns are higher than the net returns with the difference between the two being the fees. For our sample, the average fee charged has been 5.15% p.a., ranging from 2.57% for dedicated short bias to 6.07% for managed futures.

Table 1
Statistical Properties of Net and Gross Returns

	Sample Size		
	Live	Graveyard	Total
Convertible Arbitrage	72	69	141
Dedicated Short Bias	15	14	29
Emerging Markets	118	114	232
Equity Market Neutral	94	92	186
Event Driven	203	150	353
Fixed Income Arbitrage	78	73	151
Global Macro	66	93	159
Long Short Equity	591	575	1,166
Managed Futures	115	176	291
Multi Strategy	81	48	129
All Hedge Funds	1,433	1,404	2,837

	Net					
	Compound Annual Ret	Annualised Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability
Convertible Arbitrage	10.38%	4.23%	-0.80	5.15	46.69	0.00%
Dedicated Short Bias	-0.79%	18.06%	0.70	4.65	30.59	0.00%
Emerging Markets	14.41%	15.50%	-1.06	8.07	196.46	2.61%
Equity Market Neutral	11.01%	2.51%	0.50	2.67	7.29	0.00%
Event Driven	12.91%	4.41%	-1.61	10.40	422.76	0.00%
Fixed Income Arbitrage	9.16%	3.51%	-2.97	20.46	2210.69	0.00%
Global Macro	9.18%	5.99%	0.90	4.31	43.54	0.00%
Long Short Equity	16.29%	9.18%	0.03	4.54	15.41	0.05%
Managed Futures	9.83%	11.04%	0.30	2.81	2.57	27.68%
Multi Strategy	13.42%	4.70%	-0.39	5.45	43.11	0.00%
All Hedge Funds	13.17%	5.93%	0.05	4.07	7.54	2.31%

	Gross					
	Compound Annual Ret	Annualised Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability
Convertible Arbitrage	14.32%	4.81%	-0.65	4.88	33.99	0.00%
Dedicated Short Bias	1.77%	19.50%	0.84	5.31	52.87	0.00%
Emerging Markets	19.86%	16.75%	-0.85	6.90	117.89	0.00%
Equity Market Neutral	15.42%	2.96%	0.54	2.76	7.90	1.92%
Event Driven	17.43%	5.07%	-1.44	9.37	317.91	0.00%
Fixed Income Arbitrage	13.43%	3.83%	-2.64	17.79	1602.94	0.00%
Global Macro	13.62%	6.92%	1.01	4.62	32.35	0.00%
Long Short Equity	21.76%	10.47%	0.18	4.56	16.60	0.02%
Managed Futures	15.89%	12.59%	0.37	2.96	3.55	16.94%
Multi Strategy	18.45%	5.34%	-0.26	4.95	26.47	0.00%
All Hedge Funds	18.31%	6.72%	0.19	3.86	5.71	5.75%

When examining the standard deviation of returns, the empirical results are in line with our earlier Monte Carlo simulation, and in all cases the gross returns exhibit higher annualised standard deviation than net returns with the average difference being 0.78%. For skewness, the empirical results are also as expected with an average increase of 0.14. With regard to kurtosis the results are much less clear cut, with increases for some strategies and decreases for others. Overall, however, there is a reduction in kurtosis of 0.21. The combination of all of this means that gross hedge fund returns look far more “normal” than net returns and in fact, contrary to Brooks and Kat [2002], for our sample it would appear that on average hedge fund returns display positive skewness and do not exhibit significantly excess kurtosis.

Performance Attribution

In order to attribute hedge fund returns between alpha, beta and fees, Ibbotson and Chen [2006] carry out regressions on net of fee hedge fund returns, using S&P 500 total returns (including both concurrent and with a one-month lag), U.S. Intermediate-term Government Bond returns (including one-month lag), and cash (U.S. Treasury Bills) as benchmarks. They constrain all style weights to sum to one, but allow individual style weights to be negative or above one to account for shorting and leverage. Once they have calculated alphas, they deducted this from the net return to give the return from beta. Then, using the median management and incentive fee levels, they estimate what the fees on this total net return would have been to "gross it up".

We replicate Ibbotson and Chen's methodology using the net of fee returns for our sample of hedge funds and the following risk factors:

- the total return of the Wilshire 5000 composite index;
- the total return of Lehman US Aggregate Index; and
- one month USD LIBOR.

We then compare this to the results we obtain by calculating the gross return before performing the regressions. The results are presented in Tables 2 and 3 which are directly comparable to Tables 5 and 6 and Figure 1 in Ibbotson and Chen [2006].

By construction, the alpha estimate for gross returns will be larger by at least the management fees, although in all cases, the increase is much larger than this (the average increase being 4.51% p.a.). For our sample using gross returns, alpha is significant at the 5% level for all 10 strategies, whereas when using net returns it is only significant for 6 of them. For all strategies, the magnitude of beta for the risky assets (stocks and bonds) is greater and consequently the return attributable to beta is also larger (the average increase being 0.64% p.a.). This implies that although the major impact of fees is indeed on alpha, the effect on beta is not insignificant.

Table 2
Regression Results for Equally Weighted Hedge Fund Indices

Regression Results: 1994-2006		Compound Annual Return	Annual Alpha	Betas (Sum of Betas = 1)			
				Stocks	Bonds	Cash	RSQ
Convertible Arbitrage	Using Net Returns	10.38%	3.87% **	0.20	0.27	0.53	31.1%
	Using Gross Returns	14.32%	7.38% **	0.22	0.31	0.47	29.6%
Dedicated Short Bias	Using Net Returns	-0.79%	4.10%	-1.12	0.21	1.91	76.1%
	Using Gross Returns	1.77%	7.89% **	-1.22	0.17	2.05	77.0%
Emerging Markets	Using Net Returns	14.41%	4.27%	0.87	-0.17	0.30	41.7%
	Using Gross Returns	19.86%	8.86% **	0.94	-0.16	0.22	41.5%
Equity Market Neutral	Using Net Returns	11.01%	5.75% **	0.07	0.08	0.85	24.3%
	Using Gross Returns	15.42%	9.89% **	0.08	0.08	0.84	22.6%
Event Driven	Using Net Returns	12.91%	5.76% **	0.31	0.05	0.64	59.8%
	Using Gross Returns	17.43%	9.64% **	0.36	0.07	0.57	59.1%
Fixed Income Arbitrage	Using Net Returns	9.16%	3.84% **	0.07	0.11	0.82	9.6%
	Using Gross Returns	13.43%	7.79% **	0.08	0.13	0.79	10.7%
Global Macro	Using Net Returns	9.18%	2.81% *	0.18	0.37	0.45	16.2%
	Using Gross Returns	13.62%	6.78% **	0.20	0.43	0.36	15.8%
Long/Short Equity	Using Net Returns	16.29%	7.51% **	0.59	-0.07	0.48	69.3%
	Using Gross Returns	21.76%	12.21% **	0.66	-0.09	0.43	66.6%
Managed Futures	Using Net Returns	9.83%	5.05%	-0.10	0.94	0.17	11.5%
	Using Gross Returns	15.89%	10.88% **	-0.12	1.10	0.03	12.2%
Multi-Strategy	Using Net Returns	13.42%	6.91% **	0.25	0.01	0.74	49.5%
	Using Gross Returns	18.45%	11.46% **	0.28	0.01	0.71	48.1%
All HF	Using Net Returns	13.17%	5.69% **	0.37	0.09	0.54	58.6%
	Using Gross Returns	18.31%	10.20% **	0.41	0.11	0.48	56.5%

* Significant at a 10% confidence level
** Significant at a 5% confidence level

Table 3
Analysis of Sources of Return for Equally Weighted Hedge Fund Indices

Sources of Return: Alpha, Beta, and Cost 1994-2006		Pre-Fee Return	Fees	Post-Fee Return	Alpha	Systematic Betas
Convertible Arbitrage	Using Net Returns	14.98%	4.60%	10.38%	3.87%	6.51%
	Using Gross Returns	14.32%	3.94%	10.38%	7.38%	6.94%
Dedicated Short Bias	Using Net Returns	1.01%	1.80%	-0.79%	4.10%	-4.89%
	Using Gross Returns	1.77%	2.57%	-0.79%	7.89%	-6.12%
Emerging Markets	Using Net Returns	20.01%	5.60%	14.41%	4.27%	10.13%
	Using Gross Returns	19.86%	5.46%	14.41%	8.86%	11.00%
Equity Market Neutral	Using Net Returns	15.76%	4.75%	11.01%	5.75%	5.26%
	Using Gross Returns	15.42%	4.41%	11.01%	9.89%	5.53%
Event Driven	Using Net Returns	18.14%	5.23%	12.91%	5.76%	7.16%
	Using Gross Returns	17.43%	4.52%	12.91%	9.64%	7.79%
Fixed Income Arbitrage	Using Net Returns	13.46%	4.29%	9.16%	3.84%	5.33%
	Using Gross Returns	13.43%	4.26%	9.16%	7.79%	5.64%
Global Macro	Using Net Returns	13.47%	4.29%	9.18%	2.81%	6.37%
	Using Gross Returns	13.62%	4.45%	9.18%	6.78%	6.84%
Long/Short Equity	Using Net Returns	22.37%	6.07%	16.29%	7.51%	8.78%
	Using Gross Returns	21.76%	5.47%	16.29%	12.21%	9.56%
Managed Futures	Using Net Returns	14.28%	4.46%	9.83%	5.05%	4.78%
	Using Gross Returns	15.89%	6.07%	9.83%	10.88%	5.01%
Multi-Strategy	Using Net Returns	18.77%	5.35%	13.42%	6.91%	6.50%
	Using Gross Returns	18.45%	5.03%	13.42%	11.46%	6.99%
All HF	Using Net Returns	18.46%	5.29%	13.17%	5.69%	7.48%
	Using Gross Returns	18.31%	5.15%	13.17%	10.20%	8.12%

Factor Model Specification and Replication

Using gross rather than net of fee returns when attempting to duplicate hedge fund performance via factor replication should produce better results for two main reasons. First, as we have already demonstrated, the use of net of fee returns for performance attribution leads to an underestimation of the return that is attributable to beta, and hence it follows that using gross returns in attempting to replicate hedge fund returns should produce better results by capturing this additional beta return. Second, the option-like nature of incentive fees creates a non-linear payoff to the factors which should be eliminated by using gross returns.

In order to assess the difference between replicated net and gross hedge fund returns, we employ a methodology similar to that of Hasanhodzica and Lo [2007]. However, whereas Hasanhodzica and Lo and others have used the same small number of factors for every strategy, we start with a large set of 11 candidate factors and undertake a procedure to identify the significant factors for each strategy individually. This is because of the heterogeneous nature of hedge fund strategies and the advantage is that it avoids the use of superfluous factors in the regressions. Table 4 shows the set of 11 candidate factors. These factors were chosen because they provide a broad cross section of risk exposures which have all been identified in previous studies as significant. Importantly, all of the factors are investable via traditional funds, exchange traded funds or futures which is essential if they are to be used for replication. We classify the factors into two groups: those that require investment and those that are cash neutral. To ensure that when we construct clones and restrict the sum of betas to be equal to one, this restriction only applies to factors that require investment.

In order to identify the significant factors for each strategy, we first extract monthly returns for live and graveyard funds from the TASS database for January 1990 to December 1994 and construct equally weighted strategy indices. Although this sample will be severely affected by survivorship bias, because we are only looking to identify the factors that drive returns rather than making any judgements about performance, we feel that this is an acceptable approach. Next we run regressions for all possible combinations of one to eleven factors, a total of 2^{11} = 2,048 regressions, in order to identify the most parsimonious model, which we define as the one with the lowest Akaike Information Criterion (AIC). The results are shown in Table 5.

Table 4
Candidate Factors for Replication

Factors Requiring Investment

Name	Description	Datastream Mnemonic
MKT	Dow Jones Wilshire 5000 Composite Total Return	WILEQTY
CMDTY	GSCI Commodity Total Return	GSCITOT
BOND	Lehman US Agggregate Total Return	LHAGGBD
EMERGING	MSCI Emerging Markets Index Total Return	MSEMKFL
GLOBAL_STOCKS	JP Morgan Global Broad Excluding U.S. Total Return	JPMBXUS
GLOBAL_BONDS	MSCI World Excluding U.S. Total Return	MSWFXU
DVIX	Change In CBOE VIX Index	CBOEVIX

Cash Neutral Factors

Name	Description	Datastream Mnemonic
SMB	Dow Jones Wilshire Small Cap Minus Dow Jones Wilshire Large Cap (Both Total Return)	WILDJSC & WILDJLC
USD	Finex-US Dollar Index Return	NDXCS00
CREDIT	Lehman US Credit Intermediate Bond Index Minus Lehman Government Intermediate (Both Total Return)	LHCRPIN & LHGOVIN
SLOPE	Lehman US Treasury: 20+ Year Index Minus Lehman Short Treasury Index (Both Total Return)	LHTR20Y & LHSHORT

The findings are in line with what one would expect. Equity based factors are identified as significant for those strategies that involve equities such as long/short equity, dedicated short bias and event driven. Bond or credit factors are identified as significant for fixed income strategies such as convertible arbitrage and fixed income arbitrage. The R-squared of the regressions ranges from 5.2% for managed futures to 76.17% for long/short equity, showing that factor models appear to perform much more satisfactorily for some strategies than for others.

Table 5
Results of Factor Selection

	AIC	R^2	MKT	SMB	USD	CMDTY	BOND	CREDIT	SLOPE	EMERGING	GLOBAL_ STOCKS	GLOBAL_ BONDS	DVIX
Convertible Arbitrage	-4.23	28.00%				-0.1676		4.7782					0.3358
						(0.0761)		(1.1339)					(0.1400)
Dedicated Short Bias	-3.43	12.82%	-0.4704										
			(0.1512)										
Emerging Markets	-4.86	49.04%	0.1741					1.7949		0.1918			
			(0.0895)					(0.8859)		(0.0465)			
Equity Market Neutral	-6.00	18.97%	0.0976	0.2139		0.0903							0.0219
			(0.0559)	(0.0688)		(0.0336)							(0.0643)
Event Driven	-6.09	57.78%	0.1432		0.0979		0.2597	1.3747		0.0589			0.0373
			(0.0659)		(0.0568)		(0.1718)	(0.5388)		(0.0275)			(0.0616)
Fixed Income Arbitrage	-5.44	38.55%			0.3530	-0.1130		1.5706				0.5375	-0.0704
					(0.1421)	(0.0409)		(0.6105)				(0.1492)	(0.0733)
Global Macro	-5.08	21.59%		-0.2030				2.4284		0.0731	-0.1027	0.3253	
				(0.1227)				(0.7591)		(0.0443)	(0.0625)	(0.1232)	
Long/Short Equity Hedge	-6.60	76.17%	0.2698	0.1895	0.1387	0.0800			0.0890	0.0771	-0.0388	0.1854	
			(0.0457)	(0.0582)	(0.0895)	(0.0248)			(0.0719)	(0.0219)	(0.0297)	(0.1116)	
Managed Futures	-4.46	5.02%			0.4379					0.0000	-0.1298	0.6477	
					(0.2274)						(0.0737)	(0.2698)	
Multi-Strategy	-5.01	31.16%			0.3873	0.1032	0.7322	-3.6661		0.1485			
					(0.0940)	(0.0542)	(0.2531)	(0.9248)		(0.0431)			

Having identified the factors that drive hedge fund returns for each individual strategy, we now attempt to construct linear clones using rolling window regressions. In addition to the factors identified above, we also introduce another factor, 1 month U.S. Dollar LIBOR, to allow for leverage. Using the factors identified above plus the LIBOR factor, for each individual hedge fund strategy we run a rolling window regression using a 24 month window from January 1995 to December 2006 as shown in equation (9)

$$R_t = \alpha + \sum_{i=1}^{n} \beta_{i,t} F_{i,t} + \varepsilon_t \tag{9}$$

subject to $\sum_{i=1}^{n} \beta_{i,t} = 1$ for those factors classified as requiring investment plus LIBOR.

The estimated regression coefficients β_{it}^{*} are then used as portfolio weights to construct simple clone returns R_{it}^{*} using equation (10)

$$R_{it}^{*} = \sum_{i=1}^{n} \beta^{*}{}_{i,t} \tag{10}$$

In order to match the volatility of the clone returns to the volatility of the underlying hedge fund returns, we calculate a leverage factor γ from equation (11)

$$\gamma_{it} = \frac{\sqrt{\sum_{k=1}^{24} (R_{it-k} - \overline{R}_{it})^2 / 23}}{\sqrt{\sum_{k=1}^{24} (R_{it-k}^{*} - \overline{R}_{it}^{*})^2 / 23}} \tag{11}$$

This leverage factor is then used to calculate the clone returns $\hat{R}_{it}$ using equation (12)

$$\hat{R}_{it} = \left(\gamma_{it} R_{it}^{*}\right) - \left(1 - \gamma_{it}\right) LIBOR_t \tag{12}$$

This procedure was repeated for the indices and individual funds using both net and gross returns, which results in a clone series running for 10 years from January 1997 to December 2006, the results are presented in Tables 6 and 7.

Table 6
Replication of Indices

Replication of Indices 1997-2006								
		Index		Clone			
		Compound Annual Return	Annual Standard Deviation	Compound Annual Return	Annual Standard Deviation	Mean R2 of Regression	Correlation Between Clone & Index
Convertible Arbitrage	Using Net Returns	10.10%	4.27%	5.65%	4.64%	20.97%	29.15%
	Using Gross Returns	14.03%	4.89%	5.95%	5.35%	20.01%	28.35%
Dedicated Short Bias	Using Net Returns	-1.74%	18.80%	-4.56%	20.88%	80.38%	87.91%
	Using Gross Returns	0.64%	20.23%	-5.71%	22.42%	81.19%	88.52%
Emerging Markets	Using Net Returns	15.02%	16.12%	6.53%	16.38%	73.48%	83.28%
	Using Gross Returns	20.66%	17.37%	6.47%	17.87%	72.91%	82.90%
Equity Market Neutral	Using Net Returns	9.48%	2.25%	4.47%	2.61%	23.65%	41.88%
	Using Gross Returns	13.46%	2.63%	4.61%	3.07%	23.28%	41.76%
Event Driven	Using Net Returns	12.12%	4.65%	7.16%	4.72%	66.02%	71.21%
	Using Gross Returns	16.55%	5.33%	7.78%	5.39%	64.67%	71.31%
Fixed Income Arbitrage	Using Net Returns	7.87%	3.34%	5.27%	3.71%	22.02%	50.36%
	Using Gross Returns	11.75%	3.63%	5.48%	3.99%	23.70%	50.74%
Global Macro	Using Net Returns	8.36%	5.28%	8.58%	6.89%	53.47%	61.82%
	Using Gross Returns	12.68%	6.07%	9.25%	8.01%	53.30%	62.18%
Long/Short Equity	Using Net Returns	15.22%	9.73%	8.03%	10.79%	91.90%	90.55%
	Using Gross Returns	20.51%	11.08%	8.64%	12.38%	90.70%	89.98%
Managed Futures	Using Net Returns	9.23%	10.70%	10.72%	12.39%	26.14%	32.30%
	Using Gross Returns	14.98%	12.30%	11.75%	14.19%	26.50%	32.77%
Multi-Strategy	Using Net Returns	13.54%	4.87%	6.04%	5.12%	65.39%	69.49%
	Using Gross Returns	18.54%	5.53%	6.34%	5.81%	63.67%	68.94%
All HF	Using Net Returns	12.54%	6.20%	7.44%	6.91%	65.58%	86.69%
	Using Gross Returns	17.51%	7.01%	7.68%	7.71%	64.85%	85.54%

Table 7
Replication of Individual Funds

Replication of Funds 1997-2006							
		Index		Clone			
		Compound Annual Return	Annual Standard Deviation	Compound Annual Return	Annual Standard Deviation	Mean R2 of Regression	Correlation Between Clone & Index
Convertible Arbitrage	Using Net Returns	10.10%	4.27%	5.28%	4.75%	-99.50%	29.40%
	Using Gross Returns	14.03%	4.89%	5.59%	5.40%	-4.21%	29.06%
Dedicated Short Bias	Using Net Returns	-1.74%	18.80%	-4.92%	25.54%	55.52%	88.55%
	Using Gross Returns	0.64%	20.23%	-6.17%	27.19%	56.29%	89.12%
Emerging Markets	Using Net Returns	15.02%	16.12%	6.83%	21.07%	36.41%	83.43%
	Using Gross Returns	20.66%	17.37%	6.82%	22.98%	36.22%	83.17%
Equity Market Neutral	Using Net Returns	9.48%	2.25%	5.11%	3.10%	12.68%	40.15%
	Using Gross Returns	13.46%	2.63%	5.27%	3.57%	13.00%	39.78%
Event Driven	Using Net Returns	12.12%	4.65%	8.55%	5.50%	26.31%	65.45%
	Using Gross Returns	16.55%	5.33%	9.41%	6.31%	26.02%	65.55%
Fixed Income Arbitrage	Using Net Returns	7.87%	3.34%	5.02%	4.26%	12.71%	51.08%
	Using Gross Returns	11.75%	3.63%	5.20%	4.65%	13.18%	51.18%
Global Macro	Using Net Returns	8.36%	5.28%	8.47%	8.59%	21.67%	57.04%
	Using Gross Returns	12.68%	6.07%	9.04%	9.94%	21.75%	56.96%
Long/Short Equity	Using Net Returns	15.22%	9.73%	8.05%	13.07%	40.17%	90.14%
	Using Gross Returns	20.51%	11.08%	8.77%	14.95%	39.90%	89.71%
Managed Futures	Using Net Returns	9.23%	10.70%	12.40%	13.45%	17.36%	34.25%
	Using Gross Returns	14.98%	12.30%	13.36%	15.44%	17.66%	34.27%
Multi-Strategy	Using Net Returns	13.54%	4.87%	7.23%	6.56%	23.51%	69.29%
	Using Gross Returns	18.54%	5.53%	7.61%	7.44%	23.51%	68.59%
All HF	Using Net Returns	12.54%	6.20%	7.99%	8.46%	24.02%	86.53%
	Using Gross Returns	17.51%	7.01%	8.35%	9.45%	28.75%	85.45%

In all cases, the return on the gross clones is greater in magnitude than for the net clones (more negative for dedicated short bias) although the standard deviation of the return is also slightly higher. The average improvement in return for the gross clones over the net clones is 0.24% for indices and 0.36% for individual funds. The improvement in performance of the gross clones would appear to be proportional to the goodness of fit of the model. The biggest improvement is seen in strategies such as long/short equity and event driven where the R-squared values of the regressions are high and the smallest improvement is for strategies such as equity market neutral and fixed income arbitrage where the R-squared is much lower. The correlation between the clone and fund returns is extremely high at over 85%, although there is no significant difference between the net and gross clones in either correlation or R-squared.

The Effect of Incentive Fees on the Risk Taking Behaviour of Funds

We have already demonstrated how the payoff profile of hedge fund performance fees is identical to a call option on a percentage of the fund's performance. The rationale for this fee arrangement is to "incentivize" the hedge fund manager to produce absolute returns. However, the reality is that the arrangement encourages managers to maximise the value of this fee option; their motivations could be different depending upon the delta of the option. When the delta is high, the bulk of the value in the option comes from its moneyness and little from its volatility. But when the delta is low, the reverse is true. Authors such as Scanlan and Siegel [2006] have suggested that managers who are significantly below their high water mark might have an incentive to increase risk. This has been investigated for CTAs by Fung and Hsieh [1997a] and by Brown, Goetzmann, and Park [2001], who both find little evidence of increased risk taking by managers below their high water mark. They hypothesise that career and reputation concerns as well as the increased risk of redemptions offset the adverse risk-taking incentives created by the incentive fee contract.

In order to investigate whether this is the case for the hedge funds in our sample, we examine the distribution of returns conditional upon the delta of the incentive option. 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

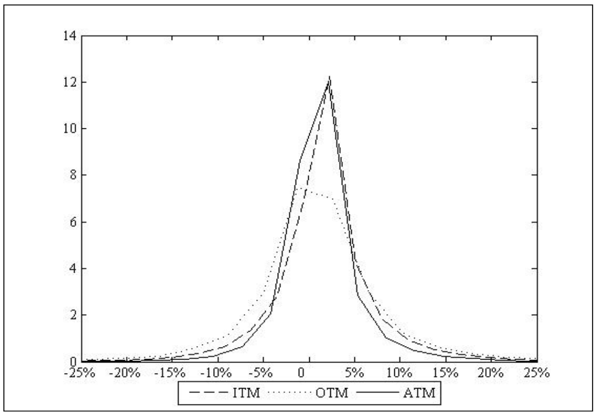
$$Moneyness_{t_t} = \frac{NAV_t}{HighWaterMark_t} \quad (13)$$

For our sample of 2,837 funds, we calculate the moneyness at each data point giving us a total of 229,101 observations. In order to investigate the relationship between the delta of the incentive option and the distribution of returns we divided the moneyness into 3 sub-samples:

- “At The Money” (ATM) where moneyness is greater than 95% and less than 105%
- “In The Money” (ITM) where moneyness is greater or equal to 105%
- “Out Of The Money” (OTM) where moneyness is less than or equal to 95%

Using these sub-samples, we examine the properties of the distribution of gross returns at time *t*+1 conditional upon the moneyness at time *t*, the results are presented in Figure 4.

Figure 4
The Effect of Incentive Fees on the Risk Taking Behaviour of Funds



Summary Statistics

	ATM	ITM	OTM	Whole Sample
Mean	1.25%	1.71%	0.98%	1.38%
Standard Deviation	4.94%	6.41%	8.51%	6.16%
Skew	3.86	1.65	1.95	2.41
Kurtosis	110.53	35.42	57.01	68.64
Observations	109,813	84,608	34,680	229,101

Results of Kolmogorov-Smirnov Test

	OTM	ATM	ITM
OTM		0.1403 (0.000)	0.1398 (0.000)
ATM	0.1403 (0.000)		0.1033 (0.000)
ITM	0.1398 (0.000)	0.1033 (0.000)	

Probability of accepting null hypothesis reported in parentheses

The three distributions appear to be very different. This is confirmed by the results of pairwise Kolmogorov-Smirnov tests, and in all cases we can reject the null hypothesis that the distributions are the same. The standard deviation of the OTM sample is statistically larger than for either the ATM or the ITM samples, which appears to support the hypothesis that hedge funds increase their risk when they are below their high water mark. However, it also appears that ITM funds also increase their risk, so it might be that funds who are ATM actually reduce their risk.

Conclusions

We have demonstrated that estimating the factor exposures of hedge funds using net of fee returns will lead to biased results due to the non-linear impact of incentive fees. We have proposed an alternative procedure to estimate the exposures of the fund using gross returns and the effect of fees independently that is simple to implement. We have also illustrated, via a stylised example, that the proposed procedure will lead to far more accurate estimates of investor exposures when the return generation procedure is known. Using a large sample of hedge fund returns, we have shown that using net of fee returns understates the return attributable to beta by up to 58 basis points per annum. Following from this, we have demonstrated that some of this additional beta exposure can be captured by basing replication on gross rather than net returns. We have also investigated the risk taking behaviour of fund managers conditional upon the delta of their incentive option and found that contrary to previous studies, there does appear to be evidence of increased risk taking for those managers who find themselves significantly below their high water mark.

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