

Do Hedge Funds Hedge?

Be cautious in analyzing monthly returns.

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In a poor year for traditional investments, 2000 was a good year for hedge funds in aggregate and a great year for some particular hedge fund styles. The year 2000 represents a textbook example of the diversification that investors desire from hedge funds. Unlike traditional investments, hedge funds can take long and short positions, and therefore have the ability to isolate a manager's security selection or timing skill from the asset class in which the manager trades. In this way, hedge funds can offer an investment not only with potentially attractive returns, but also with low to zero correlation with most traditional portfolios.¹

In recent years, hedge funds seem to have delivered. Over 1994–2000 the CSFB/Tremont index of hedge funds produced compound annual net returns of 13.2% with 10.0% annualized monthly volatility. Agarwal and Naik [2000b], Liang [2001], and Peskin et al. [2000], among others, examine monthly hedge fund returns and find only moderate correlation with most traditional asset class indexes. After adjusting for equity market exposure and other sources of systematic risk, these studies find that hedge funds still produce significant excess returns or alphas.

We argue that these results based on monthly data may be misleading. Many hedge funds hold, to various degrees and combinations, illiquid exchange-traded securities or difficult-to-price over-the-counter securities, which can lead to non-synchronous price reactions. Illiquid exchange-traded securities often do not trade at, or even near, the end of every month (even small- and medium-capitalization stocks may be subject to thin trading). Moreover, publicly available traded prices often do not exist for hard-to-price

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over-the-counter securities. The lack of prices may leave hedge funds with "flexibility" in how they mark these positions for month-end reporting. A cynic might argue that hedge funds can use this flexibility to manage their reported monthly returns, a practice that Weisman [2000] wryly calls "marketing supportive accounting."

The presence of stale prices due to either illiquidity or managed pricing can artificially reduce estimates of volatility and correlation with traditional indexes. This type of non-synchronous price reaction has been the subject of research for empirically estimating betas of small-capitalization stocks and other illiquid securities. Dimson [1979] and Scholes and Williams [1977] propose simple techniques to measure market betas by using summed betas from regressions of returns on both contemporaneous and lagged market returns.

We apply these and other techniques to hedge fund returns, and find that simple monthly beta and correlation estimates greatly understate hedge fund equity market exposure. Similarly, simple estimates of volatility using monthly returns seem to understate actual hedge fund volatility. Furthermore, when we account for a more accurate level of market exposure, we find that the broad index of hedge funds and most hedge fund subcategories do not add value over this period compared to what would be expected, given their average market exposure. In other words, according to our tests, the positive aggregate hedge fund returns over this period might be due to market exposure rather than to alpha or manager skill.

Because we focus only on aggregate hedge fund indexes, these results may or may not apply to any individual hedge fund. A carefully chosen portfolio of hedge funds may still provide both the return and the diversification benefits investors seek. In light of our results, however, we argue that at a minimum investors should be cautious analyzing monthly returns and, where possible, should use the techniques we discuss.

We first discuss the CSFB/Tremont hedge fund indexes, and then examine the risk and return characteristics of hedge funds using monthly returns. We propose some methods to account for the problem of non-synchronous pricing in monthly hedge fund returns, and finally present new results on the return and diversification benefits of hedge funds using these methods.

DATA

In order to examine the return and risk characteristics of hedge funds, we use returns for the CSFB/Tremont

hedge fund indexes from January 1994 through September 2000. These indexes consist of an aggregate hedge fund index designed to represent the industry as a whole and nine subindexes designed to track the primary hedge fund investment styles. CSFB/Tremont constructs all ten indexes monthly by asset-weighting net-of-fee returns for selected funds.²

To determine index constituents, CSFB/Tremont begins with funds in the TASS+ database that: have at least \$10 million in assets, have provided audited financial statements, and have met CSFB/Tremont's reporting requirements. The indexes exclude funds of funds, but include funds closed to new investment. This set of funds constitutes the CSFB/Tremont universe (as of November 15, 2000, there were 656 funds in the universe).

Each fund in the universe is then assigned to one of nine subcategories according to the fund's investment style. From this universe, CSFB/Tremont selects a subset of funds for inclusion in the subindexes so that each subindex represents at least 85% of the assets under management in that subcategory.

At least three potential biases may impact studies that use hedge fund indexes to proxy for the unobservable market portfolio of all hedge funds:

1. **Survivorship bias:** Survivorship bias occurs when indexes exclude all or part of the returns for dissolved or defunct funds from the index calculation. Since defunct funds typically have had very poor returns, excluding them from the index calculation will produce an unrealistically high estimate of a truly investible hedge fund portfolio. While CSFB/Tremont includes some defunct funds in the index calculations, it does not include every fund that ceased operations over the period. Moreover, TASS (and Hedge Fund Research) began collecting data on dead funds only in 1994, so hedge fund data prior to 1994 will entail significant survivorship bias and would not be suitable for accurate estimation of hedge fund risk and return.³
2. **Backfill bias:** Backfill bias occurs if database vendors backfill returns when a new fund is added instead of including its returns only on a going-forward basis. This will overstate index performance, since inclusion in the index is voluntary, and thus funds will generally be added only after very good past performance. CSFB/Tremont includes funds on a going-forward basis only, and therefore avoids any backfill bias.

EXHIBIT 1

HEDGE FUND RETURNS—MONTHLY DATA JANUARY 1994—SEPTEMBER 2000

Portfolio	Annualized Excess Return	Annualized Standard Deviation	Annualized Sharpe Ratio	Correlation With S&P 500	Maximum Monthly Return	Month of Maximum Return	Minimum Monthly Return	Month of Minimum Return
Aggregate Hedge Fund Index	8.0%	10.0%	0.80	0.52	8.1%	12/99	-8.0%	08/98
Convertible Arbitrage	5.4%	5.1%	1.07	0.13	3.1%	04/00	-5.1%	08/98
Event-Driven	7.0%	6.7%	1.05	0.60	3.4%	01/94	-12.2%	08/98
Equity Market-Neutral	6.4%	3.5%	1.85	0.48	2.8%	07/97	-1.6%	03/97
Fixed-Income Arbitrage	1.6%	4.4%	0.36	0.08	1.5%	04/95	-7.3%	10/98
Long/Short Equity	11.8%	12.6%	0.94	0.62	12.6%	12/99	-11.9%	08/98
Emerging Markets	2.3%	20.8%	0.11	0.50	16.1%	08/94	-23.4%	08/98
Global Macro	7.7%	14.4%	0.54	0.36	10.1%	08/95	-11.9%	10/98
Managed Futures	-1.2%	11.1%	-0.10	0.01	9.5%	08/98	-9.8%	09/95
Dedicated Short Bias	-7.1%	18.6%	-0.38	-0.76	22.3%	08/98	-9.1%	02/00
S&P 500	14.6%	14.2%	1.03	1.00	9.3%	03/00	-14.9%	08/98

All returns are excess of the one-month T-bill return. Annualized excess return calculated by multiplying monthly excess returns by 12. Annualized Sharpe ratio equals ratio of annualized excess return and annualized standard deviation.

3. Self-selection bias: Self-selection bias may occur if top- or bottom-performing funds lack the same incentive as other funds to report to data vendors, and thus are excluded from index calculations. This bias is generally slight, since most funds report, and even if some funds are excluded they must exhibit very strong persistence in their performance for any significant downward or upward bias to occur in index performance.

Although CSFB/Tremont attempts to minimize these biases, they are notoriously difficult to eliminate fully, even with the best intentions. Therefore, performance numbers should be evaluated in the context of these biases. In all likelihood, the estimates of average returns based on these indexes will be biased upward, primarily because of survivorship bias. Additionally, since in our particular sample period the stock market was exceptionally strong, survivorship bias in the indexes could bias our estimates of hedge fund market exposure upward since funds with high betas were more likely to survive.

INITIAL RESULTS

Hedge Fund Summary Statistics

Exhibit 1 presents summary statistics for monthly returns on the aggregate hedge fund index, the nine hedge fund subindexes, and the S&P 500 from January 1994 through September 2000. The aggregate index of hedge funds produces solid results over this period. Hedge funds posted 8.0% average annual excess returns over cash (13.2%

compound total returns) net of fees for the period, with 10.0% annualized monthly volatility, resulting in a 0.80 Sharpe ratio. This period coincides with a strong bull market, however, and some hedge funds appear to swim with the tide.

Overall, the aggregate hedge fund index has a monthly correlation of 0.52 with the S&P 500. Two of the most correlated styles are event-driven and long/short equity, which produce Sharpe ratios of 1.05 and 0.94, respectively. Not every style seems to benefit from market exposure. Convertible arbitrage funds produce impressive returns and a Sharpe ratio of 1.07, with a very low 0.13 monthly correlation with the S&P 500.

As expected, dedicated short biased funds produce returns that are highly negatively correlated with the market. Not surprisingly, given the strength of the market over this period, this style posts very poor absolute returns. Its best month is August 1998, the worst month for the market and for many of the other hedge fund styles. Managed futures, which realize close to zero correlation with the market over this period, also have their best month in August 1998. This result is consistent with previous studies that find that CTA returns exhibit a non-linear "long volatility" characteristic, where beta increases in big up markets and decreases in big down markets (Fung and Hsieh [2000]).

Finally, note that volatility varies considerably across hedge fund indexes. Using monthly data, realized volatility ranges from 3.5% per year for equity market-neutral funds to 20.8% per year for emerging markets funds. This clearly demonstrates the need for the simple, yet crucial concept of risk-adjusting returns when analyzing and comparing hedge fund performance.

Adjusting Hedge Fund Returns for Market Exposure

Given the level of market exposure (both positive and negative) evident in hedge fund returns, it behooves investors to determine whether hedge funds are adding value beyond the returns that they derive from this exposure. How a particular hedge fund makes money is an important issue for at least two reasons:

- **Diversification:** If a hedge fund has passive market exposure, and generates positive returns because the market goes up, it will possibly lose money when the market goes down, and thus will not provide the diversification benefits some hedge fund investors seek.
- **Fees:** Investors should not pay hedge fund fees for exposure they can get from index funds at a fraction of the cost.

Many hedge funds admit explicitly that they have market exposure, but claim that they add excess returns above and beyond that exposure. *Caveat emptor*. Investors should understand what this means about the pricing of these funds. These hedge funds can be viewed as selling a bundled package that includes (in proportions that vary across managers) 1) an S&P 500 index fund (or some other equity index fund) and 2) some manager skill. The skill needs to be good because the manager usually charges at least a 1% management fee plus a 20% performance fee on the S&P 500 index fund portion when the going rate is about 20 basis points from Vanguard (and even lower for institutional clients).

Unfortunately, investors cannot easily disentangle skill from market exposure. In part due to less stringent disclosure requirements, investors are rarely privy to hedge fund holdings and investment strategies. Therefore, in most cases, investors must base evaluations only on superficial strategy descriptions and historical returns.

A common approach to estimating hedge fund market exposure is to run regressions of monthly hedge fund returns on S&P 500 returns of the form:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \epsilon_{i,t} \quad (1)$$

where $R_{i,t}$ represents the net-of-fees return on hedge fund i in excess of cash, and $R_{m,t}$ represents the return on the S&P 500 in excess of cash and in excess of an annual fee of 20 basis points (as the hedge fund returns we study are net of fees, we also remove fees from our market proxy).

For simplicity, we take the S&P 500 as a proxy for equity market risk and ignore other potential measures of systematic risk such as value, size, momentum, international and emerging equity, credit, and liquidity. While these other risk factors represent an important extension of our study, as a first step we focus only on equity exposure, which generally embodies the most important risk in most investors' portfolios (even many fixed-income portfolios have equity exposure through spread, liquidity, or credit risk). Additionally, we consider only linear relations between hedge fund returns and the equity market.⁵

We can rewrite the regression in Equation (1) as:

$$R_{i,t} - \beta_i R_{m,t} = \alpha_i + \epsilon_{i,t} \quad (2)$$

$R_{i,t} - \beta_i R_{m,t}$ can be interpreted as the return on a hedged strategy, where we short β_i units of the S&P 500 against our purchase of hedge fund i . Thus, α_i represents the average return for the "hedged" hedge fund (since $\epsilon_{i,t}$ has a zero mean) and can be interpreted as the manager's realized skill. In other words, the regression intercept represents an estimate of the added value or alpha that hedge funds produce after accounting for their average market exposure or beta.

Exhibit 2 presents the results of these regressions. The results suggest that, despite possessing market exposure, hedge funds do in general appear to add value.⁶ The aggregate index returns 2.63% per year net of fees above and beyond what would be expected from its estimated beta of 0.37.⁷

The alphas for convertible arbitrage and equity market-neutral are statistically significant, which is quite impressive, given the short time period. These funds return 4.78% (t-statistic of 2.35) and 4.69% (t-statistic of 3.84) per year above and beyond what is expected from their respective market exposure, which in the case of convertible arbitrage is near zero.

Interestingly, dedicated short biased funds actually add 7.34% per year after accounting for their market exposure, although the alpha is not statistically significant due to the high return volatility. While these managers have had rough performance in absolute terms, it is solely due to their negative market exposure. If hedge funds should not get credit for average positive market exposure, to be fair, they should not be penalized for average negative market exposure. A hedge fund with negative market exposure provides tremendous risk reduction for most portfolios. If on top of that risk reduction it can add alpha, this makes it a valuable asset.

EXHIBIT 2
MONTHLY REGRESSIONS OF EXCESS HEDGE FUND RETURNS ON
CONTEMPORANEOUS S&P 500 EXCESS RETURNS
JANUARY 1994–SEPTEMBER 2000

Portfolio	Monthly Regressions		
	Alpha (Annualized %)	Beta vs. S&P 500	Adjusted R ²
Aggregate Hedge Fund Index	2.63 (0.76)	0.37 (5.46)	26.5%
Convertible Arbitrage	4.78 (2.35)	0.04 (1.12)	0.3%
Event-Driven	2.93 (1.35)	0.28 (6.62)	34.9%
Equity Market-Neutral	4.69 (3.84)	0.12 (4.89)	22.2%
Fixed-Income Arbitrage	1.24 (0.70)	0.02 (0.71)	-0.6%
Long/Short Equity	3.82 (0.95)	0.55 (6.98)	37.4%
Emerging Markets	-8.38 (-1.15)	0.74 (5.15)	24.2%
Global Macro	2.41 (0.44)	0.37 (3.43)	11.8%
Managed Futures	-1.30 (-0.29)	0.01 (0.12)	-1.2%
Dedicated Short Bias	7.34 (1.50)	-0.99 (-10.34)	57.0%

T-statistics in parentheses. Annualized alpha calculated by multiplying regression intercept by 12. Hedge fund and S&P 500 returns in the regressions are excess of one-month T-bill return.

One potential explanation for the strong positive alpha for dedicated short biased funds is survivorship bias. Given the strength of the market over this period, survivorship bias in the dedicated short biased index may be significantly greater than in the other categories. Additionally, dedicated short biased funds probably charged much lower performance fees than other funds over this period. Therefore, our use of net-of-fee returns will upwardly bias our estimates of skill for dedicated short biased funds compared to the other hedge fund styles.

A caveat is in order. Our methodology and interpretation of the results in Exhibit 2 implicitly ignores the possibility that a hedge fund's average market exposure over this period may be tactical (i.e., intentionally more than normal). Part of a hedge fund's skill and added value may come from the ability to forecast the direction of the market over long horizons. Since we examine data for 1994–2000, it is possible that some of the hedge funds that have maintained positive market exposure over this entire period have done so tactically, and thus correctly forecasted the bull market. To the extent that this is true, those hedge funds should get credit for their market-timing ability.

Few hedge funds, however, claim to seek significant added value from market timing. Obviously, the empirical analysis above and the analysis that we present below cannot determine whether the observed market exposure was passive or active, and this can have important implications for assessing manager skill.

MARK-TO-MARKET PROBLEMS IN HEDGE FUND RETURNS

Stale or Managed Prices

Both academics and practitioners have used the type of analysis represented in Exhibit 2 to evaluate hedge fund returns. Agarwal and Naik [2000b], Liang [2001], and Peskin et al. [2000], among others, find similar results. Yet we argue that the regressions presented in Exhibit 2 may produce misleading results.

The reason is that many hedge funds hold illiquid exchange-traded securities or difficult-to-price over-the-counter securities, and these holdings can lead to non-synchronous movements in returns. If securities do not trade near the end of every month, or if there are no publicly available traded prices, hedge funds have flexibility in how they mark their positions for month-end reporting (managers typically estimate prices using their own models along with broker-dealer input).⁸

Given the widespread practice of computing Sharpe ratios, correlations, betas, and other summary statistics using monthly data, hedge fund managers have a strong incentive to show monthly returns that are both consistent and uncorrelated with the market. This creates a potentially serious conflict of interest, and can lead to non-synchronous price reactions as managers use this flexibility to smooth their returns.

The presence of stale prices due to either illiquidity or managed pricing can artificially reduce estimates of volatility and correlation with traditional indexes. If hedge funds have positive market exposure, in the event the market trades off near the end of the month, and an illiquid security does not trade or is not accurately marked, the drop in price will not show up until the following month when presumably the security trades or is marked correctly. In

EXHIBIT 3

MONTHLY VERSUS QUARTERLY VOLATILITY AND MARKET CORRELATIONS JANUARY 1994–SEPTEMBER 2000

Portfolio	Annualized Excess Return	Monthly Annualized Standard Deviation	Quarterly Annualized Standard Deviation	Quarterly vs. Monthly % Difference	Monthly Correlation with S&P 500	Quarterly Correlation with S&P 500	Quarterly vs. Monthly Difference
Aggregate Hedge Fund Index	8.0%	10.0%	10.1%	0.7%	0.52	0.64	0.12
Convertible Arbitrage	5.4%	5.1%	7.2%	41.5%	0.13	0.23	0.11
Event-Driven	7.0%	6.7%	8.6%	28.3%	0.60	0.64	0.05
Equity Market-Neutral	6.4%	3.5%	4.2%	22.9%	0.48	0.50	0.02
Fixed-Income Arbitrage	1.6%	4.4%	4.8%	9.5%	0.08	0.26	0.18
Long/Short Equity	11.8%	12.6%	13.4%	6.3%	0.62	0.76	0.15
Emerging Markets	2.3%	20.8%	26.6%	28.0%	0.50	0.44	-0.06
Global Macro	7.7%	14.4%	14.4%	-0.2%	0.36	0.41	0.05
Managed Futures	-1.2%	11.1%	10.5%	-5.4%	0.01	-0.29	-0.30
Dedicated Short Bias	-7.1%	18.6%	18.7%	0.6%	-0.76	-0.78	-0.02

All returns are excess of the one-month T-bill return. Quarterly returns calculated by summing monthly returns. Annualized excess return is calculated by multiplying quarterly excess returns by 4.

some cases, a security may be so illiquid, or the “managing” of pricing so extreme, that it does not get accurately marked for several months. Thus, there may be significant lagged relations between market returns and reported hedge fund returns, rendering simple monthly regression betas understated, perhaps severely.⁹

Longer-Horizon Returns

Using longer-horizon returns is one simple way to alleviate the effects of non-synchronous price reactions on estimates of volatility and correlation. While longer-horizon returns are still affected by stale or managed pricing, the impact will represent a smaller component of these returns.

Exhibit 3 presents a comparison of volatility and correlations computed using monthly returns versus non-overlapping calendar quarterly returns. In the absence of any month-end pricing problems and if monthly returns are identically and independently distributed, annualized monthly volatility should equal annualized quarterly volatility. In the presence of stale or managed prices, however, annualized monthly volatility should be lower than annualized quarterly volatility.¹⁰

Exhibit 3 shows that in all categories except managed futures and global macro, quarterly volatility is higher than monthly volatility, and thus Sharpe ratios based on quarterly data are lower than those based on monthly data. Moreover, the difference is considerable for certain styles and appears related to the general liquidity of the underlying assets. Convertible arbitrage funds, which tend to trade in hard-to-price over-the-counter fixed-income securities, experience the greatest increase in volatility (41.5%) while managed futures funds, which tend to trade in highly liquid exchange-traded securities, experience a small drop

in volatility going from monthly to quarterly data.

Correlations also rise when quarterly data are used. The aggregate hedge fund index correlation with the S&P 500 rises to 0.64 from 0.52, and most of the subindexes also experience increases.

The evidence in Exhibit 3 supports our hypothesis that both hedge fund volatility and market risk are understated when they are estimated using monthly data.

Lagged Betas

In the presence of stale or managed prices, simple linear regressions of the form we conduct in Exhibit 2 may produce estimates of beta that are biased downward. This is a common problem when estimating betas for small firms, which because of their illiquidity suffer from a similar bias.¹¹

Dimson [1979] and Scholes and Williams [1977] propose a very simple technique to measure market betas by running regressions of returns on both contemporaneous and lagged market returns of the form:

$$R_{i,t} = \alpha_i + \beta_{0i}R_{m,t} + \beta_{1i}R_{m,t-1} + \beta_{2i}R_{m,t-2} + \beta_{3i}R_{m,t-3} + \dots + \varepsilon_{i,t} \quad (3)$$

If hedge fund returns are not fully synchronous with market returns due to stale or managed prices, then lagged market returns should also be correlated with current hedge fund returns. In this case, the summed beta (i.e., $\beta_0 + \beta_1 + \beta_2 + \beta_3 + \dots$) represents a more accurate measure of a hedge fund's true beta with the market.

In other words, we are trying to capture the fact that, assuming there is a real relation between the market and a hedge fund, when the market moves, the hedge fund

EXHIBIT 4A

MONTHLY REGRESSIONS OF EXCESS HEDGE FUND RETURNS ON CONTEMPORANEOUS AND LAGGED EXCESS S&P 500 RETURNS JANUARY 1994–SEPTEMBER 2000

Portfolio	Regression Coefficients and t-Statistics					Adjusted R ²	Hypothesis Testing	
	Alpha (annualized %)	Beta with S&P 500 (t)	Beta with S&P 500 (t - 1)	Beta with S&P 500 (t - 2)	Beta with S&P 500 (t - 3)		Sum All Betas (= 0)	Sum Lagged Betas (= 0)
Aggregate Hedge Fund Index	-4.45 (-1.16)	0.40 (6.21)	0.12 (1.85)	0.22 (3.37)	0.10 (1.45)	35.3%	0.84 (0.0%)	0.44 (0.1%)
Convertible Arbitrage	-0.98 (-0.46)	0.08 (2.16)	0.16 (4.31)	0.13 (3.46)	0.07 (1.82)	23.8%	0.43 (0.0%)	0.35 (0.0%)
Event-Driven	-2.12 (-0.91)	0.31 (8.04)	0.18 (4.39)	0.08 (1.89)	0.05 (1.19)	47.0%	0.61 (0.0%)	0.30 (0.0%)
Equity Market-Neutral	3.36 (2.32)	0.13 (5.18)	0.05 (1.95)	0.01 (0.39)	0.02 (0.84)	23.4%	0.20 (0.1%)	0.08 (10.8%)
Fixed-Income Arbitrage	-3.78 (-2.08)	0.05 (1.61)	0.10 (3.23)	0.15 (4.84)	0.06 (1.83)	25.2%	0.36 (0.0%)	0.31 (0.0%)
Long/Short Equity	-2.83 (-0.61)	0.57 (7.39)	0.10 (1.25)	0.18 (2.24)	0.14 (1.76)	40.9%	0.99 (0.0%)	0.42 (0.9%)
Emerging Markets	-16.20 (-1.88)	0.79 (5.47)	0.30 (2.02)	0.20 (0.68)	0.06 (0.39)	25.3%	1.25 (0.0%)	0.46 (11.8%)
Global Macro	-6.64 (-1.08)	0.41 (3.94)	0.12 (1.12)	0.37 (3.45)	0.09 (0.83)	21.1%	0.98 (0.0%)	0.57 (0.7%)
Managed Futures	1.72 (0.32)	-0.01 (-0.15)	-0.15 (-1.58)	-0.01 (-0.10)	-0.02 (-0.19)	-1.9%	-0.19 (38.3%)	-0.17 (34.1%)
Dedicated Short Bias	11.59 (2.00)	-1.01 (-10.45)	-0.15 (-1.51)	0.02 (0.22)	-0.13 (-1.26)	57.5%	-1.27 (0.0%)	-0.25 (19.7%)

T-statistics in parentheses. The last two columns report the sum of the contemporaneous and lagged betas (Sum All Betas) and the separate sum of the lagged betas (Sum Lagged Betas); *p*-values for the *F*-test versus zero shown in parentheses. Hedge fund and S&P 500 returns used in the regressions are excess of the one-month *T*-bill return.

EXHIBIT 4B

SUMMARY OF MONTHLY REGRESSIONS OF EXCESS HEDGE FUND RETURNS ON S&P 500 RETURNS JANUARY 1994–SEPTEMBER 2000

Portfolio	(1)	(2)	(3)	(4)	(4) – (1)
	Simple Monthly Regression Beta (Exhibit 2)	Betas from Lagged S&P 500 Regressions (Exhibit 4A)			Difference in Beta
		Betas from Contemporaneous Regression (β ₀)	Sum of Lagged Betas (β ₁ + β ₂ + β ₃)	Total Summed Beta (β ₀ + β ₁ + β ₂ + β ₃)	
Aggregate Hedge Fund Index	0.37	0.40	0.44	0.84	0.47
Convertible Arbitrage	0.04	0.08	0.35	0.43	0.38
Event-Driven	0.28	0.31	0.30	0.61	0.33
Equity Market-Neutral	0.12	0.13	0.08	0.20	0.09
Fixed-Income Arbitrage	0.02	0.05	0.31	0.36	0.33
Long/Short Equity	0.55	0.57	0.42	0.99	0.45
Emerging Markets	0.74	0.79	0.46	1.25	0.51
Global Macro	0.37	0.41	0.57	0.98	0.61
Managed Futures	0.01	-0.01	-0.17	-0.19	-0.20
Dedicated Short Bias	-0.99	-1.01	-0.25	-1.27	-0.28

should also move (e.g., if managers actually tried to sell their securities they would see this return immediately). Yet stale or managed pricing may prevent the move from fully showing up in the hedge fund's reported returns in the same month. Instead, the move may show up slowly as securities are priced correctly in subsequent months. Thus, the hedge fund appears to move with the market at a lag.

The regression with lagged market returns measures the magnitude and statistical significance of this effect and provides a potentially more accurate beta estimate. Exhibit 4A presents the details of these regressions using three

months of lagged market returns, and Exhibit 4B summarizes the results.

Exhibits 4A and 4B show some dramatic increases in beta over Exhibit 2. Lagged betas enter the regression strongly for the aggregate hedge fund index and for almost every hedge fund style. For the aggregate index, the beta more than doubles from 0.37 (column (1) in Exhibit 4B) in the simple monthly regressions to 0.84 (column (4) in Exhibit 4B) when we account for lagged relations. Perhaps most surprising, convertible arbitrage betas increase dramatically from 0.04 to 0.43. Other large increases include event-driven, which increases from 0.28 to 0.61,

and fixed-income arbitrage, which increases from 0.02 to 0.36.¹²

In fact, in every category save managed futures, the betas are magnified. The styles with positive betas produce even larger positive betas, and the styles with negative betas produce even more negative betas.

While it is clear that the lagged betas are economically significant, we also report tests of statistical significance in Exhibit 4A. We separately test the null hypotheses that the sum of all the betas (both contemporaneous and lagged) equals zero (column labeled Sum All Betas) and the sum of just the lagged betas equals zero (column labeled Sum Lagged Betas.)

For every category except managed futures, these *F*-tests strongly reject the null hypothesis that the summed beta is zero. As expected, the statistical results for just the lagged betas are not as strong, but we still reject the null hypothesis for all categories except equity market-neutral, emerging markets, managed futures, and dedicated short biased. In particular, the tests strongly reject the null hypothesis that the lagged betas are zero for convertible arbitrage, event-driven (which includes distressed debt), and fixed-income arbitrage, which represent the categories most likely to include significant illiquid exchange-traded securities and hard-to-price over-the-counter securities.

Overall, Exhibits 4A and 4B suggest that when we account for non-synchronous pricing, hedge funds seem to do a lot less hedging than simple estimates might suggest.

One quite surprising result is the large increase in beta for long/short equity, as these funds are generally perceived to trade liquid exchange-traded stocks. The beta of long/short equity funds jumps from 0.55 measured using traditional techniques, to almost double that at 0.99 using our lagged technique (i.e., we find long/short equity funds as exposed to stock market risk as an S&P 500 index fund).

There are at least three potential explanations for this jump. First, long/short funds may take significant positions in small-capitalization stocks. Again, a security does not have to be traded over-the-counter or highly illiquid for our lagged technique to be applicable. In fact, the technique was originally developed, not for illiquid fixed-income securities, but for small-capitalization stocks.¹³

Second, funds in the long/short equity index, and in fact funds in other categories, may have some portion of their assets invested in highly illiquid private securities. Third, any statistical result is subject to sampling error.

While we strongly statistically reject the hypothesis that there is no lagged effect for long/short equity funds, it is certainly possible that our results are on the high side

of reality due to random coincidental fluctuation over this period.

Clearly, the LTCM/Russian debt crisis during the fall of 1998 represents an influential data point in our analysis. Excluding the extreme four-month period of August–November 1998 from the regressions in Exhibit 4A, however, only mildly weakens our results. The aggregate hedge fund index produces a summed beta of 0.69 when we exclude this period versus 0.84 for the full sample. The summed beta of 0.69 is still significantly higher than the comparable simple monthly regression beta of 0.41, with the lagged portion statistically significant. Thus, while weaker, our basic results are robust to excluding this volatile, although perhaps informative, period.¹⁴

While our results are consistent with significant non-synchronous pricing problems in monthly hedge fund returns, they are also consistent with a real lead-lag relation between hedge fund returns and market returns. In other words, our findings might be due to actual reaction of hedge fund returns to moves in the market at a lag (not a lag in marking). For example, Mitchell and Pulvino [2000] find that the probability of deal failure for pending mergers is negatively related to lagged market returns, which could induce a positive relation between merger arbitrage strategy returns and lagged market returns.

While it is difficult to disentangle these two competing hypotheses, we find that across hedge fund styles, the significance of the lagged betas is roughly correlated with the underlying illiquidity of the securities they trade. Furthermore, if these are really true predictive effects, it means that the market and some very savvy hedge fund managers are ignoring this source of potential predictability and profits. In addition, if hedge fund investors cannot trade on this information (given lock-ups or limited liquidity for redemptions), it does not matter which explanation is correct, as both explanations imply more market risk for the hedge fund buyer.¹⁵

Asymmetric Betas

Assuming that the lagged betas we find are due to non-synchronous pricing, it remains unclear whether the non-synchronous pricing effects are caused by unintentional stale pricing due to illiquidity or from intentional managed pricing (or some of both). To shed some light on this topic, we examine the lagged betas separately for up and down markets.

Presumably, if unintentional stale prices produce the lagged betas, the effect would be symmetrical for up and

EXHIBIT 5

MONTHLY REGRESSIONS OF EXCESS HEDGE FUND RETURNS ON CONTEMPORANEOUS AND LAGGED EXCESS S&P 500 RETURNS IN UP AND DOWN MARKETS—JANUARY 1994—SEPTEMBER 2000

Portfolio	Betas in Up Markets			Betas in Down Markets		
	Contemporaneous	Sum of Lagged	Total Summed	Contemporaneous	Sum of Lagged	Total Summed
	Beta (β_0)	Betas ($\beta_1 + \beta_2 + \beta_3$)	Beta ($\beta_0 + \beta_1 + \beta_2 + \beta_3$)	Beta (β_0)	Betas ($\beta_1 + \beta_2 + \beta_3$)	Beta ($\beta_0 + \beta_1 + \beta_2 + \beta_3$)
Aggregate Hedge Fund Index	0.27	0.17	0.44	0.59	0.79	1.38
Convertible Arbitrage	0.02	0.22	0.24	0.17	0.47	0.64
Event-Driven	0.03	0.24	0.27	0.61	0.32	0.93
Equity Market-Neutral	0.13	0.18	0.31	0.11	-0.05	0.06
Fixed-Income Arbitrage	0.02	0.06	0.08	0.13	0.57	0.70
Long/Short Equity	0.41	0.51	0.92	0.75	0.36	1.11
Emerging Markets	0.45	0.01	0.46	1.21	1.01	2.22
Global Macro	0.33	-0.06	0.27	0.60	1.38	1.98
Managed Futures	0.29	-0.20	0.09	-0.34	-0.06	-0.40
Dedicated Short Bias	-0.72	-0.60	-1.32	-1.28	0.15	-1.13

down markets. If intentional managed pricing drives the results, however, the effect might be asymmetrical, as managers may be more concerned with smoothing downside returns than upside returns. If this is the case, the lagged betas in negative markets would be more significant than those in positive markets.

Exhibit 5 presents a summary of regressions on the CSFB/Tremont indexes that allow for different lagged betas for positive and negative market returns. Instead of three lagged terms as in Exhibit 4A, there are six, each multiplied by a dummy variable representing whether the market was up or down that month.

The regressions show that the summed lagged beta in up markets for the aggregate hedge fund index is 0.17, which is not statistically significant, while the summed lagged beta in down markets is 0.79, which is highly statistically significant. The test of the difference in these lagged betas is also highly statistically significant.

While it is certainly not conclusive, we think this is circumstantial evidence that intentional manager smoothing is at least a part of the effect we document.

Hedge Fund Alphas

Notice what happens to the intercepts from the regressions in Exhibit 4A. The alphas that are generally positive in Exhibit 2 are now generally negative, although not statistically significant. In Exhibit 2, the overall index of hedge funds adds about 2.6% annually when we account for market exposure using simple monthly regressions; when we account for the lagged betas, the hedge fund index subtracts about 4.5% annually. Since our summed betas are consistently higher, we require higher hedge fund returns over this strong period for the market. Since

this did not occur, the intercepts are lower. This result is especially surprising, given the likely presence of survivorship bias in the data, which would most likely bias alphas upward.¹⁶

Exhibit 6 summarizes the Sharpe ratios of three different strategies:

1. The simple unhedged returns to each hedge fund index (from Exhibit 1):

$$R_{i,t}$$

2. A monthly beta-hedged hedge fund index (using betas from Exhibit 2):

$$R_{i,t} - \beta_i R_{m,t}$$

3. A summed beta-hedged hedge fund index (using betas from Exhibit 4A):

$$R_{i,t} - (\beta_{0i} + \beta_{1i} + \beta_{2i} + \beta_{3i})R_{m,t}$$

Strategies (2) and (3) represent portfolios invested in a particular hedge fund index and short enough of the S&P 500 to reduce the in-sample beta to zero (using either the simple monthly beta from Exhibit 2 or the summed beta from Exhibit 4A).

The Sharpe ratio of the overall index drops from a respectable 0.80 to a disappointing -0.40 when we account for the summed beta.¹⁷ In fact, for every category except managed futures and dedicated short bias, Sharpe ratios drop when we adjust for market exposure according to summed betas. The only styles with positive excess returns versus our summed beta estimates are equity market-neutral, which goes from a very high, unhedged Sharpe ratio of 1.85 to a still excellent 1.05, and managed futures and dedicated short biased, which benefit significantly when their negative betas are taken into account.

EXHIBIT 6
ANNUAL SHARPE RATIOS OF UNHEDGED AND HEDGED
HEDGE FUND RETURNS JANUARY 1994–SEPTEMBER 2000

Portfolio	Unhedged and Hedged Performance		
	Monthly Unhedged Sharpe Ratio	Monthly Beta-Hedged Sharpe Ratio	Summed Beta-Hedged Sharpe Ratio
Aggregate Hedge Fund Index	0.80	0.31	-0.40
Convertible Arbitrage	1.07	0.95	-0.11
Event-Driven	1.05	0.55	-0.27
Equity Market-Neutral	1.85	1.55	1.05
Fixed-Income Arbitrage	0.36	0.28	-0.56
Long/Short Equity	0.94	0.39	-0.23
Emerging Markets	0.11	-0.47	-0.82
Global Macro	0.54	0.18	-0.40
Managed Futures	-0.10	-0.12	0.14
Dedicated Short Bias	-0.38	0.61	0.89

Adjusting for summed betas does not always make hedge fund managers appear less skillful. For example, for the year 2000 (January–September) hedge fund performance actually improves when adjusted correctly for market exposure. Over this period the aggregate hedge fund index is up 4.9% in absolute terms or a mediocre 0.50% above cash. The S&P 500 was down over this period, and, given their positive market exposure, we expect hedge funds to also be down. When we account for their market exposure using our simple beta estimate of 0.37, hedge funds actually added 2.7% above cash. Because our results indicate that the 0.37 estimated beta may be understated, when we adjust for market exposure using our summed beta estimate of 0.84, hedge funds actually add a very respectable 5.5%. In other words, this was a very good period for hedge funds in aggregate when viewed relative to our summed beta estimate.

In fact, it was a banner period for some categories, in particular, convertible arbitrage. Convertible arbitrage funds returned 20% in excess of cash, which is obviously excellent, given their low volatility. This performance improves to 22.5% when adjusted for the summed beta of 0.43. Perhaps the recent strong hedge fund performance represents support for the conjecture that hedge funds are better able to add value through slowly falling markets versus sharply crashing markets, or perhaps it is a harbinger that hedge funds are starting to hedge (maybe due to the painful 1998 experience), or perhaps it represents simple random fluctuation. Only time will tell.

Some additional caveats are in order. First, while our point estimate for the aggregate hedge fund index intercept or manager alpha is negative, the result is not statistically significant. Hedge fund returns are just too

volatile and available for too short a time period to make any definitive statements about alpha.

Second, it is likely that the potentially important biases in hedge fund returns will affect our estimates of alpha much more than our estimates of beta. While these biases (especially survivorship bias) probably lead to overstated alphas, they still add to our uncertainty.

Third, the alphas we report are based on the implicit assumption that the equity market is the only relevant risk factor for hedge funds in aggregate and for each particular hedge fund style. While we believe market beta is important, it is clearly not the only relevant risk factor in hedge fund returns, and future research should address multiple risk factors in more depth.

ROBUSTNESS TO HEDGE FUND RESEARCH INDEXES

As a final robustness check, we run analogous tests on the Hedge Fund Research (HFR) hedge fund index return series. While there are many differences between the HFR and CSFB/Tremont data, the most notable is that the CSFB/Tremont indexes are asset-weighted, while the HFR indexes are equally weighted. Thus, the HFR data will give more emphasis to smaller hedge funds. Peskin et al. [2000] find that smaller and newer hedge funds generally have higher returns, but note that these funds are the most susceptible to reporting biases and the problem of not being fully investible (i.e., a large mandate could not be invested in these funds and run in a comparable style to the one that has produced the current track record).

The results for the HFR data support our hypothesis that hedge fund market risk, when estimated using monthly returns, is significantly understated. The simple regression beta of the HFR aggregate hedge fund index versus the S&P 500 over this period is 0.38, but jumps to 0.65 when the statistically significant lagged betas are taken into account.

The “unhedged” monthly Sharpe ratio of the HFR aggregate index is 1.23, but drops to 0.03 when measured as excess returns versus the summed beta. Although both the pre- and post-hedging risk-adjusted returns are better for the HFR series, the 1.20 fall in the Sharpe ratio is exactly the same magnitude as the fall in Sharpe ratio of the

CSFB/Tremont aggregate hedge fund index (which fell from 0.80 to -0.40).

In addition, results for the comparable HFR subcategories are generally similar to those we report, with the exception of merger arbitrage. HFR provides a separate merger arbitrage index, while CSFB/Tremont aggregates merger arbitrage along with distressed securities, Regulation D, and high-yield into its event-driven index. The HFR merger arbitrage index does show strong and statistically significant positive risk-adjusted returns over the 1994-2000 period, even after accounting for lagged betas, which are positive but not statistically significant.

CONCLUSION

The recent strong bull market has produced enormous wealth. It has also been a democratic bargain, available for the participation of all investors through index funds costing only a handful of basis points per year. Hedge funds, on the other hand, are restricted investments generally available only to the few, and come at a high price tag. For this high cost, hedge funds generally claim to offer attractive returns that cannot be obtained by investing in index funds. To the extent that hedge funds can achieve these goals, they offer an investment that can be an important source of expected return and diversification for most investors' portfolios.

At first pass, cursory examination using monthly returns from 1994-2000 suggests that hedge fund investors have in fact received a great deal both in terms of return and diversification. Intentionally or unintentionally, though, hedge funds appear to price their securities at a lag. These marking problems can downwardly bias simple risk estimates based on monthly returns. When we account for this effect, we find that the return and diversification benefits vanish for the broad hedge fund universe and many subcategories.¹⁸

We propose that instead of examining simple Sharpe ratios calculated using monthly returns, investors focus on *hedged Sharpe ratios* that take into account market exposure, and use the lagged beta techniques we propose to estimate more accurate betas.¹⁹ For hedge funds that are truly uncorrelated with the market, both simple and hedged Sharpe ratios will produce the same results, but for funds with large average market exposure the results may differ dramatically.

While the short 1994-2000 period makes drawing definitive conclusions about alpha difficult, this is not the case regarding beta. The evidence we present strongly suggests that non-synchronous pricing problems, whether

due to stale or managed prices, are a significant issue in monthly hedge fund data and can lead to severely understated estimates of hedge fund risk. To the extent this is true, it follows directly that estimates of hedge fund value-added (alpha) will be overstated over any period with a rising equity market.

Our results suggest that constructing a successful hedge fund portfolio is not as simple as other studies indicate. Since we study only indexes, we certainly cannot conclude that attractive uncorrelated hedge funds (or hedge funds that add value net of their market exposure) do not exist. It may be possible to eliminate funds whose risk-adjusted returns are being inflated by the illiquidity we study, and be left with a portfolio of funds that provide attractive expected returns and diversification.

Many hedge funds make bold claims, and some produce monthly returns that seem to support those claims. Our results prompt us to warn that careful scrutiny of these claims is important and—at a minimum—that researchers and investors should use the techniques we discuss or similar methods when they evaluate hedge fund returns.

APPENDIX

CSFB/TREMONT SUBINDEX CATEGORIES*

Convertible Arbitrage

This strategy is identified by hedge investing in the convertible securities of a company. A typical investment is to be long the convertible bond and short the common stock of the same company. Positions are designed to generate profits from the fixed-income security as well as the short sale of stock, while protecting principal from market moves.

Event-Driven

This strategy is defined as equity-oriented investing designed to capture price movement generated by an anticipated corporate event. There are four popular subcategories in event-driven strategies: risk arbitrage, distressed securities, Regulation D, and high-yield investing.

Risk Arbitrage. Specialists invest simultaneously in long and short positions in both companies involved in a merger or acquisition. Risk arbitrageurs are typically long the stock of the company being acquired and short the stock of the acquirer. The principal risk is deal risk, should the deal fail to close.

Distressed Securities. Fund managers invest in the debt, equity, or trade claims of companies in financial distress and generally bankruptcy. The securities of companies in need of legal action or restructuring to revive financial stability typically trade at substantial discounts to par value, and thereby attract investments when managers perceive a turnaround will materialize.

Regulation D, or Reg D. This subset refers to investments in micro and small-capitalization public companies that are raising money in private capital markets. Investments usually take the form of a convertible security with an exercise price that floats or is subject to a look-back provision that insulates the investor from a decline in the price of the underlying stock.

High-Yield. Often called junk bonds, high-yield refers to investment in low-grade fixed-income securities of companies that show significant upside potential. Managers generally buy and hold high-yield debt.

Equity Market-Neutral

This investment strategy is designed to exploit equity market inefficiencies and usually involves being simultaneously long and short matched equity portfolios of the same size within a country. Market-neutral portfolios are designed to be either beta- or currency-neutral, or both. Well-designed portfolios typically control for industry, sector, market capitalization, and other exposures. Leverage is often applied to enhance returns.

Fixed-Income Arbitrage

The fixed-income arbitrageur aims to profit from price anomalies between related interest rate securities. Most managers trade globally with a goal of generating steady returns with low volatility. This category includes interest rate swap arbitrage, U.S. and non-U.S. government bond arbitrage, forward yield curve arbitrage, and mortgage-backed securities arbitrage. The mortgage-backed market is primarily U.S.-based, over-the-counter, and particularly complex.

Long/Short Equity

This directional strategy involves equity-oriented investing on both the long and the short sides of the market. The objective is not to be market-neutral. Managers have the ability to shift from value to growth, from small- to medium- to large-capitalization stocks, and from a net long position to a net short position. Managers may use futures and options to hedge. The focus may be regional, such as long/short U.S. or European equity, or sector-specific, such as long and short technology or health care stocks. Long/short equity funds tend to build and hold portfolios that are substantially more concentrated than those of traditional stock funds.

Emerging Markets

This strategy involves equity or fixed-income investing in emerging markets around the world. Because many emerging markets do not allow short-selling, or offer viable futures or other

derivative products with which to hedge, emerging market investing often employs a long-only strategy.

Global Macro

Global macro managers carry long and short positions in any of the world's major capital or derivative markets. These positions reflect their views on overall market direction as influenced by major economic trends and/or events. The portfolios of these funds can include stocks, bonds, currencies, and commodities in the form of cash or derivatives instruments. Most funds invest globally in both developed and emerging markets.

Managed Futures

This strategy invests in listed financial and commodity futures markets and currency markets around the world. The managers are usually referred to as commodity trading advisors, or CTAs. Trading disciplines are generally systematic or discretionary. Systematic traders tend to use price and market-specific information (often technical) to make trading decisions, while discretionary managers use a less structured approach.

Dedicated Short Bias

Dedicated short-sellers were once a robust category of hedge funds before the long bull market rendered the strategy difficult to implement. A new category, short-biased, has emerged. The strategy is to maintain net short as opposed to pure short exposure. Short-biased managers take short positions in mostly equities and derivatives. The short bias of a manager's portfolio must be constantly greater than zero to be classified in this category.

*Source: CSFB/Tremont web site
(<http://www.hedgeindex.com>).

ENDNOTES

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¹Asness [1998] discusses this topic in more detail.

²See the appendix for a description of the CFSB/Tremont subindexes and the CFSB/Tremont web site (www.hedgeindex.com) for more detailed information. The constituents of each index are publicly available.

³Please see Liang [2000] for an in-depth comparison of the TASS and Hedge Fund Research databases and an analysis of survivorship bias in hedge fund returns.

⁴Additionally, since these indexes represent portfolios of hedge funds, styles that represent 1) more funds and 2) more heterogeneous funds will tend to produce indexes with lower volatility.

⁵Agarwal and Naik [2000a], Fung and Hsieh [2000], and Mitchell and Pulvino [2000] study the performance of hedge funds using non-linear models. Additionally, we use net-of-fee returns, and managers typically charge a performance fee of 20% of any positive returns. Therefore, even if gross returns are linear in the market, net returns will not be. Since the beta on net returns will be 80% of the beta on gross returns on the upside and 100% on the downside, our net-of-fee betas may underestimate the betas on gross returns.

⁶The market correlations reported in Exhibit 1 are invariant to volatility and thus they may be compared directly across funds with differing volatilities. Betas are not invariant to volatility; the higher an asset's volatility, the higher the asset's beta (for the same level of correlation). For example, equity market-neutral has an estimated beta of only 0.12, but since its volatility is so low (3.5% annualized) this is actually a very significant beta both economically (annual returns are reduced from an unadjusted 6.4% to an alpha of 4.7%) and statistically (t-statistic of 4.89). At the other end of the spectrum, emerging markets has a 0.74 beta, but its t-statistic of 5.15 is comparable to equity market-neutral.

In the simple regression framework of Exhibit 2, the relation between beta and correlation is as follows:

$$\beta_{i,m} = \rho_{i,m}(\sigma_i/\sigma_m)$$

Therefore, the beta for an index is equal to its correlation with the S&P 500 times the ratio of the hedge fund's volatility to the S&P 500's volatility. For example, the beta of 0.12 for equity market-neutral can be computed from the data in Exhibit 1 as follows: $0.48(3.5\%/14.2\%) = 0.12$.

⁷Since volatility varies considerably across the hedge fund styles, naive comparisons of the magnitude of the alphas can be quite misleading. In contrast, both the t-statistic testing the hypothesis that the alpha is equal to zero and the Sharpe ratio of the "hedged" hedge fund in Exhibit 6 (defined as $\alpha/\text{volatility } [R_{i,t} - \beta R_{m,t}]$) are comparable across portfolios with varying volatilities.

⁸An extreme example of stale or managed pricing can be found in the "private equity" category of alternative investments. Private equity suffers from a lag in mark-to-market returns that is so severe that the techniques in this article do not apply—but this does not mean the effect does not exist. On the contrary, it is likely that most empirical estimates of private equity risk (beta and volatility) are severely understated. It appears that traditional

hedge fund managers have been crossing over more and now own some private equity-like investments. If this is the case, our techniques will not fully capture the understatement of hedge fund risk. Finally, some private equity managers and investors seem to believe these investments provide tremendous diversification for traditional portfolios, sometimes going so far as to call them "uncorrelated." Well, the ostrich thinks he's uncorrelated also, but that does not fool the lion.

⁹Non-synchronous pricing does not necessarily always reduce estimates of beta and volatility. For example, monthly volatility can be overstated for truly market-neutral strategies that are long and short securities that trade in different time zones (or are illiquid). If a hedge fund is long Japan and short the U.S., then non-synchronous closing prices can lead to overstated estimates of volatility. For example, if on the last day of the month the U.S. trades off, since Japan is closed, the portfolio is marked with the U.S. move, but no concurrent Japan move. Of course, the next day Japan would most likely gap down, but that would show up only in the following month's return.

¹⁰There are other potential reasons, besides simple sampling error, for annualized quarterly volatility to exceed annualized monthly volatility. For example, if true hedge fund returns (marked timely and accurately) are positively autocorrelated at the monthly level, we will observe an increase in volatility. In the absence of such autocorrelation in the S&P 500, we do not expect a corresponding increase in market correlation from this effect. Over our sample period, the S&P 500 monthly returns exhibit mildly negative, but statistically insignificant, autocorrelation at each of the first three lags.

¹¹A downward bias applies only for the more common case of positive market exposure. In the case of negative market exposure, as in dedicated short biased funds, non-synchronous price reactions actually bias estimates of beta upward in simple regressions (i.e., estimates are less negative than actual betas).

¹²Event-driven includes a fairly heterogeneous combination of risk arbitrage, distressed debt, high-yield, and Regulation D funds.

¹³For example, Ibbotson, Kaplan, and Peterson [1997] apply this summed beta technique to empirical tests of the capital asset pricing model. They argue that simple measures of small-capitalization stock betas are understated due to stale pricing, and thus factors like size tend to empirically dominate beta. When they account for lagged effects, the beta estimates for small-capitalization stocks increase substantially, and they find that beta does a good job in explaining cross-sectional differences in average returns.

¹⁴As an additional robustness check, we run the regressions in Exhibit 4A with the three lagged beta coefficients constrained to equal the same value as opposed to letting them vary. This has no material effect on our results. In particular, the restricted regression produces a summed beta for the aggregate hedge fund index of 0.80, as opposed to 0.84 for the unrestricted regression reported in Exhibit 4A.

¹⁵Hedge funds often require 30 days or more advance notification for fund withdrawals.

¹⁶While we focus on market risk, we also conduct initial tests using other potential explanatory risk factors. If in addition to the S&P 500, we include in our lagged regression tests the excess return of small-capitalization stocks over large stocks, we find that the aggregate hedge fund index and many hedge fund styles have a small-capitalization stock bias over this period. Since small stocks underperformed large stocks over the 1994-2000 period, this bias helps explain the negative alphas we find. In fact, when accounting for the small-capitalization stock factor, the aggregate hedge fund index has neither added nor subtracted value over this period. Our main result that standard monthly regression betas understate true beta, and thus simple estimates of performance overstate skill, remains unchanged.

We also conduct initial tests on the non-linear effects other authors have identified in hedge fund returns. In particular, adding in a squared market return shows that managed futures load positively on this "long volatility" factor, while the aggregate hedge fund index and most other individual categories load negatively on this factor. Unlike our lagged market betas, the non-linear effects are highly sensitive to the inclusion of the volatile months in the fall of 1998. Most important, inclusion of the squared market return in our lagged beta regressions has little impact on our results.

¹⁷Volatility estimates used in the denominator of the Sharpe ratios for the summed beta-hedged strategies will be overestimated due to non-synchronous pricing differences between the hedge fund returns and the S&P 500 returns. Average return estimates are not biased, however, and thus the Sharpe ratio will generally be biased toward zero (i.e., less negative for negative Sharpe ratio strategies and less positive for positive Sharpe ratio strategies).

¹⁸While we do not address this issue here, it is easy to surmise that for a taxable investor the situation is even worse, as taxes would have much more of a negative impact on hedge funds' returns than on an S&P 500 index fund. See Arnott and Jeffrey [1993] for an excellent discussion of the effects of portfolio turnover on after-tax performance of equity funds.

¹⁹This is akin to using information ratios for measuring active returns against a benchmark.

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