Hedge Fund Analysis—
Reading the Multi-Factor Tea Leaves

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Abstract
During the last few years, there has been growing interest in the use of factor models for performing risk and exposure analysis of hedge funds. While interpreting directional and spread related factors in this context is fairly straightforward, interpreting non-linear options exposures often is not. Given the variety of activities that can produce options exposures, the interpretation of multi-factor output in this regard can be more of an art than a science. This paper explores the variety of hedge fund manager activities that can drive options exposures in multi-factor analysis and the considerations that must be made in analyzing and interpreting these exposures.

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During the last few years, there has been growing interest in the use of factor models for performing risk and exposure analysis of hedge funds. Little has been written, however, on how to interpret this analysis in the context of specific hedge funds. Factor modeling makes use of linear regression or other similar models that result in an estimated “best fit” set of allocations to various market indexes, spreads, options, or other instruments. While interpreting directional and spread related factors in this context is fairly straightforward, interpreting non-linear options exposures often is not. In fact, it is often these exposures that are most useful in performing analysis on individual managers, as volatility exposures often point to important nuances in the way a manager invests.

Options exposures in a hedge fund can be driven by any one of the following phenomena:

- The actual purchase or sale of options or other volatility instruments (e.g., variance swaps, conditional variance swaps, etc.) by the hedge fund manager.
- Put-call parity—in a hedge fund multi-factor model, a put can be represented as a call and a call can be represented as a put.
- Dynamic trading of the portfolio in a fashion that has the effect of creating pseudo options exposures.
- Options exposures attached to convertible arbitrage trading.
- Options exposures attached to merger arbitrage trading.
- Volatility and options exposures arising from an interpretation of equity as a call option on the assets of a firm and debt as a short put option on the value of a firm (a Merton interpretation).

In order to derive a helpful interpretation of factor model output, it is critical that one consider the extent to which one or more of these phenomena are at work in the manager’s return series. In order to do this, some a-priori knowledge of the manager’s approach is helpful. Just as recent research into operational risk at hedge funds suggests that there is no substitute for bottom-up analysis, the same can be said here: in order to get a full picture of the drivers of manager returns, factor output should be supplemented with a bottom-up knowledge of what a manager does and how he or she manages the portfolio.

The purpose of this article is to explore each of the phenomena noted above in the context of specific hedge funds. In so doing, we are able to highlight specific areas that deserve attention and consideration when interpreting the results of multi-factor analysis of hedge funds. The body of the paper consists of an explanation of our data and methodology and six sections, each of which addresses the phenomena noted above.

Data and Methodology

The hedge fund data used in this article includes both manager data as well as HFRI index data. The index data and most of the manager data was obtained from the HFR database, while the data for one manager was obtained directly from the manager. Factor returns have been calculated based on price and rate information obtained from Bloomberg. We use exactly five years of monthly data for each piece of multi-factor analysis, going from February 2003 to January 2008. We use the standard 24-month rolling regression, which provides for 37 data points in each of the related graphs.

We withhold the identity of the managers discussed in this article, as much of the qualitative information has not been obtained through public means—and the managers may prefer that their identity not be made known. Due to the more or less secretive nature of most hedge fund managers, many studies on hedge funds lack essential insights from the managers that would substantially improve the analysis. We attempt to fill this gap by performing quantitative analysis on managers and putting this analysis in the light of qualitative information we have obtained through discussions with the manager or other means. As such, we will refer to these managers as Manager 1, Manager 2, Manager 3, and Manager 4.

2 - For analysis of volatility exposures within hedge funds, see Kuenzi and Shi (2007), Fung and Hseih (1997, 2001), and Agarwal and Naik (2000).
3 - See Christeny, et. al. (2006).
4 - See Kuenzi and Shi (2007) for a full discussion of the rationale for this choice.
The factors used in the regression are those that we have identified as being most related to the given strategy and are often different from manager to manager and from strategy to strategy. We use what we believe to be the most relevant set of factors for the different managers and hedge fund indexes examined.

Most of the previous articles related to factor analysis of hedge funds have focused on finding the appropriate model, the explanatory power of the models, and the statistical significance of the factors. As such, there is a large body of available information on these issues in the literature. Given that this study is focused on the interpretation of multi-factor output, and in order to impart our key points with reasonable brevity, we do not provide information on statistical significance of the individual models. The average r-squared across all rolling regressions shown in this article is 45%.

Direct Purchase and Sale of Options and Other Volatility Instruments
Many managers buy protective puts, enter into options overwriting strategies in order to generate income, and otherwise purchase or sell volatility related products on a regular basis. To the extent that managers invest in these instruments regularly, we would expect that this would be reflected in multi-factor output. The manager we will call Manager 1 is an Asia-focused volatility arbitrage manager who is known to be short volatility in high volatility environments and long volatility in low volatility environments. The manager achieves this through the purchase and sale of options and other volatility instruments.

The multi-factor output is shown in Exhibit 1. It is the kinds of exposures shown in Panel 2 of the exhibit—driven by actual options positions—that some might naively think would generate the bulk of hedge fund volatility exposures. As we will see in the sections below, this is one small component of the total activity that can add volatility exposures to a hedge fund.

Put–Call Parity
Put–call parity is an arbitrage relationship between calls and puts that have the same strike and expiry. It says that:

\[ C - P = S - Ke^{-r(T-t)} \]  

where \( C \) is the call price, \( P \) is the put price, \( S \) is the price of the underlying, \( K \) is the strike price, \( r \) is the interest rate and \((T-t)\) is the time to maturity expressed as fractions of a year. As we consider the output of a multi-factor model, it is useful to think of both calls and puts with reference to the three other terms in Equation (1). A call is equal to a levered long stock position plus a put:

\[ C = S - Ke^{-r(T-t)} + P \]  

And a put is equal to a short stock position plus a call:

\[ P = Ke^{-r(T-t)} - S + C \]  

Given the nature of multiple regression and like models—that they maximize the explanatory power of the independent variables without regard to the economic meaning arising from the results—it is sometimes the case that a manager’s long call position will be expressed in model output as a long put position plus a leveraged long position in the underlying. Similarly, a manager’s long put position is sometimes represented as a long call position plus a short position in the underlying.

5 - In using options for in multi-factor analysis, we employ the long and short exposure "netting" procedures described in Kuenzi and Shi (2007). Simultaneous long call and short put exposures create a synthetic forward contract. As such, any synthetic forward position is removed from the volatility exposure and added to the directional exposure.

6 - The factors used here are the returns on the MSCI Pacific Ex-Japan iShares, as well as returns on three-month at-the-money calls and puts on this underlying. The options are rolled at expiration. See Kuenzi and Shi (2007) for more on the methodology used for computing returns.
The manager that we will call Manager 2, a global technology long-short equity manager, has represented that his portfolio is short both puts and calls but is primarily short puts. The multi-factor results for this manager are shown in Exhibit 2. As can be seen, the majority of the short volatility exposure seems to come from call options until very recently. The model is absolutely accurate in terms of the short volatility exposure, but somewhat off in terms of the exact breakdown between calls and puts. It is in this context that bottom-up analysis is important. For a fund of funds manager, the ability to question the manager on the source of the short volatility exposure revealed by the multi-factor analysis is critical. A short put position in January 2008 is very different from a short call exposure.

Additionally, for a manager such as this, in which the estimated option exposures and related delta-hedging can shift dramatically, it is often helpful to consider the same model but excluding use of the volatility factors. This analysis, shown in Exhibit 3 indicates that the manager’s equity market exposure has very recently increased and largely due to a significant short put position.

Dynamic Options Replication

Another important notion is that often managers trade in the underlying securities in such a way that they end up replicating options exposures. This point is made quite powerfully in Fung and Hsieh (1997, 2001), in Agarwal and Naik (2000), and most recently in Kuenzi and Shi (2007).

It is instructive to think of dynamic trading in terms of the “Greek” exposures that managers create through various trading techniques. The Greeks refer to exposures inherent in options contracts. These exposures are often replicated based on various manager trading strategies. The Greeks that are uniquely related to volatility and most define it are gamma (Γ) and vega (ν). Market directional exposure is, of course, referred to as delta (Δ). Mathematically, these are defined as follows:

\[ \Delta = \frac{\partial V}{\partial S} \]  \hspace{1cm} (4)

\[ \Gamma = \frac{\partial^2 V}{\partial S^2} = \frac{\partial \Delta}{\partial S} \]  \hspace{1cm} (5)

\[ \nu = \frac{\partial V}{\partial \sigma} \]  \hspace{1cm} (6)

where \( V \) is the value of the portfolio, \( S \) is the value of the index, and \( \sigma \) is the implied volatility in the options market. Delta can also be thought of as the manager’s beta exposure to the underlying market. Gamma tells us how the manager adjusts his or her beta to the market as the market moves. In particular, a manager can create specific gamma exposures through different types of dynamic trading. These gamma exposures are highly related to the returns on shorter-dated options.

All else equal, longer-dated options will have more vega than shorter-dated options. Implied volatility is highly related to equity returns (daily correlation of -0.75 between changes in the S&P 500 Index and changes in the VIX implied volatility index January 1, 2002 to December 31, 2007). As such, returns to vega exposures will be highly related to these directional exposures. Overall, a combination of equities with dynamic trading that reproduces a consistent gamma exposure is likely to reproduce an equity options exposure.
Below we describe which types of dynamic trading may be most associated with particular options positions.

- **Long Call.** A manager who continually buys into rallies, trying to catch the next big move, and then sells down exposure as the market retreats from sudden bursts may have an exposure that resembles a long call.
- **Long Put.** A manager who tends to reduce exposure as the market sells off and who then legs back as sudden declines mend may create a synthetic long put exposure.
- **Short Call.** A manager who believes that the upside for stocks is limited and therefore sells into rallies and reloads market risk as prices mean revert may create a synthetic short call exposure.
- **Short Put.** A manager who always “buys the dips” and then sells into strength may end up creating a short put exposure.
- **Long Straddle (Long Call and Long Put).** A manager who expects the market to break out either up or down and is therefore ready to pile into a rally or sell into a down market but who takes off exposure as things quiet down may create a long straddle exposure.
- **Short Straddle (Short Call and Short Put).** A manager who believes that the markets are range-bound and therefore sells into rallies and buys the dips with a hope of making money from a continual reversion to current levels may create a synthetic short straddle exposure.

Exhibit 4 shows the multi-factor analysis of Manager 3, an equity long-short manager who is purported to have no direct call or put exposure but who is known to trade frequently and to look for the next big upward move in equities. The large long volatility exposures can reasonably be interpreted as arising out of these dynamic trading strategies.

It is also important to note that managers who trade frequently but who do so based purely on fundamental information or a-priori market views are unlikely to show any volatility exposure related to the above. In fact, these managers are likely to have very low r-squared in multi-factor analysis as their continual and discretionary changes in directional exposure prevent the factors from identifying any kind of consistent exposure. As such, for the hedge fund analyst, consistently low explanatory power is a fact that can hold information concerning a manager’s trading strategy.

**Options Exposures Attached to Convertible Arbitrage Trading**

Vanilla convertible bonds are essentially a corporate bond issued by a company with a call option attached to the bond, such that if the stock of the issuing company increases in price, the holder of the bond is able to trade it in for the more valuable stock. Traditional convertible arbitrage involves the purchase of the convertible bond combined with a short position in the stock of the issuing company, where the amount of the short position is equal to the delta of the option attached to the convertible bond. The net position is a delta-hedged long call option plus a long credit and long rates position.

While convertible bonds often include a variety of other provisions (some can be put back to the issuer, or can include provisions related to the level of interest rates, etc.), the bulk of the exposures are generally reflective of the previous paragraph. As such, we would expect that most convertible arbitrage managers would have a long call option exposure. We perform multi-factor analysis on the HFRI Convertible Arbitrage Index. The results are shown in Exhibit 5. The exposures are as expected—generally long volatility with a preponderance of long call exposures.

It is also important to note that a long credit exposure is reasonably highly correlated with a short put exposure (full study period monthly correlation of 0.53 between our credit factor and Russell 2000 put factor). By equation (3), the short put can in turn be represented as a short call plus a long

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8 - The factors used for equity long-short manager are the returns of the S&P 500 SPDR, small minus large (returns of the Russell 2000 iShares minus those of the S&P 500 SPDR), value minus growth (returns of the Russell 1000 Value iShares minus the returns of the Russell 1000 Growth iShares), and 3-month at-the-money calls and puts on S&P 500 SPDRs.

9 - The factors used for equity long-short manager are the returns of the Russell 2000 iShares, the returns of a 5-year interest rate swap, the returns to credit spreads (Bloomberg 5-year single-B Industrials Index minus 5-year Treasuries), and 3-month at-the-money calls and puts on the Russell 2000 iShares.
position in the underlying. As such, if convertible arbitrage managers are not hedging credit risk with CDS or asset swaps, it is possible that the short volatility exposure associated with being long credit could offset the long volatility exposure associated with the call options attached to the convertible bonds. It may also simply show itself as short put exposure.

**Options Exposures Attached to Mergers Arbitrage Trading**

Particular event trades can also produce options exposures—either because of the financial profile of a deal break or because there are actual options embedded in deal terms. A vanilla merger arbitrage position in a stock deal is akin to being long LIBOR (plus a spread) and short a put option on the equity market.\(^1\) This is based on the notion that if the market falls dramatically, deals are likely to break; these deal breaks would then cause huge and sudden losses for arbitrageurs (short downside gamma).

This short put exposure can be seen quite clearly in Panel 2 of Exhibit 6, which shows the factor exposures of the HFRI Mergers and Reorgs Index.\(^1\) Note that the exposures to the underlying index and the option are highly correlated. This can be interpreted as the equivalent of a delta-hedged option exposure. The underlying equity exposure is actually fairly stable (as shown in Exhibit 7), but as the option exposures related to the merger arb positions move, the effective delta-hedge must move around as well.

Collar deals have options embedded within them.\(^2\) A fixed-value deal allows the exchange ratio (number of acquirer’s shares to be traded for each target share) to fluctuate within a range. Outside of the range, the ratio is fixed. This gives rise to the payoff profile and delta exposure shown in Exhibit 8. This payoff profile is akin to a long collar—long call exposure at a higher strike and short put exposure at a lower strike.\(^3\)

By the same token, a fixed ratio deal provides for a fixed exchange ratio when the acquirer’s stock is within a range and a fluctuating exchange ratio when the acquirer’s stock is outside of the range. This leads to the payoff profile and delta exposure shown in Exhibit 9. This payoff is akin to a call spread—long a lower strike call and short a higher strike call.

The above makes it clear that not only are there implicit options related to merger arbitrage activity, but that often there are actual options embedded in some deals. If we include both calls and puts as factors, the output will capture the total option exposure—the combination of both the short put exposure implicit in stock deals in general and the options exposures arising from fixed value or fixed ratio deals. As such, it may be a complex combination of options exposures within the portfolio that produce the option profile observed in the output.

Exhibit 10 shows multi-factor results using at-the-money calls and puts as volatility factors rather than simply an out-of-the-money put as in the previous analysis. We still have substantial short put exposure, but we also have some long and long call exposures. The short call exposures in 2006 might be interpreted as bits of exposure to fixed value deals. The long call exposure at the end of the period might be interpreted in a number of ways. First, as the credit crisis ensued in mid-2007, cash deals driven by private equity buyers began to dry up, leaving a larger proportion of stock deals in the period might be interpreted in a number of ways. First, as the credit crisis ensued in mid-2007, cash deals driven by private equity buyers began to dry up, leaving a larger proportion of stock deals in the

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1. See, for example, Anson and Hu (2003) and Mitchell and Pulhina (2001).
2. We use a 5% out-of-the-money put on Russell 2000 Shares as the volatility factor. We also include an equity directional factor (Russell 2000 Shares) in this analysis to take account of the notion that many managers may be keeping some residual equity risk in merger arb portfolios.
3. See Branch and Wang (2005) and BNP Paribas (2003). In order to construct these pay-offs (we use notation as in BNP Paribas 2003), the deals are defined as follows. In a fixed value deal, the exchange ratio is equal to

\[
\begin{align*}
\alpha &= \min(\frac{BU}{BL}, 1) \\
\beta &= \max(\frac{BU}{BL}, 0)
\end{align*}
\]

where \(BU\) is the acquirer price representing the upper bound of the collar, \(BL\) is the lower bound, \(BA\) is the acquirer price at the time the deal is executed, \(\alpha\) is the minimum exchange ratio, and \(\beta\) is the maximum exchange ratio. Altogether, the equivalent options strategy (EOS) of the deal is:

\[
EOS = \alpha Call(BU, BL, T, t, \sigma, r, \beta) + \beta Put(BU, BL, T, t, \sigma, r, \beta)
\]

For a fixed exchange ratio deal, the exchange ratio is equal to

\[
\alpha = \frac{BU}{BL} \quad \text{and} \quad \beta = \min(\frac{BU}{BL}, 1)
\]

for an EOS of:

\[
EOS = \alpha Call(BU, BL, T, t, \sigma, r, D) + \beta Put(BU, BL, T, t, \sigma, r, D)
\]

10. Often, these deals involve an Asian feature in which the acquirer price used in the final computation of the exchange ratio is the average acquirer price over, say, the 20 days prior to deal close. For our purposes here, we a simple Black-Scholes model (without the average feature) in order to demonstrate the payoff profile and delta.

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marketplace, and thus likely a larger proportion of collar deals. Secondly, with the markets looking uneasy, bankers were likely pushing fixed ratio deals, which provide holders of the target’s stock with downside protection through a long call exposure if the market slides.

The Merton Model and Equity as a Call Option
The Merton model as presented in Merton (1974) expresses a firm’s equity as a call option on the value of the firm’s assets. If the company does well, the equity holders make a lot of money; if the company performs extraordinarily poorly, the investors loose only their option premium (what they paid for the stock). The remainder of the losses accrue to the debt holders.

If we assume the firm’s equity ($E$) to be a call option on the value of the firm ($V$), and the value of the strike price to be the amount of outstanding debt ($D$), we can then write Equation (2) above as:

$$E = V - De^{r(T-t)} + P$$

If a manager typically invests in highly volatile companies with uncertain futures (and then perhaps hedges those holdings with relatively stable and low volatility ETFs), the manager’s positions will exhibit long call exposure. An investment in a small technology firm selling at $2 per share but that might appreciate to $40 if it can make it through the next two years would be a good example of a holding that might produce a long volatility exposure in a manager’s portfolio. If the economy and the market perform well, the probability that stock of this firm will go to $40 will increase. The share price is simply an option premium paid for a small probability that the stock price will see a 20-fold increase. A portfolio filled with these types of investments is likely to show a long options exposure.

Similarly, if a highly skilled manager is able to identify investments in which $E = V - De^{r(T-t)}$, then the manager has been able to identify investments with a free option—the put, based on equation (8), is free. Manager 4, whose results are shown in Exhibit 11, claims to find companies that are trading close to their intrinsic value. The manager does not hold options or other volatility instruments in the portfolio and does not engage in any frequent trading, but rather attempts to find companies that are trading at liquidation value, at a market capitalization that equates to cash on the balance sheet, or at some other “floor” value. In that the manager shows consistently long volatility exposure, the manager seems to have been successful in this regard. For this case, it is a Merton-related interpretation that enables us to understand both the options exposures and the extent to which the manager is adding value.

Conclusion
While the directional and spread factors used in multi-factor analysis are helpful in understanding the risk exposures of individual managers, in most cases such analysis simply confirms what the manager has represented—most equity long-short managers will be slightly net long equities over time, most distressed managers will be net long credit over time, etc. A manager’s options exposures in combination with some knowledge of a manager’s strategy can be a powerful combination in understanding the nuances of what a manager really does and the resulting risk exposures. Given the variety of activities that can produce options exposures, as discussed in this paper, the interpretation of multi-factor output in this regard can be more of an art than a science.

We have highlighted a variety of issues that should be considered when performing analysis on options exposures in the context of multi-factor analysis. Questions related to options exposures related to fixed income, FX, and commodity related strategies were not addressed in this paper. These might be topics for future research.
REFERENCES


EXHIBIT 1
Manager 1 Exposures: Long Volatility Manager

Panel 1: Direction and Spread Factors

Panel 2: Volatility Factors
EXHIBIT 2
Manager 2 Exposures: Technology Long Short Equity Manager

Panel 1: Direction and Spread Factors

Panel 2: Volatility Factors
EXHIBIT 3
Manager 2 Exposures: No Volatility Factors
EXHIBIT 4
Manager 3 Exposures: Long-Short Equity Manager

Panel 1: Direction and Spread Factors

Panel 2: Volatility Factors
EXHIBIT 5
Exposures of HFRI Convertible Arbitrage Index

Panel 1: Direction and Spread Factors

Panel 2: Volatility Factors
EXHIBIT 6
Exposures of HFRI Mergers and Reorgs Index: One Volatility Factor

Panel 1: Direction and Spread Factors

Panel 2: Volatility Factors
EXHIBIT 7
Equity Exposure of HFRI Mergers and Reorgs Index

Russell 2000 Index
EXHIBIT 8
Fixed Value Merger Deal: Option Value, Payoff, and Delta

Panel 1: Option Value and Payoff

Panel 2: Delta
EXHIBIT 9
Fixed Ratio Merger Deal: Option Value, Payoff, and Delta

Panel 1: Option Value and Payoff

Panel 2: Delta
EXHIBIT 10
Exposures of HFRI Mergers and Reorgs Index: Two Volatility Factors

Panel 1: Direction and Spread Factors

Panel 2: Volatility Factors
EXHIBIT 11
Manager 4 Exposures: Long-Short Equity Manager

Panel 1: Direction and Spread Factors

Panel 2: Volatility Factors