Title	Convertible bond arbitrage: Risk and return
Author(s)	Hutchinson, Mark C.; Gallagher, Liam A.
Publication date	2010-02-01
Original citation	Hutchinson, M. C. and Gallagher, L. A. (2010) 'Convertible bond arbitrage: Risk and return', Journal of Business Finance and Accounting, 37(1/2), pp. 206-241. doi: 10.1111/j.1468-5957.2009.02178.x
Type of publication	Article (peer-reviewed)
Link to publisher's version	http://dx.doi.org/10.1111/j.1468-5957.2009.02178.x Access to the full text of the published version may require a subscription.
Rights	**© 2010, the Authors. This is the peer reviewed version of the following article: Hutchinson, M. C. and Gallagher, L. A. (2010) 'Convertible bond arbitrage: Risk and return', Journal of Business Finance and Accounting, 37(1/2), pp. 206-241, doi: 10.1111/j.1468-5957.2009.02178.x, which has been published in final form at: https://doi.org/10.1111/j.1468-5957.2009.02178.x This article may be used for non-commercial purposes in accordance with Wiley Terms and Conditions for Use of Self-Archived Versions.**
Item downloaded from	http://hdl.handle.net/10468/12103

Convertible Bond Arbitrage: Risk and Return

MARK C. HUTCHINSON AND LIAM A. GALLAGHER*

Abstract: This paper specifies a simulated convertible bond arbitrage portfolio to characterise the risks in convertible bond arbitrage. For comparison the risk profile of convertible bond arbitrage hedge fund indices at both monthly and daily frequencies is also examined. Results indicate that convertible bond arbitrage is positively related to default and term structure risk factors. These risk factors are augmented with the simulated convertible bond arbitrage portfolio, mimicking a passive investment in convertible bond arbitrage, to assess the risk and return of individual hedge funds. We provide estimates of the performance of two hedge fund indices (an equally weighted and value weighted index) and a sample of convertible arbitrage hedge funds using a factor model methodology. Lagged and contemporaneous observations of the risk factors are specified, controlling for illiquidity in the securities held by funds. We find evidence of abnormal risk adjusted returns in the individual fund data and the equally weighted hedge fund index and no evidence of abnormal risk adjusted returns in the value weighted index.

Keywords: Arbitrage, Convertible bonds, Trading, Hedge funds, Factor models

1. INTRODUCTION

Convertible arbitrageurs attempt to capture profit by combining long positions in convertible bonds with short positions in the issuer's equity. The positions are designed to generate returns from two sources: (i) income from the convertible bond coupon and short interest, and (ii) long volatility exposure from the option component of the convertible bond. In this paper, we provide estimates of the abnormal returns to convertible bond arbitrage hedge fund investments, and also describe the risks associated with these returns.

---

*The first author is Co-Director at the Centre for Investment Research and Finance Lecturer at University College Cork; and, the second author is Professor of Finance at Dublin City University. The financial support of the Irish Research Council for the Humanities and Social Sciences (IRCHSS) is gratefully acknowledged. The authors are also grateful to Sungard Trading and Risk Systems for providing data and software and Kenneth French, Øyvind Norli, Vikas Agarwal, Narayan Naik and Ĺubos Pastor for generously providing data. They also thank Lucio Sarno, Niall O'Sullivan, the editor, Peter Pope, and an anonymous referee for their comments.

Address for correspondence: Mark Hutchinson, Department of Accounting, Finance and Information Systems, University College Cork, College Road, Cork, Ireland.
e-mail m.hutchinson@ucc.ie.

Income from the convertible bond comes from the coupon paid periodically by the issuer to the holder of the bond and interest on the proceeds of the short stock sale. As the coupon is generally fixed it leaves the holder of the convertible bond exposed to term structure risk. As the convertible bond remains a debt instrument until converted, the holder of the convertible bond is also exposed to the risk of default by the issuer. The return from the long volatility exposure comes from the equity option component of the convertible bond. To capture the long volatility exposure, the arbitrageur initiates a dynamic hedging strategy. The hedge is rebalanced as the stock price and/or convertible price move.

Previous research has highlighted that hedge fund returns contain statistical features unusual in financial time series.[1] Hedge fund returns are generally non-normally distributed exhibiting negative skewness and excess kurtosis. Linear analysis of non-normal returns using standard normally distributed asset benchmarks yields inefficient results, leading to erroneous conclusions about hedge fund performance. To address this issue previous research has specified risk factors that have non-normal characteristics correcting for much of the non-normality in the return distribution of the funds. Fung and Hsieh (2001) focus on the trend following strategy specifying lookback straddles as risk factors and Mitchell and Pulvino (2001) focus on the risk arbitrage strategy constructing a risk arbitrage portfolio which serves as a benchmark of risk arbitrage performance.

The task of performance evaluation is further complicated when looking at convertible bond arbitrage as funds typically follow quite different strategies[2] and the returns of convertible bond arbitrage hedge funds exhibit serial correlation. Kat and Lu (2001) and Getmansky et al. (2004) hypothesise that the observed autocorrelation in hedge fund returns is due to illiquidity in the securities held by these funds. In the case where the securities held by a fund are not actively traded, the returns of the fund will appear smoother than true returns, be serially correlated, resulting in a downward bias in estimated return variance and a consequent upward bias in performance when the fund is evaluated using mean-variance analysis.

Overall, existing academic studies find that convertible bond arbitrage hedge funds generate significant abnormal returns. Capocci and Hübner (2004) specify a linear factor model to model the returns of several hedge fund strategies and estimate that convertible bond arbitrage hedge funds earn an abnormal return of 0.42% per month. Fung and Hsieh (2002) estimate the convertible bond arbitrage hedge fund index generates alpha of 0.74% per month. Chan et al.

---

[1] Kat and Lu (2001) and Brooks and Kat (2001) amongst others document these characteristics in hedge fund returns.

[2] Kat and Lu (2001) provide evidence that the cross correlations between hedge fund returns within strategies are low.

(2006) present evidence of no abnormal performance by convertible bond arbitrage hedge funds, but their sample is limited to one value weighted index of convertible arbitrage hedge funds.

These findings suggest that financial markets may exhibit significant inefficiency in the pricing of convertible bonds.[3] However, there are two potential non-competing explanations for the large abnormal returns documented in previous studies. The first explanation is that convertible bond arbitrage funds are receiving a risk premium for bearing risks, which are unique to the strategy and have not been fully adjusted for in previous studies. The second explanation is that the illiquidity in the securities held by individual hedge funds leads to underestimation of risk factor coefficients and biased estimates of performance. In this paper we attempt to address these issues.

To assess convertible bond arbitrage hedge fund performance we specify a simulated convertible bond arbitrage portfolio augmented with default and term structure risk factors to capture the return generating process common to convertible bond arbitrage hedge funds. By defining a set of risk factors that match an investment strategy's aims and returns, individual fund's exposures to variations in the returns of the risk factors can be identified. Following the identification of exposures, the effectiveness of the manager's activities can be compared with that of a passive investment in the risk factors. For out-of-sample comparison we demonstrate empirically that the simulated convertible bond arbitrage portfolio returns strongly resemble the returns of convertible bond arbitrage hedge fund indices. To ensure the robustness of these results we provide evidence at both daily and monthly frequencies.

As the simulated portfolio is constructed as a passive[4] convertible bond arbitrage investment and also shares the characteristics of the hedge fund indices, but contains none of the biases, it serves as a useful benchmark risk factor of individual fund performance.[5] Furthermore, the simulated portfolio's returns exhibit negative skew and excess kurtosis sharing the statistical characteristics of the convertible bond arbitrage hedge fund returns.

The second explanation for the high abnormal returns to convertible bond arbitrage reported in previous studies is that the illiquidity in the securities held by the funds leads to underestimation of risk factor coefficients and a corresponding bias in performance estimation. Although previous studies have identified the serial correlation in hedge fund returns and

---

[3] Ammann et al. (2004) and King (1986) document evidence of convertible bond under pricing on the French and US convertible bond markets. Kang and Lee (1996) also find evidence of convertible bond under pricing at issue.

[4] No analysis is undertaken on the relative valuations of the convertible bonds.

[5] The difficulty with the use of hedge fund benchmark returns to define the characteristics of a strategy and measure the performance of individual funds is hedge fund data contains three main biases, instant history bias, selection bias and survivorship bias as discussed in detail by Fung and Hsieh (2000).

attributed this to illiquidity, studies of convertible bond arbitrage performance have generally made the implicit assumption that contemporaneous risk factors fully capture the risk in convertible bond arbitrage investments despite the presence of autocorrelation. In a recent paper, Agarwal et al. (2007) investigate the role of hedge funds as liquidity providers in the convertible arbitrage market. They find evidence that portfolios of convertible arbitrage hedge funds and hedge fund indices do generate significant alphas but these alphas are compensation for providing liquidity to convertible bond issuers during the new issue period.

Taking an alternate approach, drawing on Getmansky et al's (2004) model of illiquidity in hedge fund returns and the non-synchronous trading literature on beta estimation in the presence of thin trading, we specify a statistical model, incorporating contemporaneous and lagged observations of the risk factors, to evaluate convertible bond arbitrage performance.[6] Estimates of abnormal return to convertible bond arbitrage from our model are not significantly different from zero for the CSFB hedge fund index, are 30 basis points per annum for the HFRI index, and are 28 basis points per month, on average, for the sample of individual hedge funds.

In this paper we provide several incremental contributions to the existing literature on hedge fund and convertible bond arbitrage performance. We begin by simulating a convertible bond arbitrage portfolio which is an innovative approach to modeling the data generating process of the strategy. Providing incremental evidence on the key risk factors in the strategy, and demonstrating the robustness of the convertible bond arbitrage portfolio, we conduct a comprehensive factor analysis of both the portfolio and two hedge fund indices. As a further robustness check we examine the data generating process of daily convertible bond arbitrage returns. This is the first study to provide this evidence, using high frequency data, specifically for the convertible bond arbitrage strategy. We also present a statistical model of convertible bond arbitrage returns allowing for illiquidity documented in the returns of the strategy. Finally, we provide performance estimates for both individual funds and indices of convertible bond arbitrage returns. Prior literature has either focused on the hedge fund indices or, more recently, portfolios of convertible bond arbitrage funds. This is the first paper to examine the strategy at the individual fund level.

The remainder of the paper is organised as follows. In the next section we describe the construction of the simulated portfolio. Section 3 provides a definition of the risk factor models specified to test the out of sample properties of the simulated portfolio, and Section 4 presents results from estimation of risk factors on the simulated convertible bond arbitrage portfolio and

---

[6] Asness et al. (2001) demonstrate that lagged S&P500 returns are significant explanatory variables for several hedge fund indices.

the convertible bond arbitrage hedge fund indices. Section 5 describes the convertible bond arbitrage performance measurement models and Section 6 presents results from the estimation of convertible bond arbitrage risk and performance. Section 7 concludes the paper.

2. CONSTRUCTING THE BENCHMARK PORTFOLIO

To provide a benchmark for the convertible bond arbitrage strategy we construct a simple convertible bond arbitrage portfolio, designed to capture income and volatility. The portfolio combines long positions in convertible bonds with delta neutral hedged short positions in the issuer's equity. These hedges are then rebalanced daily, maintaining the delta neutral hedge.

The simulated portfolio focuses exclusively on the traditional convertible bond as this allows us to use a universal hedging strategy across all instruments in the portfolio. Due to data constraints, we focus exclusively on convertible bonds listed in the United States between 1990 and 2002. To enable the forecasting of volatility, issuers with equity listed for less than one year were excluded from the sample.[7] Any non-standard convertible bonds and convertible bonds with missing or unreliable data were removed from the sample. The final sample consists of 503 convertible bonds, 380 of which were live at the end of 2002, with 123 dead. The terms of each convertible bond, daily closing prices and the closing prices and dividends of their underlying stocks were included. Convertible bond terms and conditions data were provided by Monis. Closing prices and dividend information came from DataStream and interest rate information came from the United States Federal Reserve Statistical Releases.

The convertible bond portfolio is an equally weighted portfolio of delta neutral hedged long convertible bonds and short stock positions. In order to initiate a delta neutral hedge for each convertible bond the delta for each convertible bond is estimated on the trading day it enters the portfolio.[8] The delta estimate is then multiplied by the convertible bond's conversion ratio to calculate Δ_{it} the number of shares to be sold short in the underlying stock (the hedge ratio) to initiate the delta neutral hedge. On the following day the new hedge ratio, Δ_{it+1}, is calculated, and

---

[7] GARCH(1,1) is specified to estimate volatility. There is a variety of volatility forecasting models such as GARCH, EGARCH, IGARCH, A-GARCH, NA-GARCH, V-GARCH in the literature. Poon and Granger (2003) provide a comprehensive review of volatility forecasting. None of the variants consistently outperforms the GARCH model of Bollerslev (1986).

[8] Delta estimates are generated using Monis ConvertiblesXL V5.00 convertible bond pricing software. ConvertiblesXL is a 200 step trinomial spreadsheet based pricing, analysing and hedging tool used widely in the investment bank and brokerage industry. The delta is estimated for each bond on each trading day in Convertibles XL using the stock price, volatility, dividend yield and interest rate. The credit risk of the bond is estimated using the stock price.

if $\Delta_{it+1} > \Delta_{it}$ then $\Delta_{it+1} - \Delta_{it}$ shares are sold, or if $\Delta_{it+1} < \Delta_{it}$, then $\Delta_{it} - \Delta_{it+1}$ shares are purchased maintaining the delta neutral hedge. The delta of each convertible bond is then recalculated daily and the hedge is readjusted maintaining the delta neutral hedge.

Daily returns were calculated for each position on each trading day up to and including the day the position is closed out. A position is closed out on the day the convertible bond is delisted from the exchange.[9] Convertible bonds may be delisted for several reasons: the company may be bankrupt, the convertible may have expired or the convertible may have been fully called by the issuer.

The daily returns for a position *i* on day *t* are calculated as follows.

$$R_{it} = \frac{P_{it}^{CB} - P_{it-1}^{CB} + C_{it} - \Delta_{it-1}(P_{it}^{U} - P_{it-1}^{U} + D_{it}) + r_{t-1}S_{i,t-1}}{P_{it-1}^{CB} + \Delta_{it-1}P_{it-1}^{U}} \tag{1}$$

where R_{it} is the return on position *i* at time *t*, P_{it}^{CB} is the convertible bond closing price at time *t*, P_{it}^{U} is the underlying equity closing price at time *t*, C_{it} is the coupon payable at time *t*, D_{it} is the dividend payable at time *t*, Δ_{it-1} is the delta neutral hedge ratio for position *i* at time *t – 1* and $r_{t-1}S_{i,t-1}$ is the interest on the short proceeds from the sale of the shares. Daily returns are then compounded to produce a position value index for each hedged convertible bond over the entire sample period.

The value of the convertible bond arbitrage portfolio on a particular date is given by the formula.

$$V_t = \frac{\sum_{i=1}^{i=N_t} W_{it} PV_{it}}{F_t} \tag{2}$$

where V_t is the portfolio value on day *t*, W_{it} is the weighting of position *i* on day *t*, PV_{it} is the value of position *i* on day *t*, F_t is the divisor on day *t* and N_t is the total number of position on day *t*. W_{it} is set equal to one for each live hedged position.

[9] Asquith and Mullins (1991) indicate the holder of a convertible bond will generally only convert early if converted dividends are greater than the bond's coupon to capture a cash-flow advantage. This occurs relatively infrequently and the decision to convert also depends on the investors' tax position. Relaxing our assumption, that a position is closed out on the day the convertible bond is delisted from the exchange, would lead to a marginal increase in the portfolio's return.

The portfolio divisor is adjusted to account for changes in the constituents in the portfolio. Following a portfolio change the divisor is adjusted such that equation (3) is satisfied.

$$\frac{\sum_{i=1}^{i=N_t} W_{ib} PV_i}{F_b} = \frac{\sum_{i=1}^{i=N_t} W_{ia} PV_i}{F_a} \tag{3}$$

where PV_i is the value of position *i* on the day of the adjustment, W_{ib} is the weighting of position *i* before the adjustment, W_{ib} is the weighting of position *i* after the adjustment, F_b is the divisor before the adjustment and F_a is the divisor after the adjustment.

Thus the post adjustment index factor F_a is then calculated as follows:

$$F_a = \frac{F_b x \sum_{i=1}^{i=N_t} W_{ib} PV_i}{\sum_{i=1}^{i=N_t} W_{ia} PV_i} \tag{4}$$

As the margins on the strategy are small relative to the nominal value of the positions convertible bond arbitrageurs usually employ leverage. Calamos (2003) and Ineichen (2000) estimate that for an individual convertible bond arbitrage hedge fund this leverage may vary from two to ten times equity. However, the level of leverage in an efficiently run portfolio is not static and varies depending on the opportunity set and risk climate. Khan (2002) estimates that in mid 2002 convertible bond arbitrage hedge funds were at an average leverage level of 2.5 to 3.5 times, whereas Khan (2002) estimates that in late 2001 average leverage levels were approximately 5 to 7 times.

From a strategy analysis perspective it is therefore difficult to ascribe a set level of leverage to the portfolio. Changing the leverage applied to the portfolio has obvious effects on returns and risk as measured by standard deviation. We apply leverage of two times to the portfolio as this produces a portfolio with a similar average return to indices of convertible bond arbitrage hedge fund returns. Finally monthly returns[10] were calculated from the index of convertible bond portfolio values.

[10] All monthly return calculations are logarithmic.

Insert Table 1 about here

Summary statistics for the monthly returns on the simulated convertible bond arbitrage portfolio in excess of the risk free rate of interest, *CBRF*, are presented in Panel A of Table 1 with summary statistics for the excess return on two hedge fund indices; the HFRI Convertible Bond Arbitrage Index, *HFRIRF*; and, the CSFB Tremont Convertible Bond Arbitrage Index, *CSFBRF*. The CSFB Tremont Convertible Bond Arbitrage Index is an asset-weighted index (rebalanced quarterly) of convertible bond arbitrage hedge funds beginning in 1994 whereas the HFRI Convertible Bond Arbitrage Index is equally weighted with a start date of January 1990.[11] Although the CSFB Tremont indices controls for survivor bias, according to Ackermann et al. (1999), HFR did not keep data on dead funds before January 1993. This will bias upwards the performance of the HFRI index pre 1993. The average return on *CBRF* is 0.33% per month with a variance of 3.104. The average return is lower and the variance higher than the two convertible bond arbitrage hedge fund indices, *CSFBRF* and *HFRIRF*. *CBRF* is negatively skewed and has positive kurtosis as do the two hedge fund indices.

3. TESTING THE ROBUSTNESS OF THE BENCHMARK PORTFOLIO

In this section asset pricing models are employed to test the out of sample properties of the simulated portfolio: the market model derived from the Capital Asset Pricing Model (CAPM) described in Sharpe (1964) and Lintner (1965), the Fama and French (1993) three factor stock model, the Fama and French (1993) three factor bond model, the Fama and French (1993) combined stock and bond model, the Carhart (1997) four factor model, Eckbo and Norli's (2005) liquidity factor model, a model incorporating Pastor and Stambaugh's (2003) liquidity factor and finally two models with Agarwal and Naik (2004) option based risk factors. This section briefly describes these models, providing an explanation of the expected relationship between convertible bond arbitrage excess returns and the individual factors.

The market model is a single index model, which assumes that all of a stock's systematic risk can be captured by one market factor. The intercept of the equation, α, is commonly called Jensen's (1968) alpha and is usually interpreted as a measure of out- or under-performance. The equation to estimate is the following:

[11] For details on the construction of the CSFB Tremont Convertible Bond Arbitrage Index see www.hedgeindex.com. For details on the construction of the HFRI Convertible Bond Arbitrage Index see www.hfr.com.

$$y_t = \alpha + \beta_{RMRF} RMRF_t + \varepsilon_t \qquad (5)$$

where $y_t = R_t - R_{ft}$, R_t is the return on the hedge fund index at time t, R_{ft} is the risk free rate at month t, $RMRF_t$ is the excess return on the market portfolio on month t, ε_t is the error term, α is the intercept representing skill and β_{RMRF} is the slope of the regression. As convertible bond arbitrageurs are exposed to credit risk, which is typically strongly related to equity market returns, there should be a significantly positive β_{RMRF} coefficient.

The Fama and French (1993) three factor stock model is estimated from an expected form of the CAPM model. This model extends the CAPM with the inclusion of two factors to account for size and market to book ratio of firms. It is estimated from the following equation:

$$y_t = \alpha + \beta_{RMRF} RMRF_t + \beta_{SMB} SMB_t + \beta_{HML} HML_t + \varepsilon_t \qquad (6)$$

where SMB_t is the factor mimicking portfolio for size (small minus big) at time t and HML_t is the factor mimicking portfolio for book to market ratio (high minus low) at time t.[12] Capocci and Hübner (2004) specify the *HML* and *SMB* factors in their models of hedge fund performance. Moreover, Agarwal and Naik (2004) specify the *SMB* factor in a model of convertible bond arbitrage performance and find it has a positive relation with convertible bond arbitrage returns. As the opportunities for arbitrage are greater in the smaller less liquid issues e*x ante* it would be expected that a positive relationship between convertible bond arbitrage returns and the size factor. There is no *ex ante* expectation of the relationship between the factor mimicking for book to market equity and convertible bond arbitrage returns though Capocci and Hübner (2004) report a positive *HML* coefficient for convertible bond arbitrage.

Fama and French (1993) also propose a three factor model for the evaluation of bond returns. They draw on the seminal work of Chen et al. (1986) to extend the CAPM incorporating two additional factors taking the shifts in economic conditions that change the likelihood of default and unexpected changes in interest rates into account. This model is estimated from the following equation

$$y_t = \alpha + \beta_{RMRF} RMRF_t + \beta_{DEF} DEF_t + \beta_{TERM} TERM_t + \varepsilon_t \qquad (7)$$

[12] For details on the construction of SMB and HML see Fama and French (1992, 1993).

where DEF_t is the difference between the overall return on a market portfolio of long-term corporate bonds[13] minus the long term government bond return[14] at month *t*. $TERM_t$ is the factor proxy for unexpected changes in interest rates. It is constructed as the difference between monthly long term government bond return and the short term government bond return.[15]

It is expected that convertible bond arbitrage returns will be positively related to both of these factors as the strategy generally has term structure and credit risk exposure. The growth of the credit derivative market has provided the facility for arbitrageur's to hedge credit risk. The magnitude and significance of the DEF_t coefficient, (β_{DEF}) should indicate to what degree hedge funds have availed of this facility.

Fama and French (1993) also estimate a combined model when looking at the risk factors affecting stock and bond returns. As a convertible bond is a hybrid bond and equity instrument we also estimate this model using the following equation:

$$y_t = \alpha + \beta_{RMRF} RMRF_t + \beta_{SMB} SMB_t + \beta_{HML} HML_t + \beta_{DEF} DEF_t + \beta_{TERM} TERM_t + \varepsilon_t \quad (8)$$

As arbitrageurs attempt to hedge equity market risk, it is expected that the bond market factors will be the most significant in explaining convertible bond arbitrage excess returns in this model.

Carhart's (1997) four factor model is an extension of Fama and French's (1993) stock model. It takes into account size, book to market and an additional factor for the momentum effect. This momentum effect can be described as the buying of assets that were past winners and the selling of assets that were past losers. This model is estimates using the following equation:

$$y_t = \alpha + \beta_{RMRF} RMRF_t + \beta_{SMB} SMB_t + \beta_{HML} HML_t + \beta_{UMD} UMD_t + \varepsilon_t \quad (9)$$

where UMD_t is the factor mimicking portfolio for the momentum effect. *UMD* is constructed in a slightly different manner to Carhart's (1997) momentum factor[16]. Six portfolios are constructed

---

[13] The return on the CGBI Index of high yield corporate bonds is used rather than the return on the composite portfolio from Ibbotson and Associates used by Fama and French (1993) due to its unavailability.

[14] The return on the Lehman Index of long term government bonds is used rather than the return on the monthly long term government bond return from Ibbotson and Associates used by Fama and French (1993) due to its unavailability.

[15] The return on the Lehman Index of short term government bonds is used rather than the one month treasury bill rate from the previous month used by Fama and French (1993).

[16] Carhart (1997) constructs his factor as the equally weighted average of firms with the highest thirty percent eleven-month returns lagged one period minus the equally weighted average of firms with the lowest thirty percent eleven month returns lagged by one period.

by the intersection of two portfolios formed on market value of equity and three portfolios formed on prior twelve month returns. *UMD* is the average return on the two high prior return portfolios and the two low prior return portfolios. There is no *ex ante* expectation for the relationship between convertible bond arbitrage returns and the momentum factor. Capocci and Hübner (2004) report a negative coefficient for convertible bond arbitrage hedge funds.

The final model employed is Eckbo and Norli's (2005) extension of the Carhart model incorporating a liquidity factor. Eckbo and Norli (2005) estimated the following equation:

$$y_t = \alpha + \beta_{RMRF} RMRF_t + \beta_{SMB} SMB_t + \beta_{HML} HML_t + \beta_{UMD} UMD_t + \beta_{TO} TO_t + \varepsilon_t \quad (10)$$

where *TO* is the return on a portfolio of low-liquidity stocks minus the return on a portfolio of high-liquidity stocks.[17] Arbitrageurs generally operate in less liquid issues so a negative relationship between the liquidity factor and convertible bond arbitrage returns is expected.

For robustness we also specify a model incorporating Pastor and Stambaugh's (2003) liquidity factor.

$$y_t = \alpha + \beta_{RMRF} RMRF_t + \beta_{SMB} SMB_t + \beta_{HML} HML_t + \beta_{UMD} UMD_t + \beta_{LIQ} LIQ_t + \varepsilon_t \quad (11)$$

where *LIQ* is Pastor and Stambaugh's (2003) measure of market liquidity. Pastor and Stambaugh's (2003) measure is constructed as a cross-sectional average of individual-stock liquidity measures. Each stock's liquidity in a given month, estimated using that stock's within-month daily returns and volume, represents the average effect that a given volume on day *t* has on the return for day *t + 1*.[18]

Agarwal and Naik (2004) provide evidence that convertible bond arbitrage returns are related to a short put option on a US equity index. To adjust for non-linearity and the potential use of options and to examine the interaction of the option based factor and bond market factors we specify the following models.

$$y_t = \alpha + \beta_{RMRF} RMRF_t + \beta_{SMB} SMB_t + \beta_{HML} HML_t + \beta_{UMD} UMD_t + \beta_{SPPA} SPPA_t + \varepsilon_t \quad (12)$$

$$y_t = \alpha + \beta_{RMRF} RMRF_t + \beta_{SMB} SMB_t + \beta_{HML} HML_t + \beta_{SPPA} SPPA_t + \beta_{DEF} DEF_t + \beta_{TERM} TERM_t + \varepsilon_t \quad (13)$$

[17] For details on the construction of TO see Eckbo and Norli (2005).
[18] For details on the construction of *LIQ* see Pastor and Stambaugh's (2003).

where *SPPA* is Agarwal and Naik's (2004) at the money put option based risk factor.[19] It is constructed by purchasing an at the money put option (February expiry) on the S&P500 on the first trading day in January and selling that option on the first trading day in February and buying another at the money put option that expires in March. Repeating this process creates the time series *SPPA*.

Table 1, Panel B presents summary statistics of the explanatory factor returns.[20] The mean risk premium for the risk factors is simply the mean values of the explanatory variables. *UMD* the momentum factor produces a large 1.14% mean return but this factor also has the largest variance and standard error. The two bond market factors *DEF* and *TERM* have low standard errors but of the two only *DEF* exhibits an average return (0.54%) significantly different from zero at standard levels. *SPCA, SPCO, SPPA* and *SPPO* are Agarwal and Naik (2004) at the money call, out of the money call, at the money put and out of the money put option based risk factors respectively. All exhibit negative mean returns. Other than *SMB*, *TO* and the four option based factors all of the explanatory variables returns have significantly negative skew and all have positive kurtosis other than *SPCA*.

Insert Table 2 about here

Table 2, Panel A presents a correlation matrix of the explanatory variables. There is a high absolute correlation between *TO* and several factors, *RMRF*, *SMB, DEF* and the four option based factors *SPCA*, *SPCO*, *SPPA* and *SPPO*.[21] The four option based factors are highly correlated. *DEF* is also significantly positively correlated with *RMRF, SMB* and *UMD* the momentum factor is negatively correlated with *HML*.

Table 2, Panel B presents the correlations between the three dependent variables, *CBRF*, *CSFBRF* and *HFRIRF* and the explanatory variables. All of the variables are highly correlated as evident by cross correlations ranging from 0.32 to 0.80, all significant at the 1% level. All are positively related to *DEF* the default risk factor and *SMB* the factor proxy for firm size. *CBRF* and *HFRIRF* are positively correlated with *RMRF* and all are negatively related to *TO* the

---

[19] For details on the construction of *SPPA* see Agarwal and Naik (2004).

[20] We are grateful to Kenneth French for providing data on *SMB*, *RMRF*, *HML* and *UMD*. *TO* and *LIQ* data was generously provided by Øyvind Norli and Ĺubos Pastor respectively. We are also grateful to Vikas Agarwal and Narayan Naik for providing data on *SPCA*, *SPCO*, *SPPA* and *SPPO*.

[21] Consistent with Agarwal and Naik (2004) we scale *SPPA* by a factor of 100 in our estimated risk factor models.

liquidity factor. *CBRF* and *HFRIRF* are positively correlated with *SPCA* and *SPCO* and all three convertible bond arbitrage series are negatively correlated with *SPPA* and *SPPO*.

4. RESULTS OF ESTIMATING RISK FACTOR MODELS

In this section, the results of estimating the risk factor models defined in the previous section on the simulated convertible bond arbitrage portfolio are presented. Out-of-sample comparison results are also presented from estimating the risk factor models on two indices of convertible bond arbitrage hedge fund returns.

Insert Table 3 about here

Table 3 presents results of the OLS estimation of the risk factor models discussed above on *CBRF*, the simulated convertible bond arbitrage portfolio excess returns, from January 1990 to December 2002. The error term of the return regression is potentially heteroskedastic and autocorrelated. Although the conditional heteroskedasticity and autocorrelation are not formally treated in the OLS estimate of the parameter, the t-stats in parenthesis below the parameter estimates are heteroskedasticity and autocorrelation consistent due to Newey and West (1987).[22] Jacque Bera test statistic from the test of residual normality and Ljung and Box (1978) Q-Statistics, testing the joint hypothesis that the first ten lagged autocorrelations of the residual are all equal to zero, are reported.

The first result (I) is from estimating the market model. The market coefficient value of 0.20 is significantly positive indicating that there is a positive relationship between convertible bond arbitrage returns and the market portfolio. This is a finding consistent with Capocci and Hübner (2004) who estimate a significantly positive market coefficient for convertible bond arbitrage hedge funds of 0.06.[23] However the low adjusted R^2 indicates that this one factor model may not fully capture the risk in convertible bond arbitrage. The second result (II) is from estimation of the Fama and French (1993) three factor stock model. The factor loadings on all three factors are significantly positive, consistent with Capocci and Hübner's (2004) findings for convertible bond arbitrage. It should be highlighted that the *SMB* coefficient indicates that

[22] For all the time-series analysis in this chapter, adjusting the autocorrelation beyond a lag of 3 periods does not yield any material differences. A t-stat based on 3 lags is adopted for regressions.
[23] However, our finding of a significant positive market coefficient is not consistent with Chan et al. (2006) and Agarwal and Naik (2004).

convertible bond arbitrageurs appear to favour issues from smaller companies perhaps due to the greater arbitrage opportunities. The next result (III) is from estimating the Carhart (1997) four factor model. The momentum factor adds little explanatory value to the regression and both the Ecko and Norli (2005) *TO* factor (IV) and Pastor and Stambaugh (2003) *LIQ* factor (V) add no explanatory power to the estimated model.

Model VI is from estimation of the Fama and French (1993) bond factor model. The coefficients on both factors, *DEF* and *TERM*, are highly significant, with coefficient weightings greater than 0.20 and the overall explanatory power of the regression improves with an adjusted R^2 of 37.1%. The results indicate that convertible bond arbitrageurs have significant term structure and credit risk. With the improvement in model fit the estimated alpha coefficient has reduced to 0.07% per month. The result for Model VII is from estimating the combined Fama and French's (1993) bond and stock factor models. The coefficients for *RMRF*, *SMB* and *HML* are all significantly different from zero although the inclusion of these factors adds little to the explanatory power of the model. Finally, Models VIII and IX are from estimating the risk factor models incorporating the Agarwal and Naik (2004) option based risk factor. For the simulated series this factor is not significantly different from zero and provides no increase in explanatory power.

Consistent with the evidence presented by Brooks and Kat (2001) of serial correlation in convertible bond arbitrage returns the Q-Stats are significant at the 1% level indicating that the residuals of the estimated regressions presented in Table 3 exhibit serial correlation.

Insert Tables 4 and 5 about here

For comparison, Tables 4 and 5 report results from the same series of regressions, only this time applied to the HFRI Convertible Bond Arbitrage Index from January 1990 to December 2002 and the CSFB Tremont Convertible Bond Arbitrage Index from January 1994 to December 2002. Results are strikingly similar to the simulated portfolio but the explanatory power of the regressions is lower. Again the major risks faced by the arbitrageur are default risk, term structure risk and the risk from investing in the issues of small companies. In Table 4 *SPPA*, the at the money put option factor, is significant in Model VIII with a similar coefficient reported for the HFRI index in Agarwal and Naik's (2004) study. However, when *DEF* and *TERM* are also specified in Model IX the coefficient is no longer significant. The residuals of all estimated regressions exhibit autocorrelation and the Q-Stats are higher than those reported for the simulated portfolio residuals.

The results reveal that of the factors specified, default and term structure risk factors are the most significant in convertible bond arbitrage returns. This result is robust for the simulated convertible bond arbitrage portfolio and two indices of convertible bond arbitrage hedge fund returns, providing further evidence that the simulated convertible bond arbitrage portfolio captures the key risk characteristics of the convertible bond arbitrage strategy. The results also indicate that the simulated portfolio shares more characteristics with the HFRI index than the CSFB Tremont index. We attribute this to the similar construction of the HFRI index and the simulated portfolio, which are both equally weighted.

Next, to provide an additional robustness check of the simulated portfolio's convertible bond arbitrage characteristics we follow Boyson, Stahel and Stulz (2006) and Li and Kazemi (2007) and examine hedge fund strategy characteristics using higher frequency daily data.[24] Due to limited high frequency risk factor data we limit our analysis of the daily simulated portfolio data generating process and two hedge fund indices using the Fama and French (1993) bond market model.

$$y_t = \alpha + \beta_{RMRFD} RMRFD_t + \beta_{DEFD} DEFD_t + \beta_{TERMD} TERMD_t + \varepsilon_t \qquad (14)$$

where $RMRFD_t$ is the daily excess return on the market portfolio on day t, $DEFD_t$ is the difference between the overall daily return on a market portfolio of long-term corporate bonds[25] minus the long term government bond daily return[26] at day t. $TERMD_t$ is the factor proxy for unexpected changes in interest rates. It is constructed as the difference between daily long term government bond return and the short term government bond daily return at day t.[27] To correct for the potential downward bias in beta estimation when using daily convertible bond data two lags of the daily return on each of the risk factors are specified in addition to the contemporaneous return when estimating (14). This downward bias is caused by non-synchronous trading between the illiquid convertible bonds and the more liquid asset class factors.[28]

---

[24] We thank an anonymous referee for encouraging us to explore this robustness check.

[25] The return on the DataStream Index of high yield corporate bonds is specified rather than the return on the composite portfolio from Ibbotson and Associates used by Fama and French (1993) due to its unavailability.

[26] The return on the DataStream Index of long term government bonds is specified rather than the return on the monthly long term government bond return from Ibbotson and Associates used by Fama and French (1993) due to its unavailability.

[27] The return on the DataStream Index of short term government bonds is specified rather than the one month treasury bill rate used by Fama and French (1993).

[28] Scholes and Williams (1977) and Dimson (1979) amongst others show that betas of securities that trade less (more) frequently than the index used as the market proxy are downward (upward) biased.

There are currently two vendors reporting daily convertible bond arbitrage hedge fund index returns, HFR calculate the HFRX indices and Dow Jones calculate the Dow Jones Hedge Fund Indexes. At September 2007 the Dow Jones convertible bond arbitrage index contains six constituents. HFR do not report the number of constituents in the HFRX convertible bond arbitrage index but report a total of 60 funds in the HFRX Global Hedge Fund Index, which represent an aggregate of the individual strategy indices. The HFRIX series begins on the 31st March 2003 and the DJ series begins on the 1st January 2004. Data is collected for both series to 21st August 2007.[29] The simulated portfolio runs from 1st January 1990 to 31st December 2002.

Table 6 displays descriptive statistics of the three daily convertible arbitrage series in Panel A and the explanatory factors in Panel B. *HFRXCA* is the HFR daily convertible arbitrage index, *DJCA* is the Dow Jones daily convertible arbitrage index and *SIMCB* is the simulated convertible arbitrage portfolio. The mean raw returns of both *HFRXCA* (1% per annum) and *DJCA* (2.1% per annum) are not significant from zero. Both exhibit negative skewness and positive kurtosis.

Insert Tables 6 and 7 about here

Table 7 presents results from estimating (14) for the two daily hedge fund indices and the simulated convertible bond arbitrage portfolio. The two hedge fund indices and the simulated portfolio all exhibit significantly positive coefficients on the default and term structure risk factors. Only the simulated portfolio exhibits a significant coefficient on the market factor. However, we are cautious in interpreting these regression estimates. As each of the regressions cover different sample periods, we present these results simply to illustrate the robustness of our earlier findings: first, that the simulated portfolio shares the characteristics of the convertible bond arbitrage strategy; and second, that default and term structure risk factors are significant in the convertible bond arbitrage data generating process.

In the next section we present a statistical model, incorporating the results from this section of the paper, which allows for illiquidity in convertible bond arbitrage hedge fund returns.

[29] Unfortunately, data is unavailable for the daily hedge fund indices for a sample period overlapping the simulated portfolio sample.

5. PERFORMANCE MEASUREMENT MODELS

By specifying risk factors with returns which capture the data generating process of the convertible bond arbitrage strategy, we are able to evaluate the performance of the hedge fund indices and individual convertible bond arbitrage hedge funds relative to this portfolio. In this section the convertible bond arbitrage performance model, which specifies the excess returns of the simulated portfolio (*CBRF*) and default (*DEF*) and term (*TERM*) structure risk factors is defined. As *CBRF* does not include non-traditional convertible bonds, *DEF* and *TERM* are specified to capture the risk from investing in the convertible securities not included in *CBRF*. We estimate a risk factor model, incorporating lags of the risk factors, following Asness, et al. (2001) and Getmansky et al. (2004) who demonstrate empirically that omitting lagged market observations can lead to downward biased estimates of market risk.

Getmansky et al. (2004) define a statistical model demonstrating how a linear factor model specification incorporating contemporaneous and lagged observations of risk factors can lead to consistent risk factor coefficient estimates. Assuming the true economic return satisfies the following factor model.

$$R_t = \mu + \gamma F_t + \varepsilon_t,\ E[F_t] = E[\varepsilon_t] = 0,\ \varepsilon_t, F_t, \sim \text{IID},\ \text{Var}(R_t) \equiv \sigma_t \tag{15}$$

where R_t is the true return of a hedge fund in period t, F_t is a set of common factors and ε_t is the error term. True returns represent the change in the economic value of the fund's securities in a frictionless market. However, true returns are not reported. Instead R^0_t denotes the reported return in period t and let

$$R^0_t = \theta_0 R_t + \theta_1 R_{t-1} + \ldots + \theta_k R_{t-k} \tag{16}$$

Substituting (15) into (16) reported returns can be expressed as

$$R^0_t = \mu + \gamma(\theta_0 F_t + \theta_1 F_{t-1} + \ldots + \theta_k F_{t-k}) + \upsilon_t \tag{17}$$

where

$$\upsilon_t = \theta_0 \varepsilon_t + \theta_1 \varepsilon_{t-1} + \ldots + \theta_k \varepsilon_{t-k} \tag{18}$$

which is the weighted average of the fund's true returns over the most recent $k + 1$ periods, including the current period. If we estimate the following linear regression of reported returns on contemporaneous and lagged risk factor returns the beta estimates will be consistent.

$$R^0_t = \mu + \beta_0 F_t + \beta_1 F_{t-1} + \ldots + \beta_k F_{t-k} + \upsilon_t \tag{19}$$

Given

$$1 = \theta_0 + \theta_1 + \ldots + \theta_k \tag{20}$$

We can obtain an estimator for β:

$$\hat{\beta} = \hat{\beta}_0 + \hat{\beta}_1 + \ldots + \hat{\beta}_k \tag{21}$$

Although, the expected factor returns in (15) are zero, if over a sample period $F_t > 0$ ($F_t < 0$), omitting lags of the risk factors, F_{t-n}, which are positively related to R^0_t will lead to downward (upward) biased estimates of β and a consequent upward (downward) bias in μ, the estimated skill of the fund. Asness et al. (2001) demonstrate this empirically using the market model and a sample of hedge fund index returns. When the estimated summed beta coefficients are more positive, relative to contemporaneous betas, and the mean market risk factor is also positive, the estimated intercept is lower than for a model where the lagged risk factors are omitted.

In this paper convertible bond arbitrage returns are assumed to be linearly related to the returns on a set of asset class factors described as:

$$y_t = \alpha + \beta_{CBRF}'\,CBRF + \beta_{DEF}'\,DEF + \beta_{TERM}'\,TERM + \varepsilon_t \tag{22}$$

where y_t is the excess return on the hedge fund, $DEF = (DEF_t, DEF_{t-1}, DEF_{t-2})$, $TERM = (TERM_t, TERM_{t-1}, TERM_{t-2})$ and $CBRF = (CBRF_t, CBRF_{t-1}$ and $CBRF_{t-2})$. The β coefficient is the sum of the contemporaneous β and lagged β s.

Results from estimation of (22) for the HFRI and CSFB Tremont hedge fund indices and individual convertible bond arbitrage funds from the HFR and TASS databases are presented in the following section.

6. CONVERTIBLE BOND ARBITRAGE FUND PERFORMANCE

In this section of the paper we present results from estimating the convertible bond arbitrage performance measurement model (22). We initially estimate the performance of the two hedge fund indices before examining the performance of the individual funds.

Insert Table 8 about here

Table 8 presents the results from OLS estimation of the two performance measurement models for the HFRI (Panel A) and CSFB Tremont (Panel B) convertible bond arbitrage hedge fund indices. The first estimated model presented in Panel A displays is the summed coefficients from estimating (22) for the HFRI index (with corresponding *T*-Stats from the t-tests that $\alpha = 0$ and $\beta_{it} + \beta_{it-1} + \beta_{it-2} = 0$).[30] The coefficients on *CBRF*, *DEF* and *TERM* are all significant from zero at the 1% level. The intercept is significant from zero at the 1% level indicating abnormal performance of 32 basis points per month. The second estimated model presented in Panel A exhibits the un-summed coefficients from estimating (22) for the HFRI index (with corresponding *T*-Stats from the t-tests that $\alpha = 0$, $\beta_{it} = 0$ for i = *CBRF*, *DEF* and *TERM* in row 2). With the exception of the coefficient on $CBRF_{t-2}$ all β coefficients are significant from zero, with the expected sign.

The results for the CSFB Tremont index are displayed in Panel B. Results from estimating (22) with summed and un-summed coefficients are presented (with corresponding *T*-Stats). Consistent with the HFRI index the summed β coefficients are significant from zero with the anticipated sign, but for the CSFB Tremont index the estimated α is not significant different from zero at acceptable statistical levels. This finding of no abnormal performance is consistent with Chan et al. (2006). Examining the un-summed coefficients from estimating (22) for the CSFB Tremont index, with the exception of the coefficient on $CBRF_t$ and $CBRF_{t-2}$ all β coefficients are significant from zero, with the expected sign.

Results from estimating these models, for both the HFRI and CSFB Tremont index, find mixed evidence of abnormal performance by convertible bond arbitrageurs. For the equal weighted HFRI index we find evidence of significant skill (alpha) while for the CSFB Tremont index the skill term is insignificant from zero. Our model (22) demonstrates an increase in efficiency relative to the estimated models reported in Tables 4 and 5. The explanatory power of all estimated regressions is higher than the risk factor specifications, estimated in Table 4 and 5, and the Jacque and Bera statistics indicate that the estimated residuals exhibit less non-normality than the models presented in Table 4 and 5.

Next we estimate the risk and performance of individual convertible bond arbitrage hedge funds. The individual fund data was sourced from the HFR and TASS databases. The original

[30] Test statistics are autocorrelation and heteroskedasticity consistent due to Newey and West (1987).

HFR database consisted of 105 funds and the TASS database consisted of 218 funds. However, many funds have more than one series in the database, due to a dual domicile or a fund reporting in two currencies. Several funds report to both HFR and TASS databases. To ensure that no fund was included twice, the cross correlations between the individual funds returns were estimated. If two funds had high correlation coefficients then the details of the funds were examined in detail. Finally, in order to have adequate data to run the factor model tests, any fund that does not have 24 consecutive monthly returns between 1990 and 2002 is excluded. The final sample consisted of one hundred and ten hedge funds. Of these one hundred and ten funds, sixty six were still alive at the end of December 2002 and forty four were dead.

Insert Table 9 about here

Descriptive statistics on each hedge fund are reported in Table 9. The mean number of observations is sixty two months up to a maximum of one hundred and fifty. The mean monthly return is 0.58% and the higher returning fund generated a mean return of 3.17%. The mean skewness is -0.40 and the mean kurtosis is 5.45. The Ljung and Box (1978) Q-Statistic tests the joint hypothesis that the autocorrelations of up to an order of ten are all equal to zero. The results reject this hypothesis for eighty nine of the hedge funds.

Insert Table10 about here

Table 10 presents results from estimating the risk factor model (22) for individual convertible bond arbitrage hedge funds. The mean explanatory power from estimating the model for the one hundred and ten hedge funds of the model is 21% (adjusted R^2).[31] The estimated fund coefficients for *DEF*, *TERM* and *CBRF* are significantly different from zero for forty-nine, forty-eight and thirty-four hedge funds, respectively. The mean estimated fund coefficient for *DEF* is 0.37, compared to a range of 0.26 to 0.43 for the convertible bond arbitrage indices. The mean estimated fund coefficient of *TERM* is 0.34, compared to a range of 0.31 to 0.55 for the convertible bond arbitrage indices, and the mean estimated fund coefficient for *CBRF* is 0.33, compared to a range of 0.19 to 0.20 for the convertible bond arbitrage indices. The estimated alphas are significantly positive for fifty-one hedge funds and significantly negative for seven

---

[31] With several lags of the risk factors specified the model is likely to be over-parameterized for some funds leading to lower adjusted R^2s.

hedge funds. Furthermore, the mean estimated fund alpha, for the one hundred and ten hedge funds, is a statistically significant 0.28% per month.[32]

There are several results in Table 10 which illustrate the divergent strategies followed by hedge funds which are classified as following the convertible bond arbitrage strategy. Nineteen of the estimated regressions for individual funds (Funds 8, 11, 12, 15, 42, 43, 45, 46, 51, 70, 74, 76, 78, 79, 81, 82, 84, 87 and 93) have negative adjusted R^2. Omitting these funds from the sample leads to an overall increase in mean explanatory power (adjusted R^2 25%) and a corresponding increase in the mean estimated fund coefficients of *DEF* (0.44), *TERM* (0.40) and *CBRF* (0.39).

Several of the funds also exhibit negative estimated coefficients on the *DEF* (Fund 13 and 17), *TERM* (Fund 4, 17, 29, 31 and 108) or *CBRF* (Fund 29, 77, 78, 98 and 100) risk factors though at least one of the estimated coefficients is positive for each of the funds.

The results reported here for both hedge fund indices and the individual funds are similar, demonstrating the robustness of our performance measurement models. The estimated coefficients on *CBRF*, *DEF* and *TERM* are all statistically significant, positive and of similar magnitude. We find evidence of convertible bond arbitrage abnormal performance. The HFRI index and the individual funds exhibit abnormal performance of approximately 30 basis points per month. When the performance model is specified for the CSFB Tremont index we find no evidence of abnormal risk adjusted performance.

These finding are important for investors in hedge funds generally and the convertible bond arbitrage strategy, in particular. Despite controlling for various alternate factor specifications and the potential bias in risk factor and performance estimation, from illiquidity in the securities held by funds, we find positive evidence on the value added by convertible bond arbitrage hedge fund managers.

On an aggregate basis we document abnormal performance in the equally weighted index of convertible arbitrage hedge funds and the average performance of individual funds. However, an investor in hedge funds must be wary. We find no evidence of out performance in the value weighted CSFB Tremont index and there is considerable cross-sectional variance within the sample of individual fund performance estimates. Though, almost half of the sample (fifty one funds) exhibit abnormal performance, seven of the fund managers exhibit negative performance and the remaining fifty two funds add no value to a passive investment in the risk factors. For our sample period the odds of investing with a hedge fund manager who exhibits skill were slightly worse than fifty/fifty.

[32] All of the coefficients are significant at the 1% level.

6. CONCLUSION

In this paper we generated a simple convertible bond arbitrage portfolio to identify sources of convertible bond arbitrage risk. This portfolio shares the risk characteristics of convertible bond arbitrage benchmark indices but contains none of the biases. Evidence from estimating risk factor models on this portfolio and the hedge fund indices, at monthly and daily frequencies, finds support for the simulated portfolio capturing the key characteristics in the return generating process of convertible bond arbitrage. Since the simulated portfolio shares the risk profile of convertible bond arbitrage, it serves as a useful benchmark of hedge fund performance. The returns on the simulated portfolio also exhibit negative skewness and excess kurtosis, sharing the statistical characteristics of convertible bond arbitrage hedge funds..

Evidence from examining the equally weighted HFRI and value weighted CSFB Tremont hedge fund indices and individual hedge funds from the HFR and TASS databases finds support for the default risk factor, term structure risk factor and the excess return on the simulated portfolio being significant factors in convertible bond arbitrage hedge fund returns, particularly if both lagged and contemporaneous observations of the risk factors are specified. This is a result which supports Asness et al. (2001) and Getmansky et al. (2004), that to efficiently estimate the risks faced by hedge funds a model which includes lags of the explanatory variables should be specified.

In aggregate we present positive news for investors in hedge funds. When a non-synchronous model of hedge fund performance is estimated results indicate that the average convertible bond arbitrage hedge fund generates a statistically significant alpha of 0.28% per month, or 3.4% per annum. Slightly fewer than half of funds exhibit skill while the remainder fail to out-perform (or in seven cases significantly under-perform) a passive investment in the risk factors. When this model is specified for the hedge fund indices we find mixed evidence of abnormal performance. For the HFRI equally weighted index the estimate of abnormal performance from this model is 30 basis points per month, whereas for the CSFB Tremont index our estimate of abnormal performance is insignificant from zero.

However, these results must be considered in the context of the previously documented biases in the hedge fund databases[33]. This suggests that convertible bond arbitrage hedge funds may have generated only modest abnormal (risk-adjusted) returns over the sample period.

---

[33] For example Liang (2000) examines HFR and TASS databases documenting survivor bias of 2% per annum.

References

Ackermann, C., R. McEnally and D. Ravenscraft (1999), 'The Performance of Hedge Funds: Risk, Return and Incentives', *Journal of Finance*, Vol.54, No. 3 (June), pp. 833-874.

Agarwal, V. and N.Y. Naik (2004), 'Risks and Portfolio Decisions Involving Hedge Funds', *Review of Financial Studies*, Vol.17, No.1 (Spring), pp. 63-98.

Agarwal, V., W. Fung, Y.C. Loon and N.Y. Naik (2007), 'Liquidity Provision in the Convertible Bond Market: Analysis of Convertible Arbitrage Hedge Funds'. Working Paper, Available at SSRN: http://ssrn.com/abstract=885945

Ammann, M., A. Kind and C. Wilde (2004), 'Are Convertible Bonds Underpriced? An Analysis of the French Market', *Journal of Banking and Finance*, Vol.27, No.4 (April), pp. 635-653.

Aragon, G.O. (2006), Share Restrictions and Asset Pricing: Evidence from the Hedge Fund Industry", *Journal of Financial Economics,* Forthcoming.

Asquith P. and D.W. Mullins (1991) 'Convertible Debt: Corporate Call Policy and Voluntary Conversion', *Journal of Finance*, Vol.46, No.4 (Sep), pp. 1273-1289.

Asness, C., R. Krail and J. Liew (2001), 'Do Hedge Funds Hedge?', Journal of Portfolio Management, Vol.28, No.1 (Fall), pp. 6-19.

Bauer, R., K. Koedijk and R. Otten (2005), 'International Evidence on Ethical Mutual Fund Performance and Investment Style', *Journal of Banking and Finance*, Vol.29, No.7 (July), pp. 1751-1767.

Bollerslev, T. (1986), 'Generalised Autoregressive Heteroskedasticity', *Journal of Econometrics* Vol.31, No.3 (April), pp.307-327.

Boyson, N.M., Stahel, C.W. and Stulz, R.M. (2006), 'Is There Hedge Fund Contagion?', NBER Working Paper No. W12090, Available at SSRN: http://ssrn.com/abstract=888292.

Brennan, M.J. and A. Subrahmanyam (1996), 'Market Microstructure and Asset Pricing: On the Compensation for Illiquidity in Stock Returns', *Journal of Financial Economics*, Vol.41, No.3 (July), pp. 441-464.

Brennan, M.J., T. Chordia and A. Subrahmanyam (1998), 'Alternative Factor Specifications, Security Characteristics and the Cross-Section of Expected Returns', *Journal of Financial Economics*, Vol.49, No.3 (September), pp. 345-374.

Brooks, C. and H.M. Kat (2001), 'The Statistical Properties of Hedge Fund Index Returns and their Implications for Investors', Working paper (CASS Business School).

Brown, S.J., W. Goetzmann and R.G. Ibbotson (1999), 'Offshore Hedge Funds: Survival and Performance 1989-95', *Journal of Business*, Vol.72, No.1 (January), pp. 91-117.

Calamos, N. (2003), 'Convertible Arbitrage: Insights and Techniques for Successful Hedging', (New Jersey: John Wiley and Sons).

Capocci, D. and G. Hübner (2004), 'Analysis of Hedge Fund Performance' *Journal of Empirical Finance* Vol.11, No.1 (January), pp. 55-89.

Carhart, M.M. (1997), 'On Persistence in Mutual Fund Performance', *Journal of* Finance, Vol.52, No.1 (March), pp. 56-82.

Chan, N., M. Getmansky, S.M. Haas and A.W. Lo (2006) 'Systemic Risk and Hedge Funds', NBER book, "The Risks of Financial Institutions," edited by Mark Carey and Rene Stulz, University of Chicago Press.

Chen, N-F., R. Roll and S. Ross (1986), 'Economic Forces and the Stock Market', *Journal of Business*, Vol.59, No.3 (July), pp. 383-403.

Cochrane, D. and G.H. Orcutt (1949), 'Application of Least Squares Regression to Relationships Containing Autocorrelated Error Terms', *Journal of American Statistical Association*, Vol.44, No.245 (March), pp. 32-61.

Davies, J.L. (2001), 'Mutual Fund Performance and Management Style', *Financial Analysts Journal*, Vol.57, No.1 (January/February), pp. 19-27.

Dimson, E. (1979), 'Risk Measurement when Shares are Subject to Infrequent Trading', *Journal of Financial Economics*, Vol.7, No.2 (June), pp. 197-226.

Eckbo, B. and Ø. Norli (2005), 'Liquidity Risk, Leverage and Long-Run IPO returns', *Journal of Corporate Finance*, Vol.11, No.1-2 (March), pp. 1-35.

Fama E.F. and K.R. French. (1992), 'The Cross-Section of Expected Stock Returns', *Journal of Finance*, Vol.47, No.2 (June), pp. 427-465

------ ------ (1993), 'Common Risk Factors in the Returns on Stocks and Bonds', *Journal of Financial Economics*, Vol.33, No.1 (February), pp. 3-56

Fung, W. and D.A. Hsieh (1997), 'Empirical Characteristics of Dynamic Trading Strategies: the Case of Hedge Funds', *Review of Financial Studies*, Vol.10, No.2 (Summer), pp. 275–302.

------ ------ (2000), 'Performance Characteristics of Hedge Funds: Natural vs. Spurious Biases', *Journal of Financial and Quantitative* Analysis, Vol.35, No.3 (September), pp. 291–307.

------ ------ (2001), 'The Risk in Hedge Fund Trading Strategies: Theory and Evidence from Trend Followers', *Review of Financial Studies*, Vol.14, No.2 (Summer), pp. 313–341.

------ ------ (2002), 'Hedge Fund Benchmarks: Information Content and Biases', *Financial Analysts Journal*, Vol.58, No.1 (January/February), pp. 22 – 34.

Getmansky M., A.W. Lo and I. Makarov (2004), 'An Econometric Model of Serial Correlation and Illiquidity in Hedge Fund Returns', *Journal of Financial Economics*, Vol.74, No.3 (December), pp. 529-609.

Ineichen, A. (2000) *In Search of Alpha* (United Kingdom: UBS Warburg Research Publication).

Kang, J.K. and Y.W Lee (1996), ‘The Pricing of Convertible Debt Offerings’, *Journal of Financial Economics*, Vol.41, No.2 (June), pp.231-248.

Kat, H.M. and S. Lu (2002), ‘An Excursion into the Statistical Properties of Hedge Funds’, Working Paper (CASS Business School).

Khan, S.A. (2002), ‘A Perspective on Convertible Arbitrage’, *Journal of Wealth Management*, Vol.5, No.2 (Fall), pp. 59–65.

King, R. (1986), ‘Convertible Bond Valuation: an Empirical Test’, *Journal of Financial Research* Vol.9, No.1 (March), pp. 53-69.

Li Y. and H. Kazemi (2007), ‘Conditional Properties of Hedge Funds: Evidence from Daily Returns’, *European Financial Management*, Vol.13, No.2 (March), pp. 211–238.

Liang B. (2000), ‘Hedge Funds: the Living and the Dead’, *Journal of Financial and Quantitative Analysis*, Vol.35, No.3 (September), pp. 72-85.

Lintner J. (1965), ‘The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolio and Capital Budgets’, *Review of Economics and Statistics* Vol.47, No.1 (February), pp. 13-37.

Ljung G. and G. Box (1978), ‘On a Measure of Lack of Fit in Time Series Models’, *Biometrika*, Vol.67, No.2 (August), pp. 297-303.

Mitchell, M. and T. Pulvino, (2001), ‘Characteristics of Risk and Return in Risk Arbitrage’, *Journal of Finance,* Vol.56, No.6 (December), pp. 2135-2175.

Newey W.K. and K.D. West (1987), ‘A Simple, Positive Semi-definite Heteroskedasticity and Autocorrelation Consistent Covariance Matrix’, *Econometrica*, Vol.55, No.3 (May), pp. 707-708.

Pastor, Ĺ. and R.F. Stambaugh (2003), ‘Liquidity Risk And Expected Stock Returns’, *Journal of Political Economy*, Vol.111, No.3 (June), pp. 642-685.

Poon, S.-H. and C. Granger (2003), ‘Forecasting Volatility in Financial Markets: a Review’, *Journal of Economic Literature*, Vol.41, No.2 (June), pp. 478-539.

Scholes, M. and J.T. Williams (1977), ‘Estimating Betas from Nonsynchonous Data’, *Journal of Financial Economics*, Vol.5, No.3 (December), pp. 309-327.

Sharpe W.F. (1964), ‘Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk’, *Journal of Finance*, Vol.19, No.3 (September), pp. 425-442.

Wermers, R. (2000), ‘Fund Performance: An Empirical Decomposition into Stock-Picking Talent, Style, Transactions Costs, and Expenses’, *Journal of Finance*, Vol.55, No.4 (August), pp. 1655-1695.

Table 1

Summary Statistics

Panel A: Dependent Variables

	Mean	*Variance*	*Skew*	*Kurtosis*	*Jacque-Bera*
HFRIRF	0.55***	0.98	-1.37	3.12	112.32***
CSFBRF	0.45***	1.92	-1.69	4.34	136.07***
CBRF	0.33***	3.10	-1.36	9.00	573.96***

Panel B: Explanatory Returns

	Mean	*Variance*	*Skew*	*Kurtosis*	*Jacque-Bera*
RMRF	0.49	20.39	-0.61	0.57	11.66***
SMB	0.15	12.72	0.45	1.72	24.49***
HML	0.10	18.03	-0.64	5.58	212.9***
DEF	0.54***	9.39	-0.38	2.59	47.2***
TERM	0.11**	5.82	-0.36	0.22	3.65
UMD	1.14***	25.93	-0.71	5.46	207.33***
TO	-0.11***	7.40	0.61	1.12	17.85***
LIQ	0.39***	39.19	-0.51	5.15	178.83***
SPCA	-2.78	6,955.89	0.82	-0.15	17.69***
SPCO	-4.50	8,474.62	1.11	0.70	35.1***
SPPA	-15.36	8,075.06	1.76	3.31	151.46***
SPPO	-19.17	8,385.30	1.97	4.29	220.38***

Notes:

***, ** and * indicate significance at the 1%, 5% and 10% level respectively.

Statistics are generated using RATS 5.0

RMRF is the excess return on Fama and French's (1993) market proxy, *SMB* and *HML* are Fama and French's factor-mimicking portfolios of size and market to book equity. *UMD* is the Carhart (1997) factor mimicking portfolio for one-year momentum. *TERM* and *DEF* are Fama and French's proxies for the deviation of long-term bond returns from expected returns due to shifts in interest rates and shifts in economic conditions that change the likelihood of default. *TO* and LIQ are Eckbo and Norli (2005) and Pastor and Stambaugh (2002) liquidity factors. *SPCA, SPCO, SPPA* and *SPPO* are Agarwal and Naik (2004) at the money call, out of the money call, at the money put and out of the money put option based risk factors respectively. *CSFBRF* is the excess return on the CSFB Tremont Convertible Bond Arbitrage index, *HFRIRF* is the excess return on the HFRI Convertible Bond Arbitrage index and *CBRF* is the excess return on the simulated convertible bond arbitrage portfolio. All of the variables are monthly from January 1990 to December 2002 except the CSFB Tremont Convertible Bond Arbitrage Index which is from January 1994 to December 2002.

Table 2

Cross correlations, January 1990 to December 2002

Panel A: Explanatory Variables

	RMRF	*SMB*	*HML*	*DEF*	*TERM*	*UMD*	*TO*	*LIQ*	*SPCA*	*SPCO*	*SPPA*	*SPPO*
RMRF	1.00											
SMB	0.19	1.00										
HML	-0.34	-0.37	1.00									
DEF	0.35	0.36	0.06	1.00								
TERM	0.09	-0.16	-0.06	-0.68	1.00							
UMD	-0.17	0.01	-0.56	-0.41	0.28	1.00						
TO	-0.80	-0.47	0.30	-0.41	0.05	0.22	1.00					
LIQ	0.16	-0.03	0.06	0.11	-0.06	-0.14	-0.15	1.00				
SPCA	0.81	-0.05	-0.21	0.12	0.23	-0.17	-0.57	0.12	1.00			
SPCO	0.77	-0.06	-0.20	0.11	0.24	-0.17	-0.55	0.09	0.97	1.00		
SPPA	-0.89	-0.12	0.22	-0.28	-0.17	0.19	0.69	-0.19	-0.70	-0.66	1.00	
SPPO	-0.85	-0.12	0.20	-0.27	-0.18	0.17	0.66	-0.19	-0.65	-0.61	0.99	1.00

Panel B: Dependent Variables and Explanatory Variables

	RMRF	*SMB*	*HML*	*DEF*	*TERM*	*UMD*	*TO*	*LIQ*	*SPCA*	*SPCO*	*SPPA*	*SPPO*	*HFRIRF*	*CSFBRF*
HFRIRF	0.35	0.30	-0.10	0.28	0.09	-0.06	-0.46	0.16	0.29	0.29	-0.37	-0.36	1.00	
CSFBRF	0.15	0.22	0.02	0.23	0.05	-0.05	-0.25	0.07	0.12	0.11	-0.18	-0.17	0.80	1.00
CBRF	0.50	0.30	-0.03	0.39	0.01	-0.21	-0.51	0.15	0.48	0.50	-0.47	-0.46	0.48	0.32

Notes:

With the exception of the *CSFBRF* correlations, coefficients greater than 0.25, 0.19 and 0.17 are significant at the 1%, 5% and 10% levels respectively. *CSFBRF* correlation coefficients greater than 0.22, 0.17 and 0.14 are significant at the 1%, 5% and 10% levels respectively. All of the correlations cover the period January 1990 to December 2002 except for correlations with the CSFB Tremont Convertible Bond Arbitrage Index which cover the period January 1994 to December 2002.

Table 3

Regressions on the simulated convertible bond arbitrage portfolio excess returns

Model	α	β_{RMRF}	β_{SMB}	β_{HML}	β_{UMD}	β_{TO}	β_{LIQ}	β_{SPPA}	β_{DEF}	β_{TERM}	*JB-Stat*	*Q-Stat*	*Adj.* R^2
I	0.2268	0.2028									52.06***	494.9***	27%
	(1.54)	(5.07)***											
II	0.1906	0.2186	0.1216	0.1050							55.77***	593.53***	33%
	(1.40)	(5.21)***	(3.50)***	(4.84)***									
III	0.0974	0.2464	0.1397	0.1627	0.0624						52.65***	419.48***	35%
	(0.57)	(4.86)***	(3.95)***	(3.28)***	(1.48)								
IV	0.0976	0.2458	0.1393	0.1626	0.0624	-0.0015					52.65***	419.84***	34%
	(0.56)	(3.82)***	(3.32)***	(3.27)***	(1.49)	(-0.02)							
V	0.1034	0.2502	0.1386	0.1640	0.0609		-0.0154				48.35***	417.33***	35%
	(0.61)	(4.84)***	(4.02)***	(3.29)***	(1.44)		(-1.10)						
VI	0.0738	0.1174							0.2848	0.3656	50.99***	404.3***	37%
	(0.52)	(3.64)***							(4.10)***	(3.79)***			
VII	0.0934	0.1528	0.1009	0.0758					0.1868	0.3070	49.13***	428.48***	40%
	(0.71)	(4.48)***	(2.92)***	(3.60)***					(3.18)***	(3.59)***			
VIII	0.1686	0.1258	0.1244	0.0959				-0.4923			54.25***	373.89***	34%
	(1.19)	(1.70)*	(3.53)***	(4.94)***				(-1.13)					
IX	0.0851	0.1036	0.1026	0.0716				-0.2749	0.1802	0.2920	49.41***	329.59***	40%
	(0.63)	(1.55)	(2.95)***	(3.68)***				(-0.72)	(3.05)***	(3.79)***			

Notes:

Results from regressions on simulated convertible bond arbitrage portfolio returns in excess of the risk free rate of interest. JB-Stat is the Jacque Bera test statistic from the test of residual normality and Q-Stat is the Ljung –Box test statistic from the joint test for autocorrelation in the first ten lags of the residual. t-statistics in parenthesis are heteroskedasticity and autocorrelation-consistent, due to Newey and West (1987). ***, ** and * indicate significance at the 1%, 5% and 10% level respectively.

Table 4
Regressions on the HFRI Convertible Bond Arbitrage Index excess returns January 1990 to December 2002

Model	α	β_{RMRF}	β_{SMB}	β_{HML}	β_{UMD}	β_{TO}	β_{LIQ}	β_{SPPA}	β_{DEF}	β_{TERM}	*JB-Stat*	*Q-Stat*	*Adj.* R^2
I	0.5099	0.0764									79.48***	60.85***	12%
	(4.72)***	(4.02)***											
II	0.4948	0.0751	0.0824	0.0338							92.98***	62***	18%
	(4.83)***	(4.13)***	(4.07)***	(2.30)**									
III	0.4339	0.0933	0.0942	0.0715	0.0408						86.17***	60.87***	20%
	(3.80)***	(4.92)***	(4.22)***	(3.10)***	(2.15)**								
IV	0.4406	0.0608	0.0748	0.0705	0.0444	-0.0740					91.51***	66.37***	21%
	(3.85)***	(2.07)**	(3.02)***	(3.03)***	(2.38)**	(-1.56)							
V	0.4308	0.0914	0.0948	0.0708	0.0415		0.0079				86.92***	57.05***	20%
	(3.73)***	(5.14)***	(4.16)***	(3.08)***	(2.14)**		(0.58)						
VI	0.4044	0.0175							0.2022	0.2240	78.08***	40.94***	26%
	(3.64)***	(1.17)							(3.85)***	(4.10)***			
VII	0.4126	0.0178	0.0521	0.0024					0.1741	0.2126	87.82***	45.08***	28%
	(3.87)***	(0.96)	(2.67)***	(0.12)					(3.09)***	(3.67)***			
VIII	0.4781	0.0045	0.0845	0.0269				-0.3746			77.26***	78.24***	20%
	(4.80)***	(0.13)	(4.18)***	(1.87)*				(-1.85)*					
IX	0.4050	-0.0271	0.0536	-0.0015				-0.2507	0.1680	0.1989	76.13***	53.43***	29%
	(3.86)***	(-0.70)	(2.67)***	(-0.08)				(-1.23)	(3.05)***	(3.38)***			

Notes:
This table reports results from regressions on HFRI Convertible Bond Arbitrage Index returns in excess of the risk free rate of interest. JB-Stat is the Jacque Bera test statistic from the test of residual normality and Q-Stat is the Ljung –Box test statistic from the joint test for autocorrelation in the first ten lags of the residual. t-statistics in parenthesis are heteroskedasticity and autocorrelation-consistent, due to Newey and West (1987). ***, ** and * indicate significance at the 1%, 5% and 10% level respectively.

Table 5

Regressions on the CSFB Tremont Convertible Bond Arbitrage Index excess returns, January 1994 to December 2002

Model	α	β_{RMRF}	β_{SMB}	β_{HML}	β_{UMD}	β_{TO}	β_{LIQ}	β_{SPPA}	β_{DEF}	β_{TERM}	*JB-Stat*	*Q-Stat*	*Adj.* R^2
I	0.4343	0.0422									148.94***	258.85***	1%
	(2.15)**	(1.47)											
II	0.4186	0.0475	0.0925	0.0524							158.13***	233.38***	6%
	(2.15)**	(1.67)*	(2.70)***	(2.38)**									
III	0.3370	0.0780	0.1105	0.1093	0.0546						155.56***	214.93***	7%
	(1.50)	(2.23)**	(2.51)**	(2.04)**	(1.32)								
IV	0.3619	0.0236	0.0787	0.1047	0.0593	-0.1292					151.28***	248.09***	7%
	(1.63)	(0.48)	(1.56)	(1.93)*	(1.48)	(-1.35)							
V	0.3376	0.0759	0.1105	0.1084	0.0547		0.0050				157.4***	211.73***	6%
	(1.52)	(2.25)**	(2.51)**	(2.07)**	(1.31)		(0.25)						
VI	0.3636	-0.0283							0.2573	0.2581	175.62***	146.45***	12%
	(1.73)*	(-0.85)							(2.61)***	(3.15)***			
VII	0.3669	-0.0192	0.0567	0.0155					0.2178	0.2400	178.41***	152.33***	12%
	(1.79)*	(-0.43)	(2.09)**	(0.48)					(1.97)**	(2.66)***			
VIII	0.4057	-0.0279	0.0983	0.0479				-0.4092			146.52***	181.62***	7%
	(2.09)**	(-0.30)	(2.59)***	(2.34)**				(-0.80)					
IX	0.3607	-0.0671	0.0609	0.0133				-0.2711	0.2103	0.2254	168.4***	131.25***	12%
	(1.77)*	(-0.60)	(2.11)**	(0.41)				(-0.56)	(2.07)**	(2.76)***			

Notes:

This table reports results from regressions on the CSFB Tremont Convertible Bond Arbitrage Index returns in excess of the risk free rate of interest. JB-Stat is the Jacque Bera test statistic from the test of residual normality and Q-Stat is the Ljung –Box test statistic from the joint test for autocorrelation in the first ten lags of the residual. t-statistics in parenthesis are heteroskedasticity and autocorrelation-consistent, due to Newey and West (1987). ***, ** and * indicate significance at the 1%, 5% and 10% level respectively.

Table 6

Descriptive statistics of daily equally weighted convertible bond arbitrage and explanatory factor returns

Panel A: Dependent Variables	*Mean*	*Variance*	*Skew*	*Kurtosis*	*JB Stat*
HFRXCA	0.004	0.045	-0.468	2.002	225.2***
DJCA	0.008	0.042	-0.579	2.579	304.8***
SIMCB	0.015**	0.121	-3.72	103.351	15,170***
Panel B: Explanatory Variables	*Mean*	*Variance*	*Skew*	*Kurtosis*	*JB Stat*
RMRF	0.029**	0.923	-0.137	4.115	3,157***
DEF	-0.001	0.176	-0.189	3.93	2,893***
TERM	0.009	0.340	-0.109	2.282	975.5***

Notes:

***, ** and * indicate significance at the 1%, 5% and 10% level respectively.

Statistics are generated using RATS 5.0 *HFRXCA* and *DJCA* are the HFR and Dow Jones daily convertible arbitrage indices. SIMCB is the simulated convertible arbitrage portfolio. *RMRF* is the excess return on Fama and French's (1993) market proxy, *TERM* and *DEF* are Fama and French's daily return proxies for the deviation of long-term bond returns from expected returns due to shifts in interest rates and shifts in economic conditions that change the likelihood of default.

Table 7

Regression of daily equally weighted convertible bond arbitrage returns

Panel A: Simulated Portfolio 1st January 1990 to 31st December 2002

Dependent Variable	α	β_{RMRF}	β_{DEF}	β_{TERM}	*JB-Stat*	*Q-Stat*	*Adj. R^2*	*N*
R_{CBSIM} - R_f	0.01	0.14	0.23	0.18	2,987,687***	356.68***	8.2%	3389
	(1.90)*	(4.76)***	(3.01)***	(3.62)***				

Panel B: HFRIX Daily Convertible Arbitrage Index 31st March 2003 to 21st August 2007

Dependent Variable	α	β_{RMRF}	β_{DEF}	β_{TERM}	*JB-Stat*	*Q-Stat*	*Adj. R^2*	*N*
R_{HFRIX} - R_f	-0.01	0.03	0.53	0.31	2,865,179***	359.26***	12.9%	1029
	(-1.48)	(1.42)	(3.96)***	(3.69)***				

Panel C: Dow Jones Daily Convertible Arbitrage Index 1st January 2004 to 21st August 2007

Dependent Variable	α	β_{RMRF}	β_{DEF}	β_{TERM}	*JB-Stat*	*Q-Stat*	*Adj. R^2*	*N*
R_{DJCB} - R_f	-0.01	-0.03	0.57	0.36	2,987,687***	356.68***	28.4%	849
	(-0.95)	(-1.61)	(4.86)***	(4.63)***				

Notes:

This table presents results from the following series of regression of convertible bond arbitrage returns on contemporaneous and lagged excess risk factor returns. $R_{CB} - R_f = \alpha + \beta_{RMRF}RMRF + \beta_{DEF}DEF + \beta_{TERM}TERM + \varepsilon_t$; $R_{CB} - R_f = \alpha + \beta_{RMRF}RMRF + \beta_{SMB}SMB + \beta_{HML}HML + \beta_{DEF}DEF + \beta_{TERM}TERM + \varepsilon_t$ where R_{CB} is the daily return on the equal weighted convertible bond arbitrage portfolio, $RMRF = (RMRF_t, RMRF_{t-1}$ and $RMRF_{t-2})$, $SMB = (SMB_t, SMB_{t-1}$ and $SMB_{t-2})$, $HML = (HML_t, HML_{t-1}$ and $HML_{t-2})$, $DEF = (DEF_t, DEF_{t-1}, DEF_{t-2})$ and $TERM = (TERM_t, TERM_{t-1}, TERM_{t-2})$. Panel A of the table presents results for the simulated portfolio over the period 1st January 1990 to 31st December 2002. Panel B of the table presents results for the simulated portfolio over the period 31st March 2003 to 21st August 2007. Panel C of the table presents results for the simulated portfolio over the period 1st January 2004 to 21st August 2007. The β coefficient is the sum of the contemporaneous β and lagged β s. *T*-Stats from testing $\alpha = 0$ and $(\beta_{it} + \beta_{it-1} + \beta_{it-2}) = 0$, for i = *RMRF, SMB, HML, DEF* and *TERM* are in parenthesis. Test-statistics are heteroskedasticity and autocorrelation-consistent, due to Newey and West (1987).

Table 8

Result of regressions on the HFRI and CSFB Tremont Convertible Bond Arbitrage Index excess returns

Panel A: HFRI Hedge Fund Index												
α	$\beta_{CBRF(t\ to\ t\text{-}2)}$	$\beta_{DEF(t\ to\ t\text{-}2)}$	$\beta_{TERM(t\ to\ t\text{-}2)}$							*JB Stat*	*Q Stat*	*Adj.* R^2
0.3173	0.2036	0.2607	0.3137							49.27***	76.6***	38%
(3.02)***	(2.69)***	(3.03)***	(2.98)***									
α	$\beta_{CBRF(t)}$	$\beta_{CBRF(t\text{-}1)}$	$\beta_{CBRF(t\text{-}2)}$	$\beta_{DEF(t)}$	$\beta_{DEF(t\text{-}1)}$	$\beta_{DEF(t\text{-}2)}$	$\beta_{TERM(t)}$	$\beta_{TERM(t\text{-}1)}$	$\beta_{TERM(t\text{-}2)}$	JB Stat	Q Stat	Adj. R^2
0.3173	0.1085	0.1034	-0.0084	0.1397	0.0521	0.0689	0.1591	0.0799	0.0746	49.27***	76.6***	38%
(3.02)***	(2.23)**	(3.23)***	(-0.25)	(2.65)***	(1.65)*	(2.30)**	(3.28)***	(1.81)*	(1.91)*			
Panel B: CSFB Tremont Hedge Fund Index												
α	$\beta_{CBRF(t\ to\ t\text{-}2)}$	$\beta_{DEF(t\ to\ t\text{-}2)}$	$\beta_{TERM(t\ to\ t\text{-}2)}$							*JB Stat*	*Q Stat*	*Adj.* R^2
0.2131	0.1889	0.4389	0.5122							97.52***	197.24***	20%
(0.92)	(1.80)*	(3.76)***	(2.50)**									
α	$\beta_{CBRF(t)}$	$\beta_{CBRF(t\text{-}1)}$	$\beta_{CBRF(t\text{-}2)}$	$\beta_{DEF(t)}$	$\beta_{DEF(t\text{-}1)}$	$\beta_{DEF(t\text{-}2)}$	$\beta_{TERM(t)}$	$\beta_{TERM(t\text{-}1)}$	$\beta_{TERM(t\text{-}2)}$	*JB Stat*	*Q Stat*	*Adj.* R^2
0.2131	0.0279	0.1061	0.0550	0.2178	0.0928	0.1283	0.2368	0.1225	0.1530	97.52***	197.24***	20%
(0.92)	(0.29)	(1.85)*	(0.68)	(2.73)***	(1.79)*	(1.61)	(3.82)***	(2.39)**	(2.41)**			

Notes:

This table presents the results of estimating the following model of hedge fund index returns: $y_t = \alpha + \beta_0' \ CBRF + \beta_1' \ DEF + \beta_2' \ TERM + \varepsilon_t$ Where $DEF = (DEF_t, DEF_{t-1}, DEF_{t-2})$, $TERM = (TERM_t, TERM_{t-1}, TERM_{t-2})$, $CBRF = (CBRF_t, CBRF_{t-1}$ and $CBRF_{t-2})$ and y_t is the excess return on the index at time *t-1*. The β coefficients reported in the first row of Panel A and B is the sum of the contemporaneous β and lagged β s. *T*-Test Statistics from testing $\alpha = 0$ and $(\beta_{it} + \beta_{it-1} + \beta_{it-2}) = 0$, for $i = DEF$, *TERM* and *CBRF* are in parenthesis. Individual β coefficients and corresponding *T*-Test statistics are reported in the second row of Panel A and B. Panel A presents results for the HFRI hedge fund index and Panel B Presents results for the CSFB Tremont index. JB-Stat is the Jacque Bera test statistic from the test of residual normality and Q-Stat is the Ljung –Box test statistic from the joint test for autocorrelation in the first ten lags of the residual. t-statistics in parenthesis are heteroskedasticity and autocorrelation-consistent, due to Newey and West (1987). ***, ** and * indicate significance at the 1%, 5% and 10% level respectively.

Table 9

Statistics on individual hedge fund returns

ID	*Mean*	*Variance*	*Skew*	*Kurtosis*	*Q Stat*	*ID*	*Mean*	*Variance*	*Skew*	*Kurtosis*	*Q Stat*	*ID*	*Mean*	*Variance*	*Skew*	*Kurtosis*	*Q Stat*
1	0.64	2.01	-0.68	3.01	9.88	17	0.24***	0.37	0.34	-0.55	6.89***	33	0.01*	53.39	-0.18	2.22	18.99*
2	0.63**	7.67	0.31	2.85	24.44**	18	0.97**	3.34	0.79	2.42	12.56**	34	0.87***	4.28	-0.17	0.55	45.63***
3	1.44*	5.33	1.97	6.89	8.43*	19	0.53***	2.70	-2.38	6.06	69.54***	35	0.57***	8.61	-1.27	4.54	25.25***
4	1.22	4.36	2.14	9.11	13.98	20	0.6*	2.16	-1.73	4.04	19.06*	36	0.3***	0.30	-1.51	3.50	48.46***
5	0.9***	9.55	-0.64	4.49	26.93***	21	-0.06	34.63	-5.76	34.37	0.65	37	0.53***	0.92	-0.07	1.23	17.51***
6	0.95***	8.11	-1.22	4.41	28.18***	22	1.01***	2.45	0.38	0.13	68.09***	38	0.46**	1.59	-1.16	5.56	23.93**
7	0.65	1.22	-0.65	1.91	12.77	23	0.31***	0.76	-0.53	1.00	35.64***	39	0.61***	1.32	0.20	1.12	21.18***
8	0.86***	0.70	1.15	2.11	141.5***	24	0.49*	1.57	1.30	5.97	18.67*	40	0.53**	0.58	-1.18	2.42	17.33**
9	0.41	9.32	-0.02	0.01	10.09	25	0.6*	2.16	-1.73	4.04	19.06*	41	0.83***	3.95	-3.01	12.58	33.99***
10	1***	3.08	0.17	-0.26	16.35***	26	0.59	2.09	-0.55	2.64	12.03	42	0.81***	1.24	-0.93	1.79	10.24***
11	0.27***	0.28	1.66	7.84	33.56***	27	0.64***	0.98	-0.52	1.15	33.43***	43	0.40	0.98	-1.01	1.89	15.17
12	0.48***	1.14	0.33	1.79	28.94***	28	0.7***	0.90	-0.07	-0.76	16.26***	44	1.24***	4.78	-2.87	11.52	35.38***
13	0.06	0.11	-0.41	1.98	4.12	29	-0.6***	6.65	-0.17	-0.70	7.03***	45	1.14***	9.07	-0.22	1.89	32.46***
14	0.69***	0.48	0.22	0.29	24.31***	30	0.9**	3.93	0.64	1.44	9.56**	46	0.62**	0.99	-0.92	2.01	23.68**
15	0.73***	1.02	0.54	0.02	18.89***	31	0.65***	5.46	-2.05	6.58	35.81***	47	0.58***	1.02	0.32	3.03	28.71***
16	0.87***	0.63	0.54	-0.38	20.09***	32	0.45**	1.70	0.38	-0.04	23.68**	48	0.56***	1.15	0.47	1.67	29.8***

Notes:
This table presents descriptive statistics on the one hundred and ten hedge funds included in the sample. For each fund N is the number of monthly return observations, Min and Max are the minimum and maximum monthly return, Skew and Kurt are the skewness and kurtosis of the hedge funds return distribution and JB-Stat is the Jacque Bera test statistic from the test of residual normality.

Table 9 Continued

ID	*Mean*	*Variance*	*Skew*	*Kurtosis*	*Q Stat*	*ID*	*Mean*	*Variance*	*Skew*	*Kurtosis*	*Q Stat*	*ID*	*Mean*	*Variance*	*Skew*	*Kurtosis*	*Q Stat*
49	0.4**	0.39	-0.45	0.90	23.11**	70	-0.39***	10.73	1.26	3.34	26.58***	91	0.81***	2.22	0.06	0.92	71.63***
50	0.46***	1.53	-0.62	1.28	43.11***	71	-0.52**	11.82	0.17	-0.76	8.38**	92	0.52*	0.60	-0.34	1.53	8.97*
51	0.59	3.36	-2.53	11.99	14.36	72	0.21	18.61	-6.61	45.54	3.92	93	0.98***	3.44	1.63	4.48	8.47***
52	0.62	2.00	-0.50	0.13	10.46	73	-0.10	20.44	-6.10	38.32	3.95	94	0.14	17.91	-9.57	101.32	5.4
53	0.62***	1.92	-0.56	4.34	35.68***	74	-0.29***	2.02	-0.93	0.01	117.77***	95	1.29***	1.26	-0.52	2.51	69.84***
54	0.38***	0.53	-0.67	2.72	33.27***	75	-0.42***	7.03	-1.23	3.59	18.27***	96	0.73***	6.36	-3.26	20.19	82.95***
55	0.41***	0.32	-0.47	1.00	34.26***	76	0.11***	0.27	-0.34	0.80	41.23***	97	1.56***	29.30	0.65	0.15	10.34***
56	0.91***	2.23	-0.23	7.86	50.24***	77	0.54	0.73	2.26	9.33	18.14	98	0.96***	1.40	1.13	1.24	16.56***
57	0.32***	14.62	-3.38	20.76	112.67***	78	0.64**	0.99	-0.37	0.72	25.05**	99	0.21	9.10	0.64	0.18	9.14
58	0.16***	21.44	0.30	4.38	90.58***	79	0.94	8.29	7.11	55.07	8.19	100	-0.09*	5.19	-1.21	2.27	18.06*
59	0.36***	4.79	-0.19	-0.43	42.02***	80	1.17***	1.41	0.63	-0.10	19.22***	101	1.56***	6.73	-0.99	5.18	36.31***
60	0.59	5.62	0.10	-0.14	13	81	0.6**	69.82	0.40	1.70	11.7**	102	1.62***	6.70	-0.73	4.45	38.43***
61	0.1**	1.50	-0.40	1.62	24.46**	82	0.84**	1.50	-0.11	0.56	28.08**	103	0.46***	0.32	-0.08	0.63	40.71***
62	0.57***	7.97	-0.22	0.19	25.86***	83	0.51*	3.87	0.61	4.25	8.96*	104	0.61**	1.81	-0.57	3.41	31.27**
63	3.17*	30.63	1.49	2.29	9.88*	84	0.6***	0.50	0.29	0.57	16.89***	105	1.56***	2.31	0.20	0.40	12.05***
64	-0.85**	86.83	-0.44	0.45	35.57**	85	0.65***	1.45	-0.98	2.95	49.58***	106	0.74***	2.15	1.25	5.70	27.99***
65	0.39***	8.89	-0.44	1.35	31.53***	86	0.68	2.05	-0.53	0.12	10.47	107	1.02	7.45	0.58	4.28	14.39
66	-0.14***	9.39	0.41	0.94	31.55***	87	1.01	1.39	0.12	2.93	7.62	108	-0.21	3.55	0.11	0.37	1.49
67	0.52***	9.75	-3.06	17.91	95.58***	88	1.13***	1.44	0.11	0.82	18.97***	107	1.02	7.45	0.58	4.28	43.59***
68	0.78***	3.72	0.08	-0.04	54.47***	89	0.93***	7.23	-0.22	5.14	44.4***	109	0.05***	23.07	0.32	0.73	46.25***
69	-0.55***	10.83	-0.36	-0.13	9.74***	90	0.44*	0.64	2.29	12.75	21.76*	110	-0.07***	19.97	0.67	1.49	71.63***

Table 10

Estimating non-synchronous regressions of individual fund risk factors

Panel A: Mean Coefficients	α	β_{DEF}	β_{TERM}	β_{CBRF}	Adj. R^2
	0.28***	0.37***	0.34***	0.33***	21%

Panel B: Individual Fund Coefficients

ID	α	β_{DEF}	β_{TERM}	β_{CBRF}	Adj. R^2	Q Stat	ID	α	β_{DEF}	β_{TERM}	β_{CBRF}	Adj. R^2	Q Stat
1	0.51***	0.08	0.00	0.42	10%	35.37*	17	0.08	-0.2***	-0.2***	0.33*	5%	69.84***
2	-0.01	0.04	-0.41	1.18*	17%	23.07	18	1.1***	0.28	0.20	-0.21	25%	54.47***
3	1.28***	-0.47*	-0.70	1.34**	22%	20.34	19	-0.22	0.89***	0.88***	0.13	43%	32.48
4	1.09***	-0.46**	-0.73**	1.4***	30%	18.19	20	0.33	0.31	0.27	0.12	7%	27.73
5	0.15	1.01***	0.76**	0.97	52%	37.69**	21	-0.47	0.61	1.91*	0.25	29%	47.3***
6	0.43	0.56	0.38	1.13	30%	20.25	22	0.86**	0.21	0.49*	-0.12	7%	50.33***
7	0.58***	0.18**	0.25***	0.5**	32%	22.53	23	-0.20	0.51***	0.53***	0.03	26%	59.51***
8	0.8***	0.05	0.18	0.04	-1%	38.99**	24	-0.05	0.6***	0.71***	-0.20	26%	57.99***
9	-0.01	0.28	0.62**	0.54*	47%	70.85***	25	0.33	0.31	0.27	0.12	7%	56.18***
10	1.04***	0.4**	0.43	0.05	18%	59.97***	26	0.47***	0.08	0.06	0.36	8%	24.35
11	0.28***	0.03	0.01	-0.03	-9%	71.59***	27	0.2*	0.66***	0.51***	0.02	40%	24.6
12	0.4**	-0.06	0.23	0.49*	-1%	61.86***	28	0.47***	0.09	0.23*	0.5**	39%	26.65
13	-0.1**	-0.09**	0.01	0.46***	49%	65.17***	29	0.09	0.49***	-0.98***	-1.69***	74%	32.49
14	0.63***	-0.01	0.07	0.44**	3%	69.8***	30	0.7**	0.09	0.08	0.97**	47%	35.52*
15	0.65***	-0.05	0.05	0.32	-11%	67.48***	31	0.45	-0.31	-0.8*	1.02**	12%	83.31***
16	0.66***	-0.10	0.12	0.76***	12%	68.31***	32	-0.05	0.26	0.19	0.37	5%	73.34***

Notes:

This table presents the results of estimating the following model of hedge fund returns. $y_t = \alpha + \beta_0' \, CBRF + \beta_1' \, DEF + \beta_2' \, TERM + \varepsilon_t$ Where y_t is the excess return on the portfolio at time t-1, $DEF = (DEF_t, DEF_{t-1}, DEF_{t-2})$, $TERM = (TERM_t, TERM_{t-1}, TERM_{t-2})$ and $CBRF = (CBRF_t, CBRF_{t-1}$ and $CBRF_{t-2})$. The β coefficient is the sum of the contemporaneous β and lagged βs. ***, ** and * indicate significance, at the 1%, 5% and 10% level respectively, for α and βs for *DEF*, *TERM a*nd *CBRF*. T-test statistics are heteroskedasticity and autocorrelation-consistent, due to Newey and West (1987).

Table 10 Panel B Continued

ID	α	β_{DEF}	β_{TERM}	β_{CBRF}	Adj. R^2	Q Stat	ID	α	β_{DEF}	β_{TERM}	β_{CBRF}	Adj. R^2	Q Stat
33	-1.58	-0.96	-1.12	4.52***	10%	41.55**	54	0.32***	0.01	0.12	0.46***	16%	48.48***
34	-0.37	0.51**	0.33	0.78**	29%	84.76***	55	0.17**	0.38***	0.29***	0.01	38%	34.62*
35	-0.61	1.03*	0.51	1.03**	41%	26.47	56	0.68***	0.37**	0.29	0.14	14%	77.86***
36	0.18*	0.13**	0.32***	-0.14	21%	47.87***	57	-1.09	2.2***	1.42**	0.17	35%	115.52***
37	0.4**	-0.16	0.05	0.09	16%	64.39***	58	-0.83	1.1*	0.41	0.89	13%	99.73***
38	0.10	0.38**	0.26*	0.52**	38%	39.36**	59	-0.15	0.16	0.4**	0.6***	44%	83.58***
39	0.43***	0.05	0.08	0.82***	50%	35.55*	60	-0.91*	0.87*	0.59	0.9*	36%	83.94***
40	0.25***	0.19***	0.16**	0.14	53%	29.47	61	0.08	0.11	0.32*	-0.14	7%	86.48***
41	0.55	-0.01	-0.22	0.77*	17%	96.2***	62	-0.99	2.31***	2.02***	-0.78	17%	81.47***
42	0.58**	-0.24*	0.07	0.40	-2%	93.16***	63	3.86**	-1.37	0.30	0.95	17%	60.1***
43	0.38***	0.12	0.10	0.10	-2%	40.92**	64	-1.78**	1.24**	0.77	0.32	15%	32.58
44	0.67	0.22	0.03	0.89***	22%	52.48***	65	0.20	0.28	-0.11	0.31	9%	68.11***
45	1.15	-0.06	-0.10	0.08	-19%	184.14***	66	-0.35	0.8***	0.77**	-0.28	12%	65.56***
46	0.56***	0.14	0.10	0.00	-2%	52.47***	67	-0.28	1.81**	1.09*	-0.14	37%	75.13***
47	0.44**	0.14	0.39**	-0.09	19%	45.63***	68	-0.03	0.17	-0.28	1.16***	29%	82.61***
48	0.29***	0.21*	0.21	0.59***	30%	47.3***	69	-0.17	-0.23	-0.84	0.00	25%	75.29***
49	0.19**	0.18**	0.14**	0.16*	43%	60.74***	70	-1.32	1.58	1.44*	-0.29	-12%	90.64***
50	0.33***	0.00	-0.07	0.61***	36%	25.66	71	-1.74***	0.55	1.42	2.09	16%	78.09***
51	0.66**	0.07	-0.15	-0.47	-5%	31.16	72	-1.66***	3.18***	1.9***	-0.65	77%	90.94***
52	0.64***	0.15	0.13	0.11	7%	46.24***	73	-2.1***	3.31***	2.14***	-0.70	81%	90.58***
53	0.22	0.72***	0.66***	-0.25	13%	36.93**	74	-0.6*	0.27	0.22	0.41	-14%	95.74***

Table 10 Panel B Continued

ID	α	β_{DEF}	β_{TERM}	β_{CBRF}	Adj. R^2	Q Stat	ID	α	β_{DEF}	β_{TERM}	β_{CBRF}	Adj. R^2	Q Stat
75	-0.52**	1.56***	0.96***	-0.73	34%	92.79***	93	0.82**	-0.03	0.22	0.64	-12%	105***
76	0.07	-0.08	-0.03	0.20	-1%	109.65***	94	-0.12	-0.07	0.47*	0.54*	11%	8.28
77	0.58***	0.26***	0.21**	-0.42*	6%	107.27***	95	1.08***	0.34***	0.26**	0.08	30%	8.28
78	0.73***	0.14	0.09	-0.3**	-5%	119.53***	96	0.53	0.24	-0.06	0.33	1%	49.07***
79	0.93***	-0.03	-0.36	0.43	-8%	90.59***	97	1.85***	1.88***	2.96***	-1.27	29%	48.84***
80	1.18***	0.62***	1.1***	-0.27	42%	87.48***	98	1.11***	0.61***	0.79***	-0.77*	16%	47.69***
81	-0.77	-1.19	-0.57	4.66	-3%	76.7***	99	0.04	0.14	-0.32	0.59	36%	46.42***
82	0.86***	0.09	0.09	-0.15	-7%	111.64***	100	-0.03	0.93***	0.8***	-0.71**	27%	50.63***
83	0.14	0.27	0.96***	0.60	9%	104.64***	101	1.56***	0.71**	0.39	0.02	14%	49.44***
84	0.65***	0.22***	0.29**	-0.10	-3%	112.78***	102	1.62***	0.72**	0.41	0.00	15%	34.14*
85	0.47**	0.19	0.08	0.26	18%	116.17***	103	0.36***	0.02	0.03	0.32***	13%	47.48***
86	0.58***	0.25	0.44*	0.51	9%	112.47***	104	0.42***	0.33**	0.34***	0.14	16%	43.58***
87	1***	0.12	0.15	0.20	-18%	115.37***	105	1.56***	0.49**	0.65***	-0.07	18%	46.34***
88	1.21***	0.4**	0.59***	-0.24	2%	113.41***	106	0.59***	0.36**	0.58***	0.8*	44%	27.81
89	0.21	1.23**	0.91*	0.19	24%	102.5***	107	0.82***	0.67***	0.91***	1.41**	45%	49.14***
90	0.43***	0.23*	0.28**	-0.19	10%	126.5***	108	-0.11	0.06	-0.35*	-0.18	30%	50.85***
91	0.48**	0.24	0.28	0.41*	14%	118.26***	109	-0.24	0.21	-0.38	0.75	8%	61.18***
92	0.45***	0.03	-0.15	0.32	31%	121.57***	110	0.04	0.44	-0.74	-0.79	11%	33.61*