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Simulating Convertible Bond Arbitrage Portfolios

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Abstract

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Keywords: Arbitrage, Convertible bonds, Hedge funds

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1. Introduction

Convertible bond arbitrageurs derive returns from two areas, income and long volatility exposure. Income comes from the coupon paid periodically by the issuer of the convertible bond and from interest on the short stock position. 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. Prior studies of convertible arbitrage hedge funds have documented significant positive abnormal returns from the strategy. However, it is well known that the hedge fund data contains several characteristics which upwardly bias these performance estimates. In this paper we create a simulated convertible bond arbitrage portfolio free of these biases, designed to capture income and volatility, and we also provide evidence of the historical risk and performance of the strategy.

First issued in the United States in the nineteenth century, a simple convertible bond is defined as a corporate bond, paying a fixed coupon, with security, maturing at a certain date with an additional feature allowing it to be converted into a fixed number of the issuer's common stock. According to Calamos (2003) this convertible clause was first added to fixed income investments to increase the attractiveness of investing in rail roads of what was then the emerging economy of the United States. Convertible bonds have grown in complexity and are now issued with features such as put options, call protection, ratchet clauses, step up coupons and floating coupons. Perhaps due to this complexity relatively few individual or institutional investors

incorporate convertible into their portfolios. It has been estimated that hedge funds account for seventy percent of the demand for new convertible issues and eighty percent of convertible transactions (see Barkley, 2001; McGee, 2003).

While the overall market for convertible bonds has been growing to an estimated \$351.9 billion by the end of December 2003 (BIS, 2004), the hedge fund industry has also been growing at a phenomenal rate. Initially hedge fund investors were interested in large global/macro hedge funds and the majority of the funds went into these strategies. Fung and Hsieh (2000a) estimate that in 1997 twenty seven large hedge funds accounted for at least one third of the assets managed by the industry. However, investors have been increasingly interested in lower volatility non-directional arbitrage strategies. Data from Tremont Advisors and the Barclay Group indicate that convertible arbitrage total market value grew from just \$768m in 1994 to \$64.9bn in 2004, an astonishing growth rate of 50% on average per annum.

Academic literature on dynamic trading strategies has generally focused on modelling the relationship between the returns of hedge funds which follow such strategies and the asset markets and contingent claims on those assets in which hedge funds operate (see, for example, Fung and Hsieh, 1997; Liang, 1999; Schneeweis and Spurgin, 1998; Capocci and Hübner, 2004; Agarwal and Naik, 2004). The difficulty with these studies is that the use of hedge fund returns to define the characteristics of a strategy introduces biases as discussed in Fung and Hsieh (2000b) and Getmansky, Lo and Makarov (2004).

Hedge fund data contains four main biases, instant history bias, selection bias survivorship bias and smoothing. An instant history bias occurs if hedge fund database vendors back fill a hedge funds performance when they add it to a database. A selection bias occurs if the hedge funds in an observable portfolio are not representative of that particular class of hedge funds. Some funds may be classified as convertible arbitrage but may generally operate a long only strategy. Survivorship bias occurs if funds drop out of a database due to poor performance. The resulting database is therefore biased upwards as poor performing funds are excluded. Liang

(2000) examines the survivorship bias in hedge fund returns by comparing two large databases (HFR and TASS) finding survivorship bias of 2% per year. Performance smoothing occurs if hedge funds report only part of the gains in months when a fund has positive returns so as to partially offset potential future losses and thereby reduce volatility and improve risk-adjusted performance measures such as the Sharpe (1966) ratio and the Jensen (1968) alpha. Smoothing is difficult to implement with liquid instruments, but with portfolios of illiquid convertible bonds, managers do have some discretion when reporting returns. Getmansky, Lo and Makarov (2004) provide evidence that, of all the hedge fund strategies, smoothing is most prevalent in the convertible arbitrage hedge fund data.

In this paper we address the issue of convertible arbitrage risk and performance analysis in three ways. First, we construct a simulated portfolio convertible arbitrage portfolio, free of instant history bias, selection bias, survivorship bias and smoothing, by combining financial instruments in a manner akin to that ascribed to practitioners who operate that strategy.¹ Drawing on the asset pricing literature, we then define a set of equity and bond market risk factors that match the investment strategy's aims and returns, and identify the portfolios' historical exposures to variations in the returns of these risk factors. Finally, we subdivide our sample according to equity market returns providing evidence of non-linearity in the relationship between convertible bond arbitrage returns and risk factors and further evidence on the performance of the strategy.

To construct the simulated portfolio we match long positions in convertible bonds with short positions in the issuer's equity. This creates a delta neutral hedged convertible bond position that captures income and volatility. We then combine the delta neutral hedged positions into two convertible bond arbitrage portfolios, one equally weighted, the other weighted by market capitalisation of the convertible issuers' equity. To confirm that our portfolios have the characteristics of a convertible arbitrageur we compare the returns of the convertible bond

¹ Fung and Hsieh (2001) and Mitchell and Pulvino (2001) follow a similar methodology to provide evidence of the risks in the trend following and merger arbitrage strategies.

arbitrage portfolio and the returns from two indices of convertible arbitrage hedge funds in a variety of market conditions.

By defining a set of asset classes that match an investment strategy's aims and returns, the portfolio's exposures to variations in the returns of the asset classes can be identified. Multi-factor asset class models have been specified extensively in the hedge fund and mutual fund literature to assess risk and performance of investment funds.² Following the identification of exposures, the effectiveness of the strategy can be compared with that of a passive investment in the asset mixes. Unsurprising given the hybrid nature of convertible securities, we provide evidence that the strategy is significantly related to both equity and bond market factors. We report significantly positive coefficients for the excess market return, a size factor and default and term structure risk factors. Despite the inclusion of these factors the strategy still appears to generate small positive abnormal risk adjusted returns.

Finally, we investigate non-linearity in the relationship between convertible arbitrage returns and risk factors. As convertible bonds are effectively an equity option combined with a bond we have a theoretical expectation that the portfolio's exposure to risks would vary depending on market returns. When the stock price falls the equity option moves out of the money and the convertible bond acts more like bond than equity. Effectively, the convertible arbitrageur is short a credit put option.³ By subdividing the sample by equity market returns we are able to demonstrate the changing risks faced by the convertible arbitrageur. We provide evidence that the convertible arbitrage portfolios become more exposed to equity market risk factor in normal and rising markets and more exposed to default and term structure risk in falling markets. Unlike Agarwal and Naik (2004) we find no evidence of an increase in equity market risk in falling equity markets. We attribute the difference in findings to the specification of default and term

² These models can be loosely classified as Sharpe (1992) asset class factor models following Sharpe's (1992) paper on asset allocation, management style and performance evaluation.

³ Some convertible arbitrage funds hold credit default swaps to hedge credit risk, however these hedges are likely to be imprecise.

structure risk factors in our asset pricing model. We also demonstrate empirically that estimated alphas are only significantly positive in the rising equity market sub-sample and only for the market capitalisation weighted portfolio.

The remainder of the paper is organised as follows. In the next section, we describe a typical convertible bond arbitrage position and provide a thorough description of how our portfolio is constructed. A comparison of the returns of the convertible bond arbitrage portfolio with the returns of two convertible arbitrage hedge fund indices and some market factors is given in Section 3. Section 4 provides a discussion of the convertible arbitrage risk factor models. In Section 5, we present results from estimating the risk factor models and provide some evidence of non-linearity. Section 6 concludes the paper.

2. Description of a convertible bond arbitrage position and portfolio construction

Fundamentally, convertible bond arbitrage entails purchasing a convertible bond and selling short the underlying stock creating a delta neutral hedge long volatility position.⁴ This is considered the core strategy underlying convertible bond arbitrage. The position is set up so that the arbitrageur can benefit from income and equity volatility. The arbitrageur purchases the convertible bond and takes a short position in the underlying stock at the current delta. The hedge neutralizes equity risk but is exposed to interest rate and volatility risk. Income is captured from the convertible coupon and the interest on the short position in the underlying stock. This income is reduced by the cost of borrowing the underlying stock and any dividends payable to the lender of the underlying stock.

The non-income return comes from the long volatility exposure. The hedge is rebalanced as the stock price and/or convertible price move. Rebalancing will result in adding or subtracting from the short stock position. Transaction costs and the arbitrageur's attitude to risk will affect

⁴ The arbitrageur may also hedge credit risk using credit derivatives, although these instruments are a relatively recent development. The short equity position partially hedges credit risk, as generally, if an issuer's credit quality declines this will also have a negative effect on the issuer's equity.

how quickly the hedge is rebalanced and this can have a large effect on returns. In order for the volatility exposure to generate positive returns the actual volatility over the life of the position must be greater than the implied volatility of the convertible bond at the initial set up of the hedge. If the actual volatility is equal to the implied volatility you would expect little return to be earned from the long volatility exposure. If the actual volatility over the life of the position is less than the implied volatility at setup then you would expect the position to have negative non-income returns.⁵

Convertible bond arbitrageurs employ a myriad of other strategies. These include the delta neutral hedge, bull gamma hedge, bear gamma hedge, reverse hedge, call option hedges and convergence hedges.⁶ However Calamos (2003) describes the delta neutral hedge as “the bread and butter” hedge of convertible bond arbitrage.

Convertible securities are of various different types including traditional convertible bonds, mandatory convertibles and convertible preferred. This paper focuses exclusively on the traditional convertible bond as this allows us to use a universal hedging strategy across all instruments in the portfolio. We also 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. 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

⁵ It should be noted that the profitability of a long volatility strategy is dependent on the path followed by the stock price and how it is hedged. It is possible to have positive returns from a position even if actual volatility over the life of the position is less than implied volatility at the set up of the position and vice versa.

⁶ For a detailed description of the different strategies employed by convertible arbitrageurs see Calamos (2003).

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.

A GARCH(1,1) model is employed to estimate volatility as an input in the calculation of the theoretical value of a convertible bond and the corresponding hedge ratio.⁷ For each convertible bond one estimate of future volatility σ_{n+k}^2 is forecast following Bollerslev (1986). Equation (1) sets out how future volatility was estimated from the inclusion date, day n to the redemption date, day k , using five years of historical closing prices of the underlying stock up to and including day $n-1$, the day before the bond is included in the portfolio.⁸

$$E(\sigma_{n+k}^2) = V_L + (\alpha + \beta)^k (\sigma_n^2 - V_L) \quad (1)$$

$$\sigma_n^2 = \gamma V_L + \alpha u_{n-1}^2 + \beta \sigma_{n-1}^2 \quad (2)$$

subject to

$$\gamma + \alpha + \beta = 1 \quad (3)$$

where σ_n^2 is the estimate of volatility on day n , V_L is the long run variance rate, u_{n-1}^2 is the squared percentage change in the market variable between the end of day $n-2$ and the end of day $n-1$ and σ_{n-1}^2 is the estimate of volatility on day $n-1$. The parameters α and β are estimated to maximise the objective function (4).

$$\sum_{i=1}^m \left(-\ln(v_i) - \frac{u_i^2}{v_i} \right) \quad (4)$$

where v_i is the estimate of the variance rate σ_i^2 , for day i made on day $i-1$.

⁷ There are a large number of variants in the GARCH family including IGARCH, A-GARCH, NA-GARCH, V-GARCH, Thr.-GARCH, GJR-GARCH, E-GARCH and NGARCH. Empirical evidence on their relative performance is mixed (see Poon and Granger (2003) for a comprehensive review). As none of the variants consistently outperforms, GARCH(1,1) is used in this study.

⁸ For some equities in the sample five years of historic data was unavailable. In this situation volatility was forecast using available data, restricted to a minimum of one year. Only equities with a minimum of one year of historical data were included in the original sample.

In order to initiate a delta neutral hedge for each convertible bond we need to estimate the delta for each convertible bond on the trading day it enters the portfolio. 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 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.⁹

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

$$R_{it} = \frac{P_{it}^{CB} - P_{it-1}^{CB} + C_{it} - \Delta_{it-1}(P_{it}^U - P_{it-1}^U + D_{it}) + r_{t-1}S_{i,t-1}}{P_{it-1}^{CB} + \Delta_{it-1}P_{it-1}^U} \quad (5)$$

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.

⁹ As discussed earlier, due to transaction costs, an arbitrageur would not normally rebalance each hedge daily. However to avoid making ad hoc decisions on the timing of the hedge, we rebalance the portfolio daily and also exclude transaction costs.

A summary of the individual convertible bond arbitrage return series is presented in Table 1. The majority of new positions were added in the years 1990, 2001 and 2002.¹⁰ The average position duration was 11.6 years, and the average position return was 70.1%, 4.7% per annum. The maximum return on an individual position was 460.7% and the minimum position return was -95.6%. 235 new positions were added in 2001, with average position duration of 1.6 years and average position return of 6% per annum. 1997, 1998 and 1999 are the years when the fewest new positions were added to the portfolio. In 1997 and 1998 one new position was added in each year, and in 1999 only four new positions were added. The lowest returns were generated by positions added in 1999 and 2000, with average annual returns of -2.25% and -2%, respectively. The closing out of positions is spread reasonably evenly over the sample period, with the exception of 2002 where the majority of positions were closed out when the portfolio is liquidated at 31st December 2002.

Two convertible bond arbitrage portfolios are calculated – an equally weighted and market capitalisation weighted – using a similar methodology to CSFB Tremount Hedge Fund Index (2002). As the market capitalisation portfolio has a bigger weighting of large convertible bond issues it should be more liquid and be of a higher credit quality, thus intuitively one would expect fewer arbitrage opportunities.

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

$$V_t = \frac{\sum_{i=1}^{i=N_t} W_{it} PV_{it}}{F_t}, \quad (6)$$

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

¹⁰ In 1990, 66 new positions were added, of which 55 were listed prior to 1990.

t . For the equally weighted portfolio W_{it} is set equal to one for each live hedged position. For the market capitalization index the weighting for position j is calculated as follows.

$$W_{jt} = \frac{MC_{jt}}{\sum_{i=1}^{i=N_t} MC_{it}} \quad (7)$$

where W_{jt} is the weighting for position j at time t , N_t is the total number of position on day t and MC_{it} is the market capitalization of issuer i at time t . To avoid daily rebalancing of the market capitalization weighted portfolio the market capitalizations on the individual positions are updated at the end of each calendar month. However, if a new position is added or an old position is removed during a calendar month then the portfolio is rebalanced.

On the inception date of both portfolios, the value of the divisor is set so that the portfolio value is equal to 100. Subsequently the portfolio divisor is adjusted to account for changes in the constituents or weightings of the constituent positions in the portfolio. Following a portfolio change the divisor is adjusted such that equation (8) is satisfied.

$$\frac{\sum_{i=1}^{i=N_t} W_{ib} PV_i}{F_b} = \frac{\sum_{i=1}^{i=N_t} W_{ia} PV_i}{F_a} \quad (8)$$

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_{ia} 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.

$$F_a = \frac{F_b \times \sum_{i=1}^{i=N_t} W_{ib} PV_i}{\sum_{i=1}^{i=N_t} W_{ia} PV_i} \quad (9)$$

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 arbitrage hedge fund this leverage may vary from one to ten times equity. However, the level of leverage in a well run portfolio is not static and varies depending on the opportunity set and risk climate. Khan (2002) estimates that in mid 2002 convertible arbitrage hedge funds were at an average leverage level of 2.5 to 3.5 times equity, with estimates approximating 5 to 7 times equity in late 2001. In the case of our simulated portfolios we apply leverage of one times equity to both our portfolios as this produces portfolios with a similar average return to the HFRI Convertible Arbitrage Index and the CSFB Tremont Convertible Arbitrage Index.¹¹

Table 2 presents annual return series for the equally weighted and market capitalization weighted convertible bond arbitrage portfolios, the CSFB Tremont Convertible Arbitrage Index, the HFRI Convertible Arbitrage Index, the Russell 3000 Index, the Merrill Lynch Convertible Securities Index and the risk-free rate. The two highest returning years for the convertible bond arbitrage portfolios, 1991 and 1995 correspond with the two highest returning years for the Russell 3000, the Merrill Lynch convertibles index and the HFRI hedge fund index. In 1991 the equally weighted index returned +17.2%, the market capitalization weighted index returned 17.43% and the HFRI index returned +16.2%. However, the convertible bond arbitrage strategy was outperformed by a simple buy-and-hold equity (+26.4%) or convertible bond (+21.6%) strategy. 1995 produced strong returns with the equally weighted portfolio +23.2%, the market capitalization weighted portfolio +16.9%, the HFRI index +18.1% and the CSFB Tremont hedge fund index +15.3%. Again the strategy was outperformed by a simple buy-and-hold equity strategy (+29%) but outperformed the general convertible securities market.

¹¹ To ensure the level of leverage is not an important factor in our results we apply alternative levels of leverage to the portfolio from 0 to 5 times. Results were not materially different than for the 1 times equity portfolio and are available from the authors.

The lowest returns for the equally weighted convertible bond arbitrage portfolio occur in 1990 and 1994, which also corresponds with negative returning years for the Russell 3000 and Merrill Lynch convertible securities index.¹² The HFRI index had a below average return of +2.14% in 1990 and had its lowest return of -3.8% in 1994. The CSFB Tremont index does not date back to 1990 but in 1994 it had also had its lowest return of -8.4%. The two lowest returning years for the market capitalization weighted index were 1990 and 1992. In 1998 the CSFB Tremont index also had a negative return of -4.5%, however none of the other indices or portfolios had negative returns.

More recently in 2000, 2001 and 2002, after the bursting of the dotcom bubble, both of the convertible bond arbitrage portfolios (returning an average 7.3% for the equally weighted and 5.52% for the market capitalization weighted), the HFRI Convertible Arbitrage Index and the CSFB Tremont Convertible Arbitrage Hedge Fund Index have performed well. During this period the Russell 3000 and the Merrill Lynch Convertible Securities Index had an average annual return of -16.1% and -10.26%. This performance has demonstrated the diversification benefits of the convertible bond arbitrage strategy. However, it should be noted that the sample period has been characterized by rapidly falling interest rates and an increase in convertible issuance.

Looking at the distribution of the monthly returns, both the equal weighted and the market capitalization weighted portfolios display negative skewness of -1.23 and -0.77, respectively. The CSFB Tremont index and the HFRI index also display negative skewness. This is consistent with other studies (see Agarwal and Naik, 2004; Kat and Lu, 2002). The monthly returns from the equal weighted and the market capitalization weighted portfolios also display positive kurtosis. Similar to Kat and Lu (2002), we find that the estimates of kurtosis appear to be high relative to the two hedge fund indices.

¹² Ineichen (2000) notes that 1994 was not a good year for convertible arbitrage characterised by rising US interest rates.

3. Validation of Convertible Arbitrage Portfolios

A comparison of the convertible bond arbitrage portfolios with two market standard hedge fund indices and the overall market portfolio for a variety of market conditions provides a starting point in validating the robustness of the two generated portfolios. Furthermore, as highlighted earlier, investors have become interested in lower volatility non-directional arbitrage strategies because of the diversification benefits they bring to their portfolios in a low-return equity environment. A comparison across market conditions provides evidence of this diversification benefit dependence to market swings.

Table 3 presents the correlation coefficients between the monthly returns on the equally weighted convertible bond arbitrage portfolio (Equal), the market capitalization weighted portfolio (MC), the CSFB Tremont Convertible Arbitrage Index (CSFB), the HFRI Convertible Arbitrage Index (HFRI), the Russell 3000, the Merrill Lynch Convertible Securities Index (MLCS) and the VIX Index (VIX)¹³. As the CSFB data is unavailable prior to 1994 the correlation coefficients cover returns from January 1994 to December 2002.¹⁴

The Equal, MC, CSFB and HFRI indices are all positively correlated with the MLCS index. With the exception of the CSFB index they are also all positively correlated with equities. The Equal is positively correlated with the MC, CSFB and HFRI indices over the entire sample period. Surprisingly, the MC is not correlated with the CSFB index, although it is positively correlated with the HFRI index. Monthly returns on the VIX are negatively correlated with both the Equal and MC portfolios indicating that they are both negatively correlated with implied volatility. Neither of the hedge fund indices has any correlation with the VIX. This is surprising as convertible bond arbitrage is a long volatility strategy.

¹³ The VIX index is an equity volatility index calculated by the Chicago Board Option Exchange. It is calculated by taking a weighted average of the implied volatilities of 8 30-day call and put options to provide an estimate of equity market volatility.

¹⁴ Correlation coefficients were estimated for the entire sample period 1990 to 2002 for all variables excluding the CSFB data. There was no change in the sign or significance of any of the coefficients.

Next we ranked our sample of 108 monthly returns by equity market return and subdivided the sample into four equal sized sub-samples of 27 months. State 1, which is presented in Panel A of Table 4, covers the correlations between convertible bond arbitrage returns and market factors in the 27 lowest equity market returns (ranging from -16.8% to -2.6%). The Equal portfolio and the two hedge fund indices are positively correlated with the MLCS index in this sub-sample. The Equal portfolio is positively correlated with the two hedge fund indices and the three are all negatively correlated with the VIX. In this sub-sample the MC portfolio is not correlated with any of the other return series or market factors. The Equal portfolio shares more characteristics with the hedge fund indices, than the MC portfolio does.

Panel B of Table 4 looks at the correlations between convertible bond arbitrage returns and market factors in the 27 next lowest equity market returns (ranging from -2.2% to +1.3%). None of our convertible arbitrage portfolios or indices has any correlation with equities in this sub-sample. Both the CSFB and HFRI indices are correlated with the MLCS and VIX indices. The Equal portfolio is positively correlated with the MC portfolio and also the two hedge fund indices are positively correlated.

Panel C of Table 4 looks at the correlations between convertible arbitrage returns and market factors in the 27 next lowest equity market returns (ranging from +1.4% to +3.9%). The two hedge fund indices are positively correlated with the MLCS index and each other. The MC portfolio is also correlated with the HFRI index.

The final sub-sample, looking at the correlations between convertible arbitrage returns and market factors in the 27 highest equity market returns (ranging from +4.0% to 7.6%) is presented in Panel D of Table 4. The Equal portfolio is positively correlated with the MC portfolio and the HFRI index. Both the CSFB and HFRI indices are positively correlated with the VIX in this sample period.

Based on the evidence presented in this section the two hedge fund indices appear to share many of the characteristics of our convertible bond arbitrage portfolios. Over the entire

sample period they are all positively correlated, and when the sample is subdivided they share similar characteristics.

4. Convertible bond arbitrage performance measurement

Prior analysis of convertible bond arbitrage in the literature has highlighted the perceived abnormal positive risk adjusted returns that the strategy generates. Ineichen (2000) uses a linear one factor model to document the abnormal returns generated by convertible arbitrage hedge fund indices. More recently, Capocci and Hübner (2004), utilising a linear specification, document convertible arbitrage funds exhibiting significant positive abnormal returns using both single factor and multi factor models. Regardless of the performance measure, model or sample employed convertible bond arbitrage exhibit a significant positive abnormal return (Kazemi and Schneeweis, 2003).

To aid the definition of appropriate risk factors we first decompose the returns of the two convertible arbitrage portfolios into their fixed income and equity option components.¹⁵ Figure 1 graphically displays the proportion of total returns derived from each of these sources for the equally weighted and market capitalisation weighted portfolios. For the equally weighted (market capitalisation weighted in parenthesis) portfolio which has an average annual return of 8.5% (9.3%) the fixed income component contributes 3.2% (3.0%) with the balance of 5.4% (6.3%) coming from the equity option component. As can be seen graphically the annualised standard deviation of the fixed income component is lower, 0.8% (0.8%), than the equity option component with an annualised standard deviation of 5.61% (6.6%).

Given this evidence we specify four asset pricing models using combinations of equity and bond market factors to isolate the convertible arbitrage data generating process: 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

¹⁵ We are grateful to an anonymous reviewer for this suggestion.

(1993) three factor bond model and the Fama and French (1993) combined stock and bond model. Below we briefly review these models, providing an explanation of the expected relationship between convertible arbitrage 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:

$$R_{CB} - R_f = \alpha + \beta_{RMRF} RMRF + \varepsilon_t \quad (10)$$

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 (the yield on a one month treasury bill), $RMRF_t$ is the excess return on the market portfolio (here the Russell 3000 is specified as a market proxy) on month t , α is the error term α and β_{RMRF} are the intercept and the slope of the regression, respectively. As convertible arbitrageur's are exposed to equity option risk there should be a significantly positive β_{MKT} 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 which take the size and market to book ratio of firms into account. It is estimated from the following equation:

$$R_{CB} - R_f = \alpha + \beta_{RMRF} RMRF + \beta_{SMB} SMB + \beta_{HML} HML + \varepsilon_t \quad (11)$$

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 .¹⁶ Capocci and Hübner (2004) specify the HML and SMB factors in their models of hedge fund

¹⁶ For details on the construction of SMB and HML see Fama and French (1992, 1993).

performance. Agarwal and Naik (2004) specify the *SMB* factor in a model of convertible arbitrage performance and find it has a positive relation with convertible arbitrage returns. As the opportunities for arbitrage are greater in the smaller less liquid issues *ex ante* it would be expected that a positive relationship between convertible 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 arbitrage returns though Capocci and Hübner (2004) report a positive *HML* coefficient for convertible arbitrage.

Fama and French (1993) also propose a three factor model for the evaluation of bond returns. They draw on 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

$$R_{CB} - R_f = \alpha + \beta_{RMRF}RMRF + \beta_{DEF}DEF + \beta_{TERM}TERM + \varepsilon_t \quad (12)$$

Where DEF_t is the difference between the overall return on a market portfolio of long-term corporate bonds¹⁷ minus the long term government bond return at month t ¹⁸. $TERM_t$ 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 return¹⁹. It is expected that convertible arbitrage returns will be positively related to both of these factors as the strategy generally has term structure and credit risk exposure.

¹⁷ 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.

¹⁸ 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.

¹⁹ 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).

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 combined model:

$$R_{CB} - R_f = \alpha + \beta_{RMRF}RMRF + \beta_{SMB}SMB + \beta_{HML}HML + \beta_{DEF}DEF + \beta_{TERM}TERM + \varepsilon_t \quad (13)$$

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 (10) to (13). This downward bias is caused by non-synchronous trading between the illiquid convertible bonds and the more liquid asset class factors.²⁰

Table 5, Panel B presents summary statistics of the daily explanatory factor returns.²¹ None of the risk factors have average returns significantly different from zero. *RMRF* has the largest variance and four of the factors, *RMRF*, *SMB*, *TERM* and *DEF* exhibit significant negative skewness at the 1% level. All of the factors exhibit significant excess kurtosis. Table 5, Panel C presents a correlation matrix of the explanatory variables daily returns. There is a high absolute correlation between two of the equity market factors, *RMRF* and *HML*, and the bond factors *TERM* and *DEF*. In the next section we report results from estimating the relationship between the simulated portfolio returns and these risk factors.

5. Results of the asset class factor model regressions

In this section, the results of estimating the risk factor models defined in the previous section on the simulated convertible arbitrage portfolio are presented. We also present empirical

²⁰ 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.

²¹ Data on *SMB* and *HML* was provided by Kenneth French.

evidence supporting our hypothesis of non-linearity in the relationship between simulated portfolio returns and risk factors.

Table 6 presents results of the OLS estimation of the risk factor models discussed above for the equally weighted convertible bond arbitrage portfolio. Although the conditional heteroskedasticity and autocorrelation are not formally treated in the OLS estimate of the parameters, the test statistics are heteroskedasticity and autocorrelation consistent due to Newey and West (1987). As discussed above contemporaneous observations and two lags are specified for each risk factor. The β coefficients are the sum of the contemporaneous β and lagged β s. P -values from testing the general linear restrictions that $\alpha = 0$ and $(\beta_{it} + \beta_{it-1} + \beta_{it-2}) = 0$, for $i = RMRF, SMB, HML, DEF$ and $TERM$ are in parenthesis.

The first reported results are for the market model. The market coefficient value of 0.14 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 arbitrage hedge funds of 0.06. The second result 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 arbitrage. The penultimate result 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. The final result is an estimation of the combined Fama and French's (1993) bond and stock factor models. The coefficients for $RMRF, SMB, HML, DEF$ and $TERM$ are all significantly different from zero. Estimated alphas from the four models are all significantly positive at, at least the 5% significance level.

Table 7 reports similar results for the market capitalisation weighted index. Factor loadings on equity market risk factors are larger than for the equal weighted portfolio. This is

unsurprising given the market capitalisation weighted portfolio derives a larger proportion of returns from the equity option component than the equal weighted portfolio. Estimated alphas from the four models are all significantly positive at the 5% significance level.

The results reported in Tables 6 and 7 provide evidence that the convertible bond arbitrage strategy has significant risk exposure to both equity and bond market factors. As a larger proportion of returns are derived from the higher variance equity option component these factors explain a large proportion of returns in a linear framework. Nonetheless, the bond market factors are also highly significant.

Next we investigate non-linearity in the relationship between these risk factors and the simulated portfolio returns. Agarwal and Naik (2004) document that convertible bond arbitrage hedge funds exhibit written naked put option like returns, with a stronger correlation between the returns of convertible arbitrage hedge fund indices and equities in down markets. This finding is inconsistent with theoretical expectations. The convertible bond is a hybrid bond and equity instrument. As the underlying equity price decreases we expect the delta of the convertible to fall and it to become more bond and less equity like. We would expect to find a decrease in equity market risks and an increase in fixed income risks under these conditions.

To investigate this we rank and subdivide the sample by historical equity market returns. We estimate the combined equity and bond performance measurement model (13) for the equally weighted and market capitalisation weighted portfolios in three sub-samples. First, in weak equity markets, when the excess market return is at least one standard deviation less than the mean; second, in strong equity markets, when the excess market return is at least one standard deviation greater than the mean; and, finally in benign equity markets, when the excess market return is within one standard deviation of the mean.

Table 8 reports the results of OLS estimation of the risk factor model for the three sub-samples. (To aid comparison the full sample regression from Table 6 is also reported in Panel A.) There are three main results to note from this table. Panel B reports results after restricting the

sample to those days where the excess market return is at least one standard deviation less than the mean. First, Note the increase in coefficient values for the bond market factors and the decrease in coefficients and significance for the equity market factors. Second, note the decrease in coefficient values and significance for the bond market factors, *DEF* and *TERM* in Panel C the results for the sub-sample at least one standard deviation greater than the mean. Finally, the estimated alphas in each of these sub-samples are not significantly different from zero.

Table 9 reports a similar set of results for the market capitalisation weighted portfolio. Again the *DEF* and *TERM* coefficients increase in magnitude and significance when stock returns are low. The equity related coefficients decrease in this sub-sample and increase in size and significance when equity returns are at least one standard deviation greater than the mean. In Table 9 only the alpha estimated in Panel C (equity market returns at least one standard deviation greater than the mean) is significantly positive.

These results provide more evidence on the risks in the convertible arbitrage strategy. The strategy is exposed to both equity and bond market risk factors but these risk exposures are non-stationary. When equity market returns are weak the aggregate delta of the convertibles in the portfolio falls and the portfolio is more exposed to default and term structure risk factors. When equity market returns are high the aggregate delta of the bonds increases and the portfolios equity market risk exposure increases. Failing to correct for this inherent non-linearity can lead to erroneous conclusions on performance. The estimated alphas reported in Tables 8 and 9 are only significant in rising equity markets and only for the market capitalisation weighted portfolio. These results contrast with the linear full sample model in Table 6 and 7 with estimated alphas significantly positive irrespective of the performance measurement model specified.

6. Conclusion

In this paper we simulate a convertible bond arbitrage portfolio providing evidence on the characteristics of this dynamic trading strategy. As this simulated portfolio is free of the biases

found in self reported hedge fund data, it serves as a useful benchmark to evaluate the risks and performance of the strategy.

We combine long positions in convertible bonds with short positions in the common stock of the issuer to create individual delta neutral hedged convertible bonds in a manner consistent with an arbitrageur capturing income. These individual positions are then dynamically hedged on a daily basis to capture volatility and maintain a delta neutral hedge. We then combine these positions into two convertible bond arbitrage portfolios and demonstrate that the monthly returns of our convertible bond arbitrage portfolio are positively correlated with two indices of convertible arbitrage hedge funds.

Next we decompose the returns of these portfolios into fixed income and equity option components aiding the definition of a set of appropriate risk factors. We provide evidence that the portfolios have statistically significant positive relationships with excess equity returns, a size factor and default and term structure risk factors. We also include a book-to-market factor which has a weaker relationship with portfolio returns. Results of these different linear asset class factor models suggest the strategy generates superior risk adjusted returns.

To investigate the findings of Agarwal and Naik (2004), that convertible arbitrage has an increase in equity market risk in depreciating markets we investigate for non-linearity in the relationship between simulated portfolio returns and the bond and equity market risk factors. Consistent with theoretical expectations we find that equity related risk coefficients increase and decrease in appreciating and depreciating equity markets respectively. Likewise, bond related risk coefficients decrease and increase in appreciating and depreciating equity markets respectively. Correcting for this non-linearity eliminates the perceived abnormal risk adjusted performance of the portfolios.²²

²² With the exception of the market capitalisation weighted portfolio in the appreciation equity markets sub-sample.

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Figure 1
Decomposed Returns

This figure graphically depicts the proportion of portfolio returns coming from the fixed income portion of the portfolio and the equity option component. Panel A displays the historical cumulative returns of the equally weighted portfolio. Panel B displays the historical cumulative returns of the market capitalisation weighted portfolio.

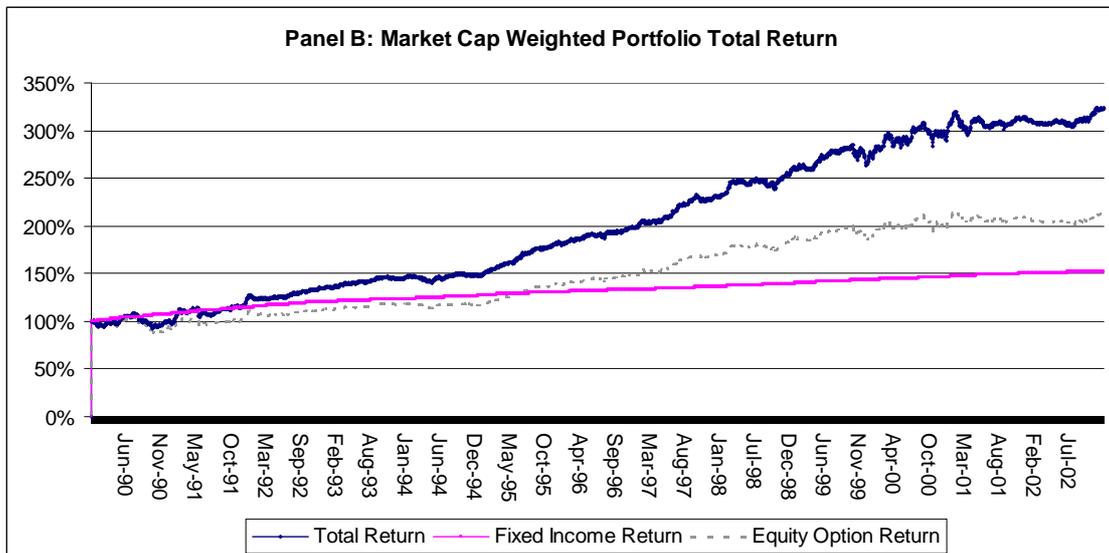
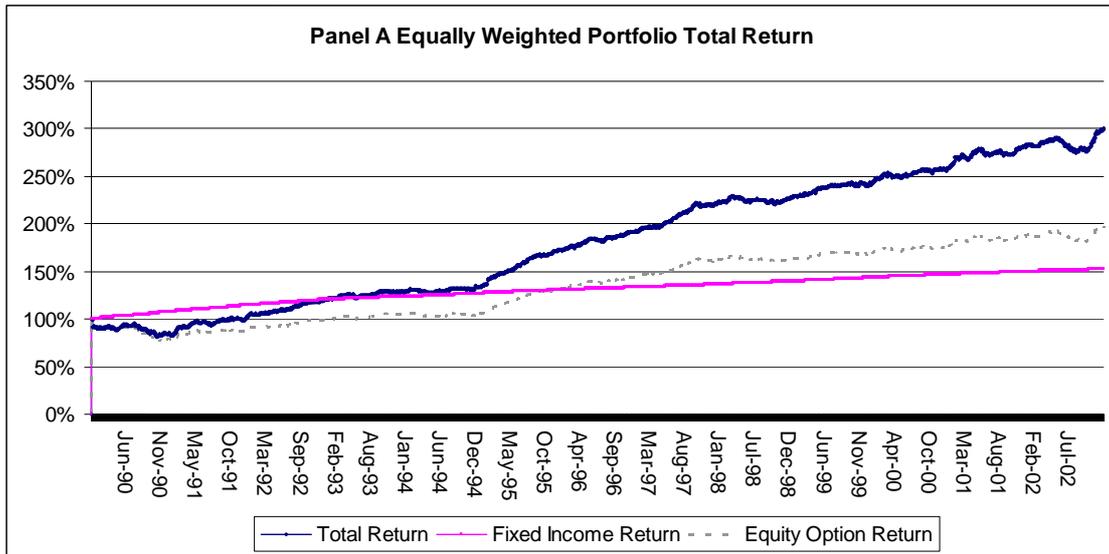


Table 1
Sample summary

This table presents a summary of the individual convertible bond hedges constructed in this paper. Position duration is measured as the number of trading days from the addition of the hedged convertible position to the portfolio to the day the position is closed out. Max position return is the maximum cumulated return of a position from the date of inclusion to the date the position is closed out. Min position return is the minimum cumulated return earned by a position from the date of inclusion to the date the position is closed out. Average position return is the average cumulated return of a position from the date of inclusion to the date the position is closed out. Number of positions closed out is the number of positions which have been closed during a year.

Year	Number of New Positions	Average Position Duration (Yrs)	Max Position Return %	Min Position Return %	Average Position Return %	Number of Positions Closed out
1990	66	11.6	460.7	(95.6)	70.1	
1991	9	9.8	127.5	7.9	51.6	
1992	11	10.1	154.9	(59.5)	20.5	1
1993	10	9.7	88.1	1.26	39.6	2
1994	27	8.3	178	(99.1)	51.4	2
1995	33	6.8	453	(85.5)	46.7	2
1996	10	6.9	194.4	2.9	52.5	14
1997	1	5.4	22.2	22.2	22.2	12
1998	1	5	1	1	1	11
1999	4	3.5	24.1	(69.6)	(7.7)	8
2000	15	2.3	80.7	(85.5)	(4.6)	4
2001	235	1.6	344.3	(96.9)	9.81	16
2002	81	0.27	58.7	(29.6)	0.9	431
Complete Sample	503					503

Table 2**Annual convertible bond arbitrage return series**

This table presents the annual return series for the equally weighted and market capitalization weighted convertible bond arbitrage portfolios, the CSFB Tremont Convertible Arbitrage index, the HFRI Convertible Arbitrage Index, the Russell 3000 Index, the Merrill Lynch Convertible Securities Index and the risk-free rate. The CSFB Tremont Convertible Arbitrage Index is an index of convertible arbitrage hedge funds weighted by assets under management. The HFRI Convertible Arbitrage Index is an equally weighted index of convertible arbitrage hedge funds. The Russell 3000 Index is a broad based index of United States equities and the Merrill Lynch Convertible Securities Index is a broad based index of convertible securities. The risk free rate of interest is represented by the yield on a three-month treasury bill. All annual returns are obtained by compounding monthly returns. Annual standard deviations are obtained by multiplying the standard deviation of monthly returns by $\sqrt{12}$.

Year	Equally Weighted (%)	Mkt Cap Weighted (%)	CSFB Tremont Index (%)	HFRI Index (%)	Russell 3000 (%)	Merrill Lynch CB Index (%)	VIX (%)	Risk Free Rate (%)
1990	-15.83	0.63		2.14	-9.13	-14.43	-17.98	7.75
1991	18.42	21.08		16.21	26.36	21.63	17.82	5.54
1992	16.09	8.82		15.14	6.38	14.70	12.90	3.51
1993	6.51	6.13		14.17	7.82	12.67	17.17	3.07
1994	4.17	2.72	-8.41	-3.80	-2.51	-12.33	22.66	4.37
1995	25.64	21.12	15.33	18.11	28.95	17.00	13.90	5.62
1996	10.36	8.21	16.44	13.59	17.55	8.63	29.69	5.15
1997	13.73	15.00	13.52	11.98	25.83	13.12	2.48	5.20
1998	3.57	11.80	-4.51	7.48	20.15	3.94	83.65	4.91
1999	6.27	6.46	14.88	13.47	17.75	33.17	-1.77	4.78
2000	6.21	7.65	22.82	13.54	-8.90	-15.51	-9.15	6.00
2001	8.80	4.88	13.61	12.55	-13.49	-7.13	-7.99	3.48
2002	6.13	2.97	2.32	8.68	-25.89	-8.15	-21.17	1.64
Mean	8.47 (9.43)	9.30 (9.20)	9.74	11.02 (10.62)	6.99 (6.61)	5.18 (3.64)	0.79 (0.86)	4.69 (4.57)
Standard Deviation	6.04 (4.48)	7.03 (5.91)	4.88	3.37 (3.56)	15.41 (16.37)	12.51 (13.52)	80.47 (86.47)	5.30 (4.56)
Skew	-1.22	0.13	-1.69	-1.39	-0.73	-0.29	0.37	-0.11
Kurtosis	8.49	2.08	4.38	3.35	1.00	1.92	0.99	0.85

*To aid comparison with the CSFB Tremont Convertible Arbitrage Index figures in parenthesis are the average annual rate of return and annual standard deviation of returns from January 1994 to December 2002.

Table 3
Correlation between monthly convertible bond arbitrage returns and market factors

This table presents correlation coefficients for monthly returns on the equally weighted (Equal Portfolio) and market capitalization weighted (MC Portfolio) convertible bond arbitrage portfolios, the CSFB Tremont Convertible Arbitrage Index, the HFRI Convertible Arbitrage Index, and market factor returns. The Russell 3000 is a broad based index of US equities. The Merrill Lynch Convertible Securities Index is an index of US convertible securities and the VIX is an equity volatility index calculated by the Chicago Board Option Exchange. It is calculated by taking a weighted average of the implied volatilities of 8 30-day call and put options to provide an estimate of equity market volatility.

	Russell 3000	ML Convertible Securities	VIX	Equal Portfolio	CSFB Tremont Convertible	MC Portfolio	HFRI Convertible
Russell 3000	1.00						
ML Convertible Securities	0.73***	1.00					
VIX	-0.64***	-0.42***	1.00				
Equal Portfolio	0.50***	0.51***	-0.29***	1.00			
CSFB Tremont Convertible	0.17*	0.29***	0.04	0.33***	1.00		
MC Portfolio	0.58***	0.48***	-0.32***	0.68***	0.24**	1.00	
HFRI Convertible	0.37***	0.49***	-0.13	0.49***	0.80***	0.42***	1.00

*, **, *** indicate coefficient is significantly different from zero at the .10, .05 and .01 levels respectively.

Table 4
Correlation between monthly convertible bond arbitrage returns and market factors in different states of the economy

This table presents correlation coefficients for monthly returns on the equally weighted (Equal Portfolio) and market capitalization weighted (MC Portfolio) convertible bond arbitrage portfolios, the CSFB Tremont Convertible Arbitrage Index, the HFRI Convertible Arbitrage Index, and market factor returns in different states of the economy. The sample was ranked according to equity market returns and then divided into 4 equal sized groups with lowest returns in state 1, next lowest returns in state 2, highest returns in state 4 and next highest returns in state 3. Panels A to D represent correlations coefficients between CBA returns and market factors in each state, 1-4.

Panel A: State 1 returns							
	Russell 3000	ML Convertible Securities	VIX	Equal Portfolio	CSFB Tremont Convertible	MC Portfolio	HFRI Convertible
Russell 3000	1.00						
ML Convertible Securities	0.56***	1.00					
VIX	-0.55***	-0.40**	1.00				
Equal Portfolio	0.15	0.47**	-0.35*	1.00			
CSFB Tremont Convertible	0.57***	0.44**	-0.73***	0.59***	1.00		
MC Portfolio	0.29	0.54***	-0.39**	0.41**	0.15	1.00	
HFRI Convertible	0.40**	0.41**	-0.65***	0.62***	0.90***	0.23	1.00

*, **, *** indicate coefficient is significantly different from zero at the .10, .05 and .01 levels respectively.

Table 4 (continued)

Panel B: State 2 returns

	Russell 3000	ML Convertible Securities	VIX	Equal Portfolio	CSFB Tremont Convertible	MC Portfolio	HFRI Convertible
Russell 3000	1.00						
ML Convertible Securities	0.54***	1.00					
VIX	-0.42**	-0.05	1.00				
Equal Portfolio	0.08	0.06	-0.13	1.00			
CSFB Tremont Convertible	0.03	0.40**	0.32	0.06	1.00		
MC Portfolio	0.06	0.11	0.16	0.44**	0.14	1.00	
HFRI Convertible	-0.13	0.40**	0.45*	0.11	0.79***	0.16	1.00

Panel C: State 3 returns

	Russell 3000	ML Convertible Securities	VIX	Equal Portfolio	CSFB Tremont Convertible	MC Portfolio	HFRI Convertible
Russell 3000	1.00						
ML Convertible Securities	0.44**	1.00					
VIX	-0.09	0.05	1.00				
Equal Portfolio	0.30	0.20	0.02	1.00			
CSFB Tremont Convertible	0.13	0.44**	0.26	0.26	1.00		
MC Portfolio	0.13	0.10	-0.24	0.67***	0.28	1.00	
HFRI Convertible	0.31	0.57***	0.13	0.36*	0.82***	0.36*	1.00

*, **, *** indicate coefficient is significantly different from zero at the .10, .05 and .01 levels respectively.

Table 4 (continued)

Panel D: State 4 returns							
	Russell 3000	ML Convertible Securities	VIX	Equal Portfolio	CSFB Tremont Convertible	MC Portfolio	HFRI Convertible
Russell 3000	1.00						
ML Convertible Securities	0.13	1.00					
VIX	-0.34*	0.07	1.00				
Equal Portfolio	-0.23	0.16	0.23	1.00			
CSFB Tremont Convertible	-0.12	0.10	0.51***	0.39**	1.00		
MC Portfolio	0.02	-0.05	0.37*	0.59***	0.32	1.00	
HFRI Convertible	-0.13	0.22	0.47**	0.44**	0.80***	0.48**	1.00

*, **, *** indicate coefficient is significantly different from zero at the .10, .05 and .01 levels respectively.

Table 5: Summary statistics and cross correlations of daily returns

RMRF is the excess return on the Russell 3000 index, *SMB* and *HML* are Fama and French's factor-mimicking portfolios of size and market to book equity. *TERM* and *DEF* are 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. *EQPORT* is the excess return on the equal weighted simulated convertible arbitrage portfolio and *MCPORT* is the excess return on the market capitalisation weighted portfolio. All of the variables are daily from January 1990 to December 2002.

	Mean	Variance	Skew	Kurtosis	
Panel A: Dependent Variables					
<i>EQPORT</i>	0.0146***	0.12	-3.72***	103.35***	
<i>MCPORT</i>	0.0172**	0.20	-1.10***	19.43***	
Panel B: Explanatory Returns					
<i>RMRF</i>	0.0083	1.02	-0.20***	4.20***	
<i>SMB</i>	0.0064	0.33	-0.44***	3.80***	
<i>HML</i>	-0.0001	0.37	0.02	5.17***	
<i>TERM</i>	0.0015	0.33	-0.12***	3.03***	
<i>DEF</i>	0.0169	0.18	-0.23***	4.73***	
Panel C: Cross Correlations					
	<i>RMRF</i>	<i>SMB</i>	<i>HML</i>	<i>TERM</i>	<i>DEF</i>
<i>RMRF</i>	1.00				
<i>SMB</i>	-0.27***	1.00			
<i>HML</i>	-0.62***	-0.18***	1.00		
<i>TERM</i>	0.11***	-0.13***	0.01	1.00	
<i>DEF</i>	-0.09***	0.13***	0.00	-0.84***	1.00

Statistics are generated using RATS 5.0

*, **, *** indicate coefficient is significantly different from zero at the .10, .05 and .01 levels respectively.

Table 6

Regression of daily equally weighted convertible bond arbitrage returns

This table presents results from the following series of regression of convertible bond arbitrage returns on contemporaneous and lagged excess risk factor returns.

$$R_{CB} - R_f = \alpha + \beta_{RMRF}RMRF + \varepsilon_t$$

$$R_{CB} - R_f = \alpha + \beta_{RMRF}RMRF + \beta_{SMB}SMB + \beta_{HML}HML + \varepsilon_t$$

$$R_{CB} - R_f = \alpha + \beta_{RMRF}RMRF + \beta_{DEF}DEF + \beta_{TERM}TERM + \varepsilon_t$$

$$R_{CB} - R_f = \alpha + \beta_{RMRF}RMRF + \beta_{SMB}SMB + \beta_{HML}HML + \beta_{DEF}DEF + \beta_{TERM}TERM + \varepsilon_t$$

where R_{CB} is the daily return on the equal weighted convertible bond arbitrage portfolio, $RMRF = (RMRF_t, RMRF_{t-1} \text{ and } RMRF_{t-2})$, $SMB = (SMB_t, SMB_{t-1} \text{ and } SMB_{t-2})$, $HML = (HML_t, HML_{t-1} \text{ and } HML_{t-2})$, $DEF = (DEF_t, DEF_{t-1}, DEF_{t-2})$ and $TERM = (TERM_t, TERM_{t-1}, TERM_{t-2})$. Panel A of the table presents results for the entire sample period. Panel B presents results after restricting the sample to those days with excess market returns at least one standard deviation less than their mean. Panel C presents results after restricting the sample to days with excess market returns at least one standard deviation greater than the mean. Panel D presents results after restricting the sample to those days with excess market returns more within one standard deviation of the mean. The β coefficient is the sum of the contemporaneous β and lagged β s. P -values from testing the general linear restrictions that $\alpha = 0$ 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).

Dependent Variable	α	β_{RMRF}	β_{SMB}	β_{HML}	β_{DEF}	β_{TERM}	Adj. R ² (%)	Sample Size
$R_{CB} - R_f$	0.01 (0.01)	0.14 (0.00)					7.6%	3389
$R_{CB} - R_f$	0.01 (0.03)	0.18 (0.00)	0.08 (0.00)	0.07 (0.00)			8.3%	3389
$R_{CB} - R_f$	0.01 (0.02)	0.14 (0.00)			0.23 (0.00)	0.18 (0.00)	7.8%	3389
$R_{CB} - R_f$	0.01 (0.05)	0.16 (0.00)	0.05 (0.00)	0.05 (0.04)	0.20 (0.01)	0.16 (0.00)	8.4%	3389

Table 7

Regression of daily market capitalisation weighted convertible bond arbitrage returns

This table presents results from the following series of regression of convertible bond arbitrage returns on contemporaneous and lagged excess risk factor returns.

$$R_{CB} - R_f = \alpha + \beta_{RMRF}RMRF + \varepsilon_t$$

$$R_{CB} - R_f = \alpha + \beta_{RMRF}RMRF + \beta_{SMB}SMB + \beta_{HML}HML + \varepsilon_t$$

$$R_{CB} - R_f = \alpha + \beta_{RMRF}RMRF + \beta_{DEF}DEF + \beta_{TERM}TERM + \varepsilon_t$$

$$R_{CB} - R_f = \alpha + \beta_{RMRF}RMRF + \beta_{SMB}SMB + \beta_{HML}HML + \beta_{DEF}DEF + \beta_{TERM}TERM + \varepsilon_t$$

where R_{CB} is the daily return on the market capitalisation 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 entire sample period. Panel B presents results after restricting the sample to those days with excess market returns at least one standard deviation less than their mean. Panel C presents results after restricting the sample to days with excess market returns at least one standard deviation greater than the mean. Panel D presents results after restricting the sample to those days with excess market returns more within one standard deviation of the mean. The β coefficient is the sum of the contemporaneous β and lagged β s. P -values from testing the general linear restrictions that $\alpha = 0$ 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).

Dependent Variable	α	β_{RMRF}	β_{SMB}	β_{HML}	β_{DEF}	β_{TERM}	Adj. R ² (%)	Sample Size
$R_{CB} - R_f$	0.02 (0.02)	0.23 (0.00)					11.9%	3389
$R_{CB} - R_f$	0.02 (0.02)	0.24 (0.00)	0.11 (0.00)	0.01 (0.78)			13.3%	3389
$R_{CB} - R_f$	0.01 (0.02)	0.23 (0.00)			0.11 (0.16)	0.10 (0.09)	11.9%	3389
$R_{CB} - R_f$	0.01 (0.02)	0.23 (0.00)	0.11 (0.00)	0.00 (0.95)	0.08 (0.31)	0.10 (0.09)	13.3%	3389

Table 8

Regression of daily equally weighted convertible bond arbitrage returns

This table presents results from the following regression of convertible bond arbitrage returns on contemporaneous and lagged excess risk factor returns.

$$R_{CB} - R_f = \alpha + \beta_{RMRF}RMRF + \beta_{SMB}SMB + \beta_{HML}HML + \beta_{DEF}DEF + \beta_{TERM}TERM + \varepsilon_t$$

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 entire sample period. Panel B presents results after restricting the sample to those days with excess market returns at least one standard deviation less than their mean. Panel C presents results after restricting the sample to days with excess market returns at least one standard deviation greater than the mean. Panel D presents results after restricting the sample to those days with excess market returns more within one standard deviation of the mean. The β coefficient is the sum of the contemporaneous β and lagged β s. P -values from testing the general linear restrictions that $\alpha = 0$ 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).

Dependent Variable	α	β_{RMRF}	β_{SMB}	β_{HML}	β_{DEF}	β_{TERM}	Adj. R ² (%)	Sample Size
Panel A: Entire Sample								
$R_{CB} - R_f$	0.01 (0.05)	0.16 (0.00)	0.05 (0.00)	0.05 (0.04)	0.20 (0.01)	0.16 (0.00)	8.4%	3389
Panel B: Market Return - R_f (1 S.D. less than the mean)								
$R_{CB} - R_f$	0.03 (0.62)	0.10 (0.08)	0.02 (0.49)	-0.08 (0.14)	0.36 (0.08)	0.33 (0.01)	7.2%	403
Panel C: Market Return - R_f (1 S.D. greater than the mean)								
$R_{CB} - R_f$	0.05 (0.14)	0.17 (0.00)	0.08 (0.00)	0.03 (0.51)	0.14 (0.39)	0.13 (0.28)	13.4%	390
Panel D: Market Return - R_f (within 1 S.D. of the mean)								
$R_{CB} - R_f$	0.00 (0.66)	0.19 (0.00)	0.06 (0.00)	0.09 (0.00)	0.23 (0.01)	0.16 (0.01)	5.1%	2598

Table 9

Regression of daily market capitalisation weighted convertible bond arbitrage returns

This table presents results from the following regression of convertible bond arbitrage returns on contemporaneous and lagged excess risk factor returns.

$$R_{CB} - R_f = \alpha + \beta_{RMRF}RMRF + \beta_{SMB}SMB + \beta_{HML}HML + \beta_{DEF}DEF + \beta_{TERM}TERM + \varepsilon_t$$

where R_{CB} is the daily return on the market capitalisation weighted convertible bond arbitrage portfolio, $RMRF = (RMRF_t, RMRF_{t-1}, RMRF_{t-2})$, $SMB = (SMB_t, SMB_{t-1}, SMB_{t-2})$, $HML = (HML_t, HML_{t-1}, HML_{t-2})$, $DEF = (DEF_t, DEF_{t-1}, DEF_{t-2})$ and $TERM = (TERM_t, TERM_{t-1}, TERM_{t-2})$. Panel A of the table presents results for the entire sample period. Panel B presents results after restricting the sample to those days with excess market returns at least one standard deviation less than their mean. Panel C presents results after restricting the sample to days with excess market returns at least one standard deviation greater than the mean. Panel D presents results after restricting the sample to those days with excess market returns more within one standard deviation of the mean. The β coefficient is the sum of the contemporaneous β and lagged β s. P -values from testing the general linear restrictions that $\alpha = 0$ 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).

Dependent Variable	α	β_{RMRF}	β_{SMB}	β_{HML}	β_{DEF}	β_{TERM}	Adj. R ² (%)	Sample Size
Panel A: Entire Sample								
$R_{CB} - R_f$	0.01 (0.02)	0.23 (0.00)	0.11 (0.00)	0.00 (0.95)	0.08 (0.31)	0.10 (0.09)	13.3%	3389
Panel B: Market Return - R_f (1 S.D. less than the mean)								
$R_{CB} - R_f$	-0.02 (0.78)	0.17 (0.03)	-0.02 (0.67)	-0.14 (0.08)	0.15 (0.10)	0.17 (0.08)	5.8%	403
Panel C: Market Return - R_f (1 S.D. greater than the mean)								
$R_{CB} - R_f$	0.13 (0.03)	0.27 (0.00)	0.14 (0.00)	-0.04 (0.52)	0.07 (0.73)	0.10 (0.53)	19.7%	390
Panel D: Market Return - R_f (within 1 S.D. of the mean)								
$R_{CB} - R_f$	0.00 (0.66)	0.26 (0.00)	0.13 (0.00)	0.05 (0.12)	0.09 (0.43)	0.09 (0.27)	7.8%	2598