Liquidity Provision in the Convertible Bond Market: Analysis of Convertible Arbitrage Hedge Funds

Vikas Agarwal
Georgia State University

William H. Fung
London Business School

Yee Cheng Loon
Georgia State University

and

Narayan Y. Naik
London Business School

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Vikas Agarwal and Yee Cheng Loon are from Georgia State University, Robinson College of Business, 35, Broad Street, Suite 1221, Atlanta GA 30303, USA: e-mail: vagarwal@gsu.edu (Vikas) and fncyclx@langate.gsu.edu (Yee Cheng) Tel: +1-404-651-2699 (Vikas) +1-404-651-2628 (Yee Cheng) Fax: +1-404-651-2630. William H. Fung and Narayan Y. Naik are from London Business School, Sussex Place, Regent's Park, London NW1 4SA, United Kingdom: e-mail: bfung@london.edu (William) and nnaik@london.edu (Narayan) Tel: +44-20-7000-8223 (Narayan) +44-20-7000-8227 (William) Fax: +44-20-7000-8201. We are grateful to the following for their comments: David Vang, George Aragon, James Dow, Jeremy Large, Kumar Venkataraman, Mark Hutchinson, Melvyn Teo, Sriram Villuparam, Tao Wu, Tobias Moskowitz, Viral Acharya, Vladamir Atanasov, and the participants at the European Financial Association meetings, European Winter Finance conference 2007, FMA 2006 meetings, FMA European meetings, London School of Economics conference on "Risk and Return Characteristics of Hedge Funds", Man Group, and Second Annual Asset Pricing Retreat. *An earlier version of this paper was adjudged the best paper on hedge funds at the European Finance Association (EFA) 2006 meetings.* We are grateful for funding from INQUIRE Europe and support from BNP Paribas Hedge Fund Centre at the London Business School. Vikas is grateful for the research support in form of a research grant from the Robinson College of Business of Georgia State University. We are thankful to Burak Ciceksever and Kari Sigurdsson for excellent research assistance. We thank Albourne Partners, London for providing us the daily data on CBs and underlying stocks. We are responsible for all errors.

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Abstract

This paper analyzes the risk and rewards of providing liquidity to the convertible bond market. Using daily data on US and Japanese convertible bonds (CBs), we compute returns to a buy-and-hedge arbitrage strategy involving a long position in CBs while hedging the equity, credit, and interest rate risks. We find that this simple strategy can explain a large proportion of returns earned by convertible arbitrage (CA) hedge funds. We also show the importance of incorporating discrete exogenous shocks such as market disruption events and abnormal changes to the convertible arbitrageur's opportunity set such as imbalances between supply and demand for CBs. Finally, we demonstrate that the alphas of CA hedge funds can be explained by the original issue discount in the primary CB market. Overall, the empirical findings are consistent with the notion that arbitrageurs act as liquidity providers to the CB market.

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At the turn of the century, capitalization of global convertible bond ("CB") market stood at just under $300 billion while the US equity market was more than 50 times higher at over $1.5 trillion.[1] Yet during periods of difficult market conditions between 2000 and 2002 (with events such as the Dotcom bubble, September 11, and scandals at Worldcom and Enron), the new issues in both these markets were of a similar order of magnitude, close to $300 billion.[2] This underscores the importance of the CB market as a source of capital for corporations during adverse economic conditions.[3]

To support such a large-scale issuance of CBs, some economic agents need to provide liquidity by buying these CBs in the primary market. They also need to manage the risks associated with holding a long inventory of CBs. During the last decade, there has been a rapid growth in a particular group of economic agents, namely convertible arbitrage ("CA") hedge funds, who have been the major liquidity providers in the CB market.[4] This activity of liquidity provision raises many interesting questions: What are the risks and rewards of hedge funds that provide liquidity in the CB market? What is the nature of arbitrage that CA hedge funds engage

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[1]With the United States having the largest share of the market (about 38%) followed closely by Japan (about 31%). Source: http://www.gabelli.com/news/ahw_102299.html.

[2] Equity data is from Federal Reserve Bulletin (various issues). We thank Jeff Wurgler for making it available on his website http://pages.stern.nyu.edu/~jwurgler/

[3] Prior literature has provided different rationales for firms issuing CBs. These include mitigating the asset-substitution and underinvestment problem (Jensen and Meckling (1976), Green (1984)), resolving the disagreement between managers and debtholders regarding estimating the risk of a firm's activities (Brennan and Kraus (1987), Brennan and Schwartz (1988)), providing an alternative way of equity financing when conventional equity issuance is difficult due to asymmetric information (Constantinides and Grundy (1989), Stein (1992)), and reducing the issuance costs of sequential financing to support firm's long-term strategic investments and mitigating the overinvestment problem at the same time (Mayers (1998)). As such, the quantity of issuance is likely to be affected by business needs exogenous to the CB market. We abstract from studying the motives for issuing CBs in this paper and take the supply of CB as exogenous.

[4] Estimated number of CA hedge funds grew from less than 30 in 1995 to over 250 by the end of 2003. For evidence on CA hedge funds providing liquidity, see, e.g., Woodson (2002), Lhabitant (2002), and Bhattacharya (2000).

in —are they just high-price leveraged mutual funds that just buy-and-hold CBs or do they actively manage the different risks associated with holding a long inventory of CBs? In particular, how do they respond to different market conditions? How are they affected by mismatches between the liquidity demanded by the CB issuers and the risk capital supplied by the investors? Answers to these questions can help identify the determinants of arbitrage profit and provide insight into the risks and rewards of providing liquidity in the CB market. We answer these important questions by modeling the arbitrage strategies of CA hedge funds using daily data on CBs and underlying equities spanning over a decade from January 1993 to April 2003.

In the process of providing liquidity to the CB market, CA hedge funds often end up holding a net long position in CBs. However, unlike mutual fund managers who simply buy and hold securities, a typical CA strategy involves buying a portfolio of CBs with limited liquidity and hedging the equity, credit, and interest rate risks with more liquid instruments. In essence, convertible arbitrageurs act as liquidity providers to an illiquid CB market by hedging the systematic risks using a portfolio of more liquid securities. In this paper, we model the CA hedge fund strategy explicitly using daily prices of the underlying assets to capture the liquidity premium earned by buying illiquid CBs and actively managing the associated risks via relatively liquid instruments. For example, the equity and interest rate risks can be hedged by shorting the stock and risk-free bonds respectively.

Since CB market is relatively illiquid, we ensure that our strategy does not assume unrealistic liquidity in the secondary market. In particular, our strategy involves buying every CB at the first available price and dynamically hedging the equity, credit, and interest rate risks till maturity of the CB or the end of our sample period. For notational convenience, we refer to this buy-and-hedge strategy as strategy X. Strategy X involves actively managing a delta-neutral position while hedging the credit risk and interest rate risk in two major CB markets—CBs denominated in US Dollars and CBs denominated in Japanese Yen. We denote the returns to these two strategies as "X^{US}" and "X^{JP}". Modeling the buy-and-hedge strategy in two different countries allows us to observe the effect of changes in the respective market conditions on CA hedge fund returns.

Like other market agents, CA hedge funds are likely to be affected by extreme liquidity events in the equity and bond markets such as the Long Term Capital Management (LTCM) crisis. Naturally, increased caution among prime brokers and banks follow after such events can lead to a tightening of credit and an increase in borrowing costs—symptoms of a broad-based reduction in liquidity.[5] This gives us a rare opportunity to observe how CA hedge funds respond to a sharp deterioration of liquidity in equity and bond markets. Our empirical results document how CA hedge funds adjusted their exposures in response to stressful market conditions subsequent to the LTCM crisis.

Next we investigate the impact of asynchronous changes in the investment opportunity set and the inflow of risk capital on CA hedge funds. Extant literature has shown that hedge fund returns are adversely affected by money flows chasing past performance.[6] However, if the *supply* of CBs falls out of sync with the *demand* for CA hedge funds, it can have adverse implications for the profitability of CA hedge funds. We demonstrate empirically that supply-demand conditions in the CB market do impact CA hedge fund returns—albeit at varying

[5] For example, see for theoretical and empirical evidence in Rajan (1994), Lang and Nakamura (1995), and Ruckes (2004).

[6] See for example, Agarwal, Daniel, and Naik (2005), Getmansky (2004), and Goetzmann, Ingersoll, and Ross (2003).

degrees. To the best of our knowledge, ours is the first paper to demonstrate the combined effect of demand and supply of the underlying securities on the returns of hedge fund strategies.[7]

It has been well-documented that initial offerings of CBs are underpriced, on average (e.g., Kang and Lee (1996), Amman, King, and Wilde (2003), Chan and Chen (2005), Henderson (2005), and Loncarski et al. (2006)). To reduce our reliance on any theoretical model, we measure underpricing as the difference between the par value of the bond and the first secondary market price (see for example, Kang and Lee (1996)). In addition, there is no fixed schedule for new CB issues to commence trading in the secondary market—the new issue period. Consequently, the elapsed time between the issue date and first available price in the secondary market can vary from days to weeks. Therefore, it is possible that part of the CA hedge funds' returns will not be captured by the X-factors and will be recorded in our model as non-factor related returns, which can be attributed to the original issue discount/premium of CBs. Within the framework of our model, this source of non-factor-related return can be interpreted as compensation for providing liquidity to CB issuers during this new issue period (denoted by "A" in Figure 1). Although the CBs are underpriced, it is not possible to profit from the new issue discount immediately due to the illiquid nature of the secondary market. Thus, the arbitrageurs must be willing to manage the risk of holding CBs in their portfolios if they wish to benefit from the underpricing of new issues. The X-factors capture this active management of inventory risk once the CBs start trading in the secondary market (this period is denoted by "B" in Figure 1). Due to the lack of availability of traded prices of CBs, the extant literature has not studied this issue. Our paper fills this gap in the literature.

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[7] Mitchell and Pulvino (2001) study the effect of only *supply* in terms of the deal flow in the mergers and acquisitions market. However, they do not consider the *demand* effects as we do in this paper.

[9] Since our sample period ends in April 2003, the issuance figures for 2003 are not comparable to the other years.

Our empirical analysis shows that the observed non-factor related returns are between the return of the naïve strategy of buying all new issues of CBs and the perfect foresight strategy in which only underpriced CBs are bought. This evidence is consistent with CA hedge funds bearing some of the costs of adverse selection in order to capture the liquidity premium offered by CB issuers—non-factor related returns are below that of a perfect foresight strategy of participating only in profitable deals. Furthermore, we demonstrate that the non-factor related returns are sensitive to demand-supply conditions. Overall, our findings provide interesting insights into the risks and rewards of liquidity provision in the CB market.

The rest of the paper is organized as follows. Section I describes the data. Section II outlines the models of CA strategies used by CA hedge funds. Section III provides a description of our empirical methodology and our findings. Section IV concludes.

I. Data

Our sample consists of 1,646 US Dollar-denominated ("US" for short) and 585 Japanese Yen-denominated ("Japanese" for short) CBs with contractual information including the conversion price, maturity date, coupon payments, and dividend yield on the underlying stocks. Our sample of 1,646 US and 585 Japanese CBs is substantially larger than those used in the earlier studies for US CBs (ranging from 25 US CBs in Carayannopoulos and Kalimipalli (2003) to 458 US CBs in Henderson (2005)) and Japanese CBs (35 in Buchan (1997)). In addition, unlike previous studies, for our investigation, we use daily closing prices of the CBs and their underlying stocks from January 1993 to April 2003.

Table I provides descriptive statistics of our sample of CBs. Panel A shows that majority of firms have a single CB issue—there are 1,224 different firms issuing a total of 1,646 separate US CBs and 430 different firms issuing 585 separate Japanese CBs. Panel B provides summary statistics on issue size. The average US CB issue is $323 million and the average Yen CB issue is 20 billion Yen ($172 million). The median issue size is $175 million for US CBs and 11 billion Yen ($88 million) for Japanese CBs. Overall, the mean and median issue sizes in the US are about twice of that in Japan.

Table I, Panel C tracks the growth in the number of CB issues in our sample. The issuance activity in the US increased steadily from 91 issues in 1993 to 179 issues in 2002, reaching the peaks of 211 issues and 265 issues in 1997 and 2001 respectively.[9] In contrast, there has been a general decline in the Japanese CB issuance activity, which reached its peak in 1996 (172 issues) and then decreased to 32 issues in 2002. This variation in the supply of CBs over time and across the two markets has important implications for the rewards of liquidity provision in the CB market, as shall become clear later in Section III.E of the paper.

II. A Simple Model of Convertible Arbitrage Strategy

In order to capture the dynamic nature of hedge fund strategies, Fung and Hsieh (1997) put forward a model where a portfolio of hedge funds can be represented as a linear combination of a set of basic, synthetic hedge fund strategies.[10] Ideally, these strategies are rule-based constructs involving observable asset prices, and are similar in concept to the familiar Fama and French (1993) and Carhart (1997) long-short factors used in conventional asset pricing models. Our analysis of CA strategy follows a similar approach in constructing an X factor that captures the essence of trading strategies used by CA hedge funds. As discussed in the introduction, the CA strategy involves buying a CB and hedging out the three main sources of risks — equity risk,

[10] Researchers have examined specific hedge fund strategies using similar approach. See for example, Fung and Hsieh (2001) for trend-following strategy, Mitchell and Pulvino (2001) for merger arbitrage strategy, Agarwal and Naik (2004) for a broad range of equity-related hedge fund strategies, Gatev, Goetzmann, and Rouwenhorst (2006) for equity pairs trading strategy, and Duarte, Longstaff, and Yu (2006) for fixed income arbitrage strategies.

credit (default) risk, and interest rate risk.[11] The following section describes the construction of X factor in details.

II.A. Measuring the returns to a buy-and-hedge strategy (X factor)

As argued before, CA hedge funds act as liquidity supplier to CB issuers. On average, CB issuers reward liquidity providers through favorable terms to buyers of new CB issues. We capture this by postulating a basic CA strategy involving buying every new CB issue and hedging equity, credit, and interest rate risks — a *buy-and-hedge strategy*.[12] Anecdotal evidence suggests that most CA hedge funds are long CBs and short the corresponding hedge earning their return by intermediating between the relative liquidity of CBs and their underlying securities. We assume, accordingly, that the systematic source of return for CA hedge funds comes from managing the inventory risk of CBs once they start trading in the secondary market.

In order to measure the equity risk, we compute the daily return on an issue-size-weighted portfolio of the underlying stocks associated with each CB in the portfolio. We denote this daily return series by EQ_t.[13] Next, we proxy the credit risk, CR_t, in US (Japanese) CBs by the daily change in the spread between the returns on Baa corporate bond index (Japanese corporate bond index) and the 10-year U.S. Treasury bond index (Japanese long-term

[11]See for example Brennan and Schwartz (1977, 1980), Ingersoll (1977), McConnell and Schwartz (1986), Buchan (1997), Tsiveriotis and Fernandes (1998), Davis and Lischka (1999), and Das and Sundaram (2004). Brennan and Schwartz (1977, 1980) and Ingersoll (1977) also consider the optimal call strategies for convertible bonds. It is not obvious that call risk (redemption by the issuer) is a significant risk to CAs. First, CB prices already reflect the likelihood of redemption (e.g., by trading at parity less the accrued interest). Second, there are also behavioral aspects of market agents that are hard to quantify. For instance, Woodson (2002, p.28) notes that convertible issuers in Japan usually do not call their bonds to avoid upsetting their investors. Although this practice may be suboptimal with respect to short-term shareholder wealth maximization, it does mean that convertible arbitrageurs are only subject to a limited amount of call risk in practice.

[12] Buying CBs at issuance and holding them till maturity or the end of our sample period also provides us with two other advantages. First, it gives us defined entry and exit points. Second, it reduces reliance on trade prices in the secondary market for CBs, which are not always available due to limited liquidity in the CB market.

[13] The idea behind using issue-size-weighting is two-fold. First, it implicitly requires minimal rebalancing. Second, it gives more weight to larger issues, thereby accounting for the extent of CB availability to the arbitrageur.

government bond index).[14] Finally, we capture the interest rate risk, IR_t, in US (Japanese) CBs through the daily return index on 5-year U.S. Treasury bonds (Japanese 3-5 year government bonds).

Our modeled CA strategy involves dynamically hedging the risks of the CB portfolio. For this purpose, we estimate the hedge ratios for equity, interest rate, and credit risks by estimating the following regression over a 30-day rolling window:

$$R_{CB,t} = \gamma_0 + \gamma_1 \mathrm{EQ}_t + \gamma_2 \mathrm{IR}_t + \gamma_3 \mathrm{CR}_t + \eta_t \qquad (1)$$

where, $R_{CB,t}$ is the day t return on the issue-size-weighted portfolio of CBs, IR_t is the day t interest rate proxy, and CR_t is the day t credit risk proxy. The return on the convertible arbitrage strategy equals that on a *long* position in newly issued CBs and that on a *short* position in the corresponding stocks, government bonds, and the spread between corporate and government bonds. For computing $R_{CB,t}$, t starts on the first day of trading in the secondary market.[15] The hedge ratios (or the short positions) are given by the slope estimates in equation (1).

The return on the CB portfolio needs to be adjusted for the transaction costs associated with the attendant long/short positions. Here, we assume that the long position in the CBs is financed by borrowing at the discount rate, DISC_t, which is the Fed Funds rate (Japanese discount rate) for US (Japanese) CBs. The interest due on the cash balance from short positions in the underlying stocks (referred to as short rebate) is assumed to be at a lower rate than the borrowing rate by a spread, *s*, (or haircut) – for simplicity, we assume this to be 50 basis points for the US market. The spreads in the US and Japan should be similar when expressed as a fraction of the average borrowing rates in the two countries. Using this criterion provides us with

[14] We obtain these from the Federal Reserve Board website and Datastream.
[15] Note that the X-factor does not include the difference between the issue price and the price at the end of the first trading day. We account for this separately in section III.F.

a haircut spread of 9 basis points in Japan as interest rates in Japan were lower during our sample period.

After adjusting for transaction costs, the returns associated with hedging the equity, credit, and interest rate risks are EQ_t - ($DISC_t - s$), CR_t – ($DISC_t - s$), and IR_t – ($DISC_t - s$) respectively. We denote these cost-adjusted returns by XEQ_t, XCR_t, and XIR_t. Thus, the returns on our X factor after allowing for transaction costs is given by

$$X_t = (R_{CB,t} - \text{DISC}_t) - \hat{\gamma}_1 \text{XEQ}_t - \hat{\gamma}_2 \text{XIR}_t - \hat{\gamma}_3 \text{XCR}_t \quad (2)$$

where X_t is day t return on following the convertible arbitrage strategy, $(R_{CB,t} - \text{DISC}_t)$ is the day t return on the bond portfolio adjusted for borrowing cost (DISC_t) associated with funding the long position in the CB portfolio, and $\text{XEQ}_t, \text{XCR}_t$, and XIR_t are as defined above.[16] Please note that we have been conservative in our choice of haircut spreads. A higher spread would reduce the returns on the X-factor even further and thereby exaggerate the non-factor-related returns to the CA hedge funds. We discuss the robustness of our results to alternative levels of haircut spreads later in Section III.E.

II.B. Descriptive Statistics of returns on buy-and-hedge strategy

II.B.1 Portfolio Characteristics

Table II reports the descriptive statistics of the two X factors—X^{US} and X^{JP}. From Panel A, we can observe that on average, there are 411 (185) US (Japanese) CBs in the portfolios generating the X factor in US (Japan). These bonds have an average current yield of 13%

[16] We do not explicitly consider a "factor" for exchange rate. In practice, most CA hedge funds manage their currency exposure by hedging the exchange rate risk in their non-US bond portfolio. Typically, this is done by funding the foreign currency-denominated bond locally while putting up US dollar collateral as margin. This in effect limits the currency exposure to the unpredictable return component of the strategy and not the principal investment. When we do include an exchange rate factor, we do not find it to be significant in any of our regressions, consistent with the argument above.

(1.23%) and an average parity of 69% (82%). Finally, the average age (time since issuance) of the CBs in X^{US} and X^{JP} is roughly the same—2.4 years for the US and 2.8 years for Japan.

II.B.2 Return Characteristics

Both X factors have daily returns spanning the sample period from January 1993 to April 2003. However, CA hedge fund returns are only available on a monthly basis. Accordingly, we compound the daily X factors returns into monthly returns. Table II, Panel B provides the descriptive statistics of these monthly returns over our sample period. The US (Japanese) factor has average monthly return of 0.52% (0.24%) during the sample period. Although the average monthly returns are positive, the factors are quite volatile. The sample standard deviation of the US factor is about twice the monthly mean (1.05% vs. 0.52%). The Japanese factor is even more volatile, with a standard deviation more than four times that of the monthly mean (1.02% vs. 0.24%).

Table II, Panel C indicates that the two X factors are not highly correlated. The correlation coefficient is 0.20 and is statistically significant at the 5% level. This low level of correlation is consistent with potential diversification benefits combining these trading strategies across the two markets.

III. Empirical Methodology and Results

III.A. Components of CA Hedge Fund Returns

In the process of providing liquidity to the CB market, CA hedge funds are likely to hold net-long inventory of CBs. Although this net-long inventory position may vary over time, in an illiquid CB market, it is unlikely that a net-short inventory position can persist. Although theory suggests that arbitrageurs are likely to minimize the risk of their holdings through active hedging, practicality dictates that some level of outright exposure from time to time cannot be avoided.

For instance, it may be impractical to hedge CBs that are way out of the money.[17] We can therefore think of a CA hedge fund's return comprising of two parts—a passive component and an actively managed component. We proxy the returns on the *passive* or buy-and-hold component by CB mutual fund returns while we capture the returns on the *active* buy-and-hedge component of a CA hedge fund return by the X factor returns.

We use the returns of the *Vanguard Convertible Securities* mutual fund (*VG*), one of the largest mutual funds investing in U.S. dollar denominated CBs, to proxy the performance of a passive *buy-and-hold* strategy in US CBs. Implicit in the Vanguard fund returns are the costs associated with acquiring and carrying a long position in the CB market.[18] However, since the Yen-denominated analogue of the VG variable is not available, we construct a value-weighted index of all Japanese CBs during our sample period — JPVW.[19]

Panel A of Table III reports the descriptive statistics of the returns on passive buy-and-hold strategies in the two markets (VG and JPVW). As can be seen from the first two rows, these have inferior risk-return characteristics, i.e., lower mean returns and higher standard deviation, to the X factors—for US and JP CBs, respectively (reported in Table II, Panel B). With US CBs, the mean monthly return of VG (X^{US}) is 0.32% (0.52%) with a standard deviation of 3.72% (1.05%). For the Japanese CBs, the mean monthly return of JPVW (X^{JP}) is 0.01% (0.24%) with a standard deviation of 2.22% (1.02%). These statistics indicate higher Sharpe ratios for actively managing risks in the CB market.

III.B. Representative Portfolios of the CA Hedge Fund Universe

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17 There may also be instances where hedging is prohibited for short periods of time for new issues. Finally, not all database vendors distinguish between long-biased CB hedge funds from those that rigorously adhere to arbitrage strategies. Only Hedge Fund Research (HFR) has a separate long-biased category for these CB hedge funds.

18 As opposed to the returns of a CB index which typically does not adjust for transactions costs and may not be investable in its entirety.

19 We compute the daily value-weighted returns on the portfolio of Japanese CBs in our sample, and then compound these daily returns to obtain the monthly value-weighted return series of Japanese CBs—JPVW.

As there is no universally accepted proxy for the market portfolio of CA hedge funds, in order to ensure a broad representation of the CA hedge fund universe, we include three widely used CA indexes from three databases — the *Centre for International Securities and Derivative Markets* (*CISDM*), *CSFB Tremont* (*CT*), and *Hedge Fund Research* (*HFR*)—in our analysis. It is important to note that hedge fund indexes are generally constructed from widely diverging samples employing different index construction methods. For example, HFR weights all funds equally, CT gives higher weight to larger funds, while CISDM uses median fund's return. This allows us to test the robustness of our results to different index construction methods.

To illustrate the performance of the buy-and-hedge strategy of the arbitrageurs and the buy-and-hold strategy of the passive mutual funds (Vanguard in the US and value-weighted index of Japanese CBs in Japan), we plot them together in Panel A of Figure 2. The plot suggests that arbitrageurs fare better than the mutual funds during our sample period. We also plot the performance of the US and Japanese X factors in Panel B of Figure 2. The overall trend for the X factors is similar to that of the CA indexes indicating that these factors are going to be useful in explaining the returns on CA indexes, something we explore in the next section.

Hedge funds often report to multiple databases. Therefore, we create an additional CA portfolio using individual hedge fund data from the CISDM, CT, and HFR databases.[20] Figure 3 is a Venn diagram showing the distribution of the CA funds across the three databases. It confirms that although the HFR and CT databases overlap, they do not provide *identical* coverage. A majority of funds come exclusively from CT (about 48% or 74 distinct funds) and HFR (about 22% or 34 distinct funds) databases. Thus, consolidating data across these three databases allows us to create a more comprehensive CA hedge fund portfolio. In particular, we

[20] Agarwal, Daniel, and Naik (2005) report little overlap between these databases. Further, the individual funds in these databases may differ from those included in the indexes. For example, CT indexes require funds to have a minimum AUM of $50 million and a minimum track record of one year.

identify 155 unique funds out of a total of 207 funds that are classified as CA hedge funds spanning the sample period January 1993 to April 2003.[21] We then construct an equally-weighted portfolio of these 155 CA funds and denote this return series by *EW*.

In total, we examine three published CA indexes (*HFR, CT and CISDM*) and our sample average portfolio (*EW*). Panel A of Table III reports the descriptive statistics of monthly returns of these CA indexes and CA equally-weighted portfolio. It shows the mean (median) return for these indexes and portfolio ranges from 0.47% to 0.61% (0.68% to 0.79%) while the standard deviations (SDs) range from 0.67% to 1.38%. As expected, the broad-based variables targeting the central tendency of CA hedge funds' performance (*HFR*, *CT*, *CISDM* and *EW*) fall within a small range.

Panel B reports the correlations among the different CA indexes the CA portfolio, VG, and JPVW. Not surprisingly, we find that the CA indexes and portfolio are highly correlated with each other (correlations ranging from 0.80 to 0.93). Their correlations with VG and JPVW are positive but lower in magnitude. For VG, the range is from 0.34 to 0.60 while for JPVW, it is from 0.37 to 0.47. Finally, Table III, Panel C provides the correlations among the CA indexes, CA portfolio, VG, JPVW, and our two X factors. In general, the CA indexes and CA portfolio show positive significant correlations with both X factors.

Having examined the univariate statistics of CA funds and the passive (buy-and-hold) and active (buy-and-hedge) factors, we next conduct a multivariate analysis of CA fund returns.

III.C. Multivariate Analysis of CA Hedge Fund Returns

[21] From the 207 CA hedge funds from the three databases, we identify duplicates by matching funds by name and by comparing their return histories. When a fund appears in more than one database, we select the fund from the database that has the longest return history for that fund. Eliminating duplicated funds yields a final sample of 155 distinct CA hedge funds. The universe of CA hedge funds has grown substantially over our sample period from 29 funds managing just under $1 billion at the beginning of 1993 to 119 funds managing about $18 billion at the end of 2002.

We begin our analysis by estimating the following regression:

$$\mathrm{CA}_t = \theta_0 + \theta_1 X_t^{US} + \theta_2 X_t^{JP} + \theta_3 \mathrm{VG}_t + \theta_4 \mathrm{JPVW}_t + \psi_t \tag{3}$$

Table IV reports the results that confirm that CA hedge funds have significant exposures to both X factors. The slope coefficients on the US and Japanese X factors are significant for all the three CA indexes and CA individual hedge fund portfolio—at the 1% confidence level for all indexes and portfolio with respect to X^{US}.[22] With respect to the Japanese factor X^{JP}, all three CA indexes are significantly exposed to this factor but only at the 10% level. The loading for the Japanese factor is significant at the 1% level for the equally-weighted portfolio, EW. In addition to the exposure to the active strategies, CA indexes and portfolio also exhibit significant exposure to the two passive strategies — VG and JPVW, with the exception of the CT index not showing significant exposure to either and EW portfolio having insignificant loading on JPVW. Finally, the adjusted-R^2 range from 21.4% for CT index to 51.7% for EW portfolio.[23]

These results are consistent with CA hedge funds acting as liquidity providers in the CB market while actively managing the inventory risk of holding CBs rather than simply passively holding a portfolio of CBs. In other words, CA hedge funds do engage in arbitrage activities. Next we examine how these activities respond to changes in the market environment.

III.D. The Impact of Market Events and Sample Breaks

Since CA hedge funds provide liquidity in the CB market, their returns are likely to be affected during events of extreme illiquidity in the stock and bond markets. In this section, we

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[22] One may argue that the hedge fund returns are net-of-fees while those on our X factors are not. Therefore, for robustness, we also conduct our analysis with gross of fees returns, computed (following Agarwal, Daniel, and Naik, 2005 methodology) on portfolios constructed from CA hedge funds, and find similar results (not reported for brevity).

[23] To further highlight the economic importance of the X factors, we also compare the adjusted-R^2 from our model with the other models used in the hedge fund literature including the Carhart (1997) four-factor model, the Carhart (1997) model augmented with out-of-the-money call and put option on S&P 500 index as in Agarwal and Naik (2004), and the Fung and Hsieh (2004) seven-factor model. The results in Appendix A show that the explanatory power from these three models range from 6% to 30%, which is substantially lower than the range of 21% to 52% obtained with our parsimonious X factor model.

investigate the impact of such events on the exposures of CA funds to the buy-and-hedge and buy-and-hold factors. To model this, we follow recent work by Fung and Hsieh (2004) and Fung et al. (2007) which provide strong evidence of structural breaks in the returns of diversified portfolios of hedge funds due to major market events like the LTCM crisis. At a more micro level, market events may affect different hedge fund strategies differently.

We investigate this issue for the CA hedge funds by identifying the structural breaks systematically using several different approaches. First, we conduct an analysis of our model's forecast errors. Applying a CUSUM procedure similar to Brown, Durbin and Evans (1975), we find that the only consistent boundary violations across all CA portfolios occur during the LTCM crisis and May 2002. Second, we test for the internet bubble break in March 2000 as identified by Fung and Hsieh (2004) but do not find it to be significant for CA hedge funds. Third, we test for two other set of potential structural breaks due to illiquidity in the equity and bond markets. For the equity market, we identify the months where the Pastor and Stambaugh (2003) market-wide liquidity measure is in the bottom 1%. For the bond market, we select the months where the spread between Moody's BAA yield and AAA yield is in the top 1%. The idea here is that the spread widens during turbulent periods in the bond markets when liquidity dries up. These two extreme illiquidity events provide us with four potential breakpoints. One of these coincides with the LTCM crisis. Second is related to the internet bubble break, which we have already verified as insignificant for CA funds. The last two are in February 2002 and July 2002.

Overall, the different methods of identifying structural breaks suggest that the most common breakpoint relates to the LTCM crisis. The other breaks between February 2002 and July 2002 coincide with periods of extreme demand-supply imbalance, an issue we address in the next section. Therefore, we begin with using the LTCM crisis as the only break and estimate the following regression:

$$\begin{aligned} CA_t = {} & D1\left(\omega_0 + \omega_1 X_t^{US} + \omega_2 X_t^{JP} + \omega_3 VG_t + \omega_4 JPVW_t\right) \\ & + D2\left(\omega_0' + \omega_5 X_t^{US} + \omega_6 X_t^{JP} + \omega_7 VG_t + \omega_8 JPVW_t\right) + \kappa_t \end{aligned} \tag{4}$$

where, the pre-LTCM period dummy, D1, takes the value of 1 before the LTCM crisis in September 1998 and equals 0 otherwise. Similarly, D2 represents the post-LTCM period dummy. The other variables are as in equation (3).

Table V, Panel A reports the results. To test the hypothesis of a structural break due to the LTCM crisis, we perform the F-test for $D1 = D2 = 0$ using White's (1980) heteroskedasticity-consistent covariance matrix estimator. Significant Chi-square test statistics are present in all three CA indexes and the EW portfolio along with a number of significant interaction terms suggesting the presence of a structural break corresponding to the LTCM crisis. In addition, there is a general improvement in the adjusted R-square of the model including sample breaks compared to the earlier results reported in Table IV.

Panel A of Table V provides the factor loadings for the pre-LTCM period (top half of the panel) and the factor loadings for the post-LTCM period (middle part of Panel A). The bottom part of Panel A reports the summary statistics. Pre-LTCM, the results are broadly similar to those reported in Table IV in which no break in the sample is assumed. Generally all CA portfolios appear to engage in arbitrage activities in the US CB markets while holding some inventory passively.

In contrast, post-LTCM, passive exposure to inventory (*VG* and *JPVW*) completely disappears. With the exception of the CT index, the remaining two CA indexes and the equally-weighted CA portfolio all exhibit significant factor loadings to X^{US} which is consistent with CA hedge funds retreating to arbitrage-like activity only at the expense of holding passive inventory during the pre-LTCM period. Post-LTCM, with the exception of the CT index at the 10% significance level, the Japanese X factor did not figure at all in the regression. These results represent a divergence from the results in Table IV and point to an apparent increase in risk aversion among CA hedge funds (rising arbitrage-like activity and falling long-inventory exposure) as one would expect from liquidity providers coming out of stressful market conditions.

Finally, the post-LTCM intercepts for all the three CA indexes and the equally-weighted portfolio are positive and statistically significant at the 1% level. Compared to the results reported in Table IV, the evidence now suggests that the previously observed significant non-factor related returns come largely from CA survivors of the LTCM crisis. This in turn begs the question as to what enticed investors and CA hedge funds to return to the CB market post-LTCM and how this may affect CA hedge funds' choice of strategy?

To address these questions, we appeal to other liquidity-related variables that are specific to CA hedge funds' performance—namely, the time-varying pattern of the supply of CBs versus the demand for CA funds.

III.E. How does the supply and demand of CBs affect convertible arbitrageurs?

CA hedge funds play an important role in supplying liquidity to the CB market. As such their performance must be sensitive to the imbalances between supply of and demand for CBs over time. We begin our analysis of the impact of supply-demand mismatch on CA hedge fund performance by augmenting our sample break analysis in the previous section which focused on market wide events to events idiosyncratic to the CB markets—abnormal changes in the supply (issuance) of CBs and the demand for CA hedge funds (capital flow into the CA hedge fund sector).

To estimate the supply of CBs, we aggregate the issue size of US and Japanese CBs in US dollars every month.[25] The demand for CBs from hedge funds is estimated by aggregating the dollar flows into the 155 CA hedge funds at the end of each month in our sample. The use of issue size and flows to proxy the supply of and demand for CBs is consistent with CA hedge funds providing liquidity to the primary CB market.

The possibility exists that demand creates its own supply in the CB market in the sense that issuers deliver new issues in response to the demand from arbitrageurs; see for example Choi, Getmansky, and Tookes (2006). Consequently, the supply-demand dynamics between issuers and CA funds could follow a complex, time-varying lead lag pattern. To model this phenomenon empirically needs longer high-frequency data, which is not available. However, one can compute the imbalance between demand and supply on a period-by-period basis. Therefore, we use the differences in the cumulative supply and demand over time to identify periods of large imbalances between the supply and demand.

Figure 4 plots the *imbalance* series, which is detrended to filter out the influence of time trends. Next, we compute the standardized residuals of the *imbalance* series to identify periods of extreme mismatches that can potentially influence the liquidity provision activity of convertible arbitrageurs. Figure 4 plots this standardized residual series as well. As can be seen, the residual series bottomed around December 1999 and peaked in June 2002. These provide us two potential structural breaks emanating from supply-demand imbalances—we label these as imbalance I and imbalance II respectively. Please recall that the second break identified in June

[25] We convert the issue size of Japanese CBs into US dollars using the monthly Yen/USD exchange rate before adding it to that of US CBs.

2002 also coincides with the market wide liquidity events discussed earlier in Section III.D. Next, we empirically investigate if these breaks are supported in our data.

Altogether there are now three potential structural breaks in the data: a market wide event due to the LTCM episode (September 1998) and the two idiosyncratic events due to the supply-demand conditions of the CB market (imbalance I circa December 1999 and imbalance II circa June 2002). We extend Equation (4) to accommodate the additional structural breaks as follows:

$$CA_t = \sum_{j=1}^{4} \lambda_{0j} D_j + \lambda_1 X_t^{US} + \lambda_2 X_t^{JP} + \lambda_3 VG_t + \lambda_4 JPVW_t + \xi_t \qquad (5)$$

where, λ_i are slope coefficients defined as

$$\lambda_i = \lambda_{i1} D1 + \lambda_{i2} D2_A + \lambda_{i3} D2_B + \lambda_{i4} D2_C, \qquad i = 1, 2, 3, 4$$

The first sub period corresponds to the pre-LTCM period represented by dummy D1, as before. The post-LTCM period which was captured by dummy D2 before in equation (4) is now divided into three sub periods, denoted by $D2_A$, $D2_B$, and $D2_C$. These represent the post-LTCM period up to the pre-imbalance I period (October 1998 to December 1999), the post-imbalance I and pre-imbalance II period (January 2000 to June 2002), and the post-imbalance II period (July 2002 to April 2003). The dummies take a value of 1 if the period corresponds to one of the four sub periods and 0 otherwise. The other explanatory variables are as before.

We report the results from the regression in equation (5) in Table V, Panel B. First, we perform the F-test to test the hypothesis of structural break dummies being jointly equal to zero. The test statistic rejects it overwhelmingly in all cases. Further, we find the Chi-square statistics to be significant in cases confirming the presence of additional structural breaks arising from supply-demand imbalances. Finally, we continue to witness improvement in the explanatory power of the model going from Table IV to Table V, Panel A as well as from Panel A to Panel B of Table V. Overall, these results confirm the importance of incorporating the effect of market wide events and mismatches between supply and demand on the strategies of liquidity providers in the CB market.

As expected, the results for the first sub period are identical to those reported for the same period in Table V, Panel A. During period $D2_A$ (first sub period immediately following the LTCM crisis), we do not find much significant exposures. This is consistent with the aftermath of a market wide event such as LTCM crisis, which puts pressure on arbitrageurs to reduce risk. The remaining two sub periods, $D2_B$ and $D2_C$, show more interesting patterns. During $D2_B$ period, we observe a general shift from holding passive inventory to arbitrage activities. All the four CA portfolios—*CISDM, CT, HFR* and EW exhibit significant loadings to X^{JP} and to a lesser extent $X^{US.}$ This is consistent with a general improvement in the supply-demand condition in the market post-LTCM during which arbitrage opportunities in Japan, in particular, begin to reemerge.

Responding both to the fading memories of the LTCM event and better supply-demand conditions, the final sub period, $D2_C$ sees the revival of the arbitrage (buy-and-hedge) activity in the US market. In addition, there is a shift towards passive buy-and-hold activity in both the markets.

Comparing these new results to those reported in Table V, Panel A earlier where only the LTCM sample break was included, we now see that the post-LTCM effect of increased arbitrage activities took place much later during the third and fourth sub periods coinciding with an improvement in the supply-demand conditions. These two sub periods also are associated with significant intercept terms for all four broad-based portfolios (*CISDM, CT, HFR and EW*).[26] In the next section, we provide an interpretation of this phenomenon.

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[26] These intercepts cannot be explained by our choice of the haircut spreads. In unreported results, we test the robustness of our results to the use of different spreads ranging between zero and 100 basis points, and find

Until now, we use portfolios of CA funds either in the form of CA indexes or an equally-weighted portfolio of individual CA funds. Although this conveys the overall picture, it masks interesting cross-sectional variation among different liquidity providers to the CB market. Furthermore, investors who provide risk capital to the CA funds are arguably interested in individual fund's performance rather than the performance of non-investable CA indexes.

Unlike the indexes and portfolios, individual CA hedge funds enter and leave the databases at different points in time. Selecting funds with return history over the ten-year period would not only introduce significant survivorship bias but also reduce the sample size substantially. Therefore, we estimate a regression with the four independent variables (X^{US}, X^{JP}, VG, and JPVW) for each of the four sub periods separately.

We report the average alphas and factor loadings on the active and passive components across the 155 funds in Table VI, Panel A. Three interesting observations stand out from this cross-sectional analysis. First, we find significant average intercepts in all sub periods varying from 30 bp to 80 bp per month.[27] Second, consistent with our findings for the CA indexes and EW portfolio, we find that these intercepts are larger in the third and fourth sub periods coinciding with the improvement in the demand-supply conditions. Third, we observe that on average, individual funds show significant exposure to the active buy-and-hedge factor in the US during all sub periods except one immediately following the LTCM crisis. In contrast, they exhibit significant factor loading on the Japanese X factor during the second and third sub periods. They also show exposure to buy-and-hold strategy in the US and Japan during most sub periods.

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qualitatively similar results.

[27] Please note that the significance here is related to the cross-sectional dispersion in alphas and essentially tests if the average alphas for the 155 funds in each of the four sub periods are different from zero or not.

Since the results in Table VI, Panel A averages the intercept terms regardless of their statistical significance, we also report in Panel B, the results by including only those intercepts that are significant at the conventional levels. We find that a large number of funds deliver significant non-factor related returns (or "alphas" for short) during each of the four sub periods (23 out of 63, 15 out of 66, 53 out of 75, and 30 out of 72 respectively). The magnitude of these returns is higher (ranging from 60 bp to 170 bp per month) in the third and fourth sub periods. This finding confirms our earlier result at the portfolio level where favorable supply-demand conditions (see the upward trend in the standardized residuals of imbalance series plotted in Figure 4) appear to induce significant alphas.

Overall, the findings from this section indicate that there are significant alphas that vary across different sub periods. In the next section, we explore a potential source of these time-varying alphas.

III.F. Alphas and original issue discount in the CB market

We know from the results in Table V, Panel A that statistically significant alpha from CA hedge funds is primarily a post-LTCM phenomenon. Table V, Panel B breaks down this observation further and points to the more recent sub periods of our data as the main source of alpha. Finally, Table VI confirms these findings for individual CA hedge funds. As argued in the previous section, these two sub periods are marked by rising bond issuance accompanied by an increase in the risk capital applied towards liquidity provision in the CB market. The positive alphas from our model of CA hedge fund returns can be interpreted as compensation for providing liquidity to CB issuers during the new issue period (denoted by "A" in Figure 1).[28] We

[28] Positive alphas are also consistent with the predictions of asymmetric-information-based theoretical models of the price behavior of new issues. In models such as Benveniste and Spindt (1989), Benveniste and Wilhelm (1990), Spatt and Srivastava (1991), and Sherman and Titman (2002), better-informed investors are compensated through favorable prices for truthfully revealing their private information. Ljungqvist (2005) discusses the asymmetric

deliberately distinguish these alphas from the returns on the X-factors, which are the rewards accruing to CA hedge funds for actively managing the inventory risk once the CBs start trading in the secondary market (period denoted by "B" in Figure 1). In this section, we analyze the extent to which the observed alpha can be attributed to the underpricing of original issuance of CBs and the gains/losses from delta-hedging originating at the time of issuance. This, in turn, will shed light on the future of CA hedge fund alphas should the supply/demand continues to extreme levels.

Similar to equity initial public offerings (IPOs), empirical studies have pointed to underpricing in IPOs of convertible bonds (see for example, Kang and Lee (1996), Amman, King, and Wilde (2003), Chan and Chen (2005), Henderson (2005), and Loncarski et al (2006)). For our analysis, we define the new issue discount/premium ("NIDP") as the difference between the CB's par value and the first reported closing price. To measure this NIDP for our sample of CBs, we form a portfolio of all newly issued CBs and compute the NIDP for each bond for each month in our sample period weighting each bond in the portfolio according to its issue size. This gives us a time series of NIDP depending solely on the quantity of new CB issues and how they are priced when secondary market prices first become available.

To investigate whether CA hedge funds are able to pick out the most promising new issues, i.e., issues generating underpricing returns, we form the issue-weighted "hot issue" underpricing series. We construct this series in the same way as the NIDP series for all CB issues, except that we now select only bonds that are under priced or an NID series.

Since there is usually some delay between the issue date and the first reported price for the CBs, CA hedge funds would delta hedge the equity risk to insulate themselves from adverse

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information models and alternative theoretical models of underpricing in his comprehensive survey of the literature on initial public offerings.

movements in the prices of the underlying stocks. We have been careful to account for this somewhat subtle effect of the arbitrage activity during the "delay" period. Specifically, in addition to benefiting from the average underpricing of CBs, the liquidity providers would also incur gains/losses resulting from the delta-hedging of the stock. To compute the proceeds from delta-hedging, we multiply the delta of the CB by the stock return measured over the period between the issue date and the first day of available bond price. As with the underpricing series, we compute an issue-weighted series of monthly proceeds from delta hedging.

Table VII, Panel A reports the (a) initial offering price discount/premium from all issues—the NIDP series, (b) underpricing from only hot issues—the NID series, and (c) proceeds from the delta hedging initiated by the CA funds at the time of issuance.[29] We then consider two cases. First scenario corresponds to the liquidity provider subscribing to all the new CB issues. Second scenario represents perfect foresight where the liquidity provider only subscribes to the hot issues (the underpriced ones). The returns from underpricing in this case would be higher as the liquidity provider is able to avoid overpriced issues. In both cases, the total return would be the sum of underpricing and the proceeds from delta hedging. The last two rows of Table VII, Panel A report the total returns from these two scenarios.

If CA funds were to carry an average factor loading of one across the four factors, then they would realize the total returns from underpricing and delta-hedging computed above. However, since their average factor loading is much less than unity (see Table V, Panel B and Table VI, Panel A), they are able to capture only a part of the returns from underpricing. For example, for the CT index, the underpricing in the first sub period realized from buying all (hot) issues would be an average of the factor loadings on the four factors — 0.137 (average of 0.288,

[29] To mitigate the influence of outliers, we winsorize the underpricing series at the 5th and 95th percentile.

–0.032, 0.145, and 0.147 in Table V, Panel B) multiplied by 0.47% (2.43%) to yield 0.06% (0.33%). Hence, if the alphas are indeed related to the level of realized underpricing in the two scenarios — all issues and hot issues, then the range of average monthly alpha for the CT index should be between 0.06% and 0.33% per month. Using a similar approach, Table VII, Panel B reports the ranges of monthly alphas for the three CA indexes, equally-weighted CA portfolio, and the individual funds for the four sub periods.

Finally, we report the actual averages of monthly alphas for the three CA indexes, EW portfolio, and the individual funds from the earlier tables (Table V, Panel B and Table VI, Panel A) in Table VII, Panel C. The key result here is that in an overwhelming majority of the cases (17 out of the 20), the realized average monthly alphas fall within the corresponding range of monthly alphas reported in Table VII, Panel B. Continuing with the same example as above, the realized average alpha of 0.10% per month for the CT index in first sub period (from Panel C) is within 0.06% and 0.33% per month (from Panel B).

Overall, the results in Table VII lead us to three main conclusions. First, CA hedge funds do not buy all deals. Panels B and C of Table VII provide evidence consistent with this argument — the realized alphas in Panel C are generally greater than the lower bound of the range of monthly alphas in Panel B. Second, the lower realized alphas in Panel C partly reflect the high fees charged by hedge funds since these alphas are computed using net-of-fee returns. Finally, CA hedge funds may not buy all deals but they do not have perfect foresight. Their realized alphas are lower than the alphas earned from selecting only hot issues. It is arguably the case that one has to participate in "expensive deals" in return for being offered "attractive deals". Our findings are consistent with the notion that CA hedge funds cannot engage in cherry-picking all the time.

IV. Concluding Remarks

This paper provides a rare glimpse into the risks and rewards of providing liquidity in the convertible bond market. We do so by directly modeling the trading strategies that a convertible arbitrageur uses while managing the inventory risk of convertible bonds. Using daily data from the underlying convertible bond and stock markets in the US and Japan, we implement a buy-and-hedge trading strategy in each of these two markets. This involves buying the convertible bonds at issuance and holding them till maturity, while hedging the attendant risks – equity, interest rate, and credit risks. Our empirical results show that such an active arbitrage strategy explains a large proportion of the return variation in convertible arbitrage hedge funds. In addition, we demonstrate the importance of incorporating discrete exogenous shocks such as market wide liquidity events such as the LTCM crisis and abnormal changes to the convertible arbitrageurs' opportunity set such as imbalances between demand and supply of convertible bonds. Finally, our results reveal that the non-factor related returns or alphas of convertible arbitrage hedge funds are of an order of magnitude consistent with the original issue discount in the primary convertible bond market. Overall, these findings are consistent with the theoretical pretext that arbitrageurs act as liquidity providers to the convertible bond market.

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Table I: Descriptive statistics of U.S. and Japanese convertible bonds

This table provides the summary statistics of our sample of 1,646 U.S. and 585 Japanese convertible bonds during our sample period from January 1993 to April 2003. Panel A provides the breakdown of our sample by the number of issues per issuer. Panel B provides the summary statistics of issue size (in millions of USD). To convert the Japanese bond issue sizes from Yen to US dollars, we use the time series average of daily Yen/USD exchange rates during our sample period. Panel C reports the number of issues during each year by summing the issues across 12 months for 1993-2002 and 4 months for the last year, 2003.

Panel A: Breakdown of sample by the number of issues per issuer						
	U.S. bonds			Japanese bonds		
	Number of issues per issuer	Number of issuers	Total number of bonds	Number of issues per issuer	Number of issuers	Total number of bonds
	1	954	954	1	317	317
	2	178	356	2	87	174
	3	55	165	3	14	42
	4	20	80	4	10	40
	5	15	75	5	1	5
	7	1	7	7	1	7
	9	1	9			
		1,224	1,646		430	585
Panel B: Summary statistics of issue size						
Average issue size (mil)		$ 323			$ 172	
25th percentile (mil)		$ 100			$ 62	
50th percentile (mil)		$ 175			$ 88	
75th percentile (mil)		$ 350			$ 176	
Panel C: Number of issues each year						
		US			Japan	
1993		91			42	
1994		70			133	
1995		78			44	
1996		185			172	
1997		211			31	
1998		177			13	
1999		148			46	
2000		176			34	
2001		265			29	
2002		179			32	
Until April 2003		66			9	

Table II: Descriptive Statistics of X factor

Panel A provides the daily average of the number of bonds, current yield, parity, and age of bonds in the portfolios generating the X factor, where the daily average is taken across all bonds in each of the portfolios by weighting them on issue size during our sample period from January 1993 to April 2003. Current yield is computed using a full year's coupon divided by the bond's price (which incorporates accrued interest). Parity is the bond's conversion value as a percentage of the par value. Age of bonds is the number of years since the bond was issued. Panels B and C provide the descriptive statistics of and correlations between the monthly returns of the U.S. and Japanese X factors during our sample period from January 1993 to April 2003. The superscripts US and JP for the ABS factors indicate whether they are US or Japanese ABS factors. *, **, and *** indicate that the coefficient is significantly different from zero at the 10, 5, and 1% levels respectively.

Panel A

	X^{US}	X^{JP}
Average no. of CBs	411	185
Current yield (%)	13	1.23
Parity (%)	69	82
Age of bonds (in years)	2.4	2.8

Panel B

	Mean (%)	Median (%)	SD (%)	Min. (%)	Max. (%)	Skew	Kurt
X^{US}	0.52%	0.58%	1.05%	-1.36%	2.23%	-0.15	-0.95
X^{JP}	0.24%	0.26%	1.02%	-1.65%	2.34%	0.13	-0.27

Panel C

	X^{US}	X^{JP}
X^{US}	1.00	
X^{JP}	0.20^{**}	1.00

Table III: Descriptive Statistics of the long-biased Convertible Bond portfolios and the Convertible Arbitrage Portfolios

Panel A of this table provides the descriptive statistics of the monthly returns of the Vanguard Convertible Securities mutual fund (VG), and the value-weighted index of all Japanese convertible bonds (JPVW); three convertible arbitrage (CA) indexes (CISDM, CT, and HFR), and an equally-weighted portfolio of all CA hedge funds (EW) from January 1993 to April 2003. The descriptive statistics include mean, median, standard deviation (SD), minimum (Min.), maximum (Max.), skewness (Skew), and kurtosis (Kurt). Panel B provides the correlations among the above return series. Panel C reports the correlations between these 10 return series to the two X factors. The CT index starts in January 1994. *, **, and *** indicate that the coefficient is significantly different from zero at the 10, 5, and 1% levels respectively.

Panel A: Summary Statistics

	Mean (%)	Median (%)	SD (%)	Min. (%)	Max. (%)	Skew	Kurt
VG	0.32	0.22	3.72	-13.25	10.11	-0.43	1.33
JPVW	0.01	0.08	2.22	-7.11	8.09	0.34	1.95
CISDM	0.61	0.74	0.67	-2.35	2.20	-1.36	3.98
CT	0.47	0.79	1.38	-5.10	3.07	-1.69	4.55
HFR	0.57	0.71	0.98	-3.65	2.93	-1.39	3.99
EW	0.56	0.68	1.03	-4.00	2.55	-1.08	2.51

Panel B: Correlations between VG, JPVW, the CA indexes, and the five CA portfolios from our sample

	VG	JPVW	CISDM	CT	HFR	EW
VG	1.00					
JPVW	0.29^{***}	1.00				
CISDM	0.55^{***}	0.42^{***}	1.00			
CT	0.34^{***}	0.37^{***}	0.80^{***}	1.00		
HFR	0.51^{***}	0.44^{***}	0.93^{***}	0.80^{***}	1.00	
EW	0.60^{***}	0.47^{***}	0.92^{***}	0.81^{***}	0.90^{***}	1.00

Panel C: Correlations among CA indexes, CA portfolios, Vanguard, JPVW, and the X factors

	X^{US}	X^{JP}
VG	0.54^{***}	0.17^{*}
JPVW	0.35^{***}	0.71^{***}
CISDM	0.55^{***}	0.33^{***}
CT	0.41^{***}	0.33^{***}
HFR	0.55^{***}	0.35^{***}
EW	0.57^{***}	0.42^{***}

Table IV: Regression analysis with Vanguard Fund, Value-weighted index of Japanese convertible bonds and ABS factors

This table provides the results of the following OLS regression during our sample period from January 1993 to April 2003:

$$\text{CA}_t = \theta_0 + \theta_1 X_t^{US} + \theta_2 X_t^{JP} + \theta_3 \text{VG}_t + \theta_4 \text{JPVW}_t + \psi_t$$

where, CA_t are the excess returns (in excess of risk-free rate - US Fed Funds rate) during month *t* on the convertible arbitrage (CA) hedge fund indexes (CISDM, CT, or HFR) or our equally-weighted index of all the CA funds in our sample (EW), X_t^{US} and X_t^{JP} are the returns during month *t* on the US and Japanese X factors, VG_t is the excess return during month *t* on the Vanguard Convertible Securities mutual fund (VG), and $JPVW_t$ is the excess returns during month *t* on the value-weighted index of all Japanese convertible bonds (JPVW). *, **, and *** indicate that the coefficient is significantly different from zero at the 10, 5, and 1% levels respectively. *p*-values are computed using Newey-West (1987) standard errors.

	CISDM	***CT***	***HFR***	***EW***
Intercept	0.005***	0.002	0.004***	0.003***
X^{US}	0.193***	0.332***	0.303***	0.287***
X^{JP}	0.083*	0.275*	0.127*	0.250***
VG	0.060***	0.051	0.072***	0.105***
JPVW	0.038*	0.039	0.068**	0.037
Adj R^2	41.96%	21.41%	41.09%	51.74%

Table V: Regression analysis with structural breaks

This table provides the results of OLS regressions during our sample period from January 1993 to April 2003. Panel A reports the results from the regression:

$CA_t = D1\left(\omega_0 + \omega_1 X_t^{US} + \omega_2 X_t^{JP} + \omega_3 VG_t + \omega_4 JPVW_t\right) + D_2\left(\omega_0^{'} + \omega_5 X_t^{US} + \omega_6 X_t^{JP} + \omega_7 VG_t + \omega_8 JPVW_t\right) + \kappa_t$ where, CA_t are the excess returns during month *t* on the convertible arbitrage (CA) hedge fund indexes (CISDM, CT, or HFR) or our equally-weighted index of all the CA funds in our sample (EW), X_t^{US} and X_t^{JP} are the returns during month *t* on the US and Japanese X factors respectively, VG_t is the excess return during month *t* on the Vanguard Convertible Securities mutual fund (VG), and $JPVW_t$ is the excess returns during month *t* on the value-weighted index of all Japanese convertible bonds (JPVW). There is no intercept term as the regression includes both the dummies. The pre-LTCM (post-LTCM) period dummy, D1 (D2), takes the value of 1 (0) before (after) the LTCM crisis in September 1998 and equals 0 (1) otherwise. Panel B reports the results from the regression: $CA_t = \sum_{j=1}^{4} \lambda_{0j} D_j + \lambda_1 X_t^{US} + \lambda_2 X_t^{JP} + \lambda_3 VG_t + \lambda_4 JPVW_t + \xi_t$ where λ_i are slope coefficients defined as $\lambda_i = \lambda_{i1} D1 + \lambda_{i2} D2_A + \lambda_{i3} D2_B + \lambda_{i4} D2_C, \quad i = 1,2,3,4$. The four structural break dummies, D1, $D2_A$, $D2_B$, and $D2_C$, correspond to pre-LTCM period (February 1998 to September 1998), post-LTCM and pre-imbalance I period (October 1998 to December 1999), post-imbalance I and pre-imbalance II period (January 2000 to June 2002), and post-imbalance II period (July 2002 to April 2003). The dummies take a value of 1 if the period corresponds to one of the four subperiods and 0 otherwise. *, **, and *** indicate that the coefficient is significantly different from zero at the 10, 5, and 1% levels respectively. *p*-values are computed using Newey-West (1987) standard errors.

Panel A: Only LTCM Break

	CISDM	CT	HFR	EW
D1	0.004***	0.001	0.003*	0.003*
D1 x X^{US}	0.170**	0.288*	0.261***	0.268***
D1 x X^{JP}	0.059	-0.032	0.051	0.223**
D1 x VG	0.118***	0.145**	0.170***	0.198***
D1 x JPVW	0.045*	0.147**	0.080***	0.034
D2	0.006***	0.005**	0.005***	0.004***
D2 x X^{US}	0.254***	0.166	0.383***	0.354***
D2 x X^{JP}	0.009	0.591*	0.087	0.144
D2 x VG	0.019	0.033	0.006	0.042
D2 x JPVW	0.041	-0.035	0.089	0.071
Adj R^2	46.90%	26.59%	47.81%	56.52%
LTCM break χ^2 stat (df = 5)	287.88***	44.46***	181.99***	173.32***
D1=D2=0 F-value	40.67***	3.41**	12.01***	9.72***

Table V: Regression analysis with structural breaks (continued)

Panel B: LTCM and Demand-Supply Imbalance Breaks

	CISDM	CT	HFR	EW
D1	0.004***	0.001	0.003*	0.003*
D1 x X^{US}	0.170**	0.288*	0.261***	0.268***
D1 x X^{JP}	0.059	–0.032	0.051	0.223**
D1 x VG	0.118**	0.145**	0.170***	0.198***
D1 x JPVW	0.045*	0.147*	0.080***	0.034
$D2_A$	0.005***	–0.001	0.004*	0.002
$D2_A$ x X^{US}	0.043	–0.482	0.505	–0.168
$D2_A$ x X^{JP}	–0.076	0.968	–0.136	0.344
$D2_A$ x VG	0.050	0.118	–0.012	0.147**
$D2_A$ x JPVW	0.085	0.004	0.173	0.087
$D2_B$	0.006***	0.008***	0.006***	0.004***
$D2_B$ x X^{US}	0.158	–0.074	0.216	0.329**
$D2_B$ x X^{JP}	0.211***	1.079***	0.373***	0.335***
$D2_B$ x VG	0.016	0.076	0.008	0.036
$D2_B$ x JPVW	0.083	–0.067	0.079	0.061
$D2_C$	0.007***	0.005**	0.006**	0.008***
$D2_C$ x X^{US}	0.333***	0.597***	0.535***	0.320**
$D2_C$ x X^{JP}	–0.104	–0.015	–0.125	–0.123
$D2_C$ x VG	0.083***	0.140***	0.107***	0.099***
$D2_C$ x JPVW	0.335***	0.307*	0.347***	0.523***
Adj R^2	47.90%	29.76%	47.71%	55.63%
LTCM break χ^2 stat (df = 5)	287.88***	44.46***	181.99***	173.32***
Imbalance I break χ^2 stat (df = 5)	110.72***	13.28**	31.45***	87.90***
Imbalance II break χ^2 stat (df = 5)	72.12***	33.44***	58.44***	53.43***
$D1=D2_A=D2_B=D2_C= 0$ F-value	20.54***	2.86**	5.86***	4.75***

Table VI: Results of the structural break model for individual hedge funds

This table provides the summary of results of OLS regressions for 155 individual convertible arbitrage (CA) funds during our sample period from January 1993 to April 2003. Panel A reports the average intercepts, factor loadings, and adjusted R-squares from the regression in Table IV estimated separately for each of the four sub periods. X_t^{US} and X_t^{JP} are the returns during month *t* on the US and Japanese X factors respectively, VG_t is the excess return during month *t* on the Vanguard Convertible Securities mutual fund (VG), and $JPVW_t$ is the excess returns during month *t* on the value-weighted index of all Japanese convertible bonds (JPVW). Period I corresponds to pre-LTCM period (February 1998 to September 1998), Period II is post-LTCM and pre-imbalance I period (October 1998 to December 1999), Period III is the post-imbalance I and pre-imbalance II period (January 2000 to June 2002), and Period IV is post-imbalance II period (July 2002 to April 2003). Panel B reports the averages of the intercepts significant at the 1%, 5%, and 10% levels and the number of funds within brackets that exhibit these intercepts. *, **, and *** indicate that the coefficient is significantly different from zero at the 10, 5, and 1% levels respectively. *p*-values are computed using Newey-West (1987) standard errors.

Panel A: Average alphas and factor loadings for individual CA funds

	Period I	*Period II*	*Period III*	*Period IV*
Intercept	0.003***	0.003***	0.005***	0.008***
X^{US}	0.209***	-0.202	0.165**	0.395***
X^{JP}	0.089	0.367**	0.497***	-0.124
VG	0.197***	0.171***	0.025*	0.083***
JPVW	0.085***	0.059	0.088***	0.476***
# funds	63	66	75	72
Adj R^2	21.15%	9.78%	9.56%	34.00%

Panel B: Averages of significant alphas (number of funds)

	Period I	*Period II*	*Period III*	*Period IV*
1% level	0.007 (16)	0.008 (2)	0.009 (34)	0.017 (4)
5% level	0.010 (5)	0.009 (9)	0.006 (11)	0.015 (15)
10% level	0.007 (2)	0.009 (4)	0.006 (8)	0.014 (11)

Table VII: Analysis of alphas, underpricing, and proceeds from delta-hedging at issuance

Panel A reports the average monthly new issue discount/premium (NIDP) (difference between the first reported price and the convertible bond's par value), underpricing from only hot issues (NID), and the proceeds from the delta hedging from issuance date to the date of the first reported price. Both underpricing and delta-hedging proceeds are weighted by the issue size, and have been winsorized each sub period at the 5th and 95th percentiles. Period I corresponds to pre-LTCM period (February 1998 to September 1998), Period II is post-LTCM and pre-imbalance I period (October 1998 to December 1999), Period III is the post-imbalance I and pre-imbalance II period (January 2000 to June 2002), and Period IV is post-imbalance II period (July 2002 to April 2003). Panel B provides the range of monthly alphas for the three CA indexes (CISDM, CT, and HFR), an equally-weighted portfolio of individual hedge funds (EW), and averages of monthly alphas across individual funds during the four sub periods. This range is estimated by taking an average of their factor loadings across the four sub periods from Table V, Panel B and Table VI, Panel A, and then multiplying them with the second-last (last) row of Panel A of this table to provide the lower (upper) bound of the range. Panel C of this table reports the average monthly alphas for the three CA indexes (CISDM, CT, and HFR) from Table V, Panel B, an equally-weighted portfolio of individual hedge funds (EW) from Table V, Panel B, and averages of monthly alphas across individual funds during the four sub periods from Table VI, Panel A.

Panel A: Average issue-weighted underpricing and proceeds from delta-hedging in different subperiods

	Period I	*Period II*	*Period III*	*Period IV*
New issue discount/premium (NIDP) (1)	0.64%	1.01%	1.68%	0.79%
Underpricing from only hot issues (NID) (2)	2.60%	3.76%	5.40%	4.88%
Proceeds from delta-hedging (3)	–0.17%	0.02%	0.25%	0.09%
(1) + (3)	0.47%	1.03%	1.93%	0.88%
(2) + (3)	2.43%	3.78%	5.65%	4.97%

Panel B: Range of monthly alphas in different subperiods

	Period I	*Period II*	*Period III*	*Period IV*
CISDM alphas	0.05–0.24%	0.03–0.10%	0.23–0.66%	0.14–0.80%
CT alphas	0.06–0.33%	0.16–0.57%	0.49–1.43%	0.23–1.28%
HFR alphas	0.07–0.34%	0.14–0.50%	0.33–0.95%	0.19–1.07%
EW alphas	0.08–0.44%	0.11–0.39%	0.37–1.07%	0.18–1.02%
Individual fund alphas	0.07–0.35%	0.10–0.37%	0.37–1.09%	0.18–1.03%

Panel C: Average monthly alphas in different subperiods

	Period I	*Period II*	*Period III*	*Period IV*
CISDM alphas	0.41%	0.51%	0.60%	0.73%
CT alphas	0.10%	-0.11%	0.82%	0.53%
HFR alphas	0.26%	0.36%	0.57%	0.58%
EW alphas	0.25%	0.21%	0.44%	0.82%
Individual fund alphas	0.34%	0.29%	0.54%	0.76%

Figure 1: Lifecycle of a convertible bond

This figure plots the timeline of a convertible bond (CB) and the role of arbitrageur during the lifecycle of the bond.

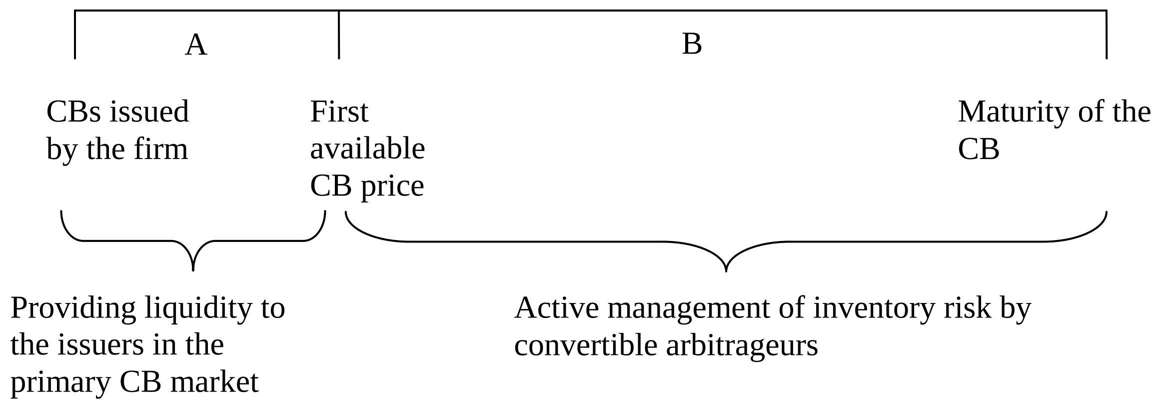
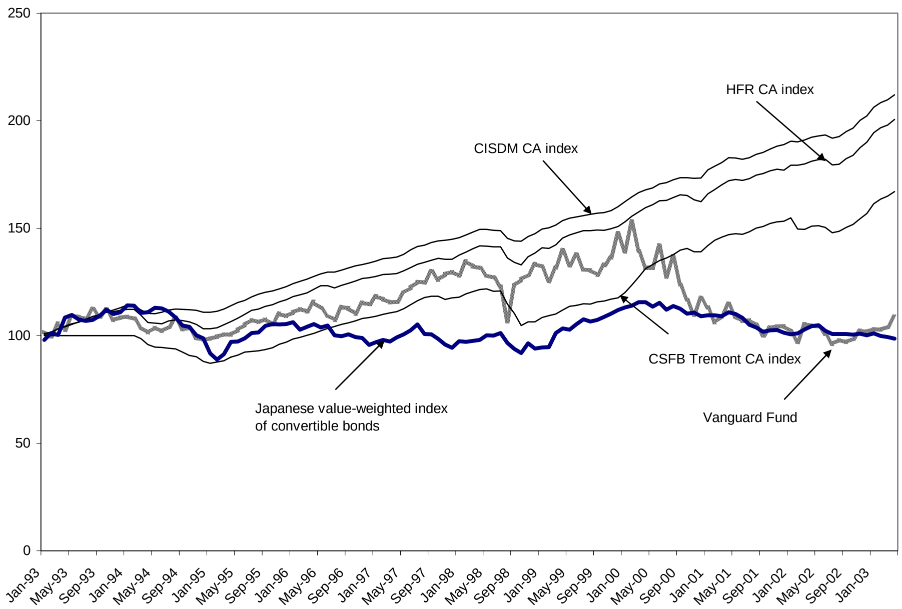


Figure 2: Cumulative Returns of Convertible Arbitrage Indexes, Vanguard Fund, Value-weighted index of Japanese convertible bonds, and ABS factors

Panel A plots the cumulative returns of the three convertible arbitrage indexes - Centre for International Securities and Derivatives Markets (CISDM), CSFB Tremont (CT), and Hedge Fund Research (HFR), Vanguard Fund, and a value-weighted index of Japanese convertible bonds while Panel B plots the cumulative returns of the two ABS factors for US and Japan (X^{US} and X^{JP}) between January 1993 and April 2003. CT index starts only in January 1994.

Panel A



Panel B

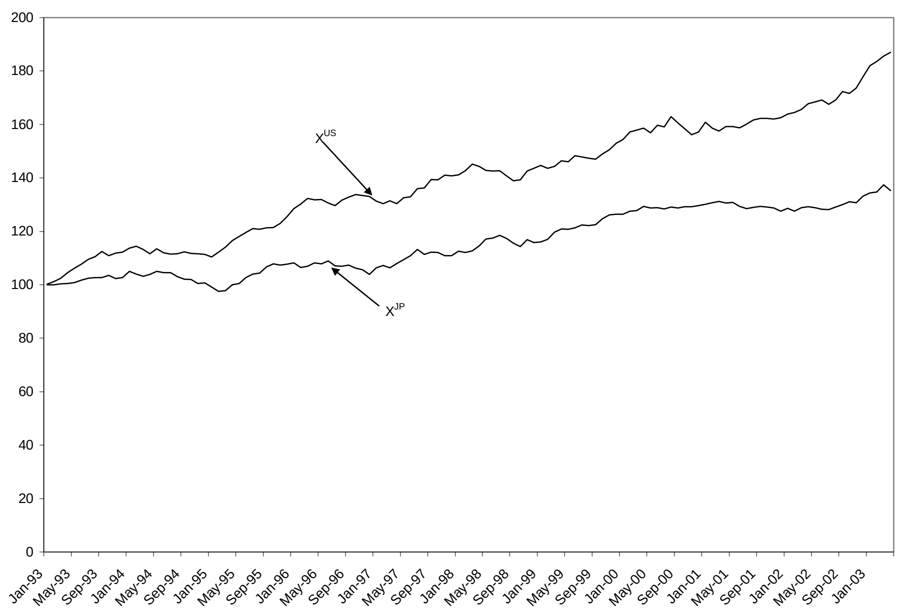


Figure 3: Distribution of Convertible Arbitrage Hedge Funds by Data Sources

This figure shows the percentage of convertible arbitrage hedge funds from the three databases namely Centre for International Securities and Derivatives Markets (CISDM), CSFB Tremont (CT), and Hedge Fund Research (HFR) during our sample period, January 1993 to April 2003.

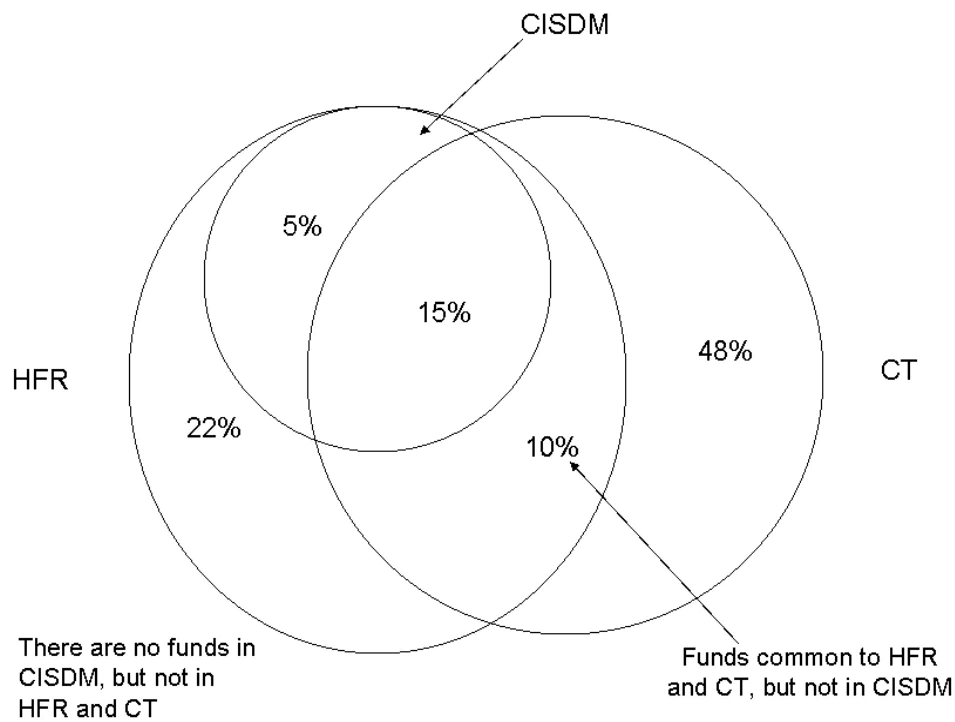
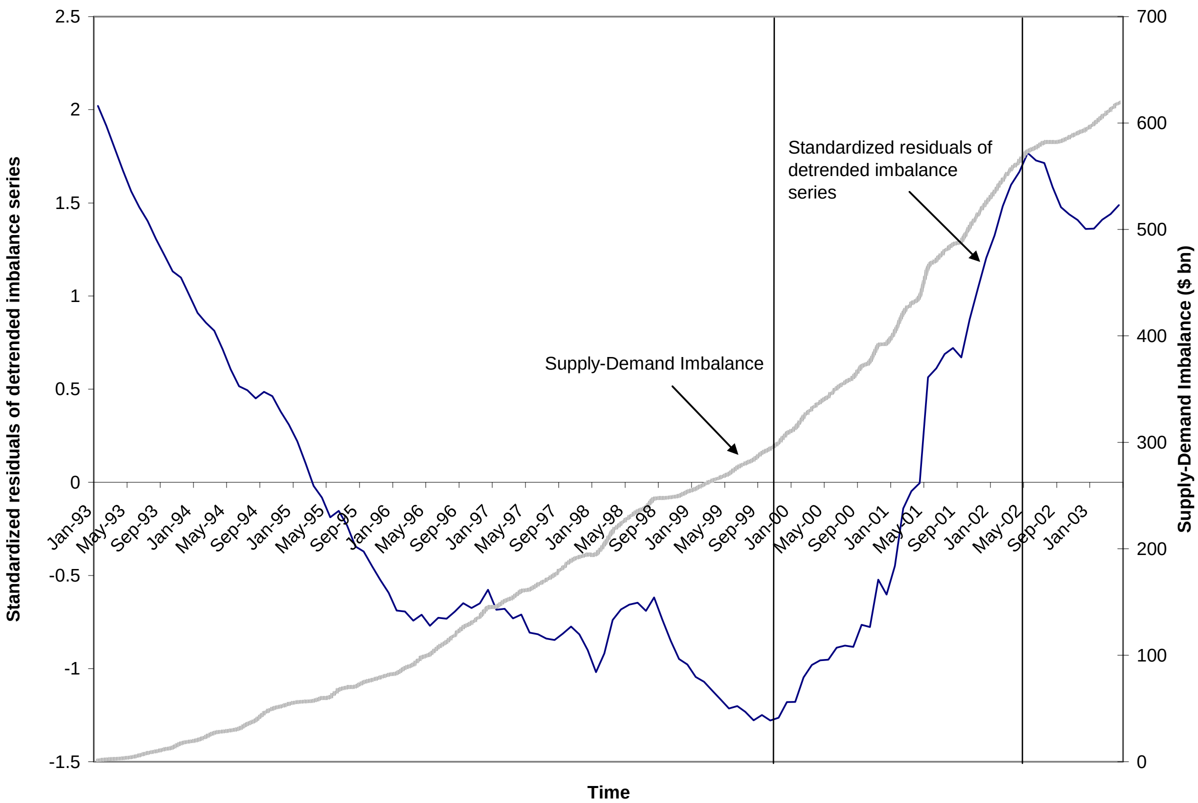


Figure 4: Trends in Demand for and Supply of Convertible Bonds

This figure plots the demand-supply imbalance (cumulative supply less cumulative demand) and the standardized residuals of the detrended imbalance series between January 1993 and April 2003. We measure the supply by the dollar issue size in the US and Japan, and the demand by the dollar flows into the convertible arbitrage funds.



Appendix A: Regression analysis using other multifactor models

This table provides the results of OLS regressions for the four CA portfolios – three CA indexes (CISDM, CT, and HFR) and an equally-weighted portfolio of individual funds (EW). Panel A reports the results from the 4–factor model of Carhart (1997), where MKTRF, SMB, HML, MOM refer to excess returns on the market (value-weighted return on all NYSE, AMEX, and NASDAQ stocks minus the one-month Treasury bill rate), Fama-French (1993) size and book-to-market factors, and momentum factor. Panel B reports the results from the Carhart (1997) 4-factor model augmented with the out-of-the-money call (OTM CALL) and put (OTM PUT) option factors as in Agarwal and Naik (2004). Panel C reports the results from the Fung and Hsieh (2004) 7-factor model including excess return on S&P 500 (SPMRF), spread between Wilshire Small Cap 1750 index and Wilshire Large Cap 750 index (SML), excess returns on 10-year Treasury (TSYMRF), credit spread, i.e., difference between CSFB High-Yield index returns and 10-year Treasury returns (HYMTSY), lookback straddles on bond futures (PTFSBD), lookback straddles on currency futures (PTFSFX), and lookback straddles on commodity futures (PTFSCOM). *, **, and *** indicate that the coefficient is significantly different from zero at the 10, 5, and 1% levels respectively. *p*-values are computed using Newey-West (1987) standard errors.

Panel A

	CISDM	***CT***	***HFR***	***EW***
Intercept	0.006***	0.004*	0.005***	0.005***
MKTRF	0.067***	0.074*	0.086***	0.111***
SMB	0.056***	0.100**	0.070***	0.086***
HML	0.042*	0.101*	0.049	0.051
MOM	-0.005	-0.008	-0.004	0.004
Adj R^2	20.70%	6.20%	15.46%	25.11%

Panel B

	CISDM	***CT***	***HFR***	***EW***
Intercept	0.006***	0.004*	0.005***	0.005***
MKTRF	0.002	-0.026	-0.017	-0.010
SMB	0.068***	0.118**	0.089***	0.108***
HML	0.043**	0.104**	0.050*	0.053*
MOM	-0.003	-0.003	-0.0003	0.008
OTM CALL	0.133	0.161	0.209	0.248
OTM PUT	-0.251	-0.432	-0.405*	-0.471**
Adj R^2	23.22%	6.91%	18.63%	29.54%

Panel C

	CISDM	***CT***	***HFR***	***EW***
Intercept	0.006***	0.005**	0.005***	0.005***
SPMRF	0.044***	0.019	0.061***	0.081***
SML	0.050***	0.071**	0.071***	0.089***
TSYMRF	0.069*	0.079	0.090*	0.086*
HYMTSY	0.120	0.218	0.115	0.137
PTFSBD	-0.010**	-0.017	-0.016**	-0.016**
PTFSFX	0.001	-0.001	0.002	0.001
PTFSCOM	0.003	0.007	0.005	0.006
Adj R^2	25.78%	7.42%	21.33%	28.29%