Types of Liquidity and Limits to Arbitrage- The Case of Credit Default Swaps

by

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I. Introduction

Arbitrage is one of central tenets of financial economics that enforces the law of one price and keeps markets efficient. Arbitrage based pricing is based on the idea that if two assets have the same payoffs in all future states of the world, they ought to have the same price in a perfect financial market. In theory, if the prices of these two assets diverge, market participants will short sell the more expensive asset and purchase the less expensive one, and as a result make a sure profit without making any investment, and without taking any risk. Duffie (1999) shows that an arbitrage based argument links the relative values of credit default swaps (CDSs) and bonds yield spreads of the associated firm (discussed in more detail in section II). The *basis* or the difference between the CDS price and the corresponding bond yield spread should theoretically be close to zero. While prior research has documented deviations from parity (e.g., Longstaff, Mithal and Neis (2005) report a 60 basis point average spread), the extent of the recent deviations have drawn scrutiny from the press and investors alike. For example, Figure 1 is a graphical depiction of the basis of a bond of Computer Science Corporation. The extent of the absolute deviation from parity (the basis) exceeds 600 basis points on a few dates, and has remained at an elevated level since the onset of the financial crisis. Reflecting these observations, a recent article in the Financial Times states:

> "It may be technical, it may be an abnormality. But it is a gift horse nonetheless. Corporate bonds are trading more cheaply than corporate default swaps. That means investors can buy a bond and then receive a

> coupon that more than pays for the cost of insuring that bond against default. This is close to free money."[2]

Given the size of the CDS market and the large pools of money (e.g., hedge funds) chasing opportunities in the financial markets these deviations in parity have attracted the attention of market participants, but these violations have persisted. Bloomberg Magazine reports on recent activity in the CDS market:

> "In the months before Lehman Brothers Holdings Inc. filed for bankruptcy in September, wider gaps between risk premiums on corporate bonds and the cost of protecting the debt from default enticed some investors to buy newly issued securities in an otherwise illiquid market."[3]

What may cause deviations in the parity relationship? Shleifer and Vishny (1997) argue that while the textbook version of arbitrage requires no capital and entails no risk, but in reality all arbitrage is constrained and is risky. In terms of constraints, none is more important than the availability of capital. As noted by Brunnermeier and Pedersen (2009): "trading requires capital and capital availability is subject to market conditions". For example, an arbitrageur seeking to exploit an apparent mispricing may buy a bond and the CDS contract. The arbitrageur would finance the bond purchase via a repurchase agreement using the asset as collateral. Thus, the ability to get collateralized loans to finance a purchase, collectively termed *"funding liquidity"*, is important in exploiting the arbitrage and ensuring that relative prices converge. Such funding liquidity is subject to economic conditions and varies with time. The unique events of the last year provide an opportunity to examine the impact of funding liquidity more closely as measures of funding liquidity have experienced increased volatility.

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[2] See Financial Times (11/20/2008) article entitled "Bond Appeal"

[3] See "Back to Basis", Bloomberg Markets, November 2008, Page 188-189.

In addition to the *funding liquidity constraints*, an arbitrageur may not be able to fully finance a bond purchase using the asset as collateral because lenders require a margin (or haircut) to protect them against adverse movements in the collateral's price and their corresponding ability to sell the asset were the borrower to default. The margin therefore depends on the type of asset under consideration (*asset risk and asset specific liquidity*). Asset specific liquidity or the ease with which a security can be traded can be driven by a number of factors, some of which are unique to the asset under consideration. In general these factors include exogenous transaction costs, inventory risk, and private information, amongst other considerations. Even though funding liquidity is related to asset specific liquidity, the relationship is not perfect and each has unique factors implicit in it. While prior studies focus on asset specific liquidity issues in explaining the basis, recent events allow us to examine the effects of funding liquidity as well.

The funding and asset specific liquidity constraints discussed above are especially important in the case of derivative assets that require leveraged purchases of the underlying asset for replication of the derivative payoffs. In recent work Garleanu and Pedersen (2009) provide a theoretical model wherein deviations in relative prices of derivatives and the underlying asset are a result of changes in both funding liquidity (shadow cost of capital to arbitrageurs) as well as asset specific liquidity (determinants of margin requirements). In particular, they show that when risk-tolerant investors are margin constrained and risk-averse investors take on optimal allocations, the basis between a derivative and its underlying asset is non-zero in equilibrium. The basis depends on relative margins of the asset and the derivatives, and the leveraged investors shadow cost of capital. This leads to the question addressed in this paper - *can the recent deviation in basis between CDS prices and bond yield spreads be explained by funding liquidity (shadow cost of capital) and asset specific liquidity (margin requirement) variations*?

Using a sample of CDS quotes and bond yield spreads for 35 firms in the Markit CDS index over the period from 06/2008 to 09/2009, we study the reported deviations in the arbitrage based parity relationship between Corporate Bond Yield Spreads and

CDS prices. The parity relationship is violated for most of the sample period even though the extent of the deviation has mitigated in the recent data (e.g., Figure 1). We first provide a theoretical background for our tests and the manner in which a hypothetical arbitrage would be constructed. This highlights the nature of the risks posed to an arbitrageur. We then examine the relationship of the basis with proxies for funding and asset specific liquidity. Our proxies for funding liquidity include changes in the arbitrageurs' capital availability (VIX index), arbitrageurs' shadow cost of capital (Libor and general collateral repo spread) as well as asset specific risk liquidity measures that determine the margin requirements (bond credit rating, trading volume, bond bid-ask yield spread, corresponding firm's stock volatility based on historical and options data), as well as other variables. In all our tests we control for a set of common market and asset risk factors. Our empirical method controls for the effects of clustering as well as firm specific fixed effects, both of which address econometric issues specific to the analysis at hand.

Overall our results show that funding liquidity constraints are an important determinant of the time variation in the basis, corroborating the fact that funding liquidity provides the source of commonality in time series of changes in the basis of these contracts over the crisis period. This commonality of liquidity as a source of risk is examined in a general equilibrium setting by Acharya and Pedersen (2005). This commonality of funding liquidity provides a source of predictable variation in the basis. In addition cross-sectional variation in the basis amongst different firms is captured by the bond specific liquidity measures, consistent with the view that differentials in margin requirements determine differences in the basis. The overall explanatory power is around 70% for the levels regression and the point estimates are reasonable and broadly consistent with related work. As we show, funding liquidity variables are a primary driver of the variation in the basis.

Our analysis thus contributes to the debate on the limits to arbitrage with a specific focus on the role of different *types of liquidity* in determining relative asset prices, not previously addressed from an empirical perspective. While the empirical research has examined the impact of liquidity in explaining the cross section of stock returns, yield differentials in on and off-the-run Treasuries, closed end funds and the prices of illiquid contracts, our paper provides direct empirical evidence to corroborate the theory on the impact of funding liquidity constraints and asset specific liquidity (margin requirements) on relative asset prices as proposed by Garleanu and Pedersen (2009). Equivalently our results are also consistent with the idea that a component of corporate bond yield spreads are driven by non-default related factors, of which one important determinant is funding liquidity. The same liquidity constraints that impose restrictions on arbitrageurs and make arbitrage costly are the ones that cause bond yields to increase as investors demand higher premiums to compensate for the intermediate term demand for liquidity.

Our findings have important implications for arbitrageurs as they deploy capital in convergence strategies. We use a simple convergence type trading strategy to examine the returns to an arbitrageur and the cash flow risks (margin calls) associated with the trade. Depending on the asset specific liquidity risk and the source of liquidity risk, the speed of convergence may vary. While aggregate liquidity shocks may diminish more quickly, some components of asset specific liquidity factors may be more persistent even though there is interaction between each type of liquidity.

In related work Blanco, Brennan and Marsh (2005) analyzed a set of 33 CDS contracts and conclude that deviations from parity can be explained by imperfections in contract specifications, liquidity and informational effects. The authors do not specifically address the types of liquidity examined here and its impact on deviations from parity. Longstaff, Mithal and Neis (2005) fit a reduced form model to CDS prices and corresponding bond yields to extract a "non-default" related component. They find that the "non-default" related component is related to measures of asset specific liquidity. The unique events in the recent years allow us to examine the additional impact of "funding liquidity" variables that have experienced a much larger variation than has been seen over any of the previous data periods. Thus most prior studies did not include any funding liquidity variables in their analysis of the basis. Our paper is closest in spirit to Coffey, Hrung and Sarkar (2009) who examine the impact of liquidity on the covered interest parity relationship with respect to different dollar denominated interest rates and exchange rate parings and conclude that funding liquidity risk can be mitigated by Central Bank interventions. In this paper our objective is to distinguish between the types of liquidity and, and their relative roles in explaining deviations of the parity relationship between bond spreads and CDS prices.

Earlier work on limits to arbitrage in the equity market includes Mitchell, Pulvino and Stafford (2002) who examine situations where the market value of a company is less than the value of equity in its subsidiary. They conclude that uncertainty over the distribution of returns and characteristics of the risks preclude an arbitrageur from exploiting this apparent differential in prices. For an arbitrageur seeking to exploit this opportunity, an increase in the mispricing before it finally corrects could result in more capital calls and a possible liquidation of the position. This type of risk is manifest for arbitrageurs in the CDS market who may need to roll over their positions in case prices do not converge over a given period. In the context of the options markets, Ofek, Richardson and Whitelaw (2002) relate violations in put-call parity to short sales constraints. From a market structure perspective, Kadapakkam (2000) finds that short-term arbitrage trades around the ex-day were earlier hampered by physical settlement procedures in Hong Kong that in turn resulted in significant abnormal returns. These returns disappeared after electronic settlement was introduced. Our paper also contributes the broader literature on the impact of liquidity on asset prices, a survey of which can be found in Amihud, Mendelson and Pedersen (2005).

The paper is organized as follows. Section II describes the CDS market and the relationship between CDS prices and bond yield spreads, the role of liquidity, and the hypothesis. Section III describes the data. Section IV has the empirical results. Section

V examines the returns to a trading strategy with different levels of leverage and discusses the limits to arbitrage in a market setting with liquidity risks. Section VI concludes.

II. The CDS-bond yield spread basis and our hypothesis

A. Credit Default Swaps

Credit Default Swaps are derivative contracts whose payouts are dependent on the creditworthiness of a firm. The purpose of these instruments is to allow market participants to trade the risk associated with certain debt-related events. In a typical CDS contract, the buyer of protection pays the seller a fixed fee each period and the seller in turn agrees to compensate the buyer if a default event occurs before the maturity of the contract. The fee paid by the buyer is typically a constant amount that is remitted on a quarterly basis. The fee is quoted in basis points per $100 of protection. In the event of a default the accrued fees are also included in the settlement. For example, suppose the buyer wishes to insure 10,000 bonds each with a face value of $1,000. If the fee is 200 basis points per year (50 basis points per quarter), the buyer pays $A/360$ X 0.02 X 10,000,000 per quarter where A is the number of days in a quarter.

Credit events that typically trigger a credit default swap payment include bankruptcy, moratorium, failure-to-pay, and default. In the most general CDS contract, the parties may agree that any sets of loans or bonds may be delivered in case of a physical settlement. In this case the reference issue serves as a benchmark against which other possible deliverable bonds or loans might be considered. It is also possible that a reference obligation is not specified, in which case, any senior unsecured obligation may be delivered. Alternately cash settlement rather than physical settlement may be specified in the contract. The cash settlement would amount to the difference between the notional and market value of the reference issue.

In this article we focus on the single-name credit default swaps that account for around half of the credit derivatives market. A single name CDS is a contract that provides protection against the risk of a credit event by a single company. These instruments also provide an easier avenue to shorting credit risk. The maturities of these issues are negotiable but we focus on default swaps for corporate with a 5-year horizon. These contracts are the most liquid of the several different types of traded derivatives and form the basic building blocks for more complex instruments.

B. Relationship between CDS prices and Bond yield spreads

A bond yield spread is the difference between the yield to maturity on a corporate bond and the corresponding maturity risk-free rate. This yield spread is determined to a large extent by the credit risk of the bond, where credit risk is the uncertainty surrounding a firm's ability to service its debt and obligations. Credit risk models "map" the default characteristics of a borrower to the price of a financial contract whose payoffs are contingent on default.[4] This article does not contribute to the literature on pricing of credit risk but instead on the arbitrage relationship that exists between a firm's CDS price and credit spread. As noted, the credit spread on a typical bond is the compensation for taking on the credit risk of the issuer. If the cost of protecting against the risk with a CDS is less than the bond's yield spread, investors can buy the bonds and the CDS contracts and collect the excess risk premium without taking any risk.

Suppose that the arbitrageur buys a corporate bond with a maturity of T years and also buys default insurance via the purchase of an equivalent maturity CDS contract at a price of p (note that the price is usually expressed as a percentage of the notional principal). If the yield to maturity of the bond is y, the annual return to the arbitrageur is equal to y-p. This return should approximately equal the T year risk-free

[4] There are two basic approaches to modeling corporate default risks. One approach, pioneered by Black and Scholes (1973) Black and Scholes (1973) and Merton (1974) and extended by Black and Cox (1976), Longstaff and Schwartz (1995) and others, explicitly models the evolution of firm value observable by investors. This approach is commonly referred to as the "structural approach". A second approach to modeling risky debt is adopted by Duffie and Singleton (1999), Jarrow and Turnbull (1995), Madan and Unal (1994), Madan and Unal (2000) wherein the authors do not consider the relation between default and firm value in an explicit manner. This approach is called the reduced form approach.

rate (denoted *r)* because the resulting investment is now insured against default. We use this relationship in our study even though it holds only approximately in many instances. Duffie (1999) shows that the relationship $y - p = r$ is exact only in the case of a par risky floating rate note and the CDS price. In practice, floating rate notes with the corresponding maturity would be difficult to find. Additionally coupon dates for the bond and CDS fees may not coincide. Often market participants will couple the purchase of a bond with an asset swap to convert the fixed payments to floating payments. However asset swap spreads are subject to many of the liquidity impacts that we are trying to examine. Therefore we employ fixed coupon yield spreads in our tests. Arbitrage is reasonably accurate even after accounting for such issues.[5,6] Thus, if $y - p > r$, the arbitrageur should theoretically enter into the following transactions to exploit the mispricing:

a. Purchase T year bond with yield y and price B.
b. Purchase CDS for maturity of T years at p.
c. Borrow B at the risk-free rate to finance the purchase.

On the other hand if $y - p < r$, the transactions correspondingly involve:

a. Sell T year bond with yield y and price B
b. Sell CDS for maturity of T years at p
c. Lend B at the risk-free rate and receive as collateral the bond that is sold

In our setting most of the observations correspond to the first case ($y - p > r$).

Many practical issues may limit the ability to exploit this arbitrage. To see the risks of implementing this arbitrage, consider Figure 2 that presents a time line with the trades and possible outcomes. First at time t=0, the arbitrageur purchases the CDS and the reference bond. However he cannot borrow the entire bond price against the

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[5] Duffie and Liu (2001) provide a model to compute the difference between fixed rate spreads and floating rate spreads and show that the spread is at most a few basis points (less than 3) in most cases. A primary reason for the difference is the slope of the yield curve. We replicate the model for conditions that existed during the sample period and find that the spread is within that range.

[6] Longstaff, Mithal and Neis (2005) estimate a reduced form model to extract the non-default related component. This approach corrects for the bias in fixed-floating rate spreads but may introduce noise due to distributional assumptions in the model.

collateral (bond) given to the lender. The haircut (*H1*) is the amount withheld to protect the lender against adverse changes in the price of the collateral. The amount withheld depends to a large extent on the asset liquidity. Hence the trader must deploy an amount of capital *H1* in addition to any outlay on the CDS position. If the basis increases and diverges even more from its level, the arbitrageur would need to deploy more capital at the end of the first period, at time 1. Thus asset specific are important in determining the amount that can be borrowed at each stage and these may evolve through time. The haircut can be reset were the collateral deemed less valuable. The availability of funds at rate *r1* at the outset (Step *c* in the arbitrage) depends on the funding constraints in the system. In most cases repos are *not* available for the longer horizon corresponding to the maturity of the bond. Indeed, most repos are short term and must be rolled over. When the repo is rolled over at time t=1, the interest rate on the repo at rate *r2* may be higher than the rate at the outset. This "rollover risk" (Acharya, Gale and Yorulmazer (2009)) and the associated costs are intimately related to the availability of funding. Thus, funding liquidity and asset liquidity are important determinants of the difference between CDS prices and yield spreads. Absent an ability to borrow or lend, the mispricing between CDS and Bond yield spreads can persist as investors anticipate the potential risks of the arbitrage.

Hypothesis*: The absolute value of the basis (the difference between CDS prices and associated bond yield spreads):*

(1) Increases with funding liquidity constraints (shadow cost of capital).
(2) Increases with decreases in asset liquidity (determinants of margin or haircut).

The hypotheses are collected in Table 1 for convenience alongside the associated proxies used in the tests. The construction of the proxies and motivation for their use is discussed in more detail in the following section.[7]

[7] Note that our objective is to explain the basis and not the CDS price (for example, Benkert (2004) explains the level of the premia using implied equity volatility amongst other firm level variables. The author finds that the liquidity proxy does not have any explanatory power).

III. Data and methodology

A. Sample

A.1. CDS prices

We collect daily bid, ask and mid-market quotes on CDS prices for single-name CDSs for the period June 1, 2008 to September 30, 2009 using Bloomberg (Bloomberg Generic Prices). Thus our sample covers the period prior to the stock market crash that accompanied the Lehman Brothers collapse in March of 2009 as well as a few months after the crash. The data includes all firms that comprise the CDS Markit index, that are deemed to be more liquid. Bloomberg Generic Prices are arithmetic means of all included contributor spreads that were received over the last rolling 24 hours. A new price is posted only when there is a new contributor price. Also, if there are five or more spreads contributed, the highest and lowest are excluded from the calculation.

Table 2 provides an alphabetical listing of all companies in our sample. We start with all firms in the Markit CDS index - there are a total of one hundred and twenty five firms in the index. We include only those firms where there were more than 50 observations, and where both a traded price for the reference bond as well as the CDS price is available. This left us with a total of thirty five firms. Table 2 shows that each firm has a negative basis on average- in other words, the cost of insurance (CDS price) is lower than the corresponding bond yield spread for this period. As graphed in Figure 1, there is considerable variation in the basis over the sample period. The standard deviation of the basis is in excess of 100 basis points on average for the sample period. Hewlett Packard has the lowest average basis (-32 basis points when the yield spread is relative to swaps (S)) whereas Toll Brothers has the highest average basis (399 basis points (S)). The high degree of volatility in the basis underlines the risk faced by arbitrageurs who would need to post additional capital in case their position loses money in the interim.

A.2 Bond yields and interest rate data

The corporate bond yield spread is defined as the difference between the yield to maturity on a reference bond and the yield to maturity on an equivalent duration Treasury security. The yield to maturity on a corporate bond is the discount rate that equates the present value of its future cash flows to its current price. To collect data on reference corporate bonds, we search Bloomberg for bonds with maturity closest to 5 years and note the corresponding Bloomberg mid-market yields and prices. We exclude bonds with embedded options, step up coupons or any special features. For the reference bond data, where a choice of liquid bond yields is available we choose bonds trading close to par, and ones whose maturity is closest to five years.

The yield to maturity on a Treasury security is the yield on the constant maturity series obtained from the Federal Reserve Bank in its H15 release based on a par bond.[8] In the cases where no corresponding Treasury yield is available for a given maturity, the yield spread is calculated using interpolation based on the Nelson and Siegel (1987) exponential functional form.

Longstaff, Mithal and Neis (2005) note that the yield on government bonds may not be the best proxy for the risk-free rate because of liquidity premia and taxation treatment.[9] As an alternative we collect five-year swap rates as an additional proxy for the risk-free rate, even though the use of the swap rate as a risk-free rate during the time period examined is beset by the impact of heightened credit risk amongst the intermediaries that are active in this market. We dwell on this point more in the results section.

[8] H15 is a weekly publication of the United States Federal Reserve Statistical release (with daily updates) for selected market interest rates.

[9] State and local income taxes are levied only on corporate bond coupons and not on treasury bond coupons. Elton, Gruber, Agrawal and Mann (2001) estimate the impact of taxes to be in the neighborhood of 30 basis points. We do not need to account for tax effects because our fixed effects econometric specification controls for such tax effects.

A.3. Funding liquidity variables

Our objective is to cull out the impact of funding liquidity and asset specific liquidity on the spread between CDS prices and bond yield spreads. The list of variables used in our tests is collected in Table 1. We first segregate the funding liquidity related variables into three categories- Arbitrageur's capital availability, funding constraint and funding risk related variables. Brunnermeier and Pedersen (2009) suggest that the VIX index is a proxy for capital availability of hedge fund managers. A higher volatility increases the capital required per unit of investment. Accordingly we employ the VIX index as one measure of funding liquidity. In addition they suggest that the level of funding constraints (shadow cost of capital) can be proxied by the Libor spread (the difference between 3-month Libor rates and 3-month T-bills) or the General Collateral Repo-Rate at which an arbitrageur can borrow in case the position requires collateralized funding. The difference between Libor and the Repo Rate is our second measure of the shadow cost of capital, consistent with previous work by Coffey, Hrung and Sarkar (2009).

Most repos are of short maturity and the arbitrageur may seek to extend the holding period of his position if prices have not converged. We need to capture the impact of this "rollover risk". We use the collateralized repo-rate level volatility (daily volatility using past 30 days data) as a measure of the risk that collateralized lending and borrowing rates could change as the arbitrageur extends the maturity of the position. We expect that higher rollover risk or other funding liquidity constraints would result in a larger basis.

A.4. Asset specific liquidity variables

The asset specific liquidity variables are collected in the lower section of Table 1. Each of these variables determines the liquidity of the asset and in turn the amount of capital that must be put up by the arbitrageur to account for risks posed to the lender. First, the margin on collateralized loans depends on the asset's return volatility and is in turn related to the underlying firm's equity volatility. The short term volatility is related to changes in the bond yield volatility and thus the margin requirement. This is consistent with the classical model of Merton (1974) wherein equity volatility is related to asset volatility that in turn determines the probability of default. Thus margin requirements would increase when a firm's equity volatility increases. We use two proxies for stock volatility – lagged 30 day volatility of daily stock returns and the average implied volatility of the 3-month at-the-money options. Both metrics are closely related as discussed later in Section IV.

Several bond specific liquidity measures have been proposed in the finance literature (e.g, those used by Longstaff, Mithal and Neis (2005) to explain the basis). These include the bond credit rating, the bond daily trading volume as well as the bid-ask yield spread. We collect the bond credit rating data, the trading volume for the reference bond from TRACE and the amount outstanding using Bloomberg, and the bid-ask yield (using Bloomberg). Our proxy for trading volume is the ratio of the number of bonds traded to the total number of outstanding bonds for that issue. The bid-ask yield spread is the difference between the ask yield and the bid yield for that bond. The bond credit rating is the average of the S&P and Moody's bond ratings for the firm (a measure that largely depends on the volatility of the firm's assets and the amount of debt). Numerical bond ratings are computed using a conversion process where AAA rated bonds are assigned a value of 22 and D rated bonds receive a value of one. For example, a firm with an "A1" rating from Moody's and an "A+" from S&P would receive an average score of 18 (the conversion numbers for S&P ratings are provided in the Appendix). We expect that higher bond liquidity would result in a lower basis. There are a number of alternate liquidity measures – these include the price impact of a trade, frequency of zero returns and latent liquidity (Mahanti, Nashikkar, Subrahmanyam, Chacko and Mallik (2008)). Our choice was driven by data availability and the appropriateness of the metric given the nature of the question posed.

The CDS bid-ask spread is a measure of the liquidity of the CDS contract and is related to liquidity of the underlying asset as well as the demand and supply for the contract itself. We expect the basis to be lower when the CDS Bid-Ask spread declines and vice versa.

In addition to the liquidity variables discussed, we include two stock market based risk factors - Small Minus Big (SMB), or the average return on the three small portfolios minus the average return on the three big portfolios; High Minus Low (HML), or the average return on the two value portfolios minus the average return on the two growth portfolios. Also, we include the stock return and the term spread (difference between five-year treasury rate and three-month treasury rate) as additional controls. The underlying corporate bond is subject to interest rate risk and it is consequently important to control for the slope of the term structure.

B. Empirical methodology

From a theoretical and empirical perspective, we want to know the relation between the level of the basis and the level of the funding and asset specific liquidity variables. In our specification however, we need to address the fact that CDS prices and yield spreads long-term average basis could be driven in part by some fixed firm specific factor. Also, there is an issue of commonality in the funding liquidity shocks that in turn lead to clustering effects. To address these issues we include firm specific fixed effects in our regression specification to allow us to consistently estimate the regression parameters. We report robust standard errors corrected for clustering, autocorrelation and heteroscedasticity.[10]

Specifically, we regress the basis (difference between the CDS rate and the bond yield spread (*p-y*)) on funding liquidity variables and firm and asset specific variables listed in Table 2. Our regression specification is

$$\begin{aligned} Basis_{i,t} = {} & a + b_0 (Fixed\_Eff)_i + b_{1-4}(Funding\_Liquidity)_{i,t} + b_{5-8}(Firm\_Specific\_Liquidity)_{i,t} \\ & + b_{9-12}(Controls)_{i,t} + \varepsilon_{i,t} \end{aligned}$$

[10] We also ran our tests using a panel approach but this did not alter our results.

(1)

where $Basis_{i,t}$ refer to the difference between the CDS price and bond yield spread for firm i on day t.

C. Measuring returns to arbitrageurs

The role of arbitrageurs is central to the arguments posed in this article. Consequently we examine the returns to arbitrageurs that seek to exploit the basis between CDS prices and yield spreads. Mitchell, Pulvino and Stafford (2002) note that a significant risk faced by arbitrageurs is that the price differentials may not get eliminated, and may diverge from fundamentals even more. Then, an arbitrageur that seeks to exploit this apparent divergence in basis would need to roll over his position and possibly put up more capital. This is referred to as "horizon risk" by the authors. A high volatility in the path of convergence may force the arbitrageur to terminate his position prematurely if capital is scarce. Our objective is to measure the volatility of returns and the risks posed to arbitrageurs while taking into account any margin calls because of divergence in the spreads after the position is initiated.

We form a sample portfolio wherein the arbitrageur buys a face value of $1 million of the underlying CDS contract and the reference bond when the absolute basis is larger than 250 basis points (median for our sample). We assume that the trade is reversed when the basis converges to 100 basis-points (a larger than one standard deviation decline in the basis). In doing our analysis we recognize the bid-ask spreads at the time of entry and exit. Also, we *mark-to-market* the returns to the arbitrageurs and include capital calls in case there is a loss and more margin is required. The marking to market is achieved using the JP Morgan CDS model wherein we compute the new daily implied hazard rate and its impact on the existing CDS values (described in Section V and the Appendix in more detail). We compute the internal rate of return for each firm based portfolio, the horizon (number of days in which the trade is reversed) and the volatility of returns. Our tests are conducted for two levels of margin - a typical level and a more conservative level of margins. The objective is to get a handle on the magnitude of returns and the risks posed to the arbitrageurs and then relate these returns to the liquidity proxies to examine the source of these returns. We also examined the returns for different entry and exit points besides the ones tabulated- the reported example is representative of the overall results.

IV. Results

A. Descriptive Statistics

Table 3a contains summary statistics for the sample. Included are the mean, standard deviation, and correlation matrix of the variables. The average basis relative to the swap rate (Basis (S)) for all the firms in the index is -272 basis points while the corresponding number is -335 basis points when spreads are computed relative to the t-bill rate (Basis (T)). The difference reflects in part the additional credit risk and liquidity factors that impact the swap rate relative to treasury rates. During this period the VIX index was on average at an elevated level (42.65) relative to its historical long term average (in the vicinity of 20).

We use two variables to measure the shadow cost of capital – the Libor Spread and the collateralized loan spread (Repo Spread). Libor spread reflects the cost of uncollateralized interbank lending rates while Repo Spread is the cost of borrowing via a repurchase agreement that is backed by collateral less the uncollateralized rate (Libor). Reflecting these differences in risk, the Repo Spread is 0.77% during the sample period.

In terms asset specific variables, this was a period of high volatility in stock returns- daily lagged stock volatility is 3.28% (computed on a rolling basis for the last 30 days) and the stock implied volatility is 48.81% using 3-month at the money options. In terms of debt variables, the mean (median) bond rating of 14.88 roughly equates to S&P rating of "BBB" with a standard deviation of "AA-/B+", which indicates that the sample contains some non-investment grade debt. The difference in CDS price bid-ask quotes of 32 basis points is the incremental percentage of insurance premium required by a CDS buyer relative to a seller. We restrict our analysis to those issues where there are some traded bond prices available. The trading volume for the reference bond issues was 0.59% per day and the bid-ask yield spread is 0.12%.

Table 3b tabulates the correlation matrix. Our two measures of basis (Basis (T) and Basis (S)) have a high degree of correlation (0.99). The VIX index is negatively related to both measures of basis (-0.54 and -0.51 respectively) consistent with the idea the basis is more negative (absolute level of basis is higher) as the VIX index increases. The first two columns show that the same negative relationship is also apparent for the Repo Spread (-0.25), and Repo Rate Volatility (-0.41) again consistent with our hypothesis. The Bond Credit-Rating is positively related to the basis reflecting the fact that lower credit risk results in a lower basis. The bond yield spread has a low (0.01) correlation with trading volume over the sample period and has a negative relationship with Libor spread (-0.24). Also, the implied volatility and historical volatility measures have a high correlation (0.88) as expected. Also, stock volatility measure is positively correlated to overall market volatility (VIX) with measures of 0.39 and 0.50 respectively, reflecting the systematic component of volatility risk.

B. Regression results

As noted earlier, we use a single-stage procedure to analyze the effect of the types of liquidity on the difference between CDS prices and bond yield spreads. Specifically, we regress the basis on funding liquidity variables and firm and asset specific variables listed in Table 2. Table 4a and 4b provide the results of this "levels" regression. Table 4a uses Basis (T) as the dependent variable while 4b has the results with Basis (S) as the dependent variable. In each instance we provide results for two specifications – Model 1 uses the Libor spread as the proxy for shadow cost of capital while Model 2 uses the Repo Spread. We also tested additional specifications that are not reported in the tables, but discussed in relevant paragraphs below.

In table 4a, the liquidity variables explain a significant proportion of the overall variation in spreads (R-squares of 0.7 for the two specifications). The VIX index, a proxy for capital availability of hedge fund managers, has a negative sign (a positive relationship with absolute basis levels). A higher volatility increases the capital required per unit of investment made by the arbitrageur and this in turn causes the spread to be more negative. To see the economic significance, an increase in the VIX by one percent increases the spread by 3.31 basis points (3.81 basis points) for model 1 (model 2). Thus a one standard deviation decline in the level of the VIX index would decrease spreads by approximately 3.31*12.4=41 basis points for Model 1 (47 basis points for Model 2). The peak value of the VIX during the sample period is in excess of 60 percent and contributes to a large proportion of the basis in those instances.

Our proxy for the level of funding constraints (shadow cost of capital) as proxied by the Libor spread (the difference between 3-month Libor rates and 3-month T bills) also has a significant negative relationship (a positive correlation with the absolute level of basis) in Model 1. The magnitude of the coefficient in Model 1 (-26.75) as well as Model 2 (-20.85) shows that elevated levels of the Libor spread contributed to a significant increase in the basis, as well as its decline in more recent data. The average Libor Spread was 1.13% during the sample period with a standard deviation of 0.67%. Thus a change of one standard deviation contributes to 26.75*0.67=18 basis points change in the basis. Also, repo rate volatility has a significant negative relationship with the basis in both specifications. Collectively the funding liquidity variables contributed to a large part of the increase in the basis, and its subsequent decline. A move from a number one standard deviation above the sample mean to one standard deviation below the sample mean would result in a collective change in the basis in excess of 150 basis points from all the three sources of funding liquidity.

In addition to funding liquidity, asset specific variables help proxy for the amount of capital (haircut) that must be put up by the arbitrageur to account for risks posed to the lender. The cross-sectional differences in basis are captured by short term stock volatility, bond credit rating, CDS Bid-Ask Spreads and bond trading volume and bond yield spread. The short-term stock volatility, a proxy for margin requirements imposed by lenders, has the hypothesized negative sign (a positive relationship with absolute basis). A higher stock volatility increases the equity capital required per unit of investment made by the arbitrageur, and this in turn causes the spread to be more negative. While we report the results for historical volatility, the results are very similar when we use implied volatility instead. Again short-term stock volatility impacts the basis by a significant amount. A one standard deviation change in the stock volatility changes the basis by 0.0186*2470=46 basis points.

The bond bid-ask yield spread is also significant and negative as expected, but its economic magnitude is not as large as some of the other metrics (5.25 basis points change from a one standard deviation change). One curious outcome is that Bond Trading Volume has a sign that is opposite to our hypothesized sign. An increase in liquidity ought to be associated with a decline in the absolute level of the basis. Our conjecture is that the in this period of crisis, increased bond trading volume was related to the fact that hedge fund managers took positions in bonds where the basis was the most attractive. This corroborates the anecdotal evidence noted in an article in Bloomberg (excerpt in the introduction) that arbitrageurs were attracted to bonds whose basis was very high and was a source of liquidity during this period.

Note that the coefficient for bond-credit rating is insignificant. However a specification that excludes bond yield spreads makes the coefficient significant and positive, that corroborates the conjecture that differences in credit rating requirements are an important determinant of differences in margin requirements and the basis across bonds. An increase in credit rating makes the basis less negative (decreases the absolute level of the basis). Finally, the CDS Bid-Ask spread is positively related to the basis as expected.

The results in Table 4b are broadly consistent with those in Table 4a. One important observation is that swap rates include credit risk and other liquidity related effects.

This in turn obfuscates the determinants of the basis and does not allow a proper segregation of liquidity effects and makes the arbitrageur funding cost variables difficult to interpret. Thus we include the table for a more complete set of tests even though the specification in table 4a is more appropriate for that task at hand. The parameter estimates for asset specific liquidity are again consistent with those in Table 4a.

It is relevant to point out that our analysis presumes that default insurance via purchase of CDS contracts does not bear default risk. In actual practice many of the banks quoting these CDS prices are themselves subject to solvency risk. Some of this uncertainty is captured by the LIBOR spread variable. To the extent that such positions are marked to market, the solvency and counterparty risk issue is mitigated.

Collectively the analysis suggests that the large increases in the basis are related to common liquidity factors. While firm-specific factors are ones that may not abate quickly or uniformly, common funding liquidity factors may be more predictable. These are important inputs as market participants gauge the manner and time over which apparent deviations amongst relative asset prices may dissipate. To investigate the role of the funding liquidity variables on arbitrageur returns, we now analyze sample trading strategies and the source of the returns.

V. Assessing the risks to arbitrageurs

Our hypothesis and analysis is predicated on the fact that the basis can be explained in an equilibrium model, and that these returns are commensurate with the structure of the economy plus the margin constraints faced by investors. It is relevant to analyze the magnitude of returns that could be earned by arbitrageurs under various scenarios and weight these returns against the risks posed to the arbitrageur as well getting at the source of these returns.

There are an infinite number of trading strategies and entry/exit points that may be employed to exploit the arbitrage opportunity. We deploy a simple convergence trading strategy that posits that the basis would revert to some long term equilibrium level once the funding liquidity risks have abated. In each of the cases examined the basis is negative and would require a purchase of the CDS contract and the bond (Case 2 in Section IIB). To assess the risk faced by arbitrageurs, we compute the internal rate of return from the cash flows generated by a trade that is initiated at the moment the prices diverge by more than 250 basis points (median for our sample) and closed out when the basis is below 100 basis points.

Par CDS contracts have a zero value at the start and therefore do not require a large deployment of capital whereas the bond purchase has to be fully funded. We examine the returns for two levels of leverage – a typical case that requires a CDS margin of 5% of the notional amount and a bond repo margin of 25%. In a second case we consider a more conservative case where the margin is double: 10% and 50% respectively for CDS and bond contracts.

The cash flows are computed as follows. We start with a notional arbitrage portfolio for a face value of $1 million of the underlying bond. The CDS contract and bond are purchased at the outset when the basis exceeds 250 basis points and the arbitrageur cash outflows correspond to the initial margins. The value of the portfolio is marked to market each day and there is a corresponding inflow or outflow depending on the change in the value of the position and the margin required. To compute the daily changes in the CDS position, we use the JP Morgan par hazard rate model to compute the implied default rate on each day. The implied hazard rate is then used to compute the change in value of the CDS based on the premiums set at the start date of the trade (See Appendix B for complete details). Also a new bond bid-price gives the new value of the bond component of the portfolio. That in turn allows us to compute the overall value of the portfolio (bond plus CDS) and any margin calls so that the margin proportions are maintained on each day.

Figure 3 provides a sample of cash flows to a position of Computer Sciences Corporation based arbitrage portfolio. Note that there are large changes in the value of the portfolio and the associated cash flows. Thus our computations specifically take into account any cash outflows to the arbitrageur. When the position is closed out at the point where the basis is 100 basis points, the bond is sold at the market bid-rate and the CDS contract is sold at the prevailing bid-based hazard rate.

Table 5 reports the mean internal rate of return for each firm, the median internal rate of return and the standard deviation of the internal rate of returns for all firms in the sample. These averages are collected at the base of the table. The median holding period is 127 days but there is considerable volatility in the daily returns. In most instances additional capital is required to sustain the position. A high volatility in the path of convergence may force the arbitrageur to terminate his position beforehand. The annualized median return is 80.53% with a 5%/25% margin whereas it is approximately 37% for the second more conservative case. Hewlett Packard bond spreads reverted quickly after the initial spike, consequently generating a large return. Even though these returns are significant, Figure 3 shows that the path to convergence would require additional capital in several instances thus posing substantial risk to arbitrageurs. The ratio of daily returns to daily standard deviation of returns, a measure of risk to reward ratio, is slightly larger than 1 in this instance.

The increase in the basis is associated with the increased aggregate liquidity constraints and funding liquidity constraints. These are important considerations for an arbitrageur seeking to exploit relative mispricing. Table 6 provides a listing of the average change in the liquidity variables from the start of the trade to the close date. Note that the holding periods for each of the positions vary but this provides a cross-check for the source of the returns that accrue to the arbitrageur. Over the holding-period of this arbitrage portfolio, the VIX index declined by over 21 points. This translates into a drop of around 3.31*21= 70 basis points in the CDS-bond yield spread, based on our regression analysis. Further the Libor spread contributes an additional 26.79*1.81=48 basis points. Hence a large proportion of the decline in the 150 basis point spread is related to the impact of the decline in funding liquidity constraints.

VI. Conclusions

This article focuses on the *types of liquidity*- funding and asset specific liquidity- and their role in determining relative asset prices. Using a sample of CDS prices and corporate bond yield spreads we show that changes in the basis between these assets is consistent with equilibrium models that relate the basis to differentials in funding liquidity (shadow cost of capital) as well as cross-sectional difference in asset specific liquidity (determinants of margins) measures. The ability to get collateralized loans and the risk and cost of funding are key factors that determined convergence in relative prices. To the extent that funding liquidity constraints are more predictable, they provide a source of commonality and predictability in relative asset returns. An equivalent interpretation of the results is that the same funding liquidity risks that contribute to an inability to easily exploit arbitrage opportunities are ones that cause bond investors to demand a higher liquidity premium. While funding liquidity is not a primary driver of the basis (and yields) in normal circumstances, the recent events provide a unique instance where such constraints were binding and thus contribute to the novelty of the results.

The two types of liquidity examined are of importance to policy makers and practitioners alike as they examine the impact of market frictions and liquidity on asset prices. Brunnermeier (2009) discusses the sequence of events that lead up to the financial crisis as well as the institutional factors that led to the funding liquidity crunch. In conjunction with this background that details the evolution and sources of funding liquidity shocks, our article adds to the analysis by exploring the subsequent impact of these funding liquidity events on the relationship between asset prices and their derivatives.

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Appendix

A. Bond Rating Numerical Conversions

This figure provides bond rating conversion codes for Moody's and S&P ratings used in the analysis. Moody's and S&P ratings of 13 and above are considered investment grade, while those below 13 are non-investment grade. The data covers the period from 1990 to 2000.

Conversion Number	Moody's Ratings	S&P Ratings
22	Aaa	AAA
21	Aa1	AA+
20	Aa2	AA
19	Aa3	AA-
18	A1	A+
17	A2	A
16	A3	A-
15	Baa1	BBB+
14	Baa2	BBB
13	Baa3	BBB-
12	Ba1	BB+
11	Ba2	BB
10	Ba3	BB-
9	B1	B+
8	B2	B
7	B3	B-
6	Caa1	CCC+
5	Caa2	CCC
4	Caa3	CCC-
3	Ca	CC
2	C	C
1	D	D

B. Computation of Arbitrageur Returns

Suppose that the arbitrageurs purchases a five-year corporate bond issued by a firm, and at the same time enters into a corresponding five-year CDS contract to protect against the associated credit risk. The purchase is initiated when the Basis diverges by more than 250 basis points and the trade is closed out when the basis is below 100 basis points. Below we detail how we compute the cash flows to the investments and the associated holding period return.

Determining the default probability curve:
A credit default swap has two valuation legs: fee and contingent. For a par credit default swap, the net present value of both legs equal to zero (JP Morgan model).

$$PV\ of\ Contingent = PV\ of\ Fee\ \ leg$$

This gives:

$$(1-R)\sum_{i=1}^{n} DF_i\{q(t_{i-1})-q(t_i)\} = S\sum_{i=1}^{n} DF_i q(t_i)d_i + S\sum_{i=1}^{n} DF_i\{q(t_{i-1})-q(t_i)\}\frac{d_i}{2}$$

where

S annual CDS premium

DF_i corresponding discount factor, which is computed by interpolating T-bill 6 month rate, T-bill 1 year rate, T-note 3 year and T-note 5 year rate;

R recovery rate of the reference obligation , which is 40% for all of our sample firms;

$q(t)$ survival probability at time t;

d_i accrual days (expressed in a fraction of one year) between payment dates. And all the CDS payments in our sample are paid semiannually.

We use a bootstrap procedure to infer the daily default probability curve for each sample firm.

Determining the Market value of the CDS:
The market value of the CDS is zero at the initial date with the annual payment of S_0. As the implied default probability and discount factors vary during the trading period, the value of the contract will change. At the first date of the suggested trading period, we assume that the trader enters into the contract of the corresponding corporate five-year par value bond. The market value of the bond changes as its maturity shortens and bond yield changes. The bond price is determined by the bond yield and the settlement date.

Determine the trading cash flows and the internal rate of return (IRR)
Cash outflows occur at the initial date as the arbitrageur initiates the arbitrage via a purchase of the corporate bond and the corresponding CDS on margin. Excess margin

is paid back at the settlement date when the trade is closed. Also, we take into account that margin calls result in outflows during the trading period should the basis diverge. With the above assumptions, we compute the cash flows of the hypothetical portfolios and accordingly, determine the internal rate of return of the investment.

Table 1: Determinants of the Basis = (CDS-Bond Yield Spread)

This table collects the main theoretical determinants of the basis (difference between CDS prices and bond yield spreads). The second column lists the associated proxies for each of the determinants and the last column gives the anticipated impact of each component.

Determinant of (CDS-yield spread)	Proxy	Impact on Absolute(Basis
Funding Liquidity		
Arbitrageurs' capital availability/volatility	VIX Index	+
Arbitrageurs' funding (shadow cost of capital)	Libor-Tbill Spread	+
	Repo-Libor Spread	+
Arbitrageurs' funding risk in rollover	Repo Rate Volatility	+
Asset Specific liquidity	Short Term Stock Volatility	+
	Long Term Stock Volatility	+
	Bond Credit Rating	-
	Bond Trading Volume	-
	Bond Bid-Ask Yield Spread	+
Risk Factors	Stock Return	
	HML	
	SMB	
	Term Spread	

Table 2. Firms in the sample

The sample consists of thirty five firms in the Markit CDS index. Data on CDS prices and bond yields is obtained from the Bloomberg Terminal. Basis is the CDS rate less the yield spread of the reference bond. *T* denotes the fact that the bond yield spread is relative to treasuries and *S* denotes that the spread relative to the swap rate.

(Table on next page)

	Basis (T)		Basis (S)	
Name	Average	St. Dev.	Average	St. Dev.
Altria Group	-245.5	120.1	-190.1	105.5
American Electric Power	-233.4	112.9	-174.8	103.2
Anadarko Petroleum Corp	-195.6	80.8	-148.8	72.9
AT&T Inc	-178.5	89.3	-122.8	75.3
Autozone,Inc	-290.3	132.7	-230.2	121.3
Burlington Northern Santa Fe C	-202.8	85.2	-149.6	74.4
Capital One Bank USA NA	-206.4	61.3	-165.8	58.5
Cardinal Health Inc	-298.9	104.8	-232.6	100.2
CBS Corp	-192.2	59.9	-151.4	58.3
Computer Sciences Corp	-288.1	149.6	-220.9	150.1
ConAgra Foods Inc	-151.1	65.9	-106.7	59.4
CSX Corp	-262.1	115.9	-196.5	112.9
Darden Restaurants Inc	-243.6	184.1	-185.8	167.9
Dominion Resources Inc/VA	-149.1	129.1	-81.4	114.9
Hewlett-Packard Co	-100.0	80.6	-32.3	64.5
Ingersoll-Rand Co	-285.7	118.0	-224.0	106.6
International Paper Co	-260.1	139.7	-192.6	136.7
Marriott International Inc/DE	-196.2	135.3	-129.4	131.6
McKesson Corp	-234.5	78.7	-185.0	69.1
National Rural Utilities Coope	-107.7	156.4	-55.0	143.9
Newell Rubbermaid Inc	-234.3	172.9	-175.3	165.4
Progress Energy Inc	-181.5	89.9	-135.0	82.4
Ryder System Inc	-229.0	158.4	-173.2	152.4
Safeway Inc	-165.5	86.2	-114.5	76.7
Sempra Energy	-281.9	135.3	-231.0	122.5
Staples Inc	-290.7	108.2	-240.9	99.4
Black & Decker Corp	-234.2	118.7	-190.1	112.0
Home Depot Inc	-156.5	79.7	-88.6	68.6
Kroger Co/The	-154.6	100.1	-91.9	87.3
Time Warner Cable Inc	-156.4	123.3	-90.8	110.2
Time Warner Inc	-181.6	171.7	-113.9	160.6
Toll Brothers Inc	-443.9	82.3	-399.3	76.5
Wells Fargo & Co	-217.7	183.3	-149.9	166.7
Whirlpool Corp	-423.4	213.0	-362.2	212.1
Xerox Corp	-169.1	153.8	-104.3	148.5

Table 3. Summary Statistics

The sample consists of 35 firms in the Markit CDS index for the sample period 06/2008 to 09/2009. Data on CDS prices and bond yields as well as other variables is obtained from the Bloomberg Terminal. Panel A report the sample statistics and Panel B collects the correlation between the variables.

Panel A: Sample Statistics

Variable	Mean	St. Dev.
Basis (T)	-335.76	125.08
Basis (S)	-272.28	118.49
VIX Index	42.65	12.41
LIBOR Spread (%)	1.13	0.67
GC-Repo Spread (%)	0.77	0.32
Short Term LIBOR Volatility (bp)	20.37	22.89
Short Term Repo Rate Volatility (bp)	15.84	15.56
Short Term Stock Volatility (%)	3.28	1.86
Stock Implied Volatility (3 month)	48.81	18.21
Bond Credit Rating (AAA=22, D=1)	14.88	3.36
CDS Bid-Ask Spread (Par rates)	0.32	0.13
Stock Return (lagged 30 day in %)	7.08×10^{-2}	3.67
Bond Trading Volume (% of Issue)	0.59	1.24
Bond Bid-Ask Yield Spread (%)	0.12	0.07
Term Spread (%)	1.82	0.38
HML (%)	-3.388×10^{-2}	1.26
SMB (%)	3.891×10^{-2}	0.94

Panel B: Correlation Matrix

Variable	B(T)	B(S)	VIX	GC	LI	LV	RRV	SV	IV	BR	SR	CDS	BTV	BS	TS	HML	SMB
Basis (T)	1.00																
Basis (S)	0.99	1.00															
VIX Index	-0.54	-0.51	1.00														
GC-Repo Spread (GC)	-0.25	-0.14	0.47	1.00													
Libor Spread (LI)	0.12	0.25	-0.16	0.70	1.00												
LIBOR Volatility (LV)	-0.35	-0.31	0.71	0.70	0.17	1.00											
Repo Rate Volatility (RRV)	-0.41	-0.36	0.66	0.62	0.15	0.71	1.00										
Short Term Stock Volatility	-0.42	-0.42	0.39	0.16	-0.15	0.27	0.26	1.00									
Stock Implied Volatility (IV)	-0.44	-0.44	0.50	0.16	-0.19	0.31	0.32	0.88	1.00								
Bond Credit Rating (BR)	0.19	0.19	0.04	0.07	0.05	0.07	0.08	0.21	0.14	1.00							
Stock Return (SR)	-0.02	-0.02	-0.08	0.01	0.01	-0.05	-0.01	0.04	-0.02	0.01	1.00						
CDS Bid-Ask Spread (CDS)	-0.25	-0.26	0.36	0.06	-0.20	0.17	0.29	0.45	0.55	-0.09	0.06	1.00					
Bond Trading Volume	-0.13	-0.15	-0.03	-0.09	-0.09	-0.05	-0.04	0.08	0.06	-0.10	-0.01	0.10	1.00				
Bond Bid-Ask Yield Spread	-0.03	-0.06	0.07	-0.12	-0.24	0.03	-0.02	0.05	0.07	0.07	-0.01	0.09	0.01	1.00			
Term Spread (TS)	0.19	0.13	-0.12	-0.11	-0.29	0.16	-0.28	-0.03	-0.05	0.00	0.03	-0.11	0.00	0.18	1.00		
HML	0.04	0.04	-0.19	-0.05	0.02	-0.16	-0.10	-0.01	-0.07	-0.01	0.48	0.02	0.01	-0.02	0.00	1.00	
SMB	-0.02	-0.02	-0.01	0.04	0.01	-0.03	0.05	0.01	-0.01	0.01	-0.02	0.00	-0.02	-0.02	-0.05	-0.05	1.00

Table 4a. Liquidity and the Basis

The sample consists of 35 firms in the Markit CDS index for the sample period 06/2008 to 09/2009. Data on CDS prices and bond yields as well as other variables is obtained from the Bloomberg Terminal. The dependent variable is the basis (difference between CDS price of a reference entity and the bond spread on the corresponding corporate bond relative to treasury bonds (Basis (T)). We report robust standard errors/t-stats corrected for clustering. T-stats corresponding to significance levels of 1%, 5% and 10% are 2.32, 1.96 and 1.65 respectively.

Dependent Variable: Basis (T)

	Model 1		Model 2	
Varaibles	coeff.	t-stat	coeff.	t-stat
Arbitrageurs' capital volatility				
VIX Index	-3.31	-13.68	-3.81	-2.78
Arbitrageurs' funding costs				
LIBOR Spread	-26.75	-3.79		
GC Repo Spread			-20.85	-3.31
Arbitrageurs' funding risk in rollover				
Repo Rate Volatility	-99.06	-5.23	-95.19	-4.91
Asset specific variables (haircut)				
Short Term Stock Volatility	-2470.65	-14.61	-2533.89	-15.17
Bond Credit Rating	-0.33	-0.12	0.43	0.14
CDS Bid-Ask Spread	0.82	2.40	0.74	2.16
Bond Trading Volume	-374.10	-4.26	-379.94	-4.25
Bond Bid-Ask Yield Spread	-75.42	-2.95	-73.22	-2.86
Stock Return	-118.96	-2.46	-129.65	-2.66
HML	-269.27	-2.11	-290.28	-2.28
SMB	-142.39	-0.87	-150.88	-0.92
Term Spread	55.86	14.05	59.95	14.52
R-Square	0.7044		0.7029	
F-Stat	312.87		308.77	
N	3268		3268	

Table 4b. Liquidity and the Basis

The sample consists of 35 firms in the Markit CDS index for the sample period 06/2008 to 09/2009. Data on CDS prices and bond yields as well as other variables is obtained from the Bloomberg Terminal. The dependent variable is the basis (difference between CDS price of a reference entity and the bond spread on the corresponding corporate bond relative to the 5 year swap rate (Basis (S)). We report robust standard errors/t-stats corrected for clustering. T-stats corresponding to significance levels of 1%, 5% and 10% are 2.32, 1.96 and 1.65 respectively.

Dependent Variable: Basis (S)

	Model 1		Model 2	
Varaibles	coeff.	t-stat	coeff.	t-stat
Arbitrageurs' capital volatility				
VIX Index	-3.68	-15.16	-3.82	-18.61
Arbitrageurs' funding costs				
LIBOR Spread	0.39	0.06		
GC Repo Spread			14.62	2.30
Arbitrageurs' funding risk in rollover				
Repo Rate Volatility	-111.77	-5.88	-127.07	-6.52
Asset specific variables (haircut)				
Short Term Stock Volatility	-2405.49	-14.12	-2499.29	-14.80
Bond Credit Rating	0.14	0.04	-0.20	-0.06
CDS Bid-Ask Spread	0.59	1.68	0.68	1.95
Bond Trading Volume	-379.99	-4.21	-380.83	-4.23
Bond Bid-Ask Yield Spread	-80.18	-3.09	-75.64	-2.92
Stock Return	-123.16	-2.51	-126.54	-2.57
HML	-321.03	-2.47	-331.42	-2.57
SMB	-274.34	-1.66	-288.22	-1.75
Term Spread	49.97	12.45	45.42	10.84
R-Square	0.6936		0.6941	
F-Stat	305.01		298.58	
N	3268		3268	

Table 5. Returns To Arbitrageurs

The sample consists of 35 firms in the Markit CDS index for the sample period 06/2008 to 09/2009. Data on CDS prices and bond yields as well as other variables is obtained from the Bloomberg Terminal. The trading rule is to buy the CDS contract and the bond when the spread exceeds 250 basis points and to close the trade when the spread converges to a level below 100 basis points. We report annualized internal rate of return for each firm when a margin of 5% is required for the CDS contract and 25% for the bond in case 1 and 10%/50% in case 2.

(Table on next page)

Firm	Days	CDS Margin =5% Bond Margin = 25%		CDS Margin =10% Bond Margin = 50%	
		Daily IRR	IRR (Annual)	Daily IRR	IRR (Annual)
Altira Group,Inc	174	0.24%	80.68%	0.13%	38.20%
American Electric Power	235	0.17%	52.16%	0.09%	25.52%
Anadarko Petroleum Corp	121	0.11%	30.14%	0.06%	15.82%
AT&T Inc	86	0.33%	127.28%	0.18%	55.73%
Autozone,Inc	305	0.16%	48.09%	0.09%	24.50%
Burlington Northern Santa Fe C	222	0.12%	34.07%	0.06%	17.29%
Capital One Bank USA NA	78	0.27%	96.65%	0.14%	43.51%
Cardinal Health Inc	329	0.13%	38.42%	0.07%	19.31%
CBS Corp	71	0.24%	80.53%	0.13%	37.03%
Computer Sciences Corp	275	0.16%	49.73%	0.09%	25.07%
ConAgra Foods Inc	65	0.15%	47.17%	0.08%	22.23%
CSX Corp	300	0.18%	55.01%	0.10%	27.94%
Darden Restaurants Inc	223	0.26%	91.29%	0.15%	45.99%
Dominion Resources Inc/VA	89	0.49%	236.39%	0.28%	98.81%
Hewlett-Packard Co	35	0.92%	879.80%	0.49%	243.53%
Ingersoll-Rand Co	235	0.17%	53.80%	0.09%	26.56%
International Paper Co	105	0.32%	123.65%	0.19%	61.01%
Marriott International Inc/DE	89	0.54%	286.41%	0.31%	117.01%
McKesson Corp	178	0.14%	41.79%	0.07%	20.33%
National Rural Utilities Coope	47	0.76%	568.95%	0.42%	184.90%
Newell Rubbermaid Inc	281	0.13%	38.92%	0.07%	20.26%
Progress Energy Inc	83	0.16%	49.89%	0.08%	23.32%
Ryder System Inc	110	0.38%	155.20%	0.22%	71.40%
Safeway Inc	166	0.09%	23.92%	0.04%	11.80%
Sempra Energy	259	0.19%	58.77%	0.10%	29.25%
Staples Inc	216	0.09%	26.43%	0.05%	14.45%
Black & Decker Corp	117	0.31%	118.08%	0.18%	55.38%
Home Depot Inc	67	0.60%	350.63%	0.34%	132.60%
Kroger Co/The	127	0.38%	161.30%	0.21%	70.87%
Time Warner Cable Inc	64	0.55%	291.52%	0.31%	116.04%
Time Warner Inc	197	0.27%	98.13%	0.16%	48.50%
Toll Brothers Inc	163	0.15%	45.56%	0.08%	22.62%
Wells Fargo & Co	118	0.34%	135.78%	0.20%	64.94%
Whirlpool Corp	335	0.14%	42.37%	0.08%	22.11%
Xerox Corp	90	0.53%	275.89%	0.30%	113.56%
Average	162	0.29%	139.84%	0.16%	56.21%
Min.	35	0.09%	23.92%	0.04%	11.80%
Median	127	0.24%	80.53%	0.13%	37.03%
Max	335	0.92%	879.80%	0.49%	243.53%
Standard Deviation	89	0.20%	173.47%	0.11%	52.04%

Table 6. Source of Returns To Arbitrageurs

The sample consists of 35 firms in the Markit CDS index for the sample period 06/2008 to 09/2009. Data on CDS prices and bond yields as well as other variables is obtained from the Bloomberg Terminal. The trading rule is to buy the CDS contract and the bond when the spread exceeds 250 basis points and to close the trade when the spread converges to a level below 100 basis points. The table reports the change in liquidity variables from the trade initiation to the trade close date.

Variable	Average change over holding period
VIX	-21.28
Libor Spread	-1.81%
GC Repo Rate	-1.16%
Repo Rate Volatility	-0.11%
Stock Volatility	-1.44%
CDS Spread (basis points)	-0.42
Trading Volume	-0.02%
Bond Bid-Ask Yield Spread	-0.24%

Figure 1: Computer Sciences Corporation: Basis between CDS and Bond Yield Spreads

This figure reports the basis or difference between the CDS price and the bond yield spread (in basis points) for Computer Sciences Corporation for the sample period 06/2008 to 09/2009. Data on CDS prices and bond yields is obtained from the Bloomberg Terminal.

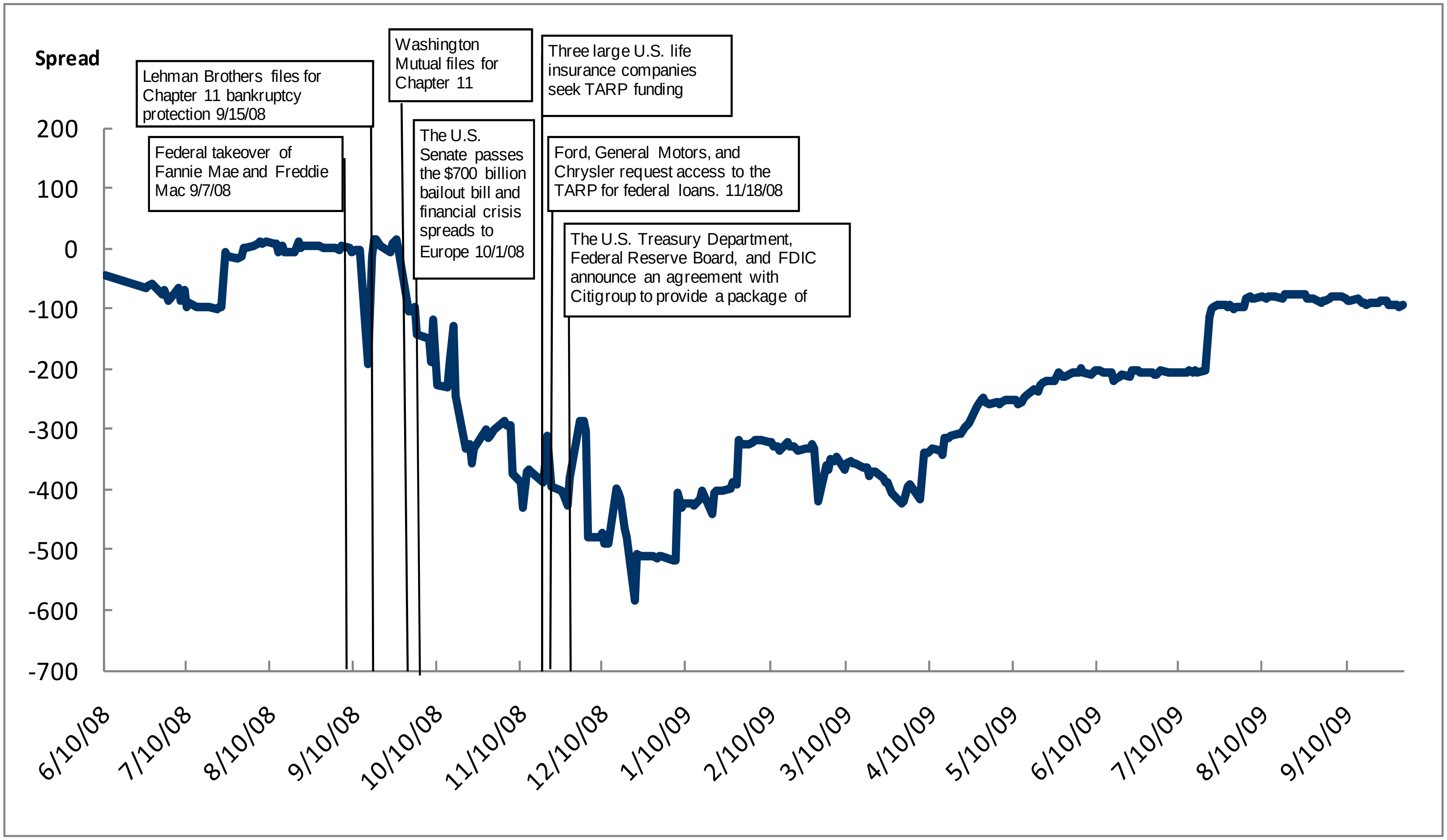

Figure 2: Transactions in a Hypothetical Arbitrage

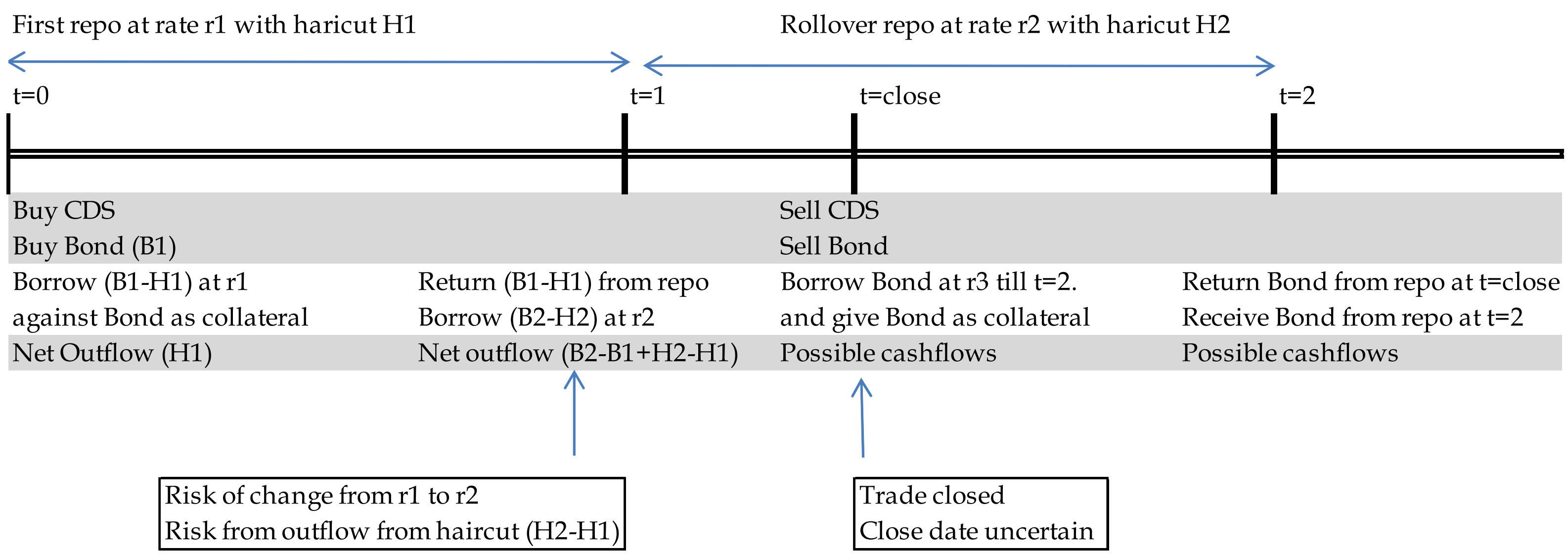

Figure 3: Cash Flows to a Hypothetical Arbitrage

This chart displays the interim cash flows to a hypothetical arbitrage on Computer Sciences Corporation when the trade is initiated at the moment the basis is more than 250 basis points. The position closed out when the spread is below 100 basis points. The margin is 10% and 50% respectively for CDS and bond contracts, and the face value of the bonds is $1 million.