# Liquidity and Arbitrage in the Market for Credit Risk

Amrut Nashikkar*    Marti G. Subrahmanyam†    Sriketan Mahanti‡

August 15, 2010

**Abstract**

The recent credit crisis has highlighted the importance of market liquidity and its interaction with the price of credit risk. We investigate this interaction by relating the liquidity of corporate bonds to the basis between the credit default swap (CDS) spread of the issuer and the par-equivalent bond yield spread. The liquidity of a bond is measured using a recently developed measure called *latent liquidity*, which is defined as the weighted average turnover of funds holding the bond, where the weights are their fractional holdings of the bond. We find that bonds with higher latent liquidity are more expensive relative to their CDS contracts, after controlling for other realized measures of liquidity. Analysis of interaction effects shows that highly illiquid bonds of firms with a greater degree of uncertainty are also expensive, consistent with limits to arbitrage between CDS and bond markets, due to the higher costs of "shorting" illiquid bonds. Additionally, we document the positive effects of liquidity in the CDS market on the CDS-bond basis. We also find that several firm-level and bond-level variables related

We acknowledge the generous support of State Street Corporation in providing the resources for conducting the research reported in this paper. We are grateful to an anonymous referee and the editor, Paul Malatesta, for detailed, helpful comments on a previous draft of this paper. We thank Craig Emrick, Gaurav Mallik, Jeffrey Sutthoff and Caroline Shi at State Street Corporation for helpful discussions and their unstinting support in putting together the databases used in this research. We thank Dion Bongaerts, George Chacko, Rainer Jankowitsch, Ahmet Kocagil, Jason Levine, Lasse Pedersen, Raghu Sundaram and Mike Piwowar, for comments on previous versions of this paper. We also thank participants at the 2006 NBER Conference on Microstructure, and the 2007 EFA meetings, and seminar participants at Universita Commerciale Luigi Bocconi, Milan, Carnegie-Mellon University, Imperial College, London, London Business School, University of Melbourne, Northwestern University, Singapore Management University and Universita Ca' Foscari, Venice. All errors remain our own.

*email: amrut.nashikkar@barclayscapital.com; Tel: +1 212 412 1848. Stern School of Business & Barclays Capital Inc., 745 7 Ave, New York, NY 10019

†email: msubrahm@stern.nyu.edu; Tel: +1 212 998 0348. Stern School of Business, New York University. 44 W 4th Street, New York, NY 10012

‡email: sriketan@idomail.com; Tel: +1 508 517 2636. Orissagroup, 1050 Winter Street, Suite 1000, Waltham, MA 02451

to credit risk affect the basis, indicating that the CDS spread does not fully capture the credit risk of the bond.

# I Introduction

Corporate bonds are amongst the least understood instruments in the US financial markets. This is surprising given the sheer size of the US corporate bond market, about 6.8 trillion dollars outstanding as of June 2009, which makes such bonds an important source of capital for US firms.[1] These bonds carry a risk of default, and hence command a yield premium or spread relative to their risk free counterparts. However, the academic literature in finance has been unable to explain a significant component of corporate bond yields/prices in relation to their Treasury counterparts, despite using a range of structural and reduced form credit risk models.

Prior studies have noted that although default risk is an important determinant of the yield spread, there are other factors such as liquidity, taxes, and aggregate market risk variables (other than credit risk) that may also play a significant role in determining the spread. Of these other factors, it has been conjectured that liquidity effects have an important role to play in the pricing of corporate bonds, and are reflected in the non-default component of their yields, i.e., the portion of the corporate bond yield that cannot be explained by factors related to default risk.[2] Since illiquid instruments are difficult to trade, investors holding them demand a risk premium that is related to the level of liquidity in the instrument. In the context of corporate bonds, this premium increases the expected return of the bond, in a way that is not directly related to the credit risk embedded in the instrument. In other words, a premium for liquidity can be thought of as a non-default related component of the yield spread.

[1]Source: Securities Industry and Financial Markets Association Website:

$http://www.sifma.org/uploadedFiles/Research/Statistics/SIFMA_USBondMarketOutstanding.pdf$

[2]See, for example, the discussion below on papers by Longstaff, Mithal, and Neis (2005), Elton, Gruber, Agrawal, and Mann (2001), Eom, Helwege, and Uno (2003) and others.

Unfortunately, the non-default component of corporate bond yields has been inadequately studied, largely due to the paucity of data. In particular, the absence of frequent trades in corporate bonds makes it difficult to compute trade-based measures of liquidity relying on quoted/traded prices or yields to measure liquidity, as has been done in the equity markets. It is difficult, therefore, to measure the liquidity of corporate bonds directly. Consequently, it is a challenge to *directly* study the impact of liquidity on corporate bond yields and prices, thus leaving the discussion of corporate bond spreads somewhat incomplete.

An important development during this decade has been the credit default swap (CDS) market, which has emerged as the barometer of the market's collective judgment of the credit risk of the bonds issued by an obligor. The CDS contract is a derivative where the underlying instruments are corporate bonds. Financial theory tells us that a strong economic relationship should exist between the CDS and its underlying instruments. The CDS spread is thus a proxy for the premium attached to credit risk, which, in a world without frictions, would be exactly equivalent to the credit risk in the underlying corporate bonds. In practice, however, it may itself be affected by market frictions, as discussed later on in the paper.[3] In this paper, we study the CDS-bond basis, the difference between the CDS spread of the issuer and the par-CDS equivalent spread of the bond, as a (somewhat imperfect) measure of the non-default component of the bond yield.[4] We relate the CDS-bond basis, to bond liquidity and other variables such as the bond characteristics, firm-level credit risk effects

[3]The CDS price is usually referred to by market participants as the CDS spread since it is seen to be analogous to a spread over LIBOR.

[4]The par CDS-equivalent spread is the spread of a hypothetical CDS contract that has the same default probability and recovery rate (assumed to be 40% here) as implied by the price of the bond. Hence, the difference between the par CDS-equivalent spread and the CDS spread more accurately captures the economic value of the basis than the simple difference between bond yield spreads and the CDS spread, which could be affected by coupon payments and the level of the risk free rates. This concept is discussed in greater detail in section 4.2 and in Appendix B.

and liquidity in the CDS market itself. There are several significant contributions we make in this study.

First, we use and further validate a new measure of bond liquidity, called latent liquidity, proposed by Mahanti, Nashikkar, Subrahmanyam, Chacko, and Mallik (2008), which is based on the holdings of bonds by investors, and thus does not require a large number of observed trades for its computation. This measure weights the turnover of the funds that own the bond by their fractional holdings; thus, it is a measure of the *accessibility* of a bond to market participants. The attractive feature of this measure is that it circumvents the problem of non-availability of transaction data for corporate bonds, and yet provides a reasonable proxy for liquidity. We show that our measure has explanatory power for the liquidity component of the CDS-bond basis, even after controlling for trading volume and other bond characteristics such as age, coupon and issue size, which have been associated with bond liquidity.

Second, we show that even after controlling for credit risk using the price of the CDS contract, corporate bond prices are still affected by factors related to the default risk in the firm. We also find that the effect is one sided - when firms are riskier, their corporate bonds tend to be relatively expensive. Furthermore, it is the *illiquid* bonds of firms with more uncertainty that are more expensive relative to their CDS contracts. Our interpretation is that this conclusion is due to the effects of frictions in the arbitrage mechanism. Agents participating in the CDS market and the corporate bond market may have different valuations for the credit risk of the obligor. However, arbitrageurs who try to profit from this difference may find it difficult to sell corporate bonds short, because of limited supply in the borrowing and lending market for corporate bonds. This makes illiquid corporate bonds of firms with greater uncertainty more likely to be expensive relative to their CDS contracts.

Third, we show that the liquidity of the CDS contract itself influences both the liquidity of the bond and the bond price itself. Bonds of issuers whose CDS contracts enjoy greater liquidity tend to be more expensive (have lower yields) in the cross-section, compared with their less liquid counterparts, after adjusting for various bond characteristics. This is evidence of liquidity spillover effects from the CDS market to the corporate bond market.

Fourth, we demonstrate the effect of individual bond characteristics, such as the presence or absence of covenants and differences in tax status, on bond prices. To our knowledge, this is the first study that studies the effect of bond covenants on bond valuation, using the CDS spread as a control for credit risk.

The novel bond-liquidity measure that we use in this paper is related to the theory proposed by Amihud and Mendelson (1986) according to which, in equilibrium, assets with the lowest transaction costs are held by investors with the shortest trading horizon, and have higher prices. Our metric, proposed by Mahanti, Nashikkar, Subrahmanyam, Chacko, and Mallik (2008), can thus be thought of as a direct measure of the activity of funds holding a particular bond. It is also related to the literature on liquidity and asset prices, most notably Vayanos and Wang (2006), who use a search-based model to provide for an endogenous concentration of liquidity in particular assets. This concentration leads to active investors participating in these assets, thus lowering transaction costs and leading to higher prices at the same time. In this sense, our measure can be thought of as *directly* measuring the extent of search frictions when the marginal holders of a particular bond wish to trade.

This paper is divided into the following sections. Section II reviews the literature from the point of view of our measure. Section III describes our data sources. Section IV discusses the latent liquidity measure and the manner in which we compute the CDS-bond basis. Section V discusses the results of our study explaining the basis in terms of liquidity metrics of the bond and CDS markets, as well as firm and bond characteristics. Section VI concludes.

# II Literature Review

This paper is related to the vast literature that attempts to describe the effect of liquidity on asset prices. Most of this literature relates to the concept of liquidity costs and associated liquidity premia in stocks, although there is some recent literature that deals with corporate bonds. While a comprehensive survey of this literature is beyond the scope of this study, we touch upon a few contributions that underpin the prevailing academic perspective on the effects of liquidity on asset prices.[5] In an early contribution in this area, Amihud and Mendelson (1986) argue that transaction costs result in liquidity premia in equilibrium, reflecting the differing expected returns for investors with different trading horizons, who have to defray their transaction costs. There is an implicit clientele effect due to which securities that are more illiquid are cheaper as a result and are held in equilibrium by investors with longer holding periods. This work has been extended and modified in different directions.[6]

A closely related branch of the literature has to do with modeling liquidity costs in corporate bonds. The earliest study of this nature is by Fisher (1959), who uses the amount outstanding of a bond as a measure of liquidity, and the earnings volatility as a measure of the credit risk of the firm, and finds that yield spreads on bonds with low issue sizes (illiquid bonds) are higher. Also notable is a recent paper by Chen, Lesmond, and Wei (2007), who provide a method for estimating transaction costs in the corporate bond market and apply it to corporate bonds. Our paper uses more detailed data on the institutional holdings of bonds to construct an alternative measure of liquidity, called latent liquidity, which can be used even in the absence of transaction data. The relationship between this measure and transaction costs as well as market impact has been demonstrated by Mahanti, Nashikkar,

[5]The literature on liquidity effects in the broad context of asset pricing is too vast for us to detail here. See Amihud, Mendelson, and Pedersen (2006) for a comprehensive survey.

[6]See Huang (2003) and Acharya and Pedersen (2005), for examples.

Subrahmanyam, Chacko, and Mallik (2008).

There have also been several attempts to decompose the yield spread on corporate bonds in terms of the component that is related to the defaultable nature of these securities, as opposed to other factors. For instance, Eom, Helwege, and Uno (2003) and Huang and Huang (2003) use structural models to explain the spreads on corporate bonds and find that most structural models are only able to explain about half of the corporate bond spreads for a range of reasonable parameters assumed for the firm value process. Elton, Gruber, Agrawal, and Mann (2001) find evidence of a significant coupon effect in corporate bonds which they attribute to the differential tax treatment of coupon payments on corporate bonds relative to Treasury securities.

An important related paper in this strand of the literature is by Longstaff, Mithal, and Neis (2005), who fit a common model of credit risk to both corporate bonds and to credit default swaps. Assuming that the CDS spread captures the default-related part of the corporate bond yield, they find evidence of a significant non-default component in the yield spread and are able to relate it to the coupon as well as variables that are related to the liquidity of a bond, such as the amount outstanding (in the cross-section), bid/ask spreads, and the liquidity premium for on-the-run treasury securities in the time series. Blanco, Brennan, and Marsh (2005) take another approach to the problem by studying co-integration between corporate bond spreads and CDS spreads. They document the presence of a strongly mean-reverting, non-default component in corporate bond yields. They also find, based on their model of information flows, that the CDS market leads the corporate bond market, and that most of the corrections introduced by this lead-lag relationship take place through the non-default component of corporate bond yields. Our paper adds to this literature by examining the role of liquidity more closely. We also examine whether frictions in the arbitrage process between bonds and the CDS contracts cause the CDS contract to capture the underlying credit risk less than completely.

Another strand of the literature that is pertinent to our research here is the work on measures of liquidity that are appropriate for the corporate bond market. Some papers that study liquidity effects using transactions based data on bonds include Chakravarty and Sarkar (1999), Hong and Warga (2000), Schultz (2001) and Hotchkiss, Warga, and Jostova (2002). More recently, Houweling, Mentink, and Vorst (2005) use liquidity-sorted portfolios in the European market, constructed using nine proxies for liquidity including issued amount, listing, currency, on-the-run or not, age, whether there are missing prices, yield volatility, the number of quote contributors, and yield dispersion. However, it is not clear that these approaches *directly* control for the credit risk of the bond, as efficiently as the CDS market.

The concept of latent liquidity that is used in this paper draws from Mahanti, Nashikkar, Subrahmanyam, Chacko, and Mallik (2008). Latent liquidity is simply the weighted average turnover of the funds holding a particular bond, where the weights are the fractions of the outstanding amount of the bond that are held by any given fund. They introduce this measure of liquidity and relate it to bond-specific characteristics, such as maturity, age, coupon, rating, the presence or absence of put/call options and other covenants. They also show that latent liquidity has explanatory power for both transaction costs and market impact.

# III Data Sources

Our primary source of data for prices and realized liquidity measures for the corporate bond market is the Trade Reporting and Compliance Engine (TRACE) database of the Financial Industry Regulatory Authority (FINRA). We first calculate the volume-weighted average price of a bond on any given day after eliminating cancellations and trade reversals from our data. In order to limit contamination by off-market trades, we consider only days when the total traded volume is greater than USD 100,000. We obtain details of bond characteristics such as coupon, issue date, maturity and issue size from Bloomberg, and match them with the TRACE data by their Committee on Uniform Securities Identification Procedures (CUSIP) number. We confirm the reported yield on the bond by performing our own yield computation and eliminating those observations for which our calculations and the reported yields differ substantially. Unlike Longstaff, Mithal, and Neis (2005), who restrict their sample to bonds around a five-year maturity, we include bonds of all maturities but include a control for maturity in our computations. From the TRACE data, we also compute the number of trades in a quarter, the number of traded days in a quarter and the total dollar amount of any bond traded within a given quarter.

In order to compute our measure of latent liquidity, we use the corporate bond holdings and transactions database of State Street Corporation (SSC), one of the largest custodians in the global financial markets. A custodian provides trade clearance, asset tracking, and valuation service support to institutional investors. The client of the custodian is the fund, i.e., the owner of the asset, which may deal with diverse broker-dealers. All these trades are cleared through the custodian, who thus has access to information about a larger number of trades than an individual broker-dealer. In addition, custodians have access to information on who *holds* the corporate bonds, and these data permit the construction of the latent liquidity measure that we employ in this research. Our database contains the end-of-quarter holdings information on all the bonds in our sample, based on which the latent liquidity measure is computed. The database covers around 15% of all bonds traded in the US markets and is reasonably representative of the overall US corporate bond market.

Our CDS data are derived from two separate sources. Prior to October 2004, we use CDS spreads supplied by GFI Group Inc, the leading broker in the CDS market.[7] The database covers over 1,000 leading corporate names on which credit protection is bought or sold on a fairly regular basis. It includes daily prices for CDS contracts for the period

[7]More information about GFI and their CDS database is available at http://www.gfinet.com.

from April 1999 to July 2005. Since October 1, 2004, a much wider coverage of CDS names is available from CMA DataVision via the Bloomberg data service, in a reliable fashion. These data cover over 2,000 issuers on whom CDS contracts are traded, and subsequent to this date, we, therefore, use these quoted CDS spreads (both bid-, ask- and mid-) for our basis computation. During the period in which the two data sources overlap, we confirm that they are substantially in agreement. This gives us confidence that our results prior to October 2004 are comparable to those after October 2004. We also confirm this conclusion by performing robustness checks by conducting our empirical analysis on the sub-sample after October 2004.

There are several advantages to using our combined data-set relative to those used in prior research:

- Our dataset covers a longer time period than has been covered by previous studies. Most notable amongst these studies is the one by Longstaff, Mithal, and Neis (2005), which uses a proprietary database of CDS spreads that covers 52 firms over a much shorter time period (from March 2001 to October 2002). The data-set used by Blanco, Brennan, and Marsh (2005) covers only 33 firms from Jan 2001 to June 2002. Our combined database covers 1,167 firms and 4,972 bonds over the period July 2002 to June 2006, with a total of 33,000 bond-quarters.

- There have been significant changes in the market for corporate bonds with the advent of hedge funds and credit derivatives over the last ten years. Our data-set covers the latter half of this period, and thus, includes more recent data. This is in contrast to the data used by many of the previous studies on corporate bond yields, which are, in many cases, based on the Warga (1997) Fixed Income Securities Database, which contains data prior to 1996, and has data on about 700 bonds.[8]

[8]See, for example, papers by Elton, Gruber, Agrawal, and Mann (2001), Huang and Huang (2003), Eom,

- Our data-set contains quotes by a large number of CDS market-makers, and is thus quite inclusive and reliable.

Data on interest rates, such as swap rates and treasury rates, are obtained from Datastream. These data are also matched by date with those for corporate bond and CDS trades in our data-set. In order to focus on the pricing of corporate bonds relative to the CDS contract, we restrict our attention to data on days on which we observe at least a quote, if not a trade, in *both* the CDS market and trades in the corporate bond market. This eliminates, as far as possible, timing mismatches in the data, and accurately captures the effect of time variation in the default risk inherent in the bond. For each bond, we also obtain data on the corresponding bond characteristics, such as coupon, rating, outstanding volume, and bond-specific features such as covenants, tax status and issuance methods from Bloomberg.[9]

We match the firms in the Compustat quarterly database by ticker and name with the bonds available in the TRACE database. This allows us to compute firm-level financial ratios, such as leverage and the proportion of tangible assets, that we might expect to have a significant bearing on the credit risk of the firm. In cases where data are not available quarterly, we use data available as of the previous financial year. In order to account for reporting delays and ensure that the information is available to the market participants at the time of the trade, we use data from the quarter *prior* to the one for which we compute the basis and the liquidity measures. Data on analyst forecasts of earnings per share for the firm are taken from the I/B/E/S database. We rely on the equity ticker of the firm derived from Compustat as our primary matching variable for I/B/E/S data. Our resulting sample is broadly similar to the samples used in prior studies of the corporate CDS market in terms of ratings and industry sectors represented, but with many more observations, both

Helwege, and Uno (2003) and others.

[9] In the empirical estimations, we follow the numerical scheme used by Compustat to assign numbers to ratings, where AAA is coded as 1, AA+ is coded as 2 and so on.

cross-sectionally and over time.[10]

# IV Methodology

## A Latent Liquidity

In this section, we describe in brief the methodology used to compute the latent liquidity measure. In simple terms, latent liquidity is the weighted average turnover of the investors holding a particular bond, the weights being the fractions of the total outstanding amount of a bond held by various funds at the beginning of the month.[11] The argument behind this computation is that since there is considerable persistence in turnover, bonds that are held by investors that have a larger turnover are likely to be more accessible and hence more highly traded in the following period. Mahanti, Nashikkar, Subrahmanyam, Chacko, and Mallik (2008) show that this measure of latent liquidity is correlated with other transaction-based measures of liquidity, such as trading volume and bid-ask spreads, in the relatively liquid segment of the market where reliable micro-structure based data are available. However, the advantage of the latent liquidity measure is that it does not require trade-based information, and is thus available *ex-ante* for a broader cross-section of bonds.

Let $\pi^i_{j,t}$ denote the fractional holding of a bond $i$, $i = 1, 2, ...I$, by fund $j$, $j = 1, 2, ...J$, at time $t$. Let $T_{j,t}$ denote the average portfolio turnover of a fund in the months from $t$ to $t-12$, where turnover is defined as the ratio of the dollar trading volume of the fund between time $t$ and $t-12$ to the value of the fund at time $t$. The latent liquidity measure for bond $i$ at time $t$ is simply defined as:

[10] See, for example, Blanco, Brennan, and Marsh (2005) and Longstaff, Mithal, and Neis (2005).

[11] For a more detailed description of the computation, as well as the relationship between latent liquidity and bond characteristics, the reader is referred to Mahanti, Nashikkar, Subrahmanyam, Chacko, and Mallik (2008).

$$L_t^i = \sum_{j=1}^{J} \pi_{j,t}^i T_{j,t} \tag{1}$$

We use equation 1 to compute a quarterly value for the latent liquidity of each bond in our sample, expressed in annual turnover terms. In this sense, the latent liquidity of the bond indicates the average trading frequency of the agents holding the bond, and consequently, the ease with which it may be traded in the presence of search frictions.

## B The Basis Between CDS Spreads and Bond Prices

The recent academic literature on corporate bond pricing has attempted to isolate the component of corporate bond yields that is *not* attributable to default risk (the non-default component). Most of the earlier papers in this area use an explicit model for pricing credit risk.[12] The advent of the CDS market has led to attempts to isolate the default risk of a certain issuer without relying too heavily on a particular model of credit risk and a specific parameterization, since a *direct* reading of the market's pricing of credit risk is available. Since CDS contracts price default risk explicitly, they are a good benchmark for the pure credit risk of the firm, and hence apply to all its traded obligations. Indeed, as argued by Duffie (1999), to a first-order approximation, there is an equivalence between the CDS spread and the spread on the floating rate obligation of a similar maturity issued by a firm, controlling for any non-default related components of the bond price.

Methodologically, there are three ways of using the CDS spread to control for credit risk in corporate bonds. The first is to use the difference between the CDS spread and the simple corporate bond yield as a model-independent (albeit noisy) proxy for the non-default component of the corporate bond yield spread. A second approach, proposed by Longstaff,

[12] For example, see papers by Huang and Huang (2003) and Eom, Helwege, and Uno (2003).

Mithal, and Neis (2005), is to apply a theoretical model of credit risk to price both the CDS and the corporate bonds simultaneously. This latter method has the advantage that any potential biases are addressed explicitly. However, the procedure is dependent on the choice of the credit risk model. The literature on credit risk models demonstrates that there remain significant pricing errors in all the models that have been used so far.[13]

Most market participants use a third method called the par-equivalent spread of the bond, in order to compute the basis.[14] This method adjusts for deviations of the bond value from par value so as to make the spread of the bond comparable with a CDS contract. We use this method in this paper.[15] The method is model-independent in the sense that it does not require the explicit calibration of a model of credit risk, because it assumes that the term structure of credit spreads is flat. While this assumption could affect our results, CDS contracts are often not available for a maturity point other than five years for many of the issuers in our dataset. Hence, controlling for the slope of the term structure using CDS contracts of other maturities would involve a drastic reduction in the size of the sample by biasing it toward the most actively traded issuers. Instead, we control for maturity effects by including a control for maturity in our regressions. While this might admittedly be an approximation, owing to the non-linear nature of default probabilities, it allows us to study a far greater cross section of issuers and of corporate bonds. Details of the methodology for computing the par CDS equivalent spread are provided in Appendix B. According to our

[13]See Huang and Huang (2003) and Eom, Helwege, and Uno (2003) for such tests of a range of credit risk pricing models.

[14]An exposition of this method is presented in the note published by J.P. Morgan Securities Inc (2001).

[15]We ignore differences between day count conventions between corporate bonds and the CDS contracts. Accrued interest on corporate bonds is usually computed using the NASD's 30/360 convention, while that on CDS contracts is computed with an actual/360 convention. This difference is, on average, less than 1 basis point and applies to all corporate bonds. Thus, it would be absorbed in the constant term in our regressions. In any event, the coefficients of the independent variables in our regressions will not be systematically biased due to this approximation.

methodology, the CDS-bond basis is defined by the following equation:

$$Basis = CDS_{actual} - CDS_{hypothetical}$$

where $CDS_{actual}$ is the actual market spread of a CDS contract on a given issuer, and $CDS_{hypothetical}$ is the spread on a hypothetical CDS contract at par that has the same default risk and recovery rate as implied by the price of a risky corporate bond issued by the same issuer. We use a recovery rate of 40%, consistent with market practice.

Following Grinblatt (2001) and Longstaff, Mithal, and Neis (2005), as well as standard market practice, we use the USD-LIBOR (London Interbank Offered Rate) swap curve as a measure of the riskless rate in our par-equivalent spread computation, i.e., the spread between the yield on a par-equivalent bond and the benchmark rate. We linearly interpolate between points on the swap curve to obtain the corresponding discount factors at semi-annual intervals, for the purpose of computing the par-equivalent spreads. The disadvantage of using the swap curve as a benchmark is that swaps themselves carry some credit risk, and hence, may slightly underestimate the credit spread implied in the corporate bond yield. However, in practice, the true "risk free" curve used to discount the cash-flows of any instrument by an agent in the market is equivalent to the cost of funding a position in that instrument. LIBOR can be thought of as being a representative funding cost for the marginal investor in the interbank market, and the swap curve reflects the long-term expectations of the evolution of LIBOR. Thus the swap curve is probably a closer representation of the true benchmark rate than alternatives such as the Treasury curve.[16] In either case, since we uniformly apply the same curve to all corporate bonds, we avoid any bias.

An important issue here is the cost of short selling corporate bonds. When the CDS-

[16]We also conducted the analysis with the Treasury curve and obtained qualitatively similar, albeit more noisy, results.

bond basis is negative, an appropriate arbitrage strategy would involve holding the bond and buying protection on it through the CDS contract to maturity. This has the effect of hedging away the credit risk in the bond, while earning the non-default component, absent liquidity costs. On the other hand, if the basis is positive, the arbitrage strategy involves "shorting" the bond and selling protection on it through the CDS contract. Selling corporate bonds short is costly because corporate bonds are difficult to "find" in the securities borrowing and lending market.[17] Typically, a rebate rate is paid on the cash collateral that is used to borrow a bond, and if this rebate rate is less than the repurchase rate on general collateral in the market, it constitutes a cost to an agent that shorts a bond. The shorting cost is priced into the bond, and constitutes a price premium.

From the above discussion, it would be useful to account for shorting costs, particularly when the basis is positive, in our analysis. We were able to obtain access to a data-set for realized borrowing costs; unfortunately this data-set covers only a small part of our sample period and our analysis was rather restricted. However, in this limited sample, we find that "shorting" corporate bonds is almost always costly, with an average shorting cost of 0.31% (calculated as the difference between the general collateral (GC) rate and the rebate rate on a bond). Shorting costs are typically high when there are supply constraints, due to lack of deliverable bonds in the face of a large "shorting" demand, which might occur when firms are in distress and have high CDS spreads. Since these costs can be quite high, we would expect the basis to be incorporated into the yield, and hence the CDS-bond basis, *ex-ante*. Since we do not have data on shorting costs for our entire sample, it is difficult to directly analyze the impact of shorting costs on the CDS-bond basis. Instead, we present indirect evidence that these costs may be significant, especially for illiquid bonds issued by firms that have uncertain valuations.

[17] See Duffie (1996) and Duffie, Garleanu, and Pedersen (2002) for details of the implications of "shorting" costs.

Our rationale for using the CDS-bond basis as a measure of the non-default component of bond yield spreads can thus be summarized as follows. First, if there is a liquidity premium in bond prices, liquid bonds have higher prices and lower yields. Latent liquidity is used as a measure of the bond's liquidity. Second, converting the bond yield to a par-equivalent spread just simulates a portfolio of the corporate bond along with a pay-fixed swap, which results in a floating rate obligation. The floating rate obligation itself can now be compared to the CDS spread. In terms of arbitrage between this hypothetical floating rate obligation and the CDS, relative liquidity in the two markets as well as short sale constraints should play a role. However, short sales constraints introduce an asymmetry because of which the price of the corporate bonds may be biased higher, its yield lower, and hence, the basis higher. Further, since the hypothetical floating rate obligation is being computed using the swap curve, rather than a true "riskfree" curve, this introduces an additional bias making the basis positive. On an average in our sample, both these effects lead to a positive basis (Table 1). Further the top 80 percent of the bonds in our sample have a positive basis, as shown in Table 1.

There are some other challenges with relating the CDS-bond basis to the non-default component of bond yield spreads. Most corporate bonds issued by firms tend to be fixed-rate bonds, and thus, this equivalence does not hold exactly. The issue is further complicated by differing definitions of the CDS contract, especially in the early years of our sample period. With the increasing use of standard International Swaps and Derivatives Association (ISDA) agreements between counter-parties, this is less of a problem in recent years. Even so, the problem of delivery terms remains. In case of a default, a typical CDS contract requires the delivery of the reference obligation (or a similar obligation) in exchange for face value or settled for an equivalent amount of cash. The bond that is deliverable into the CDS contract is typically the cheapest among the candidate bonds; hence the other bonds can be expected to trade at a premium to the cheapest-to-deliver bond.[18] Unfortunately, it is very difficult to identify the cheapest to deliver bond for a sufficiently broad sample of firms over a long time, since CDS conventions are often bilaterally defined in the over-the-counter market. We leave this as a matter of future research.

## C Liquidity in the CDS Market

As argued earlier, the CDS - bond basis may reflect the *relative* liquidity of the corporate bond relative to that of the corresponding CDS. To the extent that the *absolute* liquidity of the bond market is what gets priced into the corporate bond yields, it is necessary to account for the liquidity in the CDS market. As stated earlier, the intuition behind this argument is that the negative CDS-bond basis represents an investor's expected return from a strategy that involves holding a long position in the bond and buying protection on the issuer in the CDS market. Such an investor is exposed to potential illiquidity in both the CDS and bond markets; for unwinding the trade, the investor has to find a counter-party to sell the bond and the CDS. Therefore, in order to account for the liquidity of the CDS market, we study measures of CDS market liquidity that have an indirect effect on the corporate bond prices, in addition to bond-specific liquidity. The reason the CDS liquidity has an indirect effect on the bond price is because when the CDS market is illiquid, it is difficult to execute a negative basis trade. This would reduce the demand for a bond, which investors would have bought in a negative basis trade and potentially reduce its price, and decreasing the basis further.

Since the CDS market is fairly liquid for many of the the firms in our sample, we are able to use transaction-based measures of liquidity. One measure of CDS market liquidity is the bid-ask spread. The other is the bid-ask spread normalized by the CDS mid-price. These two

[18] This problem exists even with cash settlement, since the settlement price is established based on polling dealers for quotes. See Jankowitsch, Pullirsch, and Veza (2007) for details.

measures have somewhat different implications for transaction costs. If the bid-ask spread is highly correlated with measurement errors in the CDS spreads, it is likely to lead to a spurious estimate when used by itself. On the other hand, the percentage bid-ask spread is likely to ignore potentially important relationships between CDS spreads and liquidity. We therefore use both the absolute and the percentage bid-ask spreads in our estimation. Additionally, when the credit markets are highly volatile, there is a considerable amount of arbitrage risk involved in a CDS-bond trade. As a proxy for this risk, we use the standard deviation of CDS spread changes during the quarter as a CDS market volatility measure that might affect the basis.

## D Firm-Specific Effects

If there are no frictions in the CDS and the bond markets, all information regarding default and recovery rates should be incorporated in both the CDS spread and the bond yield spreads. Hence, we would not expect the CDS-bond basis to depend on firm-specific variables. On the other hand, if there are *structural* reasons which cause the basis to be biased in one direction, such as those outlined in the preceding discussion, we could expect variables related to credit risk to affect the basis, even over a longer period. To test this hypothesis, we use firm-specific data relating to the issuer of the bonds. We collect data on firm-specific characteristics by matching the available bonds in our sample by their ticker symbol with firms in the Compustat quarterly database. A wide variety of firm variables have been used in the literature on default and recovery rates.[19] Again, if markets were frictionless, we would not expect these variables to affect the basis, since the CDS spread is a more direct proxy of credit risk than measures based on financial accounting. If, on the other hand, the basis

[19]While an exhaustive list of these effects is beyond the scope of this study, the reader is urged to refer to Acharya, Bharath and Srinivasan (2007) for an exposition and implementation of firm- and industry-level variables.

reflects credit risk not captured by the CDS spread for structural reasons, these financial ratios may have an effect on the basis. The firm-specific variables that we use in our study are:

1. **Leverage:** The firm's financial leverage measures the fixed obligation of the firm and is a likely predictor of financial distress. We define the leverage as the ratio of the book value of debt to the sum of the book value of debt and the average market value of equity during a quarter.

2. **Tangible Assets:** Recovery rates on firms with a higher proportion of tangible assets are believed to be higher than those with a lower proportion of tangible assets.[20] Accordingly, we include the proportion of property, plant and equipment to total assets in the firm as the proxy for the tangibility of a firm's assets. A higher level of tangible assets implies a higher recovery rate in case of default.

3. **Current Ratio:** Leverage is associated with the long term credit risk of the firm. However, firms may default on their obligations because they are unable to meet their liabilities in the short term. To control for this effect, we use the current ratio - the ratio of current assets to current liabilities (including any debt maturing within the year). A higher current ratio implies a lower likelihood of default, and higher recovery rate, in the short run.

A point to note here is about financial firms, which are regulated and have high levels of leverage. An important element of the regulatory framework in financial markets is the implicit obligation by regulators to step in when a financial crisis unfolds, to prevent financial contagion. This implicit guarantee makes financial firms different from firms in other industries in so far as the high levels of leverage do not necessarily have the same impact

[20] See, *inter alia*, Acharya, Bharath and Srinivasan (2007).

on the credit risk of financial firms compared with firms in other industries. Thus the aforementioned financial ratios do not have the same meaning for financial firms. In regressions that use firm-specific variables, we exclude firms in the financial services industry from our sample, using their SIC classification. This corresponds to reducing the size of our sample by about 50%.

## E Covenants and Other Bond Characteristics

The presence or absence of specific covenants in the bond has an important implication for the basis. Different bonds issued by the same obligor may vary in terms of the extent of protection they offer in case of default, due to the presence or absence of covenants. These covenants may affect the relative prices of the bonds. Additionally bonds with different levels of protection may behave quite differently in the case of non-default corporate events such as a leveraged buy-out or an acquisition. For example, leveraged buy-outs hurt sellers of protection on the CDS contract, because they make default more likely. However, holders of bonds may be protected in terms of their seniority vis-a-vis new debt issued by the acquirer. There may also be features like special put options which allow investors to sell back the bonds to the issuer in case of an acquisition.[21]

In addition to covenants, there may be other bond characteristics that might cause differences in their tax-status and liquidity. For instance, exchange-listed bonds may be more liquid than those that are unlisted. In addition, they may be subject to additional regulatory oversight. Alternatively, some bonds, such as those subject to the European Union savings tax directive may have a different tax status compared to others.

To address these issues, we obtain an extensive list of covenants and other binary bond characteristics from Bloomberg, and use them in the form of dummy variables for the pres-

[21] The presence of such covenants may also create situations where the CDS contract is "orphaned" due to the disappearance of the reference obligations, following their buy-back by the aquiror.

ence or absence of a specific covenant. The dummy variables we use, along with their definitions and the number of bonds that have that particular covenant are listed in Appendix A. We also include a column for the likely effect we expect these dummy variables to have on the basis, and a brief explanation for why we expect such an effect.

## F Summary Statistics

Table 1 presents the summary statistics for the sample of bonds that we obtain after the filtering process, averaged at the level of the bond. The variables are grouped under three categories: bond variables, CDS variables, and firm variables. It can be seen that there is considerable variation in both the latent liquidity measure and the trading volume of the bond (the two main liquidity variables that we use in the bond market), as well as the CDS-bond basis. The latent liquidity of bonds in our sample varies between 0 and 10.78. The mean latent liquidity is 0.32 per year, with a standard deviation of around 0.47 per year. The number of trades per quarter ranges from a minimum of one trade to a maximum of around 28,000 trades, with a mean of 226 trades per quarter. The bonds in our sample range from newly issued bonds to twenty-year old bonds, with an average age of around four years and an average maturity of around seven years, while the ratings range from the highest grade (AAA) to bonds that have defaulted or are no longer rated.

There is significant variation in the CDS bid-ask spreads, ranging from almost zero to around 29%, indicating that there can be severe liquidity constraints in the CDS market. The firms in our sample range from those that have no leverage in the previous quarter, to those that are highly levered with a leverage ratio of almost 1. On average, the firms are financed by about 36% debt. We also see a significant variation in the current ratio, from 19% to 1,182%, and the proportion of the firm's fixed assets, from firms that have virtually no fixed assets to firms that almost entirely consist of fixed assets (94%).

# V Results

## A Bond Characteristics, Latent Liquidity and Other Liquidity Metrics

In order to study the relationship between latent liquidity and other bond-specific variables, we first investigate the relationship between latent liquidity and other liquidity-related metrics such as the trading volume of the bond in any quarter, the number of days on which it is traded, and the number of trades in the bond, in addition to its issue size and age. The main aim of this exercise is to confirm that these empirical estimates agree with those presented in Mahanti, Nashikkar, Subrahmanyam, Chacko, and Mallik (2008) who use a much larger sample of bonds, many of which do not have CDS contracts associated with them. We perform pooled regressions using bond-quarter observations to study how latent liquidity is affected by bond-specific variables such as coupon, amount outstanding, rating, age, maturity, as well as CDS market-related variables such as the CDS spread (to account for the effect of credit risk on the latent liquidity) and the CDS bid-ask spread (to account for the relationship between CDS market liquidity and bond market liquidity).

Table 2 shows the determinants of average latent liquidity for the bonds in our sample. Regression 1 shows that the age of the bond is strongly negatively related to latent liquidity - older bonds have poorer latent liquidity. There are also some clear coupon effects. Higher coupon bonds seem to have higher latent liquidity as compared to lower coupon bonds. At the same time, bonds with poorer credit ratings tend to have higher latent liquidity. However, when we control for CDS market liquidity and firm-specific ratios related to credit risk, it appears that a poorer rating in itself leads to lower latent liquidity. We can also see that bonds with higher issue sizes tend to be more liquid, which is intuitively reasonable. Overall, our results confirm the findings of Mahanti, Nashikkar, Subrahmanyam, Chacko, and Mallik (2008), albeit for a smaller sample of bonds with CDS contracts traded on the issuer.

We next analyze the relationship between bond liquidity and CDS market liquidity in Regression 2. In order to do this, we use the bid/ask spreads of the CDS contract as a percentage of the overall spread as a measure of its liquidity. We find that this measure of CDS market liquidity has some explanatory power for the latent liquidity of the bond. When the CDS contract is less liquid, the bonds themselves tend to be less liquid. This is over and above the bond-specific liquidity variables that we mention above. We also find that leverage seems to be a strong determinant of latent liquidity as seen in Regression 3. It appears that bonds issued by highly levered firms tend to be held more by active investors than bonds of firms with lower leverage. One possible explanation for this is that highly levered firms in our sample are generally financial firms, with large amounts of liquid debt outstanding and a more active investor base.

## B Determinants of the CDS-Bond Basis

Having ascertained what drives bond liquidity, we move on to investigate drivers of the CDS-bond basis in the context of liquidity. To do so, we compute the average quarterly basis for each bond and match it with its latent liquidity at the beginning of the quarter, along with other bond-specific variables for that quarter. This gives us about 29,000 bond-quarter observations, with all bond-specific variables included, a small reduction in our sample, from the approximately 33,000 bonds we had prior to merging the bond-specific characteristics into our data-set. (The exact numbers vary slightly across regressions depending on the independent variables used.)

We first perform univariate pooled regressions of the average CDS-bond basis of each bond, during the quarter, on variables related to the liquidity of the bond, namely its latent liquidity at the beginning of the quarter, the number of days it traded during a quarter, the number of trades during the quarter, the logarithm of the traded market value during the quarter, the issue size of the bond, and the age of the bond at the beginning of the quarter. (The standard errors are adjusted to account for clustering within bonds.) The results are presented in Table 3.

We find that each of these explanatory variables is statistically significant. An increase in latent liquidity by one standard deviation leads to an increase in the basis (and a decrease in the yield of the bond) by ten basis points. An increase in the number of trades by one standard deviation leads to an increase in the basis by about nine basis points. An increase of one standard deviation in the number of days traded per quarter leads to an increase of eight basis points in the average basis. An increase of one standard deviation in the quantity traded leads to an increase of five basis points in the basis. As bonds age, their basis reduces, leading to higher yields and lower prices. An increase of one standard deviation in the age leads to a reduction of about 16 basis points in the basis. Surprisingly, although issue size by itself leads to an increase in the basis, it is not statistically significant.

While the univariate relationships are as expected, it is important to see which of these liquidity variables are significant, once other variables have been accounted for. Specifically, we are interested in examining if latent liquidity has explanatory power for the CDS-bond basis *over and above* other realized liquidity-related variables. We next proceed to investigate this issue in detail. In doing so, we confirm several empirical findings from the literature and generate new findings of our own.

Table 4 shows the relationship between the CDS-bond basis of individual corporate bonds, the bond-specific characteristics and liquidity for a range of alternate specifications that include latent liquidity and other bond-specific liquidity measures, CDS market-specific effects and firm-level financial variables. In all the specifications presented in the table, latent liquidity has significant explanatory power for the basis, even after the inclusion of realized trading activity. This finding indicates that the liquidity premium of a bond is determined not only by the *actual* trading activity in the bond, measured by transaction metrics, but also by the pattern of investors holding the bond in terms of their *potential* trading activity, as proxied by the latent liquidity measure. This evidence provides strong support for the hypothesis that there is extra information related to liquidity in the latent liquidity measure, and that it is priced in the corporate bonds. On an average, an increase of one standard deviation in the latent liquidity seems to increase the basis by 10 bps, or reduce bond yields by around ten bps. Between the most liquid decile and least liquid decile of bonds in our sample, this indicates a difference of 1% in yield, an economically significant difference.

The significant coefficient of the coupon rate variable persists even after the inclusion of a large number of liquidity-related variables. Traditionally, as in Elton, Gruber, Agrawal, and Mann (2001), this relationship has been explained as a tax effect. However, as has been argued more recently by Longstaff, Mithal, and Neis (2005), the tax treatment on coupon income and swap rates is the same, and therefore, one would not expect to find a tax effect the difference between corporate bond yields and the swap rates. The fact that part of the coupon effect remains even when swap rates are used as the benchmark indicates that this explanation can only be partly true, at best.[22] In addition, there is anecdotal evidence that many of the participants in the corporate bond markets, such as long term pension funds, are tax-exempt. Even hedge-funds, which in recent years have become significant players in the CDS and Collateralized Debt Obligations (CDO) markets, as well as the corporate bond market directly, tend to be tax-neutral between income and capital gains. Given the large sizes of these two segments of the market, it is difficult to conclude that the marginal investor in the corporate bond market has a strong tax preference.

A larger amount outstanding of a bond tends to increase the CDS-bond basis, and makes

[22] The values of the coefficient of the coupon rate in the case of swap and treasury rates are similar as documented by Longstaff, Mithal, and Neis (2005), as well as in empirical tests using our dataset (not reported here), with swap and treasury rates as benchmarks. This evidence casts doubt on the conventional explanation of the coupon effect as being due to differential taxation of corporate versus treasury bonds.

the bond more expensive, thus increasing the CDS-bond basis. This is because bonds with larger issue sizes are likely to be more liquid relative to bonds with smaller issue sizes, even after controlling for latent liquidity, and hence have lower transaction costs. Older bonds are likely to be less liquid than newer bonds. The typical explanation for this is that older bonds get "locked up" in the portfolios of passive investors. Since latent liquidity is a far more direct measure of this effect, we expect that after controlling for latent liquidity, we should not expect age to have a significant effect on the basis. The results lend support to this hypothesis. Although the coefficient of age in the first two regressions is positive, its sign changes after the inclusion of firm level effects, indicating that age, in itself, is not a good measure of liquidity, and that latent liquidity is a better measure of the "locking-up" effect than is age.

The relationship between the basis and the number of trades in the bond is also significant. Note that the number of trades is a measure of the realized liquidity of the bond. As expected, it has a positive coefficient in the first two regressions. It should be noted that for every time period, latent liquidity is available *ex-ante*, whereas the realized trading volume is an *ex-post* measure of liquidity. Thus, latent liquidity can be used to *predict* the non-default component in the bonds, as opposed to trading volume, which is only available *ex-post* or, at best contemporaneously, with the basis.

## C CDS Market Effects

In addition to bond-specific liquidity effects, we find that the bid-ask spread in the CDS market has explanatory power for the basis, over and above the liquidity of the bond in itself. This is noteworthy, because it indicates that liquidity in the CDS market affects the prices of bonds in the cross-section. This is a phenomenon that has not been documented in the previous literature. Our results show that both bond market and CDS market liquidity variables have a strong effect on the CDS-bond basis. In fact, an increase by one basis point in the CDS bid-ask spread leads to an increase of two basis points in the CDS-bond basis. This indicates that bonds are relatively more expensive compared to the CDS contracts, when the CDS market liquidity is low. We include the CDS market volatility as a control for the riskiness of the CDS market. We find that the basis is negatively related to CDS market volatility, after controlling for other factors. Higher volatility in the CDS market makes a bond cheaper relative to the CDS contract, indicating that a strategy of buying the bond and buying protection on it in the CDS market has higher returns when the volatility of the CDS spread is high, indicating that a part of the CDS-bond basis is compensation for this risk.

## D Firm-Specific Effects

As argued earlier, if the CDS spread completely accounts for the credit risk of the issuer, we would not expect firm-specific financial variables, such as leverage and the percentage of tangible assets on the balance sheet, to have any effect on the CDS-bond basis. However, we find that these firm-specific variables, measured at the end of the prior quarter, have strong explanatory power for the basis. This finding can either mean that some of these variables affect the basis through other channels such as liquidity, or more plausibly, that the credit risk of the bond is not fully captured in the price of the CDS contract, because of frictions that exist in the arbitrage between the CDS market and the bond market.

In performing our analysis of firm-specific effects, we exclude firms in the financial services industry from the sample. This is because financial firms are highly regulated and have high leverage ratios by design. Hence, financial leverage does not have as much of an implication on their credit risk, as that of non-financial firms. This basic difference in the characteristics of the firms makes it difficult to compare them to firms in other industries. Financial firms make up about 40% of our sample, which is consistent with the proportion of financial firms in the overall corporate bond universe.[23] Removing them from the sample ensures that the results are not driven by the high leverage ratios of financial firms.

In the sub-sample of non-financial firms, the leverage ratio of the issuer, computed as the ratio of long term debt to the sum of long term debt and market value of equity of the firm, turns out to have a significant explanatory power on the basis. Firms with high leverage tend to have substantially higher CDS-bond basis than firms with low leverage. This effect seems to be clearly related to credit risk, as the inclusion of leverage drives away any explanatory power that the rating of the firms have. This indicates that bonds issued by highly leveraged firms tend to be more expensive relative to their CDS contracts. The most plausible explanation for this are the difficulty of selling these bonds short because of frictions in the market for borrowing and lending corporate bonds, and a segmentation between corporate bond and CDS markets. In other words, holders of corporate bonds may have different beliefs about default probabilities and recovery rates, as compared to agents who trade in the CDS market, but arbitrage between these two markets is costly.

While the current ratio does not seem to be particularly significant, the proportion of property, plant and equipment to total assets, which is used as a measure of the firms tangible assets has a strong negative coefficient. A firm with higher tangible assets has a lower basis. This is perhaps because firms with higher tangible assets are likely to suffer from a lower uncertainty about firm values in the event of default, leading to lower shorting costs, and thus, a lower basis.

## E The Effects of Bond Covenants

Bonds are unique and have several distinguishing characteristics, particularly covenants that make them different from the CDS contract in terms of credit risk. In this section, we look at how the characteristics of these covenants affect their basis. The full list of these covenants,

[23] For example, see Mahanti, Nashikkar, Subrahmanyam, Chacko, and Mallik (2008).

along with their definitions and the expected signs of the coefficients, is given in Appendix A, Table A-1. The results reported in Table 5, represent the coefficients of the dummy variables associated with each covenant in a pooled regression, *controlling* for the bond specific, firm-specific, and CDS market variables included above. Note that the coefficients reported in Table 5 are obtained using a regression where the dependent variable is the *basis* and not the yield spread of the bond itself - that is, credit risk as measured by the CDS spread for the same issuer has already been controlled for.

We find that credit-sensitive bonds have a higher basis (are more expensive) by almost ten basis points, on average, compared to other bonds, although this effect is not statistically significant. Bonds that have an option to be defeased have a lower basis by up to eight basis points. Defeasance is the process whereby the issuer of the security sets aside cash in order to redeem the security. Defeasance thus serves to decrease the credit risk of a bond, and in doing so, acts as a signal to investors in the bond. A defeasance option allows the issuer of a bond to set-aside cash for the purpose of buying back the bond, when it is advantageous for the issuer to do so. One would normally expect defeased bonds to be more expensive relative to other bonds. We find the opposite, and puzzling result. This seems to indicate that a defeasance option serves as a signal that the issuer of the bond is of higher risk. In other words, if firms that are more likely to default have a higher likelihood of having defeasance options, investors would see that as a negative signal, and this would make the bonds cheaper relative to other bonds. We confirm this by looking at the types of firms that have defeasance as an option, and find that these are indeed primarily high leverage, poor credit rating firms. Therefore, defeasance is associated with firms of poorer credit quality, and hence, a higher CDS-bond basis.

Bonds subject to the European Union (E.U.) Savings Tax Directive tend to have a lower basis of almost 20 basis points, indicating that they are cheaper. E.U. savings taxes apply to all publicly issued bonds issued after July, 2001, and held by an investor based in the

E.U. and dependent countries. There are two possible interpretations for this effect. It could indicate some non-linearity of the basis with respect to age (since these taxes apply only to bonds issued after the year 2001, and hence are newer). Alternately, it could be because the marginal investors of these bonds are based in tax havens such as the Cayman Islands that are now subject to the increased taxes. Bonds that have an equity claw-back provision are cheaper by about 12 basis points, although this effect is not significant. This is somewhat surprising, since equity claw-back provisions afford a higher degree of protection to the debt-holders in the event of the firm getting taken over, and increasing its leverage. Secured bonds have a higher basis of up to 26 basis points as compared to unsecured bonds, indicating that they are more expensive. This is intuitive because secured bonds have a higher degree of collateral protection against unsecured bonds, and the benchmark CDS contracts that we use for comparison have senior unsecured debt as the deliverable obligation.

Similarly bonds that have third party guarantees also have a higher basis, although this effect is only marginally significant, statistically speaking. Exchange-listed bonds seem to have a marginally higher basis (although not significant) and could point to greater liquidity of bonds that are listed on an exchange vis a vis those that are not listed. This is because exchanges offer an additional venue for trading compared to the over-the-counter market for corporate bonds. Funded bonds (bonds where the issuer has the obligation to partly redeem the bond before maturity) seem to have a higher basis and are expensive relative to the CDS contract. This effect is marginally significant. This could be because the implicit credit risk in a funded bond is lower than that in non-funded bond. Surprisingly, the inclusion of special put options related to asset sales or acquisitions does not seem to have a significant effect on the basis. It is possible that these have any value only when there is a high likelihood of a corporate event such as a takeover. Tax-related call options seem to make the bonds marginally more expensive relative to other bonds. Overall, the signs of the coefficients in the regression with bond characteristics are consistent with the hypotheses listed in Appendix

A with the exception of the defeasance option, for which the explanation may be due the fact that firms of poorer credit quality typically go in for this option.

## F Interaction Between Bond-Liquidity and Firm Uncertainty

Our hypothesis is that the expected costs of selling a bond short are important drivers of the CDS-bond basis, especially for firms about whom there is much uncertainty. Since illiquid bonds are also expected to be difficult to sell short, we expect illiquid bonds issued by firms with uncertain valuations to be expensive relative to more liquid bonds. Uncertainty in the valuation of firms is also closely tied to default risk. If this is true, we would expect risky and illiquid bonds to be more expensive relative to the CDS contracts, as compared to less risky bonds. In other words, while liquidity serves to increase the price of bonds in most cases, we expect the opposite to hold true for the most illiquid bonds belonging to firms about whom uncertainty is much higher. To examine whether this is indeed the case, we perform "double sorts" on our portfolio along the liquidity and default risk dimensions. Specifically, for every quarter in our data, we form twenty-five groups of bonds, using liquidity and a variety of other variables related to uncertainty about a firm as the sorting variable - and examine the average basis in each bucket. The results for these double sorts are presented in Tables 6 and 7. We obtain similar results when we use other measures of liquidity such as trading volume, and other measures of riskiness of the firm, such as the credit rating, suggesting that these results are not the result of our choice of variables.

Table 6 shows the average basis, along with the standard estimate of the mean average basis for that subgroup when the sample is sorted along the dimension of latent liquidity and rating class. In order to construct this table, for each quarter, we first sort the observations in our dataset into quintiles by latent liquidity. Next, we create subgroups for each quintile on the basis of rating-class, and pool the sub-groups across quarters. We estimate the mean basis in each sub-group and the standard error for the estimate. The standard errors are clustered to reflect the fact that each sub-group contains multiple observations for the same bond, from different quarters. Two phenomena are apparent from the results. First, as we go toward progressively worse ratings, the CDS-bond basis increases. This means that bonds become more and more expensive relative to the CDS contracts. Moreover, for rating classes up to BBB, an increase in the latent liquidity of the bonds leads to an increase in the basis - that is, liquid bonds are more expensive. This also follows from the results of the pooled regressions mentioned above. Second, for poorer credit rating classes, the illiquid bonds have a substantially higher basis than the liquid bonds. The most illiquid bonds for the riskiest firms (those belonging to latent liquidity quintile 1) are expensive. As liquidity increases, the bonds tend to become cheaper, and finally the most liquid bonds of the riskiest firms (those belonging to latent liquidity quintile 5) are again more expensive relative to less liquid bonds (e.g. those belonging to latent liquidity quintile 4). In other words, in the poorer rating classes, liquidity serves to make the bond cheaper relative to the CDS contracts.

If the reason for the expensiveness of illiquid risky bonds in our sample is that these bonds have high shorting costs owing to uncertainty about the value of the firm, then a sort along an explicit measure of firm uncertainty for the most illiquid bonds should also show a similar result. As a measure of uncertainty, we use the standard deviation of analyst forecasts for the earnings per share of the firm from the I/B/E/S database as a proportion of the share price at the end of the quarter. Table 7 shows a double sort of the average CDS-bond basis for bonds sorted using quintiles of latent liquidity and this measure. Again, illiquid bonds of firms with the highest earnings uncertainty tend to have the highest CDS-bond basis. The result supports our intuition that the reason why illiquid and risky bonds are expensive is because shorting costs are high, given their illiquidity and their earnings uncertainty. Additionally, the observed pattern in the CDS-bond basis and liquidity mirrors the pattern for the costs of short selling documented in Nashikkar and Pedersen (2007).

In order to ensure that the results of the double sort are robust to the inclusion of other variables, we also perform regressions using two interaction variables. Table 8 presents these results. We include the following three interaction dummies. The first takes a value of 1 if the bond lies in the lowest latent liquidity quintile referred to in Table 6 and the highest quintile of risk as measured by the CDS spread. The second dummy variable takes a value of 1 if the bond lies in the lowest liquidity quintile as measured by trading volume and the highest quintile of default risk. The third dummy variable takes a value of 1 if the bond lies in the lowest liquidity quintile as measured by latent liquidity and the highest quintile of uncertainty as measured by the standard deviation of analyst EPS forecasts, normalized by the share price. All interaction dummies turn out to have positive and statistically significant coefficients, both when taken independently and when taken together. In general, illiquid bonds of firms with more uncertain valuations tend to have a CDS-bond basis that is higher than other bonds.

# VI Conclusion

The existing literature on the yield spread of US corporate bonds argues that the non-default component of corporate yields may be related to factors associated with liquidity, such as age, outstanding amount and maturity. However, since liquidity metrics based on transaction prices and volumes are difficult to compute due to infrequent trading in the corporate bond market, this conjecture is difficult to confirm at the level of individual bonds. We use a uniquely constructed data-set from one of the largest corporate bond custodians in the market to evaluate the ease of access of a bond using a recently developed measure called latent liquidity. We also use transactions data for the corporate bond market obtained from FINRA's TRACE database to compute a range of realized liquidity measures for corporate bonds and show that latent liquidity has explanatory power, over and above these measures in explaining the non-default component of yield spreads. We use the CDS-bond basis, which is the difference between the CDS price of a bond and its par equivalent credit spread, as a measure of the non-default component.

First, we confirm several relationships documented in the previous literature on the effect of factors like coupon, amount outstanding, age and trading volume on liquidity in the corporate bond market, on a much more current and extensive data-set, and in particular, on the latent liquidity measure. Second, at the level of individual bonds, we show that latent liquidity has explanatory power for the CDS-bond basis, over and above what can be captured either by bond characteristics such as coupon, amount outstanding and age, or by realized measures of liquidity such as the observed trading volume in the bond. Liquid bonds tend to be more expensive when evaluated against their CDS contracts than illiquid bonds. Third, for highly illiquid bonds belonging to firms with higher earnings uncertainty, we show that the relationship reverses. These bonds tend to be more expensive relative to their CDS contracts as compared to more liquid bonds. We believe that this is because of limited arbitrage associated with the difficulty of "shorting" corporate bonds.

We present a new result that shows that the liquidity of the CDS contract, as measured both by the bid-ask spread, and the riskiness of the CDS market, as measured by the CDS market volatility, have explanatory power for the basis of bonds, over and above bond-specific liquidity variables. This is evidence that bond market participants account for the liquidity of the CDS market when they price corporate bonds, due to the ease of hedging their positions. Accordingly, as the CDS market becomes more and more liquid, we expect the CDS-bond basis to decrease over time.

We also demonstrate that the CDS spread does not fully account for the effect of credit risk on bond prices - there are several firm-level effects related to credit risk that seem to have explanatory power over the CDS bond basis, even after we account for the differences between bonds that arise because of liquidity. We also show that cross-sectional variations in the CDS-bond basis of different bonds may arise due to varying levels of protection afforded by covenants, listing, and tax status, among other factors.

In conclusion, we present and validate a measure of corporate bond liquidity that is available at the beginning of the trading period, rather than contemporaneously, does not require transaction data, has additional explanatory power, and offers interesting insights into processes that drive liquidity in the market for credit risk. In doing so, we generate several new stylized facts on the factors that affect the yields on corporate bonds.

# References


Acharya, V.; S. Bharath; and A. Srinivasan. "Does Industry Wide Distress Affect Defaulted Firms?." *Journal of Financial Economics*, 85(2007), 787–821.

Acharya, V., and L. Pedersen. "Asset Pricing with Liquidity Risk." *Journal of Financial Economics*, 77(2)(2005), 375 – 410.

Admati, A., and P. Pfleiderer. "A Theory of Intraday Patterns: Volume and Price Variability." *Review of Financial Studies*, 3(1988), 40–48.

Admati, A., and P. Pfleiderer. "Divide and Conquer: A Theory of Intraday and Day-of-the-Week Mean Effects." *Review of Financial Studies*, 2(1989), 189–224.

Alexander, G.; A. Edwards; and M. Ferri. "The Determinants of the Trading Volume of High Yield Corporate Bonds." *Journal of Financial Markets*, 3(2000), 177–204.

Amihud, Y. "Illiquidity and Stock Returns: Cross-section and Time Series Effects." *Journal of Financial Markets*, 5(2002), 31–56.

Amihud, Y., and H. Mendelson. "Dealership Market: Market Making with Inventory." *Journal of Financial Economics*, 5(1980), 31–53.

Amihud, Y., and H. Mendelson. "Asset Pricing and the Bid Ask Spread." *Journal of Financial Economics*, 17(1986), 223–249.

Amihud, Y., and H. Mendelson. "Liquidity, Maturity, and the Yields on United States Treasury securities." *Journal of Finance*, 46(1991), 1411–1425.

Amihud, Y.; H. Mendelson; and L. Pedersen. "Liquidity and Asset Prices." *Foundations and Trends in Finance*, 1(2006), 269–364.

Assagai, S., and M. Gentler. "Asset Returns, Transactions Costs and Uninsured Individual Risk: A Stage II Exercise." *Journal of Monetary Economics*, 27(1991), 309–331.

Bagehot, W. "The Only Game in Town." *Financial Analysts Journal*, 27(1971), 12–14.

Baluchi, P.; S. Dab; and S. Forest. "The Central Tendency: A Second Factor in Bond Yields." *Review of Economics and Statistics*, 80(2002), 60–72.

Bessembinder, H.; W. Maxwell; and K. Venkataraman. "Market Transparency, Liquidity Externality, and Institutional Trading Costs." *Journal of Financial Economics*, 82(2005), 251–288.

Biais, B. "Price Formation and Equilibrium Liquidity in Fragmented and Centralized Markets." *Journal of Finance*, 48(1993), 157–185.

Blanco, R.; S. Brennan; and I. Marsh. "An Empirical Analysis of the Dynamic Relation between Investment-Grade Bonds and Credit Default Swaps." *Journal of Finance*, 60(2005), 2255–2281.

Brace, A., and M. Musiela. "The Market Model of Interest Rate Dynamics." *Mathematical Finance*, 7(1997), 127–147.

Chakravarty, S., and A. Sarkar. "Liquidity in US Fixed Income Markets: A Comparison of the Bid-Ask Spread in Corporate, Government, and Municipal Bond Markets." *Staff Report of the Federal Reserve Bank of New York*, 73(1999).

Chen, L.; D. Lesmond; and J. Wei. "Corporate Yield Spreads and Bond Liquidity." *Journal of Finance*, 62(2007), 119–149.

Copeland, T., and D. Galai. "Information Effects and the Bid-Ask Spread." *Journal of Finance*, 38(1983), 1457–1469.

Datar, V.; N. Naik; and R. Radcliffe. "Liquidity and Stock Returns: An Alternative Test." *Journal of Financial Markets*, 1(1998), 203–219.

De Jong, F., and J. Driessen. "Liquidity Risk Premia in Corporate Bonds." Working Paper, University of Amsterdam (2006).

Demsetz, H. "The Cost of Transacting." *Quarterly Journal of Economics*, 82(1968), 33–53.

Downing, C.; S. Underwood; and Y. Xing. "Is Liquidity Priced in Corporate Bonds?." Working Paper, Rice Univerity (2006).

Duffie, D. "Special Repo Rates." *Journal of Finance*, 51(1996), 493–526.

Duffie, D. "Credit Swap Valuation." *Financial Analysts Journal*, 55(1999), 7387.

Duffie, D.; N. Garleanu; and L. Pedersen. "Securities Lending, Pricing and Shorting." *Journal of Financial Economics*, 66(2002), 307–339.

Easley, D.; S. Hvidkjaer; and M. O'Hara. "Is Information Risk a Determinant of Asset Returns." *Journal of Finance*, 57(2002), 2185–2222.

Easley, D., and M. O'Hara. "Price, Trade Size, and Information in Securities Markets." *Journal of Financial Economics*, 19(1987), 69–90.

Easley, D., and M. O'Hara. "Information and the Cost of Capital." *Journal of Finance*, 59(2004), 1153 – 1183.

Edwards, A.; L. Harris; and M. Piwowar. "Corporate Bond Market Transaction Costs and Transparency." *Journal of Finance*, 62(2007), 1421–1451.

Elton, E., and C. Green. "Tax and Liquidity Effects in Pricing Government Bonds." *Journal of Finance*, 53(1998), 1533.

Elton, E.; M. Gruber; D. Agrawal; and C. Mann. “Explaining the Rate Spread on Corporate Bonds.” *Journal of Finance*, 56(2001), 247–277.

Eom, Y.; J. Helwege; and J. Uno. “Structural Models of Corporate Bond Pricing : An empirical Analysis.” *Review of Financial Studies*, 17(2003), 499–544.

Eom, Y.; M. Subrahmanyam; and J. Uno. “Coupon Effects and the Pricing of Japanese Government Bonds- An Empirical Analysis.” *Journal of Fixed Income*, 8(1998), 69 – 86.

Fama, E., and J. Macbeth. “Risk, Return, and Equilibrium: Empirical Tests.” *Journal of Political Economy*, 81(1973), 601–636.

Feldhutter, P., and D. Lando. “Decomposing Swap Spreads.” *Journal of Financial Economics*, 88(2008), 375–405.

Fisher, L. “Determinants of Risk Premiums on Corporate Bonds.” *Journal of Political Economy*, 67(1959), 217–317.

Foster, F., and S. Viswanathan. “A Theory of Intraday Variations in Volume, Variance, and Trading Costs in Securities Markets.” *Review of Financial Studies*, 3(1990), 593–624.

Garman, M. “Market Microstructure.” *Journal of Financial Economics*, 3(1976), 257–275.

Geske, R. “The Valuation of Corporate Liabilities as Compound Options.” *Journal of Financial and Quantitative Analysis*, 12(1977), 541–552.

Glosten, L., and P. Milgrom. “Bid, Ask, and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders.” *Journal of Financial Economics*, 14(1985), 71–100.

Goldstein, M.; E. Hotchkiss; and E. Sirri. “Transparency and liquidity: A Controlled Experiment on Corporate Bonds.” *Review of Financial Studies*, 20(2007), 235–273.

Greene, W. H. (2000) *Econometric Analysis*. Prentice Hall, 6 edn.

Grinblatt, M. "An Analytic Solution for Interest Rate Swap Spreads." *International Review of Finance*, 2(2001), 541–552.

Grossman, S., and M. Miller. "Liquidity and Market Structure." *Journal of Finance*, 43(1988), 617–633.

Grossman, S., and J. Stiglitz. "On the Impossibility of Informationally Efficient Markets." *American Economic Review*, 70(1980), 393–408.

Hasbrouck, J., and D. Seppi. "Common Factors in Prices, Order Flows, and Liquidity." *Journal of Financial Economics*, 59(2001), 383–411.

Ho, T., and H. Stoll. "Optimal Dealer Pricing Under Transactions and Return Uncertainty." *Journal of Financial Economics*, 9(1981), 47–73.

Hong, G., and A. Warga. "An Empirical Study of Bond Market Transactions." *Financial Analysts Journal*, 56(2000), 32–46.

Hotchkiss, E., and T. Ronen. "The Informational Efficiency of the Corporate Bond Market: An Intraday Analysis." *Review of Financial Studies*, 15(1999), 1325–1354.

Hotchkiss, E.; A. Warga; and G. Jostova. "Determinants of Corporate Bond Trading: A Comprehensive Analysis." Working Paper, University of Houston, Boston College and George Washington University (2002).

Houweling, P.; A. Mentink; and T. Vorst. "Comparing Possible Proxies of Corporate Bond Liquidity." *Journal of Banking and Finance*, 29(2005), 1331–1358.

Huang, J., and M. Huang. "How Much of the Corporate Yield Spread is Due to Credit Risk?." 14th Annual Conference on Financial Economics and Accounting (FEA); Texas Finance Festival. (2003).

Huang, M. "Liquidity Shocks and Equilibrium Risk Premia." *Journal of Economic Theory*, 109(2003), 104–129.

Huberman, G., and D. Halka. "Systematic Liquidity." *Journal of Financial Research*, 24(2001), 161–178.

Jankowitsch, R.; R. Pullirsch; and T. Veza. "The Delivery Option in Credit Default Swaps." *SSRN eLibrary*, (2007).

J.P. Morgan Securities Inc "Par Credit Default Swap Spread Approximation from Default Probabilities." *Credit Derivatives Strategy*, (2001).

Kyle, A. "Continuous Auctions and Insider Trading." *Econometrica*, 53(1985), 1315–1335.

Longstaff, F. "The Flight-to-Liquidity Premium in U.S. Treasury Bond Prices." *Journal of Business*, 77(2004), 511–526.

Longstaff, F.; S. Mithal; and E. Neis. "Corporate Yield Spreads: Default Risk or Liquidity? New Evidence from the Credit Default Swap Market." *Journal of Finance*, LX(2005), 2213–2253.

Madhavan, A., and S. Smidt. "An Analysis of Daily Changes in Specialist Inventories and Quotations." *Journal of Finance*, 48(1993), 189–210.

Mahanti, S.; A. Nashikkar; M. Subrahmanyam; G. Chacko; and G. Mallik. "Latent Liquidity: A New Measure of Liquidity with an Application to Corporate Bonds." *Journal of Financial Economics*, 88(2008), 272–298.

Merton, R. "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates." *Journal of Finance*, 29(1974), 449–270.

Nashikkar, A., and L. Pedersen. "Corporate Bond Specialness." Working Paper, New York University (2007).

O'Hara, M., and G. Oldfeld. "The Microeconomics of Market Making." *Journal of Financial and Quantitative Analysis*, 21(1986), 361–376.

Pastor, L., and R. Stambaugh. "Liquidity Risk and Expected Stock Returns." *Journal of Political Economy*, 111(2003), 642–685.

Sarig, O., and A. Warga. "Bond Price Data and Bond Market Liquidity." *Journal of Financial and Quantitative Analysis*, 24(1989), 367–378.

Schultz, P. "Corporate Bond Trading Costs: A Peek Behind the Curtain." *Journal of Finance*, 56(2001), 677–698.

Seppi, D. "Equilibrium Block Trading and Asymmetric Information." *Journal of Finance*, 45(1990), 73–94.

Staiger, D., and J. Stock. "Instrumental Variables Regression with Weak Instruments." *Econometrica*, 65(1997), 557–586.

Stoll, H. "The Supply of Dealer Services in Securities Markets." *Journal of Finance*, 33(1978), 1133–1151.

Vayanos, D. "Transaction Costs and Asset Prices: A Dynamic Equilibrium Model." *Review of Financial Studies*, 11(1998), 1–58.

Vayanos, D., and J. Vila. "Equilibrium Interest Rates and Liquidity Premium with Transaction Costs." *Economic Theory*, 13(1999), 509–539.

Vayanos, D., and T. Wang. "Search and Endogenous Concentration of Liquidity in Asset Markets." *Journal of Economic Theory*, 136(2006), 66–104.

Warga, A. "Bond Returns, Liquidity, and Missing Data." *Journal of Financial and Quantitative Analysis*, 27(1992), 605–617.

# Appendix A

| Covenant | Number of bonds | Definition | Expected effect on basis |
|---|---|---|---|
| Credit Sensitive | 38 | The bond's coupon is linked to credit rating | Positive (Greater protection) |
| Defeased | 3323 | The bond has an option to be defeased in the future, i.e. the issuer may set aside funds for the bondholders and free himself from covenants | Positive/Negative (Issuer has the option to defease, defeasement itself increases basis) |
| Equity Clawback | 39 | The issuer has an option to redeem the security using equity proceeds | Positive (Greater protection) |
| Eusd Tax | 3611 | The bond is subject to the E.U. Savings tax directive applying to bonds issued after July 2001 | Negative (Bonds are older and attract higher tax rates) |
| Exch Listed | 666 | Is Exchange listed | Positive (More liquidity and oversight) |
| Fund Terms | 84 | The issuer has the obligation to redeem the bond in part before maturity | Positive (Greater protection) |
| Guarantee | 626 | Is Guaranteed | Positive (Greater Protection) |
| Poison Put | 192 | Indicates the presence of a put option by investors or a call option by the issuer in case of ownership change | Positive (Greater protection) |
| Prin Idx Lnk | 103 | Indicates if the principal amount fluctuates with a market index | Unclear |
| Prosp On File | 5203 | The prospectus is on file with the SEC | Positive (Higher liquidity and oversight) |
| Secured | 253 | The bond is secured by collateral | Positive (Greater protection) |
| Spec Put | 1623 | The presence of a special put option in case of a corporate event like a spinoff or an asset sale | Positive (Greater protection) |
| Tap Issue | 1479 | The bond may be reissued | Unclear |
| Tax Call | 700 | The security may be called if there are changes in tax laws | Positive/Negative (The option may or may not benefit the issuer at the expense of the investors) |

Table A-1: The table above shows the list of individual bond characteristics used as dummy variables in our study of a sample of 5,692 bonds issued by 1,167 issuers that have CDS contracts associated with the issuer from July 2002 to June 2006. All the bonds considered above are traded on FINRA's TRACE reporting system and database. The first column shows the name of the characteristic for which the corresponding dummy variable takes a value of 1 if the characteristic is present, and zero otherwise. The second column shows the number of bonds with that characteristic in our sample. The third column includes a brief explanation for the dummy variable we expect in explaining the bond yields and hence, the CDS-bond basis, and the fourth column shows the sign we expect for the coefficient of the dummy variable, and a brief explanation for why this is the case.

# Appendix B

## Computation of the Par-Equivalent Bond Yield Spread and the CDS-Bond Basis

Consider the following notation:

$N$: Remaining coupon periods

$t_i$: Time of $i^{th}$ coupon period, in years, i = 1, , N

$ProbSurv(t)$: Probability of surviving till time t

$ProbDef(t)$: Probability of defaulting at time t

$\delta(t)$: day-count convention between ti-1 and ti

$P_0$: Market price of the bond at valuation date

$D(t)$: Risk-free discount factor to time t (using LIBOR swap curve)

$\lambda$: Default intensity or the mean arrival rate of default

$c$: Coupon

$F$: Face value

$r$: Constant (assumed) recovery rate

Our par-equivalent bond yield spread computation assumes that

- Defaults can take place only on the coupon payment dates.
- The default intensity is constant, i.e., the term structure of default rates for any issuer is flat.
- The recovery rate as a proportion of face value in the event of default is constant.

Using the notation above, we have:

(B-1) $$P_0 = c\sum_{i=1}^{n} \delta_{t_i} e^{-\lambda t_i} D(t_i) + Fe^{-\lambda t_N} D(t_N) + r\sum_{i=1}^{n} e^{-\lambda(t_{i-1}-t_i)} D(t_i)$$

Thus, given the price of the bond, we can solve for the constant default intensity $\lambda$. Next, consider a hypothetical CDS contract, at par, that has the same default probability as the bond. The following holds at initiation:

(B-2) $$PV(feeleg) = PV(contingentleg)$$

where the left hand side is the present value of the expected fees to be earned on the hypothetical CDS contract, and the right hand side is the present value of the expected payment to be made in case default occurs.

Thus, the bond is equivalent to a hypothetical par CDS contract with the following spread.

(B-3) $$ParCDSequivalentspread = \frac{(1-rr)\sum_{i=1}^{n} e^{-\lambda(t_{i-1}-t_i)} D(t_i)}{\sum_{i=1}^{n} \delta_{t_i} e^{-\lambda t_i} D(t_i) + \sum_{i=1}^{n} \frac{\delta_{t_i}}{2} e^{-\lambda(t_{i-1}-t_i)} D(t_i)}$$

The CDS-bond basis is simply computed as the difference between the above spread and the spread on an actual CDS contract trading in the market.

| Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| *Bond variables* | | | | |
| Coupon | 6.14 | 1.63 | 0.00 | 13.50 |
| Age (yrs) | 4.42 | 3.59 | 0.00 | 20.56 |
| Maturity (yrs) | 7.18 | 8.59 | 0.04 | 40.26 |
| Latent Liquidity | 0.32 | 0.47 | 0.00 | 10.78 |
| No. of trades (100) | 2.26 | 6.68 | 0.01 | 281.66 |
| S&P Rating | 8.47 | 3.50 | 0.00 | 20.00 |
| Issue Size (USD mio) | 0.46 | 0.58 | 0.01 | 6.50 |
| *CDS variables* | | | | |
| CDS spread(bps) | 77.02 | 152.67 | 2.00 | 5920.71 |
| CDS bid-ask (bps) | 6.47 | 25.46 | 0.00 | 2935.54 |
| Par equivalent spread (bps) | 45.13 | 161.42 | -37.28 | 7171.46 |
| Basis (bps) | 41.14 | 104.04 | -620.87 | 5738.27 |
| *Firm Variables* | | | | |
| Leverage | 0.36 | 0.21 | 0.00 | 0.98 |
| Current Ratio | 1.20 | 0.51 | 0.19 | 11.82 |
| Tangible Assets | 0.27 | 0.25 | 0.00 | 0.94 |
| Variable | 20th percentile | 40th percentile | 60th percentile | 80th percentile |
| Basis (bps) | -6 | 18.25 | 40 | 78 |

Table 1: **Summary Statistics**: This table shows the summary statistics of the the basis, the par equivalent spread, the CDS spread, age, maturity, trade count, rating, issue size, CDS bid ask spreads, firm leverage, current ratios and the percentage of tangible assets of the firm for the set of bonds in our sample. The sample consists of around 5,792 bonds issued by 1,167 firms on whom CDS contracts are actively traded from the period from July 2002 to June 2006. The prices of the bonds used for computation of the par equivalent spreads are from FINRA'S TRACE database. We compute the volume weighted average price for the day in our par equivalent spread computation, and compute a basis by subtracting it from the CDS spread for the day (if available). The CDS spreads prior to 01 Oct 2004 are from GFI Group Inc, while the ones used after 01 Oct 2004 are from CMA (via the Bloomberg data service). We compute quarterly averages of the basis, forming quarterly bond observations. The realized trade count is from TRACE. Latent liquidity is based on custodial holdings at a the largest custodian int the market. For issuer rating, we use the quarterly rating as available from Compustat. The financial ratios are based on information as reported in the quarter previous to the one for which we compute the average basis. The table also shows the quintiles of average basis in our sample.

| | Latent Liquidity | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Coupon | 0.021 | 0.037 | 0.022 |
| | (0.01)** | (0.01)** | (0.01)** |
| Age (yrs) | -0.011 | -0.016 | -0.009 |
| | (0.00)** | (0.00)** | (0.00)** |
| S&P Rating | 0.004 | -0.01 | -0.008 |
| | (0.00)** | (0.00)** | (0.00) |
| Log (Issue Size) | 0.086 | 0.093 | 0.107 |
| | (0.00)** | (0.00)** | (0.00)** |
| Maturity (yrs) | 0 | -0.001 | 0 |
| | (0.00) | (0.00) | (0.00) |
| Pct CDS Bid-ask | | -0.267 | -0.281 |
| | | (0.06)** | (0.09)** |
| CDS spread | | 0 | 0 |
| | | (0.00) | (0.00) |
| Leverage | | | 0.347 |
| | | | (0.07)** |
| Current Ratio | | | -0.06 |
| | | | (0.02)** |
| Tangible Assets | | | -0.133 |
| | | | (0.04)** |
| Constant | -0.836 | -0.789 | -0.835 |
| | (0.03)** | (0.03)** | (0.06)** |
| Observations | 37229 | 28647 | 14744 |
| R-squared | 0.11 | 0.13 | 0.12 |

Robust standard errors in parentheses
* significant at 5%; ** significant at 1%

Table 2: **Latent Liquidity and Bond-specific Variables in the Sample of Traded Bonds**: This table shows the results of a pooled regression of latent liquidity on various bond specific factors, such as coupon, rating, amount outstanding and age, CDS market liquidity factors such as the percentage bid-ask spread in the CDS contract, and firm-specific variables such as leverage, current ratio and the percentage of tangible assets. The sample is an unbalanced quarterly panel consisting of 5,792 bonds issued by 1,167 firms, obtained by matching volume-weighted traded prices on TRACE with CDS spreads on the names issuing those bonds, from July 2002 to June 2006. Figures in brackets are clustered standard errors where the clustering is done by bond.

| | Basis (bps) | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Latent Liquidity | 19.456 | | | | | |
| | (2.15)** | | | | | |
| No. of trades (100) | | 1.43 | | | | |
| | | (0.20)** | | | | |
| Days Traded | | | 0.454 | | | |
| | | | (0.06)** | | | |
| Log (Market Value Traded) | | | | 1.511 | | |
| | | | | (0.53)** | | |
| Age (yrs) | | | | | -3.776 | |
| | | | | | (0.34)** | |
| Log (Issue Size) | | | | | | 1.242 |
| | | | | | | (0.78) |
| Constant | 33.507 | 37.524 | 31.043 | 15.653 | 57.974 | 25.861 |
| | (1.71)** | (1.35)** | (2.02)** | (9.78) | (1.92)** | (9.58)** |
| Observations | 29949 | 29949 | 29949 | 29949 | 29949 | 29949 |
| R-squared | 0.01 | 0.01 | 0.01 | 0 | 0.02 | 0 |
| Robust standard errors in parentheses | | | | | | |
| * significant at 5%; ** significant at 1% | | | | | | |

Table 3: **Univariate Regressions of the Basis on Bond-Specific Liquidity Related Variables**: These regressions show the effect of latent liquidity, amount outstanding, age, number of trades, the number of days traded during a quarter and the traded market value, on the CDS-bond basis. The swap curve is used as the risk-less benchmark in computing the par-equivalent bond spreads used to compute the basis.The basis is averaged for the quarter. The sample consists of around 29,000 bond-quarter observations for 5,792 bonds issued by 1,167 firms, obtained by matching bond prices as reported on TRACE and beginning of quarter latent liquidities from the custodial database with CDS spreads, over the period from July 2002 to June 2006.

| | Dependent variable : Average CDS-Bond basis | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Coupon | -15.043 | -17.112 | -8.808 | -8.624 |
| | (1.56)** | (1.47)** | (1.52)** | (1.68)** |
| Latent Liquidity | 20.985 | 17.929 | 10.242 | 9.852 |
| | (1.88)** | (1.68)** | (2.22)** | (2.01)** |
| No. of trades (100) | 1.037 | 0.646 | -0.941 | -0.815 |
| | (0.14)** | (0.12)** | (0.29)** | (0.30)** |
| Maturity (yrs) | -2.582 | -2.481 | -2.395 | -2.394 |
| | (0.19)** | (0.18)** | (0.19)** | (0.19)** |
| Age (yrs) | 0.903 | 1.323 | -0.152 | -2.554 |
| | (0.45)* | (0.42)** | (0.45) | (0.54)** |
| Log (Issue Size) | 2.662 | 3.530 | 10.279 | 11.300 |
| | (0.69)** | (0.62)** | (0.90)** | (1.62)** |
| S&P Rating | 8.037 | 3.737 | -0.616 | -0.170 |
| | (0.71)** | (0.47)** | (0.86) | (0.81) |
| CDS Vol | | 0.054 | -0.011 | -0.019 |
| | | (0.05) | (0.05) | (0.05) |
| CDS bid-ask | | 2.209 | 2.110 | 2.085 |
| | | (0.21)** | (0.18)** | (0.18)** |
| CDS percent bid-ask | | -112.124 | 24.765 | 18.167 |
| | | (11.75)** | (14.15) | (13.76) |
| Leverage | | | 68.699 | 55.460 |
| | | | (10.36)** | (9.92)** |
| Tangible Assets | | | -9.749 | -16.628 |
| | | | (3.92)* | (5.04)** |
| Current Ratio | | | 0.921 | 1.927 |
| | | | (1.64) | (1.66) |
| Constant | 32.711 | 73.168 | -51.015 | -42.200 |
| | (10.32)** | (9.58)** | (11.78)** | (22.45) |
| Observations | 28631 | 28364 | 14568 | 14568 |
| R-squared | 0.15 | 0.44 | 0.60 | 0.61 |

Robust standard errors in parentheses
* significant at 5%; ** significant at 1%

Table 4: **Pooled Regressions of the Average Basis**: This table shows the coefficients on various bond characteristics and dummy variables including covenants for pooled regressions on around 29,000 bond-quarter observations for 5,792 bonds issued by 1,167 firms for the period from July 2002 to June 2006. The dependent variable is the average quarterly CDS-bond basis computed using par equivalent corporate bond spreads calculated using TRACE data and CDS spreads from GFI/CMA. The basis is the difference between the CDS spread and the par equivalent spread of the corporate bond. Latent liquidity information is from the custodial database, while trade count for corporate bonds is computed using TRACE data. The rating refers to the numerical code used to represent quarterly S&P ratings on domestic debt obtained from Compustat. The bond covenants are taken from Bloomberg's list of bond covenants. Firm level variables such as leverage and tangible assets are calculated using the Compustat quarterly data for the previous quarter. CDS market liquidity and standard deviations are computed using GFI/CMA CDS spreads. Table 5 shows the coefficient on dummy variables representing various bond covenants, and is an extension of column 4 of this table.

| Dependent variable : Average CDS-Bond basis | | | |
|---|---|---|---|
| Credit sensitive | 9.845 | Poison Put | -5.586 |
| | (10.94) | | (13.97) |
| Defeased | -8.454 | Prosp on File | 5.889 |
| | (2.71)** | | (8.41) |
| Equity Clawback | -12.376 | Secured | 26.488 |
| | (15.47) | | (6.99)** |
| Euro Sales Tax | -19.567 | Special Put | 3.133 |
| | (3.68)** | | (7.83) |
| Exch listed | 1.373 | Tap Issue | -3.69 |
| | (3.43) | | (2.84) |
| Funded | 48.299 | Tax call | 3.134 |
| | (28.41) | | (3.48) |
| Guaranteed | 7.192 | | |
| | (4.50) | | |

Table 5: **Coefficients of Bond Dummy Variables in Pooled Regressions of the Average Basis:** This table is a continuation of Table 4 above. It presents the coefficients of various bond characteristic dummy variables, including covenants for pooled regressions, for around 14,600 bond-quarter observations for 5,792 bonds issued by 1,167 firms the period from July 2002 to June 2006. (These coefficients are a continuation of the results of Regression 4 in Table 4. The dependent variable is the average quarterly CDS-bond basis computed using par equivalent corporate bond spreads calculated using TRACE data and CDS spreads from GFI/CMA. The basis is the difference between the CDS spread and the par equivalent spread of the corporate bond. The bond covenants are taken from Bloomberg's list of bond covenants. Firm level ratios are calculated using the Compustat quarterly data for the previous quarter. CDS market liquidity and standard deviations are computed using GFI/CMA CDS spreads.

| Latent Liquidity | Rating Class | | | | | |
|---|---|---|---|---|---|---|
| quintile | AAA | AA | A | BBB | BB | >= C |
| 1 | 25.64 | 41.79 | 21.88 | 10.46 | 72.57 | 245.08 |
| | (2.55) | (2.21) | (0.83) | (0.95) | (3.62) | (14.61) |
| 2 | 71.03 | 43.30 | 35.38 | 20.92 | 108.76 | 271.66 |
| | (5.66) | (2.52) | (1.34) | (1.73) | (15.06) | (47.12) |
| 3 | 84.34 | 44.31 | 41.32 | 24.85 | 135.06 | 137.09 |
| | (5.04) | (2.16) | (1.31) | (1.65) | (15.78) | (21.55) |
| 4 | 60.73 | 44.12 | 50.55 | 32.44 | 100.25 | 87.66 |
| | (5.87) | (2.75) | (1.29) | (1.52) | (8.74) | (11.81) |
| 5 | 81.66 | 50.19 | 52.50 | 42.70 | 92.26 | 127.12 |
| | (4.17) | (2.56) | (1.75) | (1.75) | (8.81) | (13.33) |
| F(30,23714)=131.33 | | | | | | |

Table 6: **Average Basis in Sub-sets Sorted by Latent Liquidity and Rating:** This table shows the average CDS-bond basis in a sample of around 23,000 bond-quarter observations for 5,792 bonds issued by 1,167 firms for the period from July 2002 to June 2006. For every quarter, the data are sorted along two dimensions into five groups in increasing order of their latent liquidity and further by their S&P rating class. The numbers in the table are the means computed for each sub-group. Figures in parentheses are clustered standard errors for the mean, where the clustering is by individual bond.

| Latent liquidity | Standard deviation of EPS forecast | | | | |
|---|---|---|---|---|---|
| quintile | 1 | 2 | 3 | 4 | 5 |
| 1 | 30.77 | 29.50 | 21.31 | 19.98 | 96.28 |
| | (1.27) | (1.72) | (1.49) | (1.49) | (4.77) |
| 2 | 49.51 | 37.28 | 27.63 | 22.50 | 40.25 |
| | (1.85) | (2.05) | (2.44) | (2.56) | (4.11) |
| 3 | 51.70 | 40.48 | 35.54 | 31.09 | 63.23 |
| | (1.91) | (1.86) | (2.24) | (2.53) | (5.60) |
| 4 | 55.12 | 40.49 | 35.82 | 34.89 | 73.19 |
| | (2.00) | (1.95) | (2.46) | (2.58) | (3.98) |
| 5 | 64.80 | 44.44 | 41.76 | 44.33 | 83.01 |
| | (2.05) | (2.53) | (2.81) | (2.07) | (5.09) |
| F(24,23720)=50.82 | | | | | |

Table 7: **Average Basis in Sub-sets Sorted by Latent Liquidity and Analyst Uncertainty of EPS:** This table shows the average CDS-bond basis in a sample of around 19,000 bond-quarter observations for the period from July 2002 to June 2006. For every quarter, the data are sorted along two dimensions into five groups in increasing order of their latent liquidity and further by the ratio of the standard deviation of earnings per share (EPS) forecasts as a proportion of their share price, as indicated by the I/B/E/S database. The numbers in the table are the means computed for each sub-group. Figures in parentheses are clustered standard errors for the mean, where the clustering is by individual bond.

| | Dependent variable : Average CDS-Bond basis | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Coupon | -17.634 | -17.401 | -17.719 | -17.188 |
| | (1.59)** | (1.59)** | (1.59)** | (1.80)** |
| Latent Liquidity | 16.665 | 10.783 | 14.589 | 21.242 |
| | (1.80)** | (1.74)** | (1.76)** | (2.33)** |
| No. of trades (100) | 0.142 | 0.187 | 0.193 | 0.219 |
| | (0.10) | (0.10) | (0.10)* | (0.10)* |
| Maturity (yrs) | -2.306 | -2.299 | -2.293 | -2.344 |
| | (0.18)** | (0.18)** | (0.18)** | (0.19)** |
| Age (yrs) | 2.048 | 1.686 | 1.902 | 1.51 |
| | (0.44)** | (0.44)** | (0.44)** | (0.47)** |
| Log (Issue Size) | 5.142 | 6.327 | 6.089 | 4.255 |
| | (0.67)** | (0.65)** | (0.64)** | (0.72)** |
| S&P Rating | 1.886 | 2.386 | 1.732 | 2.16 |
| | (0.55)** | (0.56)** | (0.55)** | (0.56)** |
| CDS Vol | -0.011 | 0.014 | 0.004 | -0.012 |
| | (0.06) | (0.07) | (0.07) | (0.06) |
| CDS bid-ask | 2.097 | 2.086 | 2.074 | 2.121 |
| | (0.19)** | (0.19)** | (0.18)** | (0.19)** |
| CDS pct bidask | 25.985 | 17.651 | 27.235 | -10.316 |
| | (11.30)* | (11.77) | (11.16)* | (12.90) |
| Leverage | 87.098 | 82.61 | 81.651 | 84.3 |
| | (6.16)** | (6.08)** | (6.08)** | (6.34)** |
| Tangible Assets | -18.046 | -18.278 | -17.208 | -24.178 |
| | (3.61)** | (3.47)** | (3.53)** | (3.80)** |
| Interaction Dummy (1) | 40.534 | | 26.024 | |
| | (4.92)** | | (5.53)** | |
| Interaction Dummy (2) | | 60.529 | 47.233 | |
| | | (6.32)** | (7.22)** | |
| Interaction Dummy (3) | | | | 24.929 |
| | | | | (4.24)** |
| Constant | 25.174 | 12.206 | 17.626 | 41.48 |
| | (11.39)* | (12.21) | (11.75) | (11.43)** |
| Observations | 22863 | 22863 | 22863 | 19353 |
| R-squared | 0.5 | 0.5 | 0.5 | 0.52 |

Robust standard errors in parentheses
* significant at 5%; ** significant at 1%

Table 8: **Pooled Regressions of the Average Basis with Liquidity and Risk Interaction Terms**: This table shows the coefficients on various bond characteristic dummy variables including covenants for pooled regressions for 5,792 bonds issued by 1,167 firms for the period from July 2002 to June 2006. The dependent variable is the average quarterly CDS-bond basis computed using par equivalent corporate bond spreads calculated using TRACE data and CDS spreads from GFI/CMA. The basis is the difference between the CDS spread and the par equivalent spread of the corporate bond. Latent liquidity information is from the custodial database, while trade count for corporate bonds is computed using TRACE data. The rating refers to the numerical code used to represent quarterly S&P ratings on domestic debt obtained from Compustat. Firm level variables such as leverage and tangible assets are calculated using the Compustat quarterly data for the previous quarter. CDS market liquidity and standard deviations are computed using GFI/CMA CDS spreads. The first dummy variable takes a value of 1 if the bond lies in the lowest liquidity quintile as measured by latent liquidity and the highest default risk quintile as measured by the CDS spread of the issuer. The second dummy variable takes a value of 1 if the bond lies in the lowest liquidity quintile as measured by trading volume and the highest default risk quintile as measured by the CDS spread of the issuer. The third dummy variable takes a value of 1 if the bond lies in the lowest liquidity quintile as measured by latent liquidity and the highest uncertainty quintile as measured by the standard deviation of analyst EPS forecasts for the issuer.