Latent Liquidity and Corporate Bond Yield Spreads *

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Abstract

Recent research has shown that default risk accounts only a part of the total yield spread on risky corporate bonds relative to their riskless benchmarks. One candidate for the unexplained portion of the spread is a premium for the illiquidity in the corporate bond market. We relate the liquidity of corporate bonds, as measured by their ease of market access, to the non-default component of their corporate bond yields, using the portfolio holdings database of the largest custodian in the market. The ease of access of a bond is measured using a recently developed measure called *latent liquidity* that weights the turnover of funds holding the bond by their proportional holdings of the bond. We use the credit default swap (CDS) prices of the bond issuer to control for the credit risk of a bond. At an aggregate level, we find a contemporaneous relationship between aggregate latent liquidity and the average non-default component in corporate bond prices. Additionally, for individual bonds, we find that bonds with higher latent liquidity have a lower non-default component of their yield spread. We find that bonds that are held by funds that exhibit greater *buying* activity command lower spreads (are more expensive), while the opposite is true for those that exhibit greater *selling* activity. We also find that the liquidity in the CDS market has an impact on bond pricing, over and above bond-specific liquidity effects.

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1 Introduction

Corporate bonds are amongst the least understood instruments in the financial markets. The sheer size of the US corporate bond market, about 4.5 trillion dollars outstanding at the end of 2004, makes it an important source of capital for major firms around the world. These bonds carry a risk of default, and hence command a yield premium or spread relative to their riskless 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 pricing models and calibration techniques.

Prior studies have noted that although default risk is an important determinant of the spread, there are other factors such as liquidity, taxes, and market risk variables that may also play a significant role in determining the spread. Of these other factors, it has been conjectured that liquidity effects have the largest role to play in the pricing of corporate bonds. Unfortunately, the non-default component of corporate bond yields/prices has been inadequately studied, largely due to the paucity of relevant data. In particular, the absence of frequent trades in corporate bonds makes it difficult to use market micro-structure measures of liquidity, based 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 fruitless to *directly* study the impact of liquidity on corporate bond yields and prices, thus leaving the discussion of the non-default component of corporate bond spreads somewhat unsatisfactory.

In this paper, we provide a partial answer to this question using a new measure of liquidity, called latent liquidity, proposed by Chacko, Mahanti, Mallik, and Subrahmanyam (2006), that is based on the pattern of holdings of bonds by investors, and thus does not require a large number of observed trades. 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. As documented by Chacko, Mahanti, Mallik, and Subrahmanyam (2006), the attractive feature of this measure is that it circumvents the problem of availability of transaction data for corporate bonds and yet provides a reasonable proxy for liquidity.

We study the relationship of the latent liquidity measure with bond prices and yields. Specifically we focus on the component of bond yield spreads (over the corresponding riskless benchmark) that is *not* explained by default risk and relate it to the ease of access of the bonds, as measured by latent liquidity. This approach allows us to analyze a broad sample of bonds, many of which trade infrequently, to examine liquidity effects in their pricing. We use the premium from the credit default swap (CDS) market for the issuer of the bond to control for the default risk component. The non-default component is computed using two alternate specifications for the benchmark - the treasury curve and the swap curve as proxies for the risk-free term structure of interest rates.

We use a unique database of corporate bonds assembled by one of the largest custodians in the market in our measurement of latent liquidity. Our approach using this metric of liquidity has several unique advantages, as argued by Chacko, Mahanti, Mallik, and Subrahmanyam (2006). First, it allows us to access information across a large number of dealers. Second, because the custodian has information regarding the ultimate ownership of the bonds, it is possible to compute a holdings-based measure of the accessibility of the bonds. Third, it allows us to separate the aggregate liquidity measure into "buy" and "sell" liquidity measures.

The analysis in this paper focuses on how the latent liquidity of corporate bonds affects their yields/prices, after taking into account the default risk component. We document several interesting relationships in our study. We find that latent liquidity explains a statistically and economically significant part of bond yields. We first document the inverse relationship between bond yield spreads and latent liquidity at the aggregate level, over time. We next confirm this relationship in the cross section of bonds in our sample, the traditional hypothesis that the greater the liquidity, the lower their yield spreads, and hence, the greater their prices. We then explore the sources of liquidity in greater detail and split up the measure between buy (fractional holdings weighted by buying turnover) and sell latent liquidity (fractional holdings weighted by selling turnover). Further analysis leads us to the conclusion that bonds that are easier to sell (as measured by high buy latent liquidity) are more expensive, while bonds that are easier to buy (as measured by high sell latent liquidity) tend to be less expensive.

In addition to studying the liquidity effects in the corporate bond market, we also examine liquidity effects in the CDS market, using more traditional liquidity metrics such as bid-ask spreads and trading activity. Given the higher liquidity in the CDS market, in many cases, such microstructure-based metrics of liquidity may be meaningful. We find that, over and above bond-specific liquidity measures, the liquidity of the CDS contract affects bond prices. Bonds of issuers whose CDS contracts enjoy greater liquidity tend to be cheaper in the cross-section, compared with their less liquid counterparts, after adjusting for various bond characteristics. We also confirm several relationships documented in the previous literature about the effect of factors like coupon, amount outstanding, age and trading volume on the liquidity of bonds, on a much more current and extensive data-set than has been used in previous studies.

This paper is divided into the following sections. Section 2 offers a review of the existing literature on the yield spreads of corporate bonds. Section 3 describes our data sources. Section 4 discusses the latent liquidity measure proposed by Chacko, Mahanti, Mallik, and Subrahmanyam (2006) and the manner in which we measure the non-default component of corporate bond spreads. Section 5 discusses the results of our study. Section 6 concludes.

2 Literature Review

Our paper is related to three different strands in the academic literature. First, there is a vast literature on the impact of illiquidity on asset prices. Although most of this literature is related to equity prices, the broad issues analyzed are applicable to corporate bonds. Second, there is a burgeoning literature that seeks to explain the yield spreads of corporate bonds over their treasury benchmarks. While the major component of the spread is attributed to the default component of these bonds, there is a large unexplained portion that has been variously attributed to tax, liquidity, market risk and other effects. Our focus is on the liquidity effects, which have not been satisfactorily measured so far. The third strand of the literature relates to attempts to measure liquidity in the context of a highly illiquid market such as the market for corporate bonds.

There is a considerable volume of literature, particularly in the past two decades, that attempts to describe the effect of liquidity on asset prices. Most of this literature has to do with the concept of liquidity costs and associated liquidity premia in stocks, although there is a somewhat sparse, 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.[1] In an early contribution in this area, Amihud and Mendelson (1986) argue that transactions costs result in liquidity premia in equilibrim, reflecting the differing expected returns for investors with different holding times who have to defray their transactions costs. There is an implicit clientele effect, due to which securities that are more illiquid, and are cheaper as a result, are held in equilibrium by investors with longer holding periods. This work has been extended and modified in different directions over the years.[2]

A closely related branch of literature has to do with modeling these liquidity costs. The sources of liquidity costs are two-fold: the inventory carrying costs of the dealer and the information asymmetry costs faced by the dealer in relation to informed trades.[3] On the empirical side, the literature has primarily dealt either with the equity market or the market for government bonds, both of which are characterized by high trading volumes and a large number of participants. There are a few notable exceptions of researchers who have studied 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 (2006), who provide a method of estimating transaction costs in the corporate bond market and relate them to corporate bond returns.

In a parallel development, there have also been attempts to decompose the yield spread on corporate bonds in terms of the components that are related to the defaultable nature of these securities, and to other components. 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 able to explain only a part of corporate bond spreads, if reasonable parameters are assumed for the firm value process. A similar conclusion is drawn by Eom, Helwege, and Uno (2003) who find that structural models under-predict corporate bond spreads. Elton,

[1] 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.

[2] See Huang (2003), for an example

[3] There is a vast literature, particularly dealing with the latter explanation, with Kyle (1985) being a prominent example. Again, see Amihud, Mendelson, and Pedersen (2006), for more details.

Gruber, Agrawal, and Mann (2001) find evidence of a significant tax effect in corporate bonds that is attributable to the differential treatment of coupons on corporate bonds relative to treasury securities. A 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. They find evidence of a significant non-default component in the 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 the co-integration relationship 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.

The other 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, E., and Jostova (2002). More recently, there is a paper by Houweling, Mentink, and Vorst (2005) that uses liquidity-sorted portfolios in the European market, constructed using nine proxies for liquidity including issued amount, listed, euro, on-the-run, age, missing prices, yield volatility, number of contributors and yield dispersion. Using a multi-factor model to control for interest rate and credit risk, they find evidence of a significant liquidity premium. In a similar vein, De Jong and Driessen (2006) and Downing, Underwood, and Xing (2006) use multi-factor models that include liquidity in the equity market as well as the treasury market, and find evidence of significant liquidity premia in corporate bonds.

The concept of latent liquidity that is used in this paper draws from Chacko, Mahanti, Mallik, and Subrahmanyam (2006). That paper introduces the measure and relates it to bond-specific characteristics, such as maturity, age, coupon, rating, the presence or absence of put/call options and other covenants.[4] In section 4, we discuss the concept of latent liquidity, and the extensions of the basic concept to buy versus sell latent liquidity, that we use later on, in our analysis of corporate bond prices.

3 Data Sources

Our primary source of data is the corporate bond holdings and transactions database of State State Corporation (SSC), the largest custodian in the global financial market. 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, who 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 this allows the construction of the latent liquidity measure that we employ in this research.

The database contains traded prices for corporate bonds for the period from 1994 to 2005. In addition, the end-of-month holdings information on all the bonds in our sample is also available, based on which the latent liquidity measure is computed. The database covers around 15% of all bonds traded in the US markets and is quite representative of the overall US corporate bond market.[5] A brief description of the construction of the latent liquidity measure is presented in section 4.

The prices for the CDSs are obtained come from a database supplied by GFI, the leading broker in the CDS market.[6] The database covers over 2000 leading corporate names on which credit protection is bought or sold on a fairly regular basis. It includes daily prices for CDSs for the period from April 1999 to July 2005. There are several advantages of using this data-set.

- It covers a longer time period than has been covered by previous studies. Most notable amongst these studies is Longstaff, Mithal, and Neis (2005), which uses a proprietary database

[4]The concept is also used by Chacko (2005) to document the existence of a liquidity risk premium when bonds are sorted on the basis of latent liquidity.

[5]For a detailed exposition and analysis of the representativeness of the database, please refer to Chacko, Mahanti, Mallik, and Subrahmanyam (2006).

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

of CDS prices 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.

- 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. The 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 Fixed Income Securities Database (1997).[7]

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

The prices in the database could be either transaction prices or mid-quotes. We aggregate this data in different ways to obtain measures of the prices and liquidity in the CDS market. The quotes include both bid and ask quotes, in addition to transacted prices of each CDS contract. We take the average of the quotes every day; in some cases, there are several quotes available each day. We also compute the number of trades and available quotes on any given day (whether bid or ask) for each name. In order to integrate the data sources, the names in the CDS database are matched to the corporate bond issuers in the database of corporate bonds.

Table 1 shows the top forty names (by number of quote dates) on which CDS contracts are traded. It can be seen that there is considerable variation in the number of daily quotes for the CDS contracts, both in the cross-section and in the time-series, as indicated by the average number of quotes, and the minimum and the maximum number of quotes. The variation in the mid-point of the CDS quotes is also considerable, thus indicating that the database spans a large variation in the prices of credit risk for each of the issuers. On most names, there are very few actual CDS trades on a daily basis, with some names trading as infrequently as once every few months. Most of the liquidity in the CDS is concentrated in the five-year maturity bucket, which is the bucket used by most market participants for calibration purposes. For this reason, we use the five-year

[7] See for example papers by Elton, Gruber, Agrawal, and Mann (2001), Huang and Huang (2003), Eom, Helwege, and Uno (2003) and others.

maturity bucket in our analysis.

Data on interest rates, such as treasury yields and swap rates are obtained from Datastream. These data are also matched with those on corporate bond and CDS trades in our data-set, assembled from SSC and the GFI. In order to focus on the pricing of corporate bonds, we restrict our attention to data on days on which we observe a quote in *both* the CDS market and a trade 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.

To actually estimate the non-default component of the yield spread, we employ a set of filters to ensure that we have sufficient data, and that the data are properly matched between the corporate bonds and the credit derivatives. We eliminate all issuer names that have less than 300 days of quotes available in the CDS database over our sample period. In addition to this filter, we choose bonds that have a final maturity between 4 years and 6 years on the date on which they are traded. This allows for a reasonably good match between the maturity of the CDS contract and the bond maturity, since both of them measure firm credit risk over similar horizons. Finally, we match the trade date of the bonds with that of the CDS contract, and construct a panel consisting of a cross section of corporate bonds and their price observations on the days on which trades occurred, along with CDS prices for the dates on which the corporate bonds traded. It is this panel that is used for the computation of the non-default component of the corporate bond spread. For each observation, we have the corresponding bond characteristics, such as coupon, rating (a numerically assigned number with the following scheme: Aaa - 1, Aa -2 , A - 3, Baa - 4), outstanding volume, and the latent liquidity of the bond.

Table 3 shows the decomposition of the sample into industry groups, along with a summary of the database of holdings of State Street composition, and the universe of bonds tracked by the Lehman Brothers Credit Indices. We find that the single largest industry group represented in the sample is Financial Services, followed by Media and Telecommunications. Industrials and Utilities make up a relatively small proportion of the sample. The three data-sets are roughly similar in that they are heavily biased towards Financial Services, and have similar proportions of communications, technology and manufacturing firms, indicating that the sample is quite representative of the overall market, as captured by the Lehman universe.

Similarly Table 4 shows the decomposition of the sample by their initial Moody's credit ratings. The sample is skewed towards investment grade bonds, because these are the ones that are traded more frequently *and* also have CDS contracts traded at the same time. In spite of these apparent biases, however, this sample is reasonably representative of the overall composition of the investment grade corporate bond market, though not of the corporate bond market as a whole. Table 4 also shows the rating distribution in the holdings database as well as the overall universe. The top four ratings account for around 74% of all corporate bonds outstanding. This leads us to the conclusion that the exclusion of the remaining categories from our data-set is not a very severe problem. The sample is broadly similar to the samples used in prior studies of the corporate CDS market, but with many more observations, both cross-sectionally and over time.[8]

Table 5 shows the summary statistics for the sample of bonds that we obtain after the filtering process, mentioned earlier. There are 698 bonds in our sample, and 167 issuers, with a total of around 15000 trade observations. The cross section of bonds, even after filtering, is larger than the previous studies in this area. As a basis of comparison, the study by Longstaff, Mithal, and Neis (2005) covers 52 issuers and 308 instruments, while that of Blanco, Brennan, and Marsh (2005) covers only 33 isuers and 33 instruments. Elton, Gruber, Agrawal, and Mann (2001) use around 700 bonds, but they do not use CDS data. Furthermore, as discussed earlier, many of the studies using only corporate bond data, use data from before 1996.

4 Methodology

4.1 Latent Liquidity

In this section, we describe in brief the methodology used to compute the latent liquidity measures, including the buy and the sell latent liquidity measures. Latent liquidity captures the ease of access of a corporate bond to a sell-side dealer. In simple terms, it is the weighted average turnover of the funds holding a particular bond, the weights being the fractions of the total outstanding of

[8]See, for example, Longstaff, Mithal, and Neis (2005).

a bond held by various funds.[9] The argument behind this computation is that bonds that are held by funds that have a larger turnover are likely to be more accessible and hence more highly traded. Chacko, Mahanti, Mallik, and Subrahmanyam (2006) 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 data are available . However, the advantage of this measure is that it does not require trade-based information, and is thus available for a broader cross-section of bonds.

Let $\pi^i_{j,t}$ denote the fractional holding of a bond i by fund 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 value of the fund at time t to the dollar trading volume of the fund between time t to $t-12$. The latent liquidity measure for bond i at time t is simply defined as:

$$L^i_t = \sum_j \pi^i_{j,t} T_{j,t} \tag{1}$$

Equation 1 yields a monthly number for the latent liquidity of each bond in our sample. Note that, in this sense, the latent liquidity of the bond indicates the ease with which a dealer can locate the bond in order to fulfill a buy order. It does *not* necessarily indicate the ease with which the bond may be sold, although an argument can be made that funds with a higher turnover, are more likely to add to their existing holdings of corporate bonds, than funds with a lower turnover.

There is, however, a way of splitting up the latent liquidity measure into buy and sell latent liquidity, based on who is buying or selling the bond, respectively. This can be done by measuring the turnover of "buys" and the turnover of "sells" separately for individual funds, and then weighting them by the fractional holdings. Let $\pi^i_{j,t}$ denote the fractional holding of a bond i by fund j at time t. Let $T^B_{j,t}$ denote the average buying portfolio turnover of a fund in the months from t to $t-12$, where buying turnover is defined as the ratio of the value of the fund at time t to the dollar buying volume of the fund between time t to $t-12$. The buy latent liquidity measure is simply:

[9]For a more detailed description of the computation, as well as the relationship between latent liquidity and bond characteristics, the reader is referred to Chacko, Mahanti, Mallik, and Subrahmanyam (2006).

$$L^i_{Bt} = \sum_j \pi^i_{j,t} T^B_{j,t} \tag{2}$$

The sell measure is defined similarly as

$$L^i_{St} = \sum_j \pi^i_{j,t} T^S_{j,t} \tag{3}$$

These two measures, respectively called buy and sell latent liquidity are measures of buying and selling activities of the funds holding the particular bond. We will use these measures subsequently in our analysis.

4.2 The Non-default Component of Corporate Bonds

The recent academic literature on corporate bond pricing has attempted to isolate the component of corporate bonds that is *not* caused by default risk (the non-default component). Most of the earlier papers in this area use an explicit model for pricing credit risk.[10] However, the advent of the CDS market makes it possible to isolate default risk in corporate bonds issued by a certain issuer, without relying too heavily on a particular model of credit risk and a specific parameterization, since one more reading of the market price of credit risk becomes available. Most credit default swap contracts specify a particular reference asset, but allow for settlement by physical delivery of other similar obligations of the same issuer.[11] Hence, 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 obligations. Indeed, as argued by Duffie (1999), to a first order approximation, there is an equivalence between the CDS price and the spread on the floating rate obligation of a similar maturity issued by a firm. It must be noted that most corporate bonds issued by firms tend to be fixed rate bonds, and thus this equivalence does not hold exactly. More importantly, as shown by Longstaff, Mithal, and Neis

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

[11]There are some recent moves to switch to cash settlement, rather than physical delivery, to avoid the possibility of a squeeze on the reference bond.

(2005), the corporate bond spread is biased, depending on the probability of default.

This equivalence is even more complicated by differing definitions in the CDS contract, especially in the early years of our sample period. However, 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. However, the holder of the obligation typically loses more or less than the face value of the obligation depending on the price at which it was bought, depending on market liquidity conditions for the deliverable obligations of the firm.

Subject to the above caveats, there are essentially two different approaches for isolating the non-default part of the corporate bond spread, which could then be related, in part, to liquidity effects. One possible approach is to use the difference between the corporate bond spread and the CDS spread as a model-independent, albeit noisy proxy for the non-default component of the corporate bond yield spread. An alternative approach would be to apply a theoretical model of credit risk to price both the CDS and the corporate bonds simultaneously. This has the advantage that any potential biases are addressed is the approach followed by Longstaff, Mithal, and Neis (2005). However, the procedure is dependent on the choice of the credit risk model, and the literature on credit risk models shows us that there remain significant pricing errors in all the models that have been used so far.[12] In this paper, we follow the method used by Longstaff, Mithal, and Neis (2005) to estimate the non-default component of the corporate bond yields.

Following this method, we assume that the CDS prices reflect the true probability of default and infer the non-default component of the bond prices by jointly fitting a credit risk model to both the CDS and the corporate bond prices. The method uses an affine model of credit risk and a random walk process for the non-default component. The model for the probability of default is an affine jump diffusion model of the form:

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

$$d\lambda = (a - b\lambda)dt + \sigma\sqrt{\lambda}dz_\lambda \tag{4}$$

where λ is the risk-neutral jump intensity. The non-default component γ is given by:

$$d\gamma = \eta dZ_\gamma \tag{5}$$

Appealing to the affine nature of the specification permits the derivation of simple closed form solutions to both the corporate bond price and the CDS premium that are exponentially affine in λ_t and γ_t, the risk neutral probability of default and the non-default component of the spread, respectively. Following Longstaff, Mithal, and Neis (2005), the price of a corporate bond of maturity T, coupon c and loss given default of w is given by:[13]

$$\begin{aligned} CB(c, w, T) = {} & c\int_0^T A(t)exp(B(t)\lambda)C(t)D(t)e^{-\gamma t}dt \\ & + A(T)exp(B(T)\lambda)C(T)D(T)e^{-\gamma T} \\ & + (1-w)\int_0^T exp(B(t)\lambda)C(t)D(t)(G(t) + H(t)\lambda)e^{-\gamma t}dt \end{aligned} \tag{6}$$

The price of a CDS is given by:

$$s = \frac{w\int_0^T exp(B(t)\lambda)D(t)(G(t) + H(t)\lambda)dt}{\int_0^T A(t)exp(B(t)\lambda)D(t)dt} \tag{7}$$

where

$$A(t) = exp\left(\frac{\alpha(\beta+\phi)t}{\sigma^2}\right)\left(\frac{1-\kappa}{1-ke^{\phi t}}\right)^{2\alpha/\sigma^2}$$

$$B(t) = \frac{\beta-\phi}{\sigma^2} + \frac{2\phi}{\sigma^2(1-\kappa e^{\phi t})}$$

$$C(t) = exp\left(\frac{\eta^2 t^3}{6}\right)$$

[13] For a more detailed description refer to Longstaff, Mithal, and Neis (2005).

$$G(t) = \frac{\alpha}{\phi}(e^{\phi t} - 1)exp\left(\frac{\alpha(\beta+\phi)}{\sigma^2}t\right)\left(\frac{1-\kappa}{1-\kappa e^{\phi t}}\right)^{2\alpha/\sigma^2+1}$$

$$H(t) = exp\left(\frac{\alpha(\beta+\phi)+\phi\sigma^2}{\sigma^2}t\right)\left(\frac{1-\kappa}{1-\kappa e^{\phi t}}\right)^{2\alpha/\sigma^2+2}$$

where

$$\phi = \sqrt{2\sigma^2 + \beta^2}$$

and

$$\kappa = (\beta+\phi)/(\beta-\phi)$$

Following Grinblatt (2001), and Longstaff, Mithal, and Neis (2005), we use two alternate benchmarks for the risk free rate - the par yield curve on US treasuries and the USD-LIBOR swap curve, available from Datastream.[14] We linearly interpolate between points on the curves to obtain a par curve available at semi-annual intervals. These par curves are then bootstrapped to get discount factors at each semi-annual interval. We then fit a cubic spline to the discount factors to get a functional form for the discount function D(t), for both specifications of the benchmark curve.

We make the assumption that the price of credit default swaps reflect the true price of credit risk (or, if even if they do not, the errors are unbiased and not related to liquidity). Under this assumption, we evaluate the risk neutral default intensity, λ, by assuming values for the parameters α, β, σ and δ, using equation 7 above. This value of λ is then used to fit the prices of all bonds by the same issuer. In short, we use the price of the credit default swaps to fit the value of λ, as on any given date. We then we use the λ so computed in the price for the bond on that date and obtain a value for the non-default component γ, using equation 7. Given the maturity filter that we apply on the bonds, every bond remains in our sample for a maximum of two years. The time-series average of non-default component during these two years is used in the subsequent cross-sectional study. We obtain two sets of cross-sectional estimates for the non-default component of the bond yield spread - using swap rates and treasury rates as the benchmark risk-free rates. It turns out

[14] As discussed below, neither curve provides a pure risk-free benchmark that is uncontaminated by liquidity effects. The former has clear liquidity effects embedded into the pricing of the on-the-run bond, while the latter has a small credit risk premium, due to the difference between the treasury and LIBOR rates, built into it.

that the value of the non-default component is not very sensitive to the choice of model parameters.

An important issue to remember here is the issue of "shorting" costs. When the non-default component of the yield spread in a bond is positive, a hypothetical 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. On the other hand, if the non-default component is negative, the arbitrage strategy involves shorting the bond and selling protection on it through the CDS contract. Shorting corporate bonds is costly because corporate bonds are difficult to "find" in the securities borrowing and lending market. 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 "negative" non-default premium, when such an arbitrage strategy is profitable. This could explain the fact that the non-default component is often negative when CDS spreads are extremely high.

We have access to a data-set for realized borrowing costs, but unfortunately this data-set covers only a small part of our sample period. In this limited sample, we find that shorting corporate bonds is almost always costly, with an average shorting cost of 0.48% (calculated as the difference between the general collateral rate and the rebate rate on a bond). Shorting costs are typically high when firms are in financial distress, and hence have high CDS spreads. These costs can be quite high. There are several instances of bonds having a zero rebate rate when borrowed, indicating that the shorting cost was as high as the general collateral rate itself.

Since we do not have data on shorting costs for our entire sample, it is difficult to analyze the impact of shorting costs on the non-default component. In the limited data that we have, we find little relationship between shorting costs and latent liquidity. If this relationship extends to the larger sample, we do not expect shorting costs to bias the results of our study.

5 Results

5.1 Latent Liquidity, Bond Characteristics and Modified Liquidity Variables

Table 6 shows the determinants of latent liquidity of the bonds in our sample. It shows that the age of the bond is the most significant determinant of latent liquidity. Both measures of credit quality -the initial credit rating of the bond, and the average CDS spread on the issuer imply that in our sample that bonds of poorer credit quality have higher latent liquidity. Bonds that trade less frequently and bonds with lower outstanding volumes tend to have lower latent liquidity. The coupon yield of the bond does not seem to have any explanatory power once age is controlled for. This relationship is slightly different from that reported in Chacko, Mahanti, Mallik, and Subrahmanyam (2006) for a much larger cross-sectional sample, over a somewhat longer period, for which they find that the higher coupon bonds tend to have greater latent liquidity. This could also be the result of the nature of our more recent sample period, which is mostly during a period of declining interest rates. In this period, the older bonds tend to have higher coupons, and this explains the fact that controlling for age removes all explanatory power from the coupon rate of the bond.

We also add two liquidity variables from the CDS market - the percentage bid/ask spread on the CDS contract, and the average number of daily quotes on the name. We find that the percentage bid-ask spread on the CDS contract has some explanatory power for the latent liquidity of the bond. This is over and above the bond-specific liquidity variables that we have mentioned above. In all, using these factors, we are able to explain about 28% of the variation in average latent liquidity in the cross-section of bonds in our sample.

5.2 Aggregate Latent Liquidity

Before analyzing the effect that the Latent Liquidity of a bond has on its non-default component, we examine the effect that aggregate latent liquidity in our sample has on the average non-default component of bonds traded in the market. We define aggregate latent liquidity as the average of the latent liquidity of bonds in any given month. [15]

We examine how the average latent liquidity of our sample every month affects the average non-default component that we observe for that month. For this, we compute the average non-default component using all bonds for every month, and similar monthly averages of the other measures. We include the average coupon of the bonds traded, since as bonds move in and out of our sample, the average coupon changes and this might have implications for the non-default component. Thus we get a series of averages for each month.

Table 7 shows the effects in a regression of the average non-default component in a given month, on the aggregate latent liquidity in that month, and on other variables, including the average coupon, the average bid-ask spread in the CDS market and the average number of daily quotes in the CDS contracts, in that month. To control for autocorrelation in the disturbances, we introduce an AR(1) term in the regression. The results indicate that an increase in the aggregate latent liquidity is accompanied by a decrease in the average non-default component, relative to both the treasury rate as well as swap curve benchmarks. The results are statistically and economically significant. In addition, the liquidity of the CDS market matters. An increase in average CDS bid-ask spreads drives the average non-default component up, while an increase in activity as measured by the number of quotes, drives it down.

5.3 Measurement Error Issues

We turn next to analyzing the effect of liquidity at the level of individual bonds. Here the issue of measurement error in latent liquidity becomes important. The aim of using latent liquidity is to

[15] This measure has an intuitive interpretation in terms of the average turnover of funds. Summing equation 1 over i gives us:

$$\begin{aligned} L_t &= \frac{\sum_i \sum_j \pi^i_{j,t} T_{j,t}}{i} \\ &= \frac{\sum_j \sum_i \pi^i_{j,t} T_{j,t}}{i} \\ &= \frac{\sum_j T_{j,t}}{i} \end{aligned} \tag{8}$$

This is equal to the average turnover of funds under the assumption that the ratio of the number of funds to the number of bonds stays constant over time. It is a measure of aggregate corporate bond market liquidity. However, this does not necessarily hold for a sub-sample of bonds.

obtain a better measure of the liquidity effect that drives corporate bond prices and yields than can be computed using extremely sparse transactions data. The computed measure of latent liquidity is, in a sense, different from all the other observable variables that we use in our study. It is only a noisy estimate of the true liquidity of the bond. This makes it uniquely susceptible to measurement error, though not any obvious bias, for the following reasons:

- The funds in the database that we use are a fraction, though a significant one, of the total universe of agents holding corporate bonds. Hence, a latent liquidity measure computed using our database is likely to be a very noisy estimate of the "true" liquidity of the bond.
- We use the turnover of funds in the twelve months preceding the period over which the variable is measured, rather than the (unknown) contemporaneous or future turnover.
- The variable is only available as of the beginning of every month and not prior to every possible trade-date.
- Latent liquidity is not a directly observable variable, unlike other variables such as the amount outstanding, prices, and trade-counts. Hence, the likelihood of measurement error is very high.

These errors are not likely to affect regressions affecting aggregate latent liquidity, because we have no reasons to believe that the errors across bonds are correlated. However, if liquidity is measured with error for each individual bond bond, caution should be exercised while using latent liquidity in a linear regression system at the level of each bond, because the measurement error in latent liquidity can bias and attenuate the regression coefficients. However, if we assume that the measurement error in latent liquidity is uncorrelated with the observable determinants of latent liquidity, we can correct for the measurement error when we use latent liquidity as an independent variable. We do so by using the fitted values of latent liquidity based on the last regression in Table 6 as an instrumental variable in all linear regressions that use latent liquidity as an explanatory variable. The high R-squared in the first regression and the high value of the F-statistic (> 10)gives us confidence that these are strong instruments to use.[16] In what follows, all models where latent liquidity is used as an explanatory variable use the two-stage least squares procedure to correct for measurement error in latent liquidity, the first stage of which is equation 3 in Table 6. As discussed before, estimates using the ordinary least squares (OLS) regressions result in weak and possibly biased coefficients on latent liquidity, especially when using treasury rates, and are, therefore, not reported. Instead, all the results reported here use two-stage least squares (2SLS).

In order to test whether the models using the fitted latent liquidity as an instrumental variable are correctly specified, we perform Hausman tests for specification. The null hypothesis is that the OLS models are correctly specified, and that the differences in coefficients between OLS and 2SLS are not systematic. It should be noted that:

- Under the null hypothesis, the OLS model is consistent and efficient.
- The 2SLS model is always consistent, but is less efficient than the OLS model.

The Hausman tests for all the 2-stage regressions convincingly reject the hypothesis that the OLS estimation here is consistent. We thus conclude that there is an error in variables bias when latent liquidity is used without correction.[17]

Measurement error in the dependent variable, the non-default component of the yield spread, do not bias the coefficients. However, we do correct for the fact that the average non-default component for each bond is computed using a different number of trading days for each bond. This means that the measurement error in bonds for which there is a larger amount of trade-data is likely to be lower, and the variance of this error will be proportional to the inverse of the number of trade dates for each bond. We weight our observations appropriately.

5.4 Latent Liquidity and the Non-Default Component

Tables 8 and 9 show the relationship between the average non-default component of a corporate bond on various bond specific characteristics and the (overall) latent liquidity measure. The bond

[16] A minimal cut off of 10 on the F-statistic of the first stage is used quite commonly in the literature. See Staiger and Stock (1997) and Greene (2000) for a detailed exposition.

[17] These results are not reported, owing to the uniform rejection of the OLS models, with p-values considerably below 0.01

specific characteristics examined are the coupon (to account for clientele and tax effects, albeit indirectly), and the rating of the bond (to account for any rating-related liquidity effects). In addition to the coupon and the rating, independent variables such as age, amount outstanding, and number of traded days in the CDS market are exogenous variables used to correct for errors in latent liquidity in the first stage, which is the essentially the same as the last model in Table 6.

Using both swap rates (Table 9) and treasury rates (Table 8), Model 1 shows that in a univariate regression of the non default component on overall latent liquidity, latent liquidity has significant explanatory power. The coefficient on the latent liquidity variable is negative, indicating that an increase in latent liquidity of the bond leads to a decrease in the non-default component of the yield spread, and consequently, an increase the bond price.

The inclusion of the coupon rate shows that the coupon rate has significant explanatory power, both for the specification using treasury yields and for the one that uses swap rates. An increase of 1% (per face value of 100) in the coupon rate increases the non-default component by around 8 basis points and 3 basis points, for the two cases, using the swap rates and the treasury yields, respectively. Traditionally, as in Elton, Gruber, Agrawal, and Mann (2001), this has been explained away 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 in explaining the difference between corporate bond yields and the swap reates. The fact that part of the tax effect remains even when swap rates are used indicates that this explanation can only be partly true, at best. Hence, the high value of the coefficient of the coupon rate in the case of both swap and treasury rates used as benchmarks casts doubt on the conventional explanation of the coupon effect as being due to differential taxation of corporate versus treasury bonds.

First, 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 have become significant players in the of the CDS and CDO markets, as well as the corporate bond market directly, tend to be tax-neutral. Given the large size of these two segments of the market, it is hard to believe that the marginal investor in the corporate bond market has a strong tax preference. Second, as documented in Longstaff, Mithal, and Neis (2005), this effect persists even when the Refcorp or swap term structures, which also have the same tax treatment as corporate bonds, are used as default-free interest rate benchmarks. This is, in fact, an independent robustness test. Third, the significant coefficient on the coupon rate variable persists even after the inclusion of a large number of liquidity related variables.

The coupon effect could point to the inadequacy of reduced form models to price coupon bearing bonds. One explanation proposed by Geske (1977), is that the holder of a coupon bearing bonds is short a compound put option, and hence higher coupon bonds might have a lower price. Another possible explanation is that in the relatively low interest rate environment that characterizes the time-period of our sample, higher coupon bonds tend to have a substantial premium. In such an environment, hedging the default risk in a corporate bond with a credit default swap has substantial problems. If default occurs on a bond that was bought at a premium to par, the protection on the bond is only up to the face value of a bond in a typical CDS contract. Hence, an investor holding a premium bond that defaults unexpectedly loses more relative to an investor holding a par bond by the same issuer. This could result in aversion on the part of investors to hold higher coupon bonds, and this aversion could result in a greater required yield on the bonds. The required return on higher coupon bonds would be higher in a lower interest rate environment, because the bond would have a greater premium. This issue remains to be investigated further, when a much larger data set becomes available. Finally, the initial rating of the bond at issuance, has little explanatory power, since once the credit risk of the bond is controlled for using the CDS prices, the only impact rating has on the non-default component is through its interaction with liquidity.

The coefficient of the latent liquidity variable remains highly significant, even after we add liquidity variables related to the CDS market - namely the average percentage bid-ask spread on the CDS contract, and the average number of daily quotes available to our dealer. This is noteworthy, because it indicates some degree of commonality of liquidity between the CDS market and the corporate bonds market, and is in our opinion, an entirely new result, that has received no attention previously.

Overall, even after using swap rates and treasury rates as alternative benchmarks, we find that latent liquidity has a significant impact on the level of the non-default coefficient. At a minimum, an increase of 1 unit in the latent liquidity leads to a decrease of 26 basis points in the non-default component of the bond. Since the most liquid bond in our sample has a latent liquidity of 2.36, while the least liquid bond has a latent liquidity of 0.015, within the range of latent liquidities we have, there is an implied difference of around 62 basis points between the most liquid and the least liquid bonds as measured by latent liquidity. This means that the effect is quite significant, economically speaking. For the specification using swap rates, the economic significance is even higher. It remains to be investigated why there is a difference between the relationship when swap rates are used against when treasury rates are used. It is possible that the difference between swap rates and treasury rates is itself affected by aggregate liquidity in the fixed income markets. Aggregate liquidity itself would affect the aggregate turnover of the funds. This would mean that bonds that are sampled during periods of high liquidity (a higher difference between swap rates and treasury rates) would also have a high latent liquidity number. This would result in a negative correlation between latent liquidity and the difference between the non-default component computed using treasury rates vs swap rates, thus explaining the higher coefficient when swap rates are used. We, however, remain agnostic about which benchmark to use. As shown in Feldhutter and Lando (2005), the "true" risk-less rate lies somewhere between treasury yields and swap rates. However, the fact that our result holds for both benchmarks that span the "true" risk-less rate gives us confidence that our results are robust to such a specification.

5.5 Buy and Sell Latent Liquidity and the Impact on the Non-Default Component of the Yield Spread

Latent liquidity measures the ease of access of a bond, as measured by the turnover of funds that predominantly hold the bond. However, what is priced in a bond will be the ease with which a holder of the bond can liquidate his/her position in the event of a liquidity shock. Hence, aggregate turnover, which would include both purchases and sales, might not be the most appropriate measure of buying or selling pressure, which may move the prices/yields in opposite directions. If the bond is held predominantly by funds that have a high buying turnover, it will make the bond easier to sell, because these funds are less likely to offload the bond in the market. Conversely, if a bond is primarily held by funds that have a high selling turnover, it will make it harder to sell, because the likelihood of these funds offloading the bond in the market is higher. We can thus compute two different measures of latent liquidity, based on the buying and the selling turnover of funds. As explained in the methodology section, we call these two measures buy latent liquidity and sell latent liquidity, respectively.

As a matter of fact, we would expect the buying turnover and selling turnovers to be highly correlated because high volume funds will typically engage both in buying and selling. Indeed, this can be confirmed by the fact that the correlation between buy and sell latent liquidity in our sample is very high. However, since these two have opposing effects on the non-default component of a particular bond, we expect the sign on the buy latent liquidity measure to be negative (since it indicates ease of selling) and the sign on the sell latent liquidity measure to be positive (since it indicates difficulty of selling).

Table 10 confirms this. The buy latent liquidity and the sell latent liquidity measures take up opposite and statistically significant signs. It is notable is that the inclusion of separate buy and sell measures increases the explanatory power of the overall regression. Thus, there is information contained in buy and sell liquidity, over and above all other realized measures of liquidity, despite the fact that these measures are highly correlated. The sizes of these coefficient are also quite large and economically significant.

5.6 CDS market Liquidity and the Impact on the Non-Default Component

As we have seen above, the latent liquidity of a corporate bond has an effect on its price and yield. This is both in the aggregate sense, and even more so when the buy and sell measures are considered separately. We now proceed to examine the effect of the liquidity of the CDS contract itself on the corporate bond prices. We look for the bond-specific effects, over and above those we have already considered. We consider two different measures of the liquidity of the CDS contract.

The first is the bid-ask spread as a percentage of the CDS price. The percentage bid-ask spread indicates the ease with which a buyer may buy or sell a CDS contract. A higher spread indicates difficulty of trading, since it indicates higher transactions costs, as in Amihud and Mendelson (1986). The other measure of CDS market liquidity that we consider is the average number of quotes on a contract, as available to our interdealer broker, per day. A higher number of quotes indicates higher interest in the CDS, and consequently greater liquidity. Table 11 shows four different specifications under which we test the effect of CDS market liquidity.

We find that both CDS market liquidity variables have a strong effect on the non-default component in the bond. However, of the two, the average number of daily quotes seems to drive out the effect of the percentage bid-ask spread, and the aggregate latent liquidity. As a robustness check, we test if this effect is driven by firm-level fixed effects. We do not report these results, because we find that the fixed effects are not significant. This is an interesting result because it shows that the CDS market liquidity has explanatory power on bond prices over and above bond-specific liquidity variables, and is evidence, in the cross-section, of a liquidity spill-over.

6 Conclusion

The existing literature on the yield spread of US corporate bonds shows that the non-default component in corporate bonds is 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 is virtually impossible to confirm at the level of individual bonds. We use a uniquely constructed data-set from the largest corporate bond custodian 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 CDS market obtained from a leading broker, GFI, to adjust for the credit risk of the bonds, so that can focus on the non-default component of these bonds.

We first confirm several relationships documented in the previous literature on about the effect of factors like coupon, amount outstanding, age and trading volume on liquidity, on a much more current and extensive data-set, and in particular, on the latent liquidity measure.

Secondly, we show that the average level non-default component in the market is contemporaneously related to the average latent liquidity in the market. An increase in average latent liquidity leads to a decrease in the average non-default component.

Thirdly, at the level of individual bonds, we link latent liquidity to the prices of the bonds, and find that bonds that are primarily held by funds that trade actively are more expensive, when adjusted for credit risk, than those that are held by funds that trade less actively. In addition, on closer examination, we find that bonds held by funds that have a higher buying turnover are more expensive than bonds primarily held by funds that have a higher selling turnover. This shows that, in addition to the fact that aggregate accessibility of bonds is priced, the accessibility from buyers and sellers is priced differently.

Finally, we have a unique result that shows that liquidity of the CDS contract as evidenced both by bid-ask spreads, as well as trading activity has explanatory power for the non-default component of bonds that is over and above bond-specific liquidity variables. This is true both in the cross section, at the level of individual bonds, and at an aggregate level, in the time series. This is convincing evidence that bond market participants account for the liquidity of the CDS market when they price corporate bonds. As the CDS market becomes more and more liquid, we expect the non-default component in the bonds to decrease.

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			Quotes			CDS price (bps)		
Issuer Name	**Industry**	**Days quoted**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**
FORD MOTOR CREDIT COMPANY	Financial	1373	12.21	1	82	199	20	672
GENERAL MOTORS ACCEPTANCE CORPORATION	Financial	1314	11.35	1	63	168	24	441
JPMORGAN CHASE AND CO	Financial	1164	4.15	1	16	45	16	129
AT&T CORP	Communications	1069	10.24	1	90	177	17	700
BANK OF AMERICA CORPORATION	Financial	1056	3.46	1	14	39	15	135
SEARS ROEBUCK ACCEPTANCE CORP	Consumer, Cyclical	1004	6.66	1	56	118	22	458
DELPHI CORPORATION	Consumer, Cyclical	925	7.44	1	102	151	62	367
GOLDMAN SACHS GROUP, INC.	Financial	911	3.54	1	17	45	21	113
LEHMAN BROTHERS HOLDINGS INC.	Financial	892	3.89	1	13	57	24	118
MERRILL LYNCH & CO., INC	Financial	889	4.17	1	16	50	21	136
HSBC FINANCE CORP	Financial	872	5.15	1	42	118	20	878
BEAR STEARNS COMPANIES INC.	Financial	854	3.67	1	18	53	24	125
MOTOROLA, INC.	Communications	846	5.71	1	32	188	19	563
MORGAN STANLEY	Financial	813	4.41	1	18	46	20	97
SPRINT CAPITAL CORPORATION	Communications	763	7.42	1	29	195	37	1268
HEWLETT-PACKARD COMPANY	Technology	747	3.92	1	15	89	17	293
VISTEON CORPORATION	Consumer, Cyclical	742	8.19	1	37	263	74	442
GENERAL ELECTRIC CAPITAL CORP	Financial	690	5.70	1	27	46	14	121
CIT GROUP INC	Financial	689	6.12	1	34	123	30	823
TIME WARNER INC.	Communications	685	7.28	1	29	159	35	875
CITIGROUP INC.	Financial	677	3.88	1	11	35	13	96
EASTMAN KODAK COMPANY	Industrial	671	6.33	1	48	140	18	396
INTERNATIONAL PAPER COMPANY	Basic Materials	671	3.47	1	15	82	35	150
WALT DISNEY CO	Communications	671	6.00	1	32	74	17	195
COUNTRYWIDE HOME LOANS, INC.	Financial	647	5.15	1	20	67	35	178
VIACOM INC.	Communications	640	4.56	1	23	62	22	156
FEDERATED DEPARTMENT STORES, INC.	Consumer, Cyclical	635	5.41	1	23	78	26	178
COX COMMUNICATIONS INC	Communications	616	5.36	1	52	128	35	550
RAYTHEON CO	Industrial	615	3.83	1	22	100	26	203
GOODYEAR TIRE & RUBBER COMPANY	Consumer, Cyclical	614	5.13	1	34	428	30	1375
DOW CHEMICAL COMPANY	Basic Materials	608	6.11	1	37	94	28	246
TOYS 'R' US, INC.	Consumer, Cyclical	601	6.69	1	52	263	55	700
COMPUTER ASSOCIATES INTERNATIONAL INC	Technology	572	5.41	1	38	197	43	950
ALBERTSON'S INC	Consumer, Non-cyclical	570	5.19	1	22	76	36	185
IBM	Technology	568	3.95	1	15	43	13	116
CAPITAL ONE BANK	Financial	560	5.43	1	30	161	39	933
BOEING CO	Industrial	548	4.37	1	20	53	17	140
AT&T WIRELESS SERVICES INC	Communications	543	6.34	1	45	184	21	1025

Table 1: This is a summary of the top forty (by number of trades) issuer names in the CDS database used in this research. The columns show the name of the issuer, its Bloomberg industry classification, the number of days on which the CDS contract was traded, the number of quotes available per day, and the CDS spread in terms of average, maximum and minimum. We find that there is considerable cross-sectional as well as time-series variation in the number of quotes for each CDS contract, as is seen in the average, minimum and maximum columns for the number of quotes. The data set also covers a wide variation in the CDS prices, as can be seen by the minimum and maximum mid-quotes for each of the issuers.

Issuer	Industry	Number of Bonds*	Spread Average	Average CDS	Average Basis/Spread	Non-default component over swaps Average	Max	Min	Days Traded**	Issue Size (USD mio) Minimum	Maximum
Citigroup Inc.	Financial	33	1.062	0.347	0.674	0.072	0.888	-0.367	644	100	2000
General Electric Capital Corp	Financial	27	0.925	0.496	0.464	-0.161	0.548	-0.575	589	65	2000
Hsbc Finance Corp	Financial	26	2.066	1.566	0.242	-0.059	0.641	-4.983	897	60	2000
Merrill Lynch & Co., Inc.	Financial	25	0.996	0.430	0.569	-0.026	0.820	-0.660	486	100	2000
Verizon Global Funding Corporation	Communications	21	1.414	0.883	0.375	-0.073	2.124	-2.778	221	125	2000
Wachovia Corporation	Financial	21	0.933	0.286	0.694	0.042	0.564	-0.736	207	100	1750
Ford Motor Credit Company	Financial	20	2.413	1.883	0.220	-0.036	0.974	-1.242	1687	300	2000
General Motors Acceptance Corporation	Financial	19	2.293	1.780	0.224	-0.102	0.701	-0.849	1063	25	2000
Lehman Brothers Holdings Inc.	Financial	19	1.351	0.563	0.583	0.110	0.663	-0.702	542	100	1750
Bear Stearns Companies Inc.	Financial	16	1.178	0.468	0.602	0.037	0.529	-0.210	263	150	1000
Wells Fargo & Company	Financial	14	0.838	0.288	0.657	-0.079	0.516	-0.303	154	150	1500
International Lease Finance Corporation	Financial	13	1.347	0.745	0.447	0.019	0.505	-1.664	218	100	900
Countrywide Home Loans, Inc.	Financial	12	1.278	0.703	0.450	-0.029	7.094	-0.531	339	111	1625
IBM	Technology	10	0.927	0.489	0.473	-0.185	0.287	-0.439	94	100	1500
Morgan Stanley	Financial	10	1.194	0.483	0.595	0.044	0.681	-0.446	536	100	2000
Dominion Resources, Inc.	Utilities	10	1.347	0.739	0.451	-0.026	0.314	-0.739	79	150	700
Cit Group Inc	Financial	9	2.004	1.429	0.287	-0.053	0.606	-1.018	307	200	1250
Cox Communications Inc	Communications	9	1.779	1.126	0.367	-0.104	0.427	-1.341	120	100	800
Kroger Co.	Consumer, Non-cyclical	9	1.593	0.855	0.464	0.116	0.396	-0.239	138	200	750
Raytheon Co	Industrial	9	1.790	1.146	0.360	-0.057	0.456	-0.773	228	225	1000
Comcast Cable Communications, Inc.	Communications	9	1.516	1.007	0.336	-0.046	2.021	-0.914	279	150	800
Target Corporation	Consumer, Cyclical	8	0.953	0.383	0.598	-0.039	0.298	-0.309	98	200	750
Capital One Bank	Financial	7	1.956	1.091	0.442	0.074	0.748	-0.356	220	200	1250
Clear Channel Communications Inc	Communications	7	1.949	1.409	0.277	-0.156	0.279	-1.309	157	125	750
Progress Energy Inc	Utilities	6	1.723	1.096	0.364	-0.047	0.383	-1.189	42	200	800
Sears Roebuck Acceptance Corp	Consumer, Cyclical	6	2.708	1.993	0.264	0.082	0.709	-0.549	53	15	750
Sprint Capital Corporation	Communications	6	3.355	2.371	0.293	-0.161	1.089	-3.130	460	750	1721
Union Pacific Corporation	Industrial	6	1.175	0.512	0.565	0.067	0.342	-0.380	50	150	350
Washington Mutual, Inc.	Financial	6	1.108	0.497	0.551	0.001	0.500	-0.478	118	150	1000
Goldman Sachs Group, Inc.	Financial	6	1.021	0.395	0.614	0.073	4.088	-0.188	259	113	2000
Boeing Capital Corporation	Financial	5	1.517	0.762	0.498	-0.019	0.263	-0.352	67	200	1000
Dow Chemical Company	Basic Materials	5	1.506	0.914	0.394	0.069	0.405	-0.407	82	200	500
Duke Energy Corporation	Utilities	5	1.138	0.574	0.495	-0.002	0.306	-0.448	64	200	500
International Paper Company	Basic Materials	5	1.325	0.657	0.504	0.026	0.263	-0.152	18	150	600
Kraft Foods Inc.	Consumer, Non-cyclical	5	1.100	0.589	0.465	-0.095	0.340	-0.647	71	400	1250
Lockheed Martin Corporation	Industrial	5	1.356	0.605	0.554	-0.015	0.144	-0.189	79	391	993
Norfolk Southern Corp	Industrial	5	1.382	0.582	0.579	0.119	0.508	-0.202	57	200	750
Praxair Inc	Basic Materials	5	1.090	0.338	0.690	0.130	0.405	-0.135	21	250	300
Time Warner Inc.	Communications	5	2.923	2.363	0.192	-0.167	0.619	-1.482	244	166	1000
Viacom Inc.	Communications	5	1.393	0.678	0.513	0.001	0.386	-0.367	160	397	1650

*Only Bonds with maturity between 4-6 years as of trade date

**Days on which both CDS and a bond between 4-6 year maturity traded

Table 2: This is a summary of the top forty (by number of bonds in sample) issuer names in the combined data-set. We match the CDS for each reference entity to trades in a corporate bond by that reference entity with maturity between 4 years and 5 years in order to generate the combined data set. Generally, the corporate bonds trade at a far lower frequency than the CDS. The names are in descending order of the number of bonds per issuer. For each issuer, we have the number of bonds in our sample, the average yield spread over a comparable treasury bond, the average CDS price, the ration of the average basis (defined as the difference between the spread on the bond and the CDS price) to the spread over treasury, the non-default component relative to the swap curve, the number of days for which we have observations, and the issue sizes of the bonds. There is considerable variation in the credit spread on the bonds and the amount issued per bond. 22 of these issuers appear in the top 40 CDS names by volume.

SECTOR	Lehman Credit Universe	State Street Holdings	Sample
Basic Materials	3.7%	4.1%	7.5%
Communications	14.9%	12.9%	17.5%
Consumer, Cyclical	6.7%	7.3%	5.0%
Consumer, Non-cyclical	10.2%	9.8%	5.0%
Diversified	0.2%	0.1%	0.0%
Energy	5.7%	6.9%	0.0%
Financial	44.5%	42.3%	45.0%
Industrial	6.6%	7.1%	10.0%
Technology	1.4%	1.6%	2.5%
Utilities	6.2%	8.0%	7.5%
Grand Total	**100.0%**	**100.0%**	**100.0%**

Table 3: This table presents the composition, by industry category, as defined by Bloomberg, of our sample in relation to the Lehman aggregate credit universe as of December 2004. The first column defines the industry categories, and second column shows the percentage of outstanding amount represented by that industry category in corporate bonds. The second column shows a similar decomposition for State Street holdings, from which our sample is drawn, and the third shows the decomposition for our sample which has been matched with CDS quotes.

Credit Rating	Total Outstanding	State Street Holdings	Sample	State Street Holdings
	As % Of Total	As % Of Total	As % Of Total	As % Of Total O/S
Aaa	5.72	7.55	4.01	19.08
Aa	16.19	19.92	13.90	17.78
A	23.88	22.83	45.85	13.82
Baa	23.88	23.51	36.25	14.23
Ba	7.25	7.37	-	14.69
B	9.58	10.94	-	16.51
Caa	3.86	3.70	-	13.86
C	3.10	1.29	-	6.03
Other or NA Grade	6.55	2.88	-	6.35
Total	**100**	**100**	**100**	**14.45**

Table 4: This table presents the composition, by credit rating, as defined by Moodys, of US corporate bonds outstanding, as estimated by Bloomberg, as of December 2004. The first column defines the nine credit rating categories, and the second and third columns shows the decomposition for the overall universe and for State Street holdings respectively. The fourth column shows the decomposition for our sample. The last column indicates the relative amount in the custody of State Street Corporation, as a fraction of total US dollar amounts outstanding, in each credit rating category.

Variable	Mean	Std. Dev.	Min.	Max.	N
Spread over Treasury	1.502	0.834	0.55	7.87	698
CDS spread (bps)	85.55	81.833	15	719.48	698
Coupon	6.288	1.379	2.7	11.62	698
Number of Days	17.585	33.708	1	354	698
Amount Outstanding (USD mio)	558.03	417.79	15.00	2000.00	698
Rating	3.143	0.801	1	4	698
Age	3.072	3.031	0.019	15.616	698
Latent Liquidity	0.499	0.232	0.015	2.325	698
Percentage Bid-Ask	0.175	0.116	0.0215	0.9	698
Average Daily Quotes	3.683	2.325	1	17.5	698
Non-default component (swaps)	0.047	0.367	-3	4	698
Non-default component (treasury)	0.543	0.390	-2	5	698

Table 5: **Summary Statistics on the Set of Bonds in the sample:** This table shows the summary statistics of the combined data set that we get by matching the CDS prices to the corporate bond prices and computing the average non-default component for each bond. The summary statistics here are the yield spread over treasury rates, the CDS spread in basis points, the coupon rate, the number of days the bond is traded in the sample, the amount outstanding in million USD, credit rating, average age, latent liquidity, percentage bid-ask spread in the CDS contract, the number of daily quotes, and the non-default components computed using both the treasury yield curve and swap rates as the risk-free benchmark.

	Model 1	Model 2	Model 3
	(1)	(2)	(3)
Coupon	-.0004	-.0003	-.005
	(.006)	(.007)	(.007)
Initial Rating	.046***	.034***	.035***
	(.009)	(.010)	(.010)
Age	-.034***	-.035***	-.033***
	(.003)	(.003)	(.003)
CDS spread		.00009	.0001
		(.00008)	(.00008)
Amount Outstanding	6.07e-11***	2.50e-11	1.78e-11
	(1.42e-11)	(1.90e-11)	(1.94e-11)
Percentage Bid/Ask Spread			.435***
			(.106)
Average Daily Quotes			.001
			(.003)
No. of Days Traded		.0006**	.0008***
		(.0002)	(.0003)
Const.	.445***	.481***	.428***
	(.040)	(.043)	(.047)
Obs.	676	676	676
R^2	.256	.267	.287
F statistic	57.613	40.684	33.623

Significance levels : $*$: 10% $**$: 5% $***$: 1%

Table 6: **Latent Liquidity and Bond Specific variables in the sample of traded bonds**: This is a regression of latent liquidity on various bond specific factors, such as coupon and rating, liquidity factors like amount outstanding, age and the number of days traded, and CDS market liquidity factors such as the percentage bid-ask spread in the CDS contract, and the average number of daily quotes. For the purposes of this regression, we use average values for each bond, that is each variable is obtained by averaging its value over all the trades that we observe for a given bond-CDS pair. The maturity filter we employ implies that any given bond is in our sample for a period of two years at the most. Figures in brackets are standard errors. The table shows that latent liquidity is strongly related to variables such as age and amount outstanding that have been traditionally used in the literature on corporate bonds.

	Treasury Rates	Swap Rates
	(1)	(2)
Aggregate Latent Liquidity	-.389***	-.240**
	(.138)	(.110)
Avg. Coupon	.140***	-.010
	(.031)	(.026)
Avg. CDS Bid-Ask spread	.581*	.241
	(.299)	(.206)
Avg. Daily Quotes	-.058***	-.015
	(.013)	(.010)
AR(1)	-0.07	-0.24
	(.12)	(.15)
Obs.	73	73

Significance levels : $*$: 10% $**$: 5% $***$: 1%

Table 7: **Effect of Aggregate Monthly Latent Liquidity on the average monthly non-default component under two risk free rate specifications**: These regressions show the effect of aggregate latent liquidity of the bonds in our sample, coupon, and the two CDS market liquidity variables on the non-default component in bonds. The non-default component is computed using both treasury rates and swap rates. Dependent and Independent Variables here are averages across bonds for any given month. An auto-regressive term is added to control for autocorrelations in residuals. However, this autocorrelation is not significant. The regression is estimated using maximum likelihood and the standard errors noted are computed from the outer product of the gradients of the information matrix. Figures in brackets are standard errors.

	Model 1	Model 2	Model 3
	(1)	(2)	(3)
Coupon		.081***	.071***
		(.011)	(.011)
Latent Liquidity	-.567***	-.142	-.261*
	(.128)	(.134)	(.137)
Initial Rating		-.029*	.004
		(.017)	(.017)
Percentage Bid/Ask Spread			.674***
			(.205)
Average Daily Quotes			-.028***
			(.005)
Const.	.755***	.131	.193*
	(.073)	(.104)	(.099)
Obs.	676	676	676
R^2	.	.107	.2
F statistic	19.633	28.694	37.164

Significance levels : $*$: 10% $**$: 5% $***$: 1%

Table 8: **Regressions of the non-default component using treasury rates on determinants of liquidity**: These regressions show the effect of latent liquidity, coupon, initial rating, and the two CDS market liquidity variables, on the average non-default component in the bonds. The treasury curve is used as the risk-less benchmark. All variables are bond-wise averages. The regression, thus, represents the cross-section of bonds in our sample. Fitted values of bond-wise average latent liquidity from Table 6 are used as instrumental variables to correct for the errors in variable problem for latent liquidity.Figures in brackets are standard errors.

	Model 1	Model 2	Model 3
	(1)	(2)	(3)
Coupon		.030***	.026**
		(.010)	(.010)
Latent Liquidity	-.711***	-.566***	-.610***
	(.114)	(.125)	(.133)
Rating		.0003	.019
		(.016)	(.016)
Percentage Bid-Ask			.292
			(.199)
Average Daily Quotes			-.018***
			(.005)
Const.	.369***	.108	.146
	(.065)	(.097)	(.096)
Obs.	676	676	676
R^2	.	.	.028
F statistic	39.254	18.128	17.661

Significance levels : $*$: 10% $**$: 5% $***$: 1%

Table 9: **Regressions of the non-default component using swap rates on determinants of liquidity**: These regressions show the effect of latent liquidity, coupon, initial rating, and the two CDS market liquidity variables, on the average non-default component in the bonds. The non-default component is computed using the swap curve. All variables are bond-wise averages. The regression, thus, represents the cross-section of bonds in our sample. Fitted values of latent liquidity from Table 6 are used as instrumental variables to correct for the errors in variable problem for latent liquidity.Figures in brackets are standard errors.

	Swap rates	Treasury rates
	(1)	(2)
Coupon	.060***	.089***
	(.015)	(.016)
Lat Liq-sell	1.096**	.632
	(.475)	(.490)
Lat Liq-buy	-1.386***	-.718*
	(.369)	(.381)
Initial Rating	-.013	-.013
	(.020)	(.020)
Percentage Bid/Ask Spread	.519**	.798***
	(.216)	(.223)
Average Daily Quotes	-.028***	-.033***
	(.006)	(.006)
Const.	-.100	.059
	(.128)	(.132)
Obs.	676	676
R^2	.	.172
F statistic	15.71	30.266

Significance levels : $*$: 10% $**$: 5% $***$: 1%

Table 10: **Effect of Buy and Sell Liquidity on the non-default component under two risk free rate specifications**: These regressions show the effect of buy and sell latent liquidity, coupon, initial rating, and the two CDS market liquidity variables, on the average non-default component in the bonds. The non-default component is computed using the swap curve and the treasury curve. The fitted values of latent liquidity from Table 6 are used as instrumental variables to correct for the errors in variable problem for latent liquidity. Figures in brackets are standard errors.

	Treasury Rates			Swap Rates		
	(1)	(2)	(3)	(4)	(5)	(6)
Coupon	.082***	.061***	.071***	.031***	.019*	.026**
	(.010)	(.011)	(.011)	(.010)	(.010)	(.010)
Latent Liquidity	-.096	-.440***	-.261*	-.539***	-.727***	-.610***
	(.127)	(.139)	(.137)	(.122)	(.133)	(.133)
Rating	-.004	-.002	.004	.015	.015	.019
	(.016)	(.017)	(.017)	(.016)	(.017)	(.016)
Percentage Bid-Ask		1.308***	.674***		.706***	.292
		(.177)	(.205)		(.170)	(.199)
Average Daily Quotes	-.038***		-.028***	-.023***		-.018***
	(.004)		(.005)	(.004)		(.005)
Const.	.194**	.159	.193*	.146	.124	.146
	(.099)	(.103)	(.099)	(.095)	(.099)	(.096)
Obs.	676	676	676	676	676	676
F statistic	44.057	35.759	37.164	22.032	17.46	17.661

Significance levels : $*$: 10% $**$: 5% $***$: 1%

Table 11: **Effect of CDS Liquidity on the non-default component under two risk free rate specification**: These regressions show the effect of latent liquidity, coupon, rating, and the relative effects of the two CDS market liquidity variables on the non-default component in bonds. The non-default component is computed using both treasury rates and swap rates. All variables in this regression are bond-wise averages. Each bond remains in the sample for a maximum of two years. The third model in each specification is identical to table 8 and 9.Figures in brackets are standard errors.