Liquidity Premia in the Credit Default Swap and Corporate Bond Markets

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Abstract

This paper employs a new approach to estimating the size of liquidity premia in the credit default swap (CDS) and corporate bond markets. We develop a CDS pricing model with liquidity and default, and a corporate bond pricing model with default, taxes, and liquidity using the reduced-form approach, and jointly estimate parameters of both pricing models from pooled data using the generalized method of moments. By formulating default intensity as a common factor of the spreads of the CDS and reference bonds, we are able to identify the liquidity and other components of spreads more precisely. We find that both CDS and corporate bond spreads contain significant liquidity components. On average, the liquidity premium accounts for 13% of the CDS spread and 23% of the corporate yield spread. The size of the liquidity premium increases as the rating decreases. Estimates of liquidity premia in the CDS and corporate bond markets are highly correlated, and closely linked to bond-specific and aggregate liquidity measures. Results show that liquidity is important for CDS and corporate bond pricing. Ignoring CDS illiquidity results in a significant bias in estimation of corporate yield spread components when using the CDS information to aid in decomposition of spreads.

Keywords: liquidity, default intensity, taxes, credit default swap spreads, corporate yield spreads, reduced-form approach

JEL classification: G12, G13

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1. Introduction

Understanding the determinants of corporate bond yield spreads and the credit risk derivative premium is important for academics and practitioners. The size of the U.S. corporate bond market has exceeded $5 trillion, and the credit derivatives market has experienced a tremendous growth in the past decade to reach a notional amount of $55 trillion recently.[2] From the investment perspective, it is important to know the pricing and risk of these securities, and whether investors are adequately compensated for bearing risk. From the corporate finance perspective, understanding how corporate yield and CDS spreads are determined aids in capital structure decisions and timing of new debt issuance. Furthermore, the magnitude of the default component in spreads provides valuable information for predicting credit risk and determining the optimal capital requirement for financial institutions; both issues are of considerable interest to policy makers.

A vast amount of literature has been developed in an attempt to explain the components of the corporate yield spread. In standard term structure models, the corporate yield spread is determined by two factors: risk of default and expected loss in the event of default. Later studies have sought to incorporate other factors such as taxes and aggregate factors to improve the predictive ability of the model. Important studies in this area include, among others, Jones, Mason and Rosenfeld (1984), Longstaff and Schwartz (1995), Delianedis and Geske (1998), Duffie and Singleton (1999), Duffee (1999), Collin-Dufresne, Goldstein and Martin (2001), Elton, Gruber, Agrawal and Mann (2001), Collin-Dufresne, Goldstein and Helwege (2003), Huang and Huang (2003), Eom, Helwege and Huang (2004), Kimmel (2004), De Jong and Driessen (2005), Driessen (2005), Longstaff, Mithal and Neis (2005), Ericsson and Renault (2006), Liu, Shi, Wang and Wu (2007), and Davydenko and Strebulaev (2007).

Despite the enormous amount of efforts, empirical evidence has shown that standard term structure models are unable to explain the corporate bond yield spreads satisfactorily, a perplexity dubbed as the credit spread puzzle. Jones et al. (1984) and Huang and Huang (2003) report default premium estimates which are substantially below the observed corporate yield spread whereas Eom et al. (2004) show that prediction errors of term structure models are quite high. Collin-Dufresne et al. (2001)

[2] See the survey by International Swaps and Derivatives Association (ISDA) in 2008, and the Global Financial Stability Report of IMF published in October 2008.

analyze the effects of important financial variables implied by the structural models and find that these variables explain only a small portion of the variation in spreads. Elton et al. (2001) introduce the tax factor into the term structure model and show that the tax premium accounts for a significant portion of the corporate yield spread. However, they find that a big chunk of the corporate yield spread is still left unexplained.[3]

A consensus from these studies is that some major factors are still missing in the term structure model, of which liquidity is a lead suspect. It has been long recognized that the corporate bond market is much less liquid than the equity or Treasury market, and liquidity is a potentially important factor for corporate bond pricing (see Fisher, 1959). In particular, during times of great market uncertainty, bond price will depend more heavily on liquidity. The heightened demand for liquid securities during turbulent periods manifests the critical role of liquidity in times of market stress (see Beber, Brandt, and Kavajecz, 2008). Thus, liquidity is likely to explain a substantially greater portion of yield spreads and may even dominate credit quality during flights to liquidity.

However, it has proven quite challenging to quantify the size of the liquidity premium in corporate yield spreads. First of all, the concept of liquidity is elusive, and much less quantifiable. It is often difficult to define the concept and different definitions lead to distinctly different liquidity measures. Added to this complexity is the difficulty in separating the liquidity premium from the default premium, using corporate bond data alone, as liquidity and default factors are unobserved and prices only reflect the combined effects of these factors (see Duffie and Singleton, 1999). Thus, disentangling these two risk effects requires additional information.

A viable source of such information is credit derivative prices. Credit derivatives share the same default risk as the underlying bonds of the reference entity. This feature provides financial researchers an important means with which to infer the magnitude of the default component in corporate yield spreads. Once the default premium is sorted out, it would be relatively easy to quantify the size of the liquidity premium.

Longstaff, Mithal and Neis (2005) were the first to use this novel approach to facilitate decomposition of corporate yield spreads. In their influential paper,

[3] For example, for 10-year A-rated bonds, only 17.8 percent of the spread is explained by default, and 36.1 percent by taxes, but the remaining 46.1 percent of the spread cannot be explained by the model.

Longstaff et al. used the information in the credit default swap to obtain direct measures of the default and nondefault components in corporate yield spreads. The CDS premium contains important information for default intensity, which permits them to separate the default component from the nondefault component in corporate yield spreads using the familiar reduced-form approach of Duffie and Singleton (1997, 1999). They find that the default component accounts for the majority of the corporate spread across all ratings. This result contrasts sharply with previous findings that default risk explains only a small percentage of the corporate yield spread. But the default component does not explain the entire corporate yield spread. Instead, a significant nondefault component is found for every firm in their sample. Moreover, they find that this nondefault component is strongly related to conventional liquidity measures, but only weakly related to taxes. This finding suggests that the majority of the nondefault component can be construed as the liquidity premium of corporate bonds.

The Longstaff et al. study abstracts from the issue of liquidity in the CDS market. The cited reason for this omission is that credit default swaps are contracts, and the contractual nature makes them far less sensitive to liquidity.[4] Nevertheless, this view has been questioned by several recent studies (see Tang and Yan, 2006; Acharya and Johnson, 2007; Bongaerts, De Jong, and Driessen, 2007). In addition, the Longstaff et al. model for corporate bond pricing does not incorporate the tax factor. They argue that the recent trend toward greater participation in the corporate bond markets by pension, 401k, and other tax-exempt investors raises the possibility that marginal state and local tax rates could be very small or even zero.[5] This argument is however in sharp contrast to the findings by Elton et al. (2001) and Liu et al. (2007).

Although the CDS market is in many ways more liquid than the corporate bond market, in reality, large bid-ask spreads do exist in CDS trading. If the CDS premium contains a liquidity component, failing to account for it will have an unfortunate consequence of overstating the default premium, when the CDS information is used to infer the components of the corporate yield spread.

There are reasons to believe that the CDS spread may contain a nontrivial liquidity component. First, market makers sell or buy corporate bonds to hedge against the risk of their CDS positions. Since the corporate bond market is illiquid,

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[4] See Longstaff et al. (2005, pp. 2219-2220).
[5] See Longstaff et al. (2005, p. 2240).

trading for this purpose inevitably entails liquidity cost. Therefore, in equilibrium, the CDS spread should consist of a premium to compensate for the liquidity cost associated with hedging. Moreover, the liquidity premium of CDS should be correlated with that of corporate bonds, and factors important for corporate bond market liquidity should also affect the CDS liquidity premium. Second, it is not uncommon for investors to unwind their CDS positions before the contract expires. Selling or offsetting CDS positions incurs transaction cost (e.g., bid ask spreads and adverse price impacts), which depends on market liquidity. Third, the liquidity effect is pervasive. Liquidity has been shown to be an important risk factor in many financial markets. For example, Amihud (2002), and Pastor and Stambaugh (2003) find that stock returns contain a significant liquidity premium. De Jong and Driessen (2005), and Li, Wang, Wu and He (2008) report similar findings for corporate and Treasury bond markets, respectively. Given the pervasiveness of the liquidity effect and intimate relations among financial markets, the CDS market may well be subject to a similar effect. The current financial crisis has witnessed that liquidity in the CDS market can easily dry up, much like other financial markets do during turbulent periods. CDS bid-ask spreads hit an unprecedentedly high level recently and market participants were equally vulnerable to "flight to quality" or "flight to liquidity". This suggests that the liquidity factor is important for CDS pricing.

Another related issue is that omission of the tax factor in the Longstaff et al. (2005) model makes it infeasible to obtain a precise measure of the liquidity component in the corporate yield spread. Although it is shown that their estimate of the nondefault component is strongly related to bond-specific and marketwide liquidity measures, the real magnitude of liquidity premium is unknown. Therefore, it is difficult to assess the importance of the liquidity effect relative to the effects of default and other factors in corporate bond pricing from their empirical findings.

The objective of this paper is to propose an alternative model and empirical methodology to quantify the size of liquidity premia in both CDS and corporate bond markets and to provide a better decomposition of spreads to assess the importance of liquidity relative to other factors in corporate bond and CDS pricing. This objective is achieved by developing a more general CDS pricing model that incorporates default and liquidity factors, and a corporate bond pricing model that includes default, liquidity and tax factors, and by jointly estimating the parameters of these models from pooled data using the generalized method of moments (GMM). In our empirical estimation, default intensity is formulated as a common factor in the pricing models of the CDS and reference bonds. This formulation permits us to separate the default component from the nondefault component in both CDS and corporate bond spreads. The empirical estimation method yields consistent and efficient estimates of spread components.

Accounting for the liquidity effect in the CDS pricing results in a cleaner estimate of the default premium when using the CDS information to facilitate empirical decomposition of corporate yield spreads. Moreover, including the tax factor in the corporate bond pricing model enables us to further decompose the nondefault component of spreads into tax and liquidity premia, and to assess economic significance of the liquidity effect in the corporate bond pricing. More precise estimates of spread components enhance our understanding of the relative importance of each pricing factor and variations in spread components over time and across risk categories.

In an important paper, Driessen (2005) examines whether default event risk is priced in corporate bonds and provides a decomposition of the default, liquidity and tax factors. Our paper differs from his in a number of ways. First, we employ the reduced-form approach to estimate the liquidity process. By contrast, Driessen (2005) uses the bond age as a liquidity factor and estimates the liquidity premium based on the yield difference between the low-age (less than 3 years) and high-age (greater than 3 years) portfolios.[6] This method is rather *ad hoc* because Longstaff et al. (2005) have shown that in addition to the age, corporate bond liquidity is significantly related to other bond characteristics such as coupon, bid-ask spread, issuance size, maturity, rating, and industry type. Second, in Driessen's study the effective income tax rate is exogenously set at 4.875% to generate the tax spread. This assumes that the marginal investor's income tax rate is known at this constant value for all bonds. Rather than arbitrarily assign a marginal tax rate, we develop a corporate bond pricing model with taxes to estimate the marginal tax rate directly from observed prices. Third, we make use of both CDS and corporate bond information in our empirical estimation. Apart from the benefit of resolving the identification problem in estimation of default and liquidity effects, pooling CDS and corporate bond data produces more efficient

6 See Driessen (2005), Section 4.2 (pp.176-179) for detailed discussion.

parameter estimates. Lastly, we provide a comprehensive analysis of the cross-sectional and time-series properties of the estimated liquidity premia and their relations with a variety of bond-specific characteristics and marketwide liquidity measures.

By jointly estimating the CDS and bond pricing models, we are able to quantify the size of the liquidity and other spread components more precisely and provide several unique contributions to the literature. First, we find that the CDS spread contains a sizable liquidity component. The average liquidity premium is 5.22 basis points, which account for about 13 percent of the CDS spread. The proportion of the liquidity component to the CDS spread increases as the bond rating decreases. Second, we find that in addition to the default premium, tax and liquidity premia account for a significant portion of corporate yield spreads. On average, 47% of the corporate yield spread is attributable to default risk, 30% to taxes, and 23% to the liquidity factor. The size of the corporate liquidity premium is inversely related to bond quality. Third, empirical evidence shows that CDS liquidity spreads are highly correlated with corporate bond liquidity spreads, a finding consistent with CDS hedging demand. In addition, liquidity spreads for both CDS and corporate bonds are strongly related to bond-specific and marketwide liquidity measures. These findings suggest that there are important corporate bond and marketwide liquidity dimensions in CDS and corporate bond spreads. Finally, our results show the importance of including all relevant factors in the CDS and corporate bond pricing models. Failing to account for the liquidity effect on pricing results in biased estimation of spread components, and incorrect inferences on the relative importance of pricing factors for CDS and corporate bonds.

There is a rapidly growing literature on credit default swaps. Important studies include Jarrow and Turnbull (1995), Duffie (1999), Jarrow and Yildirim (2002), Zhang (2003), Hull, Predescu and White (2004), Blanco, Brennan and Marsh (2005), Houweling and Vorst (2005), Longstaff et al. (2005), Berndt, Lookman and Obreja (2006), Cao, Yu and Zhong (2006), Chen, Cheng, Fabozzi and Liu (2006), Tang and Yan (2006), Acharya and Johnson (2007), Jorion and Zhang (2007), Longstaff and Rajan (2008), and many others. These studies have greatly enhanced our understanding of the CDS pricing, the information content of CDS spreads, and the relation between CDS and other asset returns. Recently, Bongaerts, De Jong and

Driessen (2007) examine the effect of liquidity on CDS returns using an asset pricing model based on the approach of Acharya and Pedersen (2005). They find that the effect of expected liquidity (level) is much stronger than that of liquidity risk on CDS returns. Our paper differs from theirs in that we model the CDS liquidity premium by the reduced-form approach and use the information in the CDS to facilitate empirical decomposition of corporate yield spreads.

The remainder of our paper is organized as follows. Section 2 presents CDS and corporate bond pricing models. These models are jointly fit to the CDS premium and a cross-section of corporate bond prices for each firm in empirical investigations. Section 3 discusses the data and methodology, and presents empirical results. We propose a GMM estimation method that provides efficient and consistent estimates of model parameters and spread components by pooling cross-sectional and time-series data. Section 4 examines the cross-sectional and time-series properties of the nondefault components in CDS and corporate yield spreads. Finally, Section 5 summarizes the main findings and concludes the paper.

2. Valuation models

In this section, we present a CDS pricing model with liquidity and default intensity and a generalized pricing model of corporate bonds with default, liquidity and taxes. Both are built on the reduced-form framework of Duffie and Singleton (1999).[7] We permit the stochastic liquidity process to differ in these models, but constrain the default intensity process to be identical for the CDS and reference bonds. These models form the basis for joint estimation of the components in CDS and corporate yield spreads using empirical data.

2.1 Valuation of CDS with liquidity

Let h represent the CDS liquidity process, and ω the premium required for default protection, which is assumed to be paid continuously by the buyer.[8] The value of the premium leg of a credit-default swap can be written as

$$E_t^Q\left\{\omega\int_t^T \exp\left[-\int_t^u \left(r_s+\lambda_s+h_s\right)ds\right]du\right\} \tag{1}$$

where r_s is the riskfree rate, and λ_s is default intensity, h_s is liquidity, T is the maturity

[7] See also Duffie (1998) and Lando (1998).

[8] The default swap premium is typically quoted in basis points per \$100 notional amount of the reference bond.

date, and E_t^Q denotes the expectation taken under the risk-neutral probability measure Q at current time t. The riskfree rate and default intensity are characterized by standard Cox-Ingersoll-Ross (CIR) square-root processes:[9]

$$dr = [\kappa_r \theta_r - (\kappa_r + \pi_r) r] dt + \sigma_r \sqrt{r} dW_r \tag{2}$$

$$d\lambda = [\kappa_\lambda \theta_\lambda - (\kappa_\lambda + \pi_\lambda) \lambda] dt + \sigma_\lambda \sqrt{\lambda} dW_\lambda \tag{3}$$

where κ is the speed of mean reversion, π is risk price, σ is the volatility parameter, θ is the long-term mean value, and W_r and W_λ are independent standard Brownian motions. The specification of the interest rate and default intensity processes permits mean reversion and conditional heteroskedasticity, and assures that both stochastic variables are nonnegative. For the risk-neutral dynamics of the CDS liquidity process, we postulate that

$$dh = \sigma_h dW_h , \tag{4}$$

σ_h is a positive constant and W_h is a standard Brownian motion. The dynamics of the liquidity process allow negative values. The parameters with subscripts λ, r and h are associated with the default, interest rate and CDS liquidity processes, respectively.

When the reference bond defaults, the bondholder recovers a fraction δ of the par value and the seller of default protection pays the remaining par value to the buyer. The value of the protection leg of the credit default swap is given by

$$E_t^Q \left\{ \int_t^T (1-\delta) \lambda_u \exp\left[-\int_t^u (r_s + \lambda_s) ds \right] du \right\}. \tag{5}$$

Equating the premium leg in (1) to the above protection leg gives the CDS premium

$$\omega = \frac{E_t^Q \left\{ (1-\delta) \int_t^T \lambda_u \exp\left[-\int_t^u (r_s + \lambda_s) ds \right] du \right\}}{E_t^Q \left\{ \int_t^T \exp\left[-\int_t^u (r_s + \lambda_s + h_s) ds \right] du \right\}}. \tag{6}$$

It can be shown that the expectations of the two integrals in (6) are

$$E_t^Q \left\{ \int_t^T \exp\left[-\int_t^u (r_s + \lambda_s + h_s) ds \right] du \right\} = \int_t^T d_{t,u}^r A_{t,u}^\lambda \exp\left(B_{t,u}^\lambda \lambda_t \right) d_{t,u}^h du \tag{6a}$$

and

[9] See Cox, Ingersoll and Ross (1985).

$$E_t^Q\left\{\int_t^T \lambda_u \exp\left[-\int_t^u (r_s+\lambda_s)ds\right]du\right\} = \int_t^T d_{t,u}^r \exp\left[B_{t,u}^\lambda \lambda_t\right]\left(G_{t,u}^\lambda + H_{t,u}^\lambda \lambda_t\right)du \qquad \text{(6b)}$$

where $d_{t,u}^r = E_t^Q\left\{\exp\left[-\int_t^u r_s ds\right]\right\}$, and $d_{t,u}^h = E_t^Q\left\{\exp\left[-\int_t^u h_s ds\right]\right\}$. The explicit expressions of $d_{t,u}^r$, $A_{t,u}^\lambda$, $B_{t,u}^\lambda$, $G_{t,u}^\lambda$, $H_{t,u}^\lambda$ and $d_{t,u}^h$ are given in Appendix A. Thus, the credit default swap pricing model can be written as

$$\omega = \frac{(1-\delta)\int_t^T d_{t,u}^r \exp\left[B_{t,u}^\lambda \lambda_t\right]\left[G_{t,u}^\lambda + H_{t,u}^\lambda \lambda_t\right]du}{\int_t^T d_{t,u}^r A_{t,u}^\lambda \exp\left(B_{t,u}^\lambda \lambda_t\right) d_{t,u}^h du}. \qquad (7)$$

If $\sigma_h = 0$ and h_t=0, the model degenerates to the CDS pricing formula with no liquidity component as in Longstaff et al. (2005).[10]

2.2 Valuation of corporate bonds with default, taxes, and liquidity

We next present a pricing model of defaultable bonds with tax, default and liquidity factors. Incorporating investors' taxes into the standard term structure model of defaultable bonds complicates the model considerably. In general, the pricing model depends on the tax treatment given to discount and premium bonds (see Green and Odegaard, 1997). We first consider the case that a coupon bond is sold at a market discount to a buy-and-hold investor and there is no amortization for the amount of discount before maturity. We later extend the analysis to the pricing of premium bonds and to more complicated cases involving discount and premium amortization.

The corporate bond has a coupon rate C and a face value of 1 at maturity. Coupon payments are taxed at the ordinary income tax rate, τ_i, and have zero recovery at default.[11] The value of this bond equals the equivalent martingale expectation of discounted future payoffs associated with both coupon and principal payments. The

[10] In deriving the CDS pricing formula, we assume no tax effect for two reasons. First, dealers and large institutions dominate the swap market. It is relatively easy for these institutional traders to find ways to offset taxes because they are not constrained by the tax code limiting investment interest expenses and loss deductions (see Green and Odegaard, 1997). Second, even if they do pay taxes, the tax effect on the premium and protection legs will likely be canceled out when we equate the protection leg to the premium leg to obtain the pricing formula in (6) because institutions pay a similar marginal income tax rate.

[11] The tax parameter τ_i includes both the federal and state income tax rates for corporate bonds. That is, $\tau_i = \tau_F + \tau_S(1-\tau_F)$, where τ_s is the state income tax rate and τ_F is the federal income tax rate. State taxes are deductible from income for the purpose of federal taxes and so the burden of state taxes is reduced by the federal tax rate.

portion of bond value associated with after-tax uncertain coupons is

$$E_t^Q\left\{C(1-\tau_i)\sum_{m=1}^{M}\exp\left[-\int_t^{t_m}(r_s+\lambda_s+l_s)ds\right]\right\} \tag{8}$$

where M is the total number of semiannual coupon payments, l_s is bond liquidity, t_m indexes the time of the mth cash flow, and $t_M = T$ is the last payment date.

Under the assumption of no amortization, the entire discount amount $(1-P_t)$, where P_t is the purchase price of the bond, is taxed at the capital gains rate τ_g at maturity if there is no default. Conversely, if there is default before maturity, the investor receives a tax rebate from the government where the applicable tax rate τ_g to the rebate depends on whether the loss associated with default, $P_t-\delta$, is short- or long-term. Under these conditions, the expected after-tax value of the payoff associated with the uncertain principal payment can be expressed as

$$E_t^Q\left\{[1-\tau_g(1-P_t)]\exp\left[-\int_t^{t_M}(r_s+\lambda_s+l_s)ds\right]+\int_t^{t_M}(\delta+\tau_g(P_t-\delta))\lambda_u\exp\left[-\int_t^{u}(r_s+\lambda_s+l_s)ds\right]du\right\}. \tag{9}$$

The price of the defaultable coupon bond equals the sum of the expected payoffs in (8) and (9)

$$\begin{aligned}P_t = {} & E_t^Q\left\{C(1-\tau_i)\sum_{m=1}^{M}\exp\left[-\int_t^{t_m}(r_s+\lambda_s+l_s)ds\right]\right\}+\\ & E_t^Q\left\{[1-\tau_g(1-P_t)]\exp\left[-\int_t^{t_M}(r_s+\lambda_s+l_s)ds\right]+\int_t^{t_M}(\delta+\tau_g(P_t-\delta))\lambda_u\exp\left[-\int_t^{u}(r_s+\lambda_s+l_s)ds\right]du\right\},\end{aligned} \tag{10}$$

which represents the marginal valuation of a discount coupon bond to a taxable investor. Since P_t appears on both sides of the equation, solving for it gives

$$\begin{aligned}P_t = {} & \frac{1}{Z}E_t^Q\left\{C(1-\tau_i)\sum_{m=1}^{M}\exp\left[-\int_t^{t_m}(r_s+\lambda_s+l_s)ds\right]+(1-\tau_g)\exp\left[-\int_t^{t_M}(r_s+\lambda_s+l_s)ds\right]\right.\\ & \left.+\int_t^{t_M}(1-\tau_g)\delta\lambda_u\exp\left[-\int_t^{u}(r_s+\lambda_s+l_s)ds\right]du\right\}\end{aligned} \tag{11}$$

where $Z = 1-\tau_g E_t^Q\left\{\exp\left[-\int_t^{t_M}(r_s+\lambda_s+l_s)ds\right]+\int_t^{t_M}\left(\lambda_u\exp\left[-\int_t^{u}(r_s+\lambda_s+l_s)ds\right]du\right)\right\}$.

Following Longstaff et al. (2005), we postulate that corporate bond liquidity

l_t obeys the following process

$$dl = \sigma_l dW_l \tag{12}$$

where W_l is a standard Brownian motion independent of W_r and W_λ, and σ_l is the volatility parameter of the liquidity process.[12] Similar to the CDS liquidity process, the dynamics of the corporate liquidity process take on positive and negative values.

Given the stochastic processes in (2), (3) and (12), we can obtain the analytical solution for the corporate bond pricing function in (11)

$$P_t = \frac{C(1-\tau_i)\sum_{m=1}^{M}\left(d^r_{t,t_m} d^\lambda_{t,t_m} d^l_{t,t_m}\right) + (1-\tau_g) d^r_{t,t_M} d^\lambda_{t,t_M} d^l_{t,t_M} + (1-\tau_g)\delta \int_t^{t_M} d^r_{t,u} d^l_{t,u} \gamma_{t,u} du}{1-\tau_g d^r_{t,t_M} d^\lambda_{t,t_M} d^l_{t,t_M} - \tau_g \int_t^{t_M} d^r_{t,u} d^l_{t,u} \gamma_{t,u} du} \tag{13}$$

where $\gamma_{t,u} = E_t^Q\left\{\lambda_u \exp[-\int_t^u \lambda_s ds]\right\} = \exp\left[B^\lambda_{t,u}\lambda_t\right]\left(G^\lambda_{t,u} + H^\lambda_{t,u}\lambda_t\right)$, $d^l_{t,t_m} = E_t^Q\left\{\exp[-\int_t^{t_m} l_s ds]\right\}$

and $d^\lambda_{t,t_m} = E_t^Q\left\{\exp\left[-\int_t^{t_m}\lambda_s ds\right]\right\}$. The explicit expressions for $\gamma_{t,u}$, d^l_{t,t_m} and d^λ_{t,t_m} are given in Appendix A.

In empirical estimation, we impose a constraint on the relationship between ordinary income and capital gain tax rates to be consistent with existing tax codes. The tax rate for short-term gains is equal to the regular income tax rate. For long-term gains, we set the capital gain tax rate $\tau_g = \min(0.4\tau_i, 0.20)$ before January 1, 2003, and $\tau_g = \min(0.4\tau_i, 0.15)$ henceforth.[13] The effective tax rates for the marginal investor are estimated from empirical data.

The above pricing formula applies to the case of discount bonds with no amortization and accrued interest. This pricing formula can be adjusted to account for amortization and accrued interest as well as changes in the statutory amortization rules for premium and discount bonds over time. Tax treatments and amortization rules vary for bonds issued at different dates. Appendix B presents the pricing formula for individual discount and premium bonds under different amortization and tax rules.

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[12] W_h and W_l may be correlated, i.e., $dW_h dW_l = \rho dt$. We show in Appendix A that the CDS pricing formula is independent of this correlation.

[13] The current tax law was passed May 23, 2003, and the tax rates were retroactive to January 1, 2003. The maximum long-term capital gain tax rate was reduced from 20% to 15%.

3. Data and empirical estimation

We use the CDS dataset provided by the Markit Group to estimate the pricing models. The dataset contains daily composite CDS spreads calculated from the quotes posted by a number of banks and default-swap brokers for about 2,000 reference entities incorporated in the U.S. and overseas.[14] We select the 5-year single-name CDSs for our study and match these CDS data with the corporate bond data provided by the Trade Reporting and Compliance Engine (TRACE) of the National Association of Securities Dealers (NASD). Because our TRACE dataset covers only the period from July 2002 to February 2005, we restrict both CDS and corporate bond data samples to this period.

We select corporate bonds by imposing the following screening criteria: (1) only fixed coupon issues are included; (2) bond issues with a total notional CDS amount less than $10 million are dropped; (3) bonds with callable, puttable and other embedded option features are excluded; (4) for a firm to be included in the sample, there must be at least two bonds in the bracketing set, one with a maturity shorter than 5 years and the other with a maturity longer than 5 years; and (5) bonds with time to maturity less than 2 years or longer than 10 years are excluded. In step (4), we impose the same restriction as in Longstaff et al. (2005) to assemble the corporate bond data for every CDS. In all, 596 corporate bonds for 69 firms actively traded in the CDS market are included in the final sample. The number of bonds in the bracketing set varies by firm: the mean number of bonds is 9 per firm, with a minimum of 2 and a maximum of 27. Our empirical estimation is based on observations at weekly intervals.

Table 1 reports the summary statistics for the CDS premium, and the yield and characteristics of the reference bonds. The mean CDS premium is 43.11 basis points. As expected, the CDS premium increases as the rating of the bond decreases.[15] The coupon rate and corporate bond yield also increase as the rating decreases. Average coupon rate and yield are 5.49 and 3.95 percent, respectively. Average maturity for bonds of different ratings is about 5 years. BB bonds have the largest outstanding

[14] The number of swap brokers included in the Markit dataset has increased from 13 in 2000 to 78 recently. The original data were processed by a statistical procedure to remove outliers and stale quotes.

[15] The mean CDS premium is smaller than that reported by the Longstaff et al. (2005) study that covers a sample period from 2001 to 2002. This discrepancy largely reflects the decrease in credit risk after 2002.

amount and youngest age.

In empirical investigation, r_t, λ_t, l_t, and h_t are assumed to evolve independently of each other. This assumption greatly simplifies the model while having little effect on empirical results. Although the liquidity processes l_t and h_t may be correlated, we show in Appendix A that they can be treated as if they are independent to each other without affecting the pricing formulas of CDS and corporate bonds. Given the independence assumption, we need not specify the risk-neutral dynamics of the riskless rate in CDS and corporate bond pricing. Instead, we only require that the value of a riskless zero-coupon bond (or the riskless discount function) with maturity t_m be given by $d^r_{t,t_m} = E^Q_t\left\{\exp\left[-\int_t^{t_m} r_s ds\right]\right\}$. To obtain a riskless discount function for each observation date, we collect yield data from the Federal Reserve Bank for constant-maturity 6-month, 1-, 2-, 3-, 5-, 7- and 10-year Treasury securities over the period from July 2002 to February 2005. We employ a standard cubic spline algorithm to interpolate these par yields at semiannual intervals, and bootstrap them to provide a discount curve. We then use a linear interpolation of the corresponding forward rates to obtain the value of the discount function at other maturities.

To give a sense of the magnitude of the CDS premium relative to the corporate bond yield spread, we compute the model-independent yield spread for corporate bonds as follows. We first assume that there is no credit risk for a corporate bond and discount the bond's cash flow with the riskless discount function. We then convert the riskless bond price into yield. The difference between riskless yield and the corporate bond yield is the yield spread for that particular bond. In order to obtain a 5-year-maturity yield spread, we regress yield spreads for the individual bonds in the bracketing set on their maturities, and regard the fitted value of the regression at the 5-year maturity as the estimate of the yield spread for the firm.

Table 2 reports the ratio of the CDS premium to the corporate yield spread. As shown, ratios are all less than 1. Thus, the CDS premium explains only a portion of the corporate yield spread, suggesting that there are nondefault factors important for corporate bonds. The percentage of the corporate yield spread explained by the CDS premium is on average 44% for AAA/AA firms, 50% for A firms, 64% for BBB firms, and 82% for BB firms. The proportion of the CDS premium to the corporate yield spread increases as the rating decreases. This finding is consistent with Longstaff et al. (2005) although average ratios are somewhat lower due to the decrease in credit risk over our sample period. Overall, the CDS premium explains 52% of the corporate yield spread. Nevertheless, the CDS premium may not be entirely attributable to default since it may contain a liquidity component.

3.1 Empirical methodology

We jointly estimate the CDS and corporate bond pricing models by constraining the parameters of the default process and default intensities to be identical for both CDS and reference bonds. This restriction is legitimate because the CDS and reference bonds share the same default factor. Instead of estimating the full set of parameters in the default intensity process, we estimate the following simplified version of (3) for parsimony:

$$d\lambda = (\alpha - \beta\lambda)dt + \sigma_{\lambda}\sqrt{\lambda}dW_{\lambda} \tag{3a}$$

where $\alpha = \kappa_{\lambda}\theta_{\lambda}$, and $\beta = \kappa_{\lambda} + \pi_{\lambda}$. The recovery rate δ is set equal to 60% for AAA, AA, A bonds, and 50% for BBB and BB bonds. These recovery rates are in line with the estimates of Altman and Kishore (1998).

Model parameters and liquidity and default intensities are estimated using the generalized method of moments (GMM) by pooling cross-sectional and time-series (weekly) data. Let $\hat{P}_{jt}$ be an unbiased estimate of the underlying true price P_{jt} where P_{0t} denotes the CDS premium (ω), and P_{jt}, $j > 0$ is the price of the jth corporate bond at time t. We can formulate an empirical model by adding an error term:

$$P_{jt} = \hat{P}_{jt}\left(\Theta, \Psi_t\right) + \varepsilon_{jt} \tag{14}$$

where $\Theta = \left[\theta_1, \theta_2, ..., \theta_K\right]'$ is the vector of parameters in the pricing model, Ψ_t is the vector of intensities, which is $\left[\lambda_t, h_t\right]'$ for the CDS and $\left[\lambda_t, l_t\right]'$ for corporate bonds, and the error term ε_{jt} has mean equal to zero. The objective is to choose the optimal parameters by minimizing the sum of squared errors while accounting for cross-sectional and time-series correlations in prices:

$$SSE\left(\Theta\right) = \sum_{t=1}^{T_M}\sum_{j=0}^{N_t}\left(P_{jt} - \hat{P}_{jt}\left(\Theta, \Psi_t\right)\right)^2 \tag{15}$$

where $N_t + 1$ is the number of observations in week t = 1, 2, 3,…, T_M. Define vector $f_{jt}\left(\Theta\right)$ as

$$f_{jt}(\Theta) = \begin{bmatrix} \varepsilon_{jt} \\ \frac{\partial \hat{P}_{jt}}{\partial \theta_1} \varepsilon_{jt} \\ \cdots \\ \frac{\partial \hat{P}_{jt}}{\partial \theta_K} \varepsilon_{jt} \end{bmatrix}. \tag{16}$$

The moment conditions are

$$E\left[f_{jt}(\Theta)\right] = 0 \tag{17}$$

where the gradients of price with respect to parameters are viewed as instrumental variables and the estimates of Θ are chosen to meet the moment conditions.

Let $g_T(\Theta)$ contain the sample average of $f_{jt}(\Theta)$ in the pooling estimation,

$$g_T(\Theta) = T^{-1} \sum_{t=1}^{T_M} \sum_{j=0}^{N_t} f_{jt}(\Theta) \tag{18}$$

where T is the total number of observations in the cross-sectional and time-series data sample. The GMM procedure minimizes the quadratic function

$$Q_T(\Theta) = g_T(\Theta)' W_T g_T(\Theta), \tag{19}$$

by choosing an optimal weight matrix W_T and parameters through iterations. We use an identity matrix (I) as the initial weighting matrix in the first iteration. From the second iteration and on, we employ the Newey-West (1987a) procedure to estimate the weighting matrix (S_T) which accounts for cross-sectional and time-series correlation in prices.[16] The max lag order is set equal to 10 in the Newey-West estimator of the variance-covariance matrix of $f_{jt}(\Theta)$ averaged over time and cross securities. This procedure is iterated until parameter estimates and the objective function converge.

Default intensity and liquidity are estimated jointly with model parameters by a two-step procedure during the iterative process. Given a set of model parameter estimates, we estimate period-t default intensity and liquidity of the CDS and corporate bonds by fitting the observed corporate bond and CDS data to the pricing models within the cross-section each week. For each week, we have the data for a CDS and a cross-section of corporate bonds of the reference entity. Given a set of model parameters (Θ), we fit the cross-sectional data in week t to the following model

[16] $W_T = S_T^{-1}$.

$$P_{jt} = \hat{P}_{jt}\left(\Psi_t;\Theta\right) + \varepsilon_{jt} \tag{20}$$

by choosing optimal estimates of λ_t, l_t and h_t that minimize the sum of squared errors in the cross section. Define vector $f_{jt}^*\left(\Psi_t\right)$ as

$$f_{jt}^*\left(\Psi_t\right) = \begin{bmatrix} \varepsilon_{jt} \\ \dfrac{\partial \hat{P}_{jt}}{\partial \lambda_t}\varepsilon_{jt} \\ \dfrac{\partial \hat{P}_{jt}}{\partial h_t}\varepsilon_{jt} \\ \dfrac{\partial \hat{P}_{jt}}{\partial l_t}\varepsilon_{jt} \end{bmatrix}. \tag{21}$$

The moment conditions within each cross section at time *t* are

$$E\left(f_{jt}^*\left(\Psi_t\right)\right) = 0. \tag{22}$$

Similar to (18), we define $g_t^*\left(\Psi_t\right)$ as a vector that contains the cross-sectional sample average of $f_{jt}^*\left(\Psi_t\right)$,

$$g_t^*\left(\Psi_t\right) = \frac{1}{N+1}\sum_{j=0}^{N} f_{jt}^*\left(\Psi_t\right) = \begin{bmatrix} \dfrac{1}{N+1}\left(\varepsilon_{0t} + \varepsilon_{1t} + \ldots + \varepsilon_{Nt}\right) \\ \dfrac{1}{N+1}\left(\dfrac{\partial \hat{P}_{0t}}{\partial \lambda_t}\varepsilon_{0t} + \ldots + \dfrac{\partial \hat{P}_{Nt}}{\partial \lambda_t}\varepsilon_{Nt}\right) \\ \dfrac{1}{N+1}\left(\dfrac{\partial \hat{P}_{0t}}{\partial h_t}\varepsilon_{0t} + \ldots + \dfrac{\partial \hat{P}_{Nt}}{\partial h_t}\varepsilon_{Nt}\right) \\ \dfrac{1}{N+1}\left(\dfrac{\partial \hat{P}_{0t}}{\partial l_t}\varepsilon_{0t} + \ldots + \dfrac{\partial \hat{P}_{Nt}}{\partial l_t}\varepsilon_{Nt}\right) \end{bmatrix}. \tag{23}$$

The cross-sectional GMM estimation then minimizes the quadratic form

$$Q_t^*\left(\Psi_t\right) = g_t^*\left(\Psi_t\right)' W_t^* g_t\left(\Psi_t\right), \tag{24}$$

by choosing an optimal weight matrix W_t^* and Ψ_t. We follow a similar iterative procedure above for model parameter estimation, to estimate the weight matrix, and to obtain the consistent estimates of Ψ_t. Fitting the cross-section data for each *t* to the model using the preceding procedure gives a time series of estimates for λ_t, l_t and h_t. The estimation procedure permits liquidity variables to be negative.

Given the estimates of λ_t, l_t and h_t, we reestimate model parameters from

(19) based on observed prices and these intensity series. The new parameters are in turn used to obtain another series of λ_t, l_t and h_t estimates. This procedure continues until parameter estimates and the GMM objective function converge.

Once the pricing models are estimated, we can obtain the spread components for the CDS and corporate bonds. It is straightforward to estimate the liquidity component of the CDS premium. By restricting σ_h and h_t to zero, we obtain the liquidity-adjusted CDS premium. The difference between the CDS premium and the liquidity-adjusted CDS premium is the CDS liquidity spread. Using a similar procedure, we can estimate the liquidity and tax spreads for each corporate bond. We calculate the model price (converted to yield) using the estimates of λ_t and l_t. By restricting σ_l and l_t to zero, we obtain the liquidity-adjusted yield. The difference between the model yield and the liquidity-adjusted yield is the liquidity spread. We next impose the restriction of the marginal income tax rate $\tau = 0$ and calculate the yield without liquidity and taxes. The tax spread equals the difference between the yield adjusted for liquidity and the yield adjusted for both liquidity and taxes.

The above GMM estimation procedure yields consistent and efficient estimates of parameters and intensities for both corporate bond and CDS pricing models. An advantage of this GMM procedure is that by pooling the cross-sectional and time-series information of CDS and corporate bonds in empirical estimation, it produces more efficient estimates. More importantly, by treating the default intensity as a common factor of CDS and corporate bond prices, we resolve the identification problem in estimating the liquidity component in the CDS and corporate bond spreads.

To evaluate whether introducing taxes and the CDS liquidity factor improves the explanatory power of the model, we conduct the likelihood ratio (*LR*) test:[17]

$$TJ_T(\text{restricted}) - TJ_T(\text{unrestricted}) \sim \chi^2(k) \tag{25}$$

where

$$J_T = \min_{\{\hat{\Theta}\}} g_T(\Theta)' S^{-1} g_T(\Theta),$$

T is the number of observations and k is the number of restrictions on parameters. The

[17] See Cochrane (2001) and Newey and West (1987b) for the procedure of this χ^2 difference test or D-test.

unrestricted model contains taxes in the corporate bond pricing and liquidity in the CDS pricing, whereas the restricted model constrains either or both factors to be zero. The *LR* test statistic follows a χ^2 distribution with *k* degrees of freedom.

3.2 Empirical results

We first report the results of estimation for the CDS pricing model. Table 3 shows mean values of the default and liquidity components and the ratio of each component to the CDS premium. Panel A reports the results for individual firms and Panel B summarizes the results by rating. Average CDS liquidity spreads are all above zero and vary across firms. The average liquidity spread and its proportion to the CDS premium are 1.48 bps and 8% for AAA/AA bonds, 4.25 bps and 12% for A bonds, 9.61 bps and 13% for BBB bonds, and 24.40 bps and 17% for BB bonds. Results show that the CDS liquidity premium increases in both percentage and magnitude as the bond rating decreases. For the entire sample, the liquidity spread is 5.22 bps and its proportion to the total yield spread is 13%. The remaining CDS spread is attributable to default risk (37.33 bps and 87%). Estimates of the CDS default premium are consistent with bond ratings. The default premium ranges from 17.51 to 119.87 bps, or 92% to 83% of the CDS spread by rating category.

A common practice is to attribute the entire CDS spread to the default premium, when using the information in CDS to decompose corporate yield spreads. This procedure would tend to overestimate the default component of corporate yield spreads if the CDS market is not perfectly liquid. To assess the potential bias in the estimation of the default component in corporate yield spreads, we first estimate the simple corporate bond pricing model (ignoring taxes) using the CDS information, with and without the liquidity component in the CDS pricing model. When the liquidity component is not considered in the CDS pricing, this simple model without taxes degenerates to the Longstaff et al. (2005) model. This exercise allows us to assess the impact of excluding the CDS liquidity component on estimation of the default component in corporate yield spreads when using the CDS information to aid in empirical decomposition of yield spreads.[18]

Table 4 reports the default component of the corporate yield spread estimated from the simple model, with and without CDS liquidity, for each individual firm and

[18] We jointly estimate the CDS and corporate pricing models. We estimate the simple corporate bond pricing model without taxes here for comparison with the Longstaff et al. (2005) results which did not consider taxes.

by rating category. In both models, we restrict the marginal effective income tax rate parameter (τ) to zero in the corporate bond pricing. When CDS liquidity is ignored, the estimated default component of the corporate yield spread is 19 bps (42%) for AAA/AA bonds, 38 bps (49%) for A bonds, 75 bps (63%) for BBB bonds, and 162 bps (86%) for BB bonds. The mean default premium is 44 bps or 55% of the corporate yield spread for the entire sample. These values are quite close to the mean ratio of the CDS premium to the corporate yield spread reported in Table 2. This finding is perhaps unsurprising because the entire CDS premium is attributed to the pure default premium of corporate bonds here.

Conversely, when CDS liquidity is considered, the estimated default component in corporate yield spreads decreases. The default component of the corporate yield spread is 16 bps (36%) for AAA/AA bonds, 31 bps (41%) for A bonds, 67 bps (56%) for BBB bonds, and 129 bps (69%) for BB bonds. The mean default premium across all bonds is 37 bps or 47 percent of the corporate yield spread.[19] The size of the difference between the estimates of the default component, with and without CDS liquidity, reflects the importance of accounting for the liquidity effect, when using CDS price information to facilitate decomposition of the corporate yield spreads. On average, ignoring the CDS liquidity premium leads to an overestimation of the default component by 7 bps or 8% of the corporate yield spread for the entire sample. The estimation bias is the highest for BB bonds (33 bps or 17% of the corporate spread) and the lowest for AAA/AA bonds (3 bps or 6% of the corporate spread). Higher estimation bias for lower-grade bonds occurs because the CDS liquidity premium is higher when the bond rating is lower.

We next turn to the estimation for the generalized model that considers all important factors. Table 5 reports the liquidity, tax, nondefault and default components and their ratios to the corporate yield spread estimated from the corporate bond pricing model with investors' taxes, under the condition that the CDS spread contains a liquidity component. The nondefault component is the sum of the liquidity and tax components. Panel A reports the results for individual firms and Panel B by rating category. For individual firms, the average liquidity spread ranges from 2 to 94 bps, whereas the tax spread ranges from 4 to 62 bps. The sum of these two

[19] The default spreads are different for CDS and corporate bonds (see also Longstaff et al., 2005). The difference between the estimated default spreads for CDS and corporate bonds is due to two reasons: (1) their pricing formulas differ and (2) the maturities of CDS and corporate bonds are different.

components (nondefault spread) ranges from 15 to 119 bps. The mean liquidity spread and its proportion to the corporate yield spread are 11 bps and 25% for AAA/AA bonds, 18 bps and 24% for A bonds, 26 bps and 22% for BBB bonds, and 38 bps and 20% for BB bonds. The mean tax spread and its proportion to the yield spread are 18 bps and 40% for AAA/AA bonds, 27 bps and 35% for A bonds, 27 bps and 23% for BBB bonds, and 22 bps and 11% for BB bonds.

Across all bonds, the average liquidity spread is 18 bps, and its proportion to the total yield spread is 23%. The average tax spread is 24 bps, and its proportion to the total yield spread is 30%. The proportion of the corporate spread explained by the tax premium is larger than that by the liquidity premium, suggesting that taxes play a more important role than the liquidity factor in the corporate bond pricing. The average nondefault spread is 43 bps, which explains 53% of the corporate yield spread. The remaining corporate yield spread is attributable to default risk (47% or 37 bps), which is much lower than the estimate using the restricted model that assumes the CDS spread contains no liquidity premium. This discrepancy reflects the impact of excluding CDS liquidity on estimation of default intensity. As shown in Panel B of Table 4, the default premium estimated by the restricted model is 44 bps or 55% of the corporate yield spread, which is comparable to that reported by Longstaff et al. (2005).

The liquidity spread of corporate bonds is bigger than the CDS liquidity spread reported in Table 3. The ratio of the CDS liquidity spread to the corporate liquidity spread is 13% for AAA/AA bonds, 23% for A bonds, 37% for BBB bonds, and 65% for BB bonds. The ratio increases as the bond rating decreases. The mean ratio is 28% for the entire sample. The CDS market is perceived to be more liquid than the corporate bond market and our results confirm this view. The CDS liquidity spread is much smaller than the corporate bond liquidity spread both in magnitude and percentage of spreads. Moreover, compared to the corporate bond market, the CDS market is much more liquid for high-grade bonds than for low-grade bonds.

The inverse relation between the liquidity spread of CDS and the bond rating may reflect the hedging activity of CDS dealers. In order to hedge the CDS positions, market makers sell or buy corporate bonds in the spot market. The lower the rating, the higher the risk for CDS positions and the greater the need for hedging. Liquidity is much lower for low-grade bonds, making it even more costly for market makers to hedge their CDS positions. The pattern of CDS liquidity spreads in Table 3 is consistent with higher cost of hedging credit default swaps for lower-grade bonds. This explains why the CDS liquidity spread is higher when the quality of the reference bond is lower.

3.3 Specification tests

The preceding section shows estimates of the spread components for different models. If the CDS spread indeed consists of a liquidity premium and the corporate yield spread contains a tax premium, including these variables should increase the explanatory power of the model. To examine whether CDS liquidity and tax factors add significant explanatory power to the model, we conduct the likelihood ratio test. The likelihood ratio test statistic, $TJ_T(\text{restricted}) - TJ_T(\text{unrestricted})$ where $J_T = \min_{\{\hat{\Theta}\}} g_T(\Theta)' S^{-1} g_T(\Theta)$, follows the $\chi^2(k)$ distribution with a degree of freedom equal to the number of restricted parameters k.

To evaluate model performance, we compare the generalized (unrestricted) model with taxes and the CDS liquidity component with the alternative (restricted) models. Table 6 summarizes results of the likelihood ratio test by rating category. In the first test, we restrict the CDS liquidity parameters to zero; that is, the restricted model ignores the CDS liquidity component. The mean *LR* values are significant at the one percent level for all rating groups, indicating that accounting for the CDS liquidity component effectively reduces the estimation error and improves the explanatory power of the corporate bond pricing model. In the second test, we restrict the tax rate to zero. The mean *LR* statistics in this test are also significant at the one percent level for all ratings, indicating that including the tax factor in the corporate bond pricing model significantly improves the explanatory power. Finally, we restrict both CDS liquidity parameters and the tax rate to zero. The mean *LR* values in this test are all significant at the one percent level. Results strongly indicate that incorporating both tax and CDS liquidity factors significantly improves the explanatory power of the model.

For individual firms, the proportion of corporate bonds with *LR* statistics significant at the one percent level in test 1 is 63% for AAA/AA bonds, 78% for A bonds, 73% for BBB bonds, 100% for BB bonds, and 74% for the entire sample. The proportion of corporate bonds with *LR* statistics significant at the one percent level in test 2 is 95% for AAA/AA bonds, 89% for A bonds, 100% for BBB and BB bonds, and 93% for the entire sample. The proportion of corporate bonds with *LR* values significant at the one percent level in test 3 is 84% for AAA/AA bonds, 86% for A bonds, 91% for BBB bonds, 100% for BB bonds, and 87% for the entire sample. Results indicate that including the CDS liquidity and tax factors significantly increases the explanatory power of the model for the majority of corporate bonds.

4. The nondefault components of CDS and corporate yield spreads

The results above show that the CDS spread contains a liquidity component and that a significant portion of the corporate yield spread is unrelated to default risk. We further separate the tax component from the liquidity component in the nondefault spread by directly estimating the marginal income tax rate from observed corporate bond yields. If our model does a better job in decomposing corporate yield spreads, the estimated liquidity spread should be more closely linked to firm-specific and marketwide liquidity proxies than that estimated from a restricted model. In this section, we examine the properties of the components in the nondefault spread.

4.1 Relations between CDS and corporate liquidity components

Figure 1 plots the time series of CDS and corporate liquidity spreads averaged across firms each week. Liquidity spreads decrease over time due to an improvement in the market liquidity condition over the sample period. Results show that the liquidity spreads of CDS and corporate bonds are correlated and exhibit a similar trend.

Panel A of Table 7 shows the cross-sectional correlation between average liquidity spreads of CDS and corporate bonds. The overall correlation between these spreads is 0.82. Correlation increases as the rating decreases, which ranges from 0.38 for AAA/AA bonds to 0.98 for BB bonds.

To see whether the estimated liquidity spread reflects relative illiquidity of individual securities, we collect bid and ask prices of CDS and corporate bonds from Bloomberg.[20] Bids and asks are not always available on Bloomberg for all credit default swaps and corporate bonds included in our sample. We construct the monthly bid-ask spread averaged across firms with available bid-ask data.

Panel B of Table 7 summarizes the statistics of bid-ask spreads and the time-series correlation among monthly averages of CDS liquidity spreads, corporate

[20] The Markit database does not include the bid and ask premia for CDS and neither does the TRACE database for corporate bonds.

bond liquidity spreads, and CDS and corporate bond bid-ask spreads. On average, the CDS bid-ask spread is much lower than the corporate bond bid-ask spread. All liquidity variables are positively correlated. The temporal correlation between CDS and corporate bond liquidity spreads is quite high (.90). Moreover, CDS bid-ask spreads are highly correlated with corporate bond and CDS liquidity spreads. A positive relationship is also found between bid-ask spreads of corporate bonds and liquidity spreads of corporate bonds and the CDS, and between corporate and CDS bid-ask spreads though these correlations are somewhat lower. Results show that estimated liquidity spreads reflect dealers' market making cost.

Panel C of Table 7 reports results of the cross-sectional regression of the individual CDS liquidity spread on the liquidity spread of the reference bond with the same maturity, after controlling the effects of the rating and industry type. This cross-sectional regression is conducted week by week and then aggregated over the entire sample period. Mean regression coefficients and the corresponding aggregate *T*-value are reported in the second and third columns. As shown, CDS liquidity spreads are strongly related to corporate bond liquidity spreads and the bond rating. On average, the CDS liquidity spread is lower for financial bonds.

Panel D reports the results of the Granger causality test on the dynamic relationship between the CDS and corporate bond liquidity spreads.[21] The hypothesis that the CDS liquidity spread is not Granger-caused by the corporate bond liquidity spread is rejected at all lags. Similarly, the hypothesis that the corporate bond liquidity spread is not Granger-caused by the CDS liquidity spread is strongly rejected. Results suggest a feedback relation between the liquidity premia of the CDS market and the corporate bond market. Thus, there is an interaction of the liquidity conditions in these markets.

4.2 Cross-sectional analysis of corporate bond nondefault spreads

We next examine the cross-sectional properties of the corporate bond nondefault spread and its components (taxes and liquidity). The cross-sectional differences in corporate liquidity spreads should reflect relative liquidity of individual bonds. Liquidity has many dimensions and we incorporate various proxies to reflect different interpretations of liquidity for corporate bonds. Based on the literature and data availability, we choose coupons, maturity, age, and issuance size as liquidity

[21] The ADF (augmented Dickey-Fuller) test strongly rejects the hypothesis of nonstationarity at 1% levels for both CDS and corporate bond liquidity spreads. Thus, both spread series are stationary.

proxies (see Green and Odegaard, 1997; Lonstaff et al., 2005). The coupon rate may also capture the income tax effect on corporate bond investments. The markup in the coupon to compensate for the tax burden is roughly proportional to the coupon rate.[22]

Table 8 reports the results of cross-sectional regression of the nondefault spread and its components. In addition to the variables related to liquidity and tax effects and ratings, we incorporate a dummy variable of the industry type to capture the unique feature of financial bonds. As shown, the coefficient of the coupon rate is significant at the one percent level in the nondefault component regression. Coupon payments subject investors to additional state and local taxes, and the coefficient of the coupon rate in the nondefault component partially reflects the premium needed by investors to compensate for this tax burden. Besides the coupon rate, maturity, age and the financial dummy are significant at the five percent level in the nondefault spread regression.

After the tax premium is separated from the nondefault component, one would expect the remaining spread to be a better representation of the liquidity premium and therefore, more closely related to liquidity proxies of individual bonds. Results show that this is indeed the case. The results for the liquidity spread regression show much improvement in the goodness-of-fit and *t* values. All explanatory variables are significant at least at the five percent level except for the financial dummy, which is significant only at the ten percent level. The coefficient for the coupon rate is still positive but much smaller than that in the nondefault spread regression after the tax premium is removed. The positive sign of the coupon rate coefficient in the liquidity spread regression reflects the fact that high-coupon bonds are less popular and thus less liquid than low-coupon bonds. Financial institutions prefer low-coupon bonds. Institutions such as pension funds and insurance companies typically have long-term liabilities with long durations. Low-coupon bonds are ideal for matching the interest rate sensitivity of these long-term liabilities. As a consequence, low-coupon bonds are more popular and liquid than high-coupon bonds. On the other hand, the coefficient on maturity is negative, suggesting that the liquidity premium is lower for bonds with longer maturity. The coefficient on the financial industry dummy is negative, indicating that financial firms pay a lower liquidity premium. This finding is consistent with the traditional view that debts issued by financial firms are more

[22] The markup is approximately $1/(1-\tau_i)$ of the coupon rate.

liquid than other debts. By contrast, the coefficient of the financial dummy in the nondefault spread regression carries an unexpected positive sign.[23] Results show that separating the tax component from the nondefault spread produces a cleaner measure of the liquidity spread, which significantly improves *t* values and the goodness-of-fit of the regression and generates coefficients with signs more consistent with the literature.

The coefficient of the coupon rate is positive and highly significant in the tax spread regression. This finding is consistent with the hypothesis of the income tax effect on corporate yield spread. On the other hand, the coefficients of the age and issuance size are insignificant. These results are perhaps not surprising since intuitively the tax premium should have little to do with bond liquidity. The coefficient of maturity is significantly positive, which reflects a greater tax burden incurred by higher interest income of longer-maturity bonds.

The rating variable is highly significant in the liquidity spread regression. The negative rating coefficient reflects the "flight-to-liquidity" or "flight-to-quality" premium in high-grade bonds, which are more marketable during a financial crisis. By contrast, the rating variable is insignificant for the tax spread regression, indicating that tax liability does not vary systematically with bond quality.

The adjusted R^2 value is 23% for the nondefault spread, 33% for the liquidity spread, and 43% for the tax spread regression. Overall, results suggest that our model does a better job in separating the spread components and thus reducing the noise in the liquidity and tax spread regressions.

4.3. Time-series analysis of nondefault spread components

We next examine temporal properties of the nondefault spread components. Figure 2 plots the time series of the nondefault, tax, and liquidity spreads aggregated across firms each week. The nondefault spread exhibits a downward trend over the entire sample period, and the liquidity spread shares a similar pattern. The tax spread experiences a decline before mid-2003 and then stays relatively flat afterwards. The decline in the tax spread before mid-2003 coincides with the tax cut by the Bush Administration.

Corporate yield spreads are affected by the aggregate liquidity condition because Treasury bonds trade at a premium during turbulent periods. To examine

[23] Longstaff et al. (2005) also report similar results using the nondefault component.

whether there is covariation of the nondefault or liquidity component with changes in marketwide liquidity, we regress weekly changes in these components on macroeconomic measures of liquidity such as changes in total money market mutual fund assets, the on-/off-the-run spread, and the new debt issuance. The data of money market mutual fund assets are collected from the Federal Reserve Bank. We calculate weekly changes in the total money market mutual fund assets and include the sum of the two previous weekly changes as an explanatory variable. The on-the-run yield is represented by the constant maturity 5-year Treasury rate provided by the Federal Reserve Bank, whereas the off-the-run yield is the 5-year generic Treasury rate reported by the Bloomberg system, which is based on the yields of nonbenchmark Treasury notes. The new debt issuance is the weekly total amount of the new corporate bond issuance obtained from Bloomberg.

In addition to macroeconomic liquidity variables, we construct a liquidity measure for the corporate bond market using the Amihud (2002) method. The Amihud measure focuses on the price impact of trades. Liquidity for a corporate bond is high if a large volume can be traded with little impact on price. We calculate the illiquidity measure for bond i in week j using daily return and trading data as follows:

$$ILLIQ_{ij} = \frac{1}{D_{ij}} \sum_{t=1}^{D_{ij}} \frac{|R_{ijt}|}{VOLD_{ijt}} \tag{26}$$

where D_{ij} is the number of days for which transaction data are available for bond i in week j, R_{ijt} is the bond return on day t, and $VOLD_{ijt}$ is the respective daily volume. The Amihud illiquidity index in week j, $AILLIQ_j$, is obtained by averaging over the illiquidity measures of all bonds:

$$AILLIQ_j = \frac{1}{N_j} \sum_{i=1}^{N_j} ILLIQ_{ij} \tag{27}$$

where N_j is the number of bonds in week j. We aggregate illiquidity measures across bonds week by week.

Figure 3 plots the time series of the Amihud illiquidity measure (AILLIQ). The liquidity measure exhibits a decreasing trend, which reflects an improvement in the liquidity condition of the corporate bond market during our sample period. The high fluctuations in the illiquidity index in late 2002 reflect the political uncertainty and volatility of oil prices triggered by the prewar tension in Iraq. A few other sharp spikes between March and August 2003 are observed during the Iraqi war. The spike near the beginning of July 2002 occurs when WorldCom's default jolted the financial market. Another spike toward the end of 2004 is associated with the Fed's policy shift toward a higher interest rate. Overall, the Amihud measure appears to capture important liquidity events reasonably well over our sample period.

We regress changes in aggregated spread components against the three macroeconomic liquidity measures, and/or the Amihud illiquidity measure. The Newey-West procedure is employed to account for the autocorrelation in the time-series regression. Table 9 shows the results of time-series regressions of spread components on alternative liquidity proxies.

We first report the results of regressions using the three macroeconomic liquidity proxies as explanatory variables in Panel A of Table 9. For the nondefault spread change regression, the coefficient of the lagged change in the nondefault component is negative and highly significant, indicating that it is time varying and mean-reverting. The coefficients of the change in money market mutual fund assets and the on/off-the-run spread are positive and significant at the five percent level. Results suggest that the nondefault component contains information for marketwide liquidity. The significant relationships with aggregate liquidity variables reflect the fact that variations in the nondefault spread are dominated by the liquidity component (see Figure 2). After the tax component is removed from the nondefault spread, the adjusted R^2 value for the liquidity spread regression slightly improves. The coefficients of the lagged liquidity spread variable, the change in money market assets and the on/off-the-run spread are all significant. The coefficient of the on/of-the-run spread is much more significant compared to that in the nondefault spread regression. This suggests that the liquidity spread of corporate bonds is more closely related to the liquidity of Treasury bonds. In contrast, for the tax spread regression, none of the aggregate liquidity proxies is significant, supporting the argument that the tax premium is insensitive to marketwide liquidity.

Moreover, the CDS liquidity spread is closely related to macroeconomic liquidity proxies. Both coefficients of the change in money market mutual fund assets and the on/off-the-run spread are significantly positive. For comparison, we also report the results of regression for the nondefault spreads estimated from the corporate bond pricing model without taxes, and ignoring the CDS liquidity premium, similar to Longstaff et al. (2005). The results are reported in the last two columns of Panel A. As shown, the adjusted R^2 value is much lower compared to the liquidity spread regression, and none of the coefficients for macroeconomic measures of bond market liquidity is significant at the five percent level. The results suggest that the estimated nondefault component is a noisier proxy for the liquidity premium when the CDS liquidity effect and taxes are ignored in the decomposition of corporate yield spreads.

Panel B reports the results of time-series regressions using the Amihud illiquidity measure as the marketwide liquidity proxy. For the nondefault component regression of corporate bonds, the coefficient of the change in the Amihud illiquidity measure is significant at the five percent level. For the corporate liquidity spread regression, both the *t* value and the size of the coefficient of the Amihud measure are greater and the adjusted R^2 is higher than for the nondefault spread regression, indicating that the liquidity spread is more closely related to the Amihud illiquidity. The coefficient of the change of the Amihud illiquidity measure is insignificant for the tax component regression, which again shows that the tax premium is insensitive to bond market liquidity. The CDS liquidity spread is strongly related to the Amihud liquidity measure. Results suggest that the liquidity spread estimated from the CDS pricing model is not an artifact. Instead, there is an important marketwide liquidity dimension in the CDS premium. Finally, the nondefault component estimated from the Longstaff et al. model is related to the Amihud illiquidity measure only at the ten percent significance level. This provides further evidence that the liquidity component estimated from our model contains richer information for market liquidity.

Panel C reports the results of time-series regressions by including both macroeconomic liquidity variables and the Amihud illiquidity measure. For the nondefault spread regression, the coefficient of the change in the Amihud illiquidity measure is significant at the five percent level. For the liquidity spread regression, we find a higher *t* value, a larger coefficient for the Amihud variable and a higher adjusted R^2. This again shows that the liquidity spread is a more precise measure of the corporate bond liquidity premium than the nondefault spread. The change in money market assets is the only macroeconomic variable which is barely significant at the ten percent level for both nondefault and liquidity spread regressions after adding the Amihud liquidity measure as an explanatory variable. For the tax spread regression, none of the liquidity variables is significant and the adjusted R^2 value is quite low.

The CDS liquidity spread is significantly related to both changes in the money market mutual fund assets and changes in the Amihud illiquidity measure. Results indicate that the CDS liquidity spread is closely related to marketwide liquidity measures. For the nondefault spread obtained from the Longstaff et al. model, only the coefficient of changes in the Amihud illiquidity measure is significant at the five percent level and the adjusted R^2 value is much lower than that of the liquidity spread regression.

Overall, results show that estimated liquidity spreads of CDS and corporate bonds are highly correlated with marketwide liquidity measures. The CDS premium contains a significant liquidity component which must be properly accounted for, in order to obtain a more accurate estimate of the default premium. Furthermore, the nondefault component of the corporate yield spread contains a sizable tax premium. After the nondefault component is divided into the tax and liquidity components, the liquidity spread becomes much more closely linked to marketwide liquidity measures. Results show that the liquidity component estimated from the generalized model with taxes is an improved measure of the liquidity effect on corporate bond price.

5. Conclusion

In this paper we employ a new approach to estimate liquidity premia in the CDS and corporate bond markets. This approach overcomes an identification problem in estimating the default and liquidity spreads from empirical data. We model default as a common factor in CDS and corporate bond prices, and estimate the parameters of both pricing models jointly from the pooled data, using the GMM method that accounts for cross-sectional and time-series correlation in prices. Unlike previous studies, we consider the liquidity premium in the CDS market while using the CDS information to facilitate empirical decomposition of the corporate yield spread. In addition, we introduce the tax factor into the corporate bond pricing formula to further divide the nondefault spread into the tax and liquidity components.

We find that the CDS premium contains a significant liquidity component. On average, the liquidity component explains 13% of the CDS premium. The liquidity component increases in both the magnitude and percentage of the CDS spread as the rating decreases. Using the CDS information to aid in decomposition of corporate yield spreads, we find that default risk accounts for 47% (37 bps) of the corporate yield spread, whereas tax and liquidity factors make up the remaining 53% of the spread when CDS illiquidity is considered. Conversely, if we ignore CDS illiquidity, the estimated default component accounts for 55% (or 44 bps) of the corporate yield spread, whereas the nondefault component explains only 45% of the spread. Ignoring CDS illiquidity thus results in a substantial overestimation of the default component in the corporate yield spread. This estimation bias is more serious for lower-grade bonds. For instance, the default component of the BB bond is overestimated by 33 bps, which accounts for 17% of its yield spread.

The nondefault spread estimated from the model without taxes is a biased measure of the corporate bond liquidity premium because it contains a sizable tax premium. This problem is further compounded when the CDS information is used to identify the default component of corporate yield spreads but CDS liquidity is ignored. Based on a more accurate model specification, we find that, on average, the liquidity premium accounts for 23% (18bps) of the corporate yield spread, whereas the tax premium is 30% (24 bps). Thus, a big chunk of the nondefault component is attributed to taxes. This result contrasts sharply with the finding of Longstaff et al. (2005).

Liquidity premia for CDS and corporate bonds estimated from our models are highly correlated and significantly related to bond-specific and aggregate liquidity measures. Estimates of CDS and corporate bond liquidity spreads are closely related to bond-specific illiquidity characteristics and macroeconomic liquidity measures, such as Treasury bond richness, money market mutual fund flows and the Amihud illiquidity measure. Results show that there are important individual bond and marketwide liquidity dimensions in both CDS and corporate yield spreads. This finding implies that the liquidity factor will play an even more significant role in the pricing of CDS and corporate bonds during flights to liquidity.

Our results provide important implications for corporate bond pricing and capital structure decisions. There is strong evidence that both taxes and liquidity are important determinants of the corporate yield spread. Including tax and liquidity factors in the corporate bond pricing model thus helps explain the credit spread puzzle. In addition, by separating the tax premium from the nondefault component, we obtain a more precise measure of the liquidity premium of corporate bonds. Accurate information for the size of the liquidity premium and its temporal variations is essential for understanding the role of liquidity in the timing of debt issuances, and corporate bond pricing, especially during turbulent periods. Our findings may also help explain why firms use less debt than that implied by standard structural models which are primarily based on the tradeoff between the cost of financial distress and the leverage benefit of corporate debt. Empirical evidence shows that investors' taxes and liquidity cost add a significant burden to the use of leverage, which may lower firms' incentive to finance with debt.

Appendix A

We derive the CDS pricing formula in this appendix. The expectation in (1), ignoring the constant term ω, is given by

$$E_t^Q\left\{\int_t^T \exp\left[-\int_t^u \left(r_s+\lambda_s+h_s\right)ds\right]du\right\}$$

$$= E_t^Q\left\{\int_t^T \exp\left(-\int_t^u r_s ds\right)\exp\left(-\int_t^u \lambda_s ds\right)\exp\left(-\int_t^u h_s ds\right)du\right\} \tag{A1}$$

$$= \int_t^T d_{t,u}^r d_{t,u}^\lambda d_{t,u}^h du.$$

Fubini's theorem is applied in the last equality to switch the order of expectation and integration. The discount factor associated with intensity x (= r, λ), conditional on the information available at time t, is defined as

$$d_{t,u}^x = E_t^Q \exp\left(-\int_t^u x_s ds\right). \tag{A2}$$

Given the square-root diffusion process, we can obtain the solution for the discount factor:

$$d_{t,u}^x\left(\phi_{x,1},\phi_{x,2},\phi_{x,3},u-t\right) = A_{t,u}^x\left(\phi_{x,1},\phi_{x,2},\phi_{x,3},u-t\right)e^{B_{t,u}^x\left(\phi_{x,1},\phi_{x,2},u-t\right)x_t} \tag{A3}$$

where

$$A_{t,u}^x\left(\phi_{x,1},\phi_{x,2},\phi_{x,3},u-t\right) = \exp\left[\frac{\phi_{x,3}}{2}\left(\phi_{x,2}+\Psi_x\right)\left(u-t\right)\right]\left[\frac{1-\Omega_x}{1-\Omega_x e^{\Psi_x(u-t)}}\right]^{\phi_{x,3}}, \tag{A4}$$

$$B_{t,u}^x\left(\phi_{x,1},\phi_{x,2},u-t\right) = \frac{1}{\phi_{x,1}^2}\left[\phi_{x,2}-\Psi_x\left(1-\frac{2}{1-\Omega_x e^{\Psi_x(u-t)}}\right)\right], \tag{A5}$$

$$\phi_{x,1} = \sigma_x,$$

$$\phi_{x,2} = \kappa_x + \pi_x,$$

$$\phi_{x,3} = 2\kappa_x\theta_x / \sigma_x^2,$$

$$\Psi_x = \sqrt{2\phi_{x,1}^2 + \phi_{x,2}^2},$$

and

$$\Omega_x = \frac{\phi_{x,2}+\Psi_x}{\phi_{x,2}-\Psi_x}.$$

The discount factor associated with liquidity is

$$d_{t,u}^{y} = v(t,u,y) = E_t^Q \exp\left(-\int_t^u y_s ds\right) \tag{A6}$$

where $y(=h,l)$ is liquidity process and

$$dy = \sigma_y dW_y .$$

Using the Feynman-Kac formula, we have the partial differential equation

$$v_t + \frac{1}{2}\sigma_y^2 y v_{yy} - yv = 0 . \tag{A7}$$

The boundary condition is

$$v(u,u,y) = 1 . \tag{A8}$$

From (A7) and (A8), we can obtain the following solution

$$v(t,u,y) = d_{t,u}^{y} = \exp\left(\frac{\sigma_y^2 (u-t)^3}{6} - y(u-t)\right). \tag{A9}$$

The expectation in (5) excluding the constant term $1-\delta$ is given by

$$E_t^Q\left\{\int_t^T \lambda_u \exp\left[-\int_t^u (r_s+\lambda_s) ds\right] du\right\} = \int_t^T d_{t,u}^r \exp\left[B_{t,u}^\lambda \lambda_t\right]\left[G_{t,u}^\lambda + H_{t,u}^\lambda \lambda_t\right] du \tag{A10}$$

We can obtain the second term in the integral on the right side of (A10) by following Duffie et al. (2000). Specifically,

$$\gamma_{t,u} = E_t^Q\left[\lambda_u e^{-\int_t^u \lambda_s ds}\right] = \exp\left(B_{t,u}^\lambda \lambda_t\right)\left(G_{t,u}^\lambda + H_{t,u}^\lambda \lambda_t\right) \tag{A11}$$

$$\begin{aligned} G_{t,u}^\lambda &= G_{t,u}\left(\phi_{\lambda,1}, \phi_{\lambda,2}, \phi_{\lambda,3}, u-t\right) \\ &= \frac{\phi_{\lambda,1}^2 \phi_{\lambda,3}}{2\Psi_\lambda}\left(e^{\Psi_\lambda (u-t)} - 1\right)\exp\left[\frac{\phi_{\lambda,3}\left(\phi_{\lambda,2}+\Psi_\lambda\right)}{2}(u-t)\right]\left(\frac{1-\Omega_\lambda}{1-\Omega_\lambda e^{\Psi_\lambda (u-t)}}\right)^{\phi_{\lambda,3}+1} \end{aligned} \tag{A12}$$

and

$$\begin{aligned} H_{t,u}^\lambda &= H_{t,u}\left(\phi_{\lambda,1}, \phi_{\lambda,2}, \phi_{\lambda,3}, u-t\right) \\ &= exp\left[\left(\frac{\phi_{\lambda,3}}{2}\left(\phi_{\lambda,2}+\Psi_\lambda\right)+\Psi_\lambda\right)(u-t)\right]\left(\frac{1-\Omega_\lambda}{1-\Omega_\lambda e^{\Psi_\lambda (u-t)}}\right)^{\phi_{\lambda,3}+2} . \end{aligned} \tag{A13}$$

We can further allow the CDS and corporate bond liquidity processes to be correlated:

$$dW_h dW_l = \rho dt , \tag{A14}$$

where ρ is the correlation parameter. By the Cholesky decomposition,

$$dW_h = \rho dW_l + \sqrt{\left(1-\rho^2\right)}dW_h^{'}, \tag{A15}$$

where dW_l and $dW_h^{'}$ are independent Brownian motions.

$$dh = \sigma_h dW_h = \sigma_h \left(\rho dW_l + \sqrt{1-\rho^2}\, dW_h^{'}\right), \text{ and}$$

$$d_{t,u}^{h,\rho} = E_t^Q\left\{\exp\left[-\int_t^u h_s ds\right]\right\} = E_t^Q\left\{\exp\left[-\int_t^u \left(h_t + \int_t^s dh_v\right) ds\right]\right\}$$
$$= E_t^Q\left\{\exp\left[-\int_t^u \left(h_t + \sigma_h \int_t^s \left(\rho dW_l + \sqrt{\left(1-\rho^2\right)}dW_h^{'}\right)\right) ds\right]\right\}$$
$$= E_t^Q\left\{\exp\left[-\int_t^u \left(h_t + \sigma_h \int_t^s \left(\rho dW_l\right)\right) ds\right]\right\} E_t^Q\left\{\exp\left[-\int_t^u \left(\sigma_h \sqrt{1-\rho^2} \int_t^s dW_h^{'}\right) ds\right]\right\}$$

The last equality results from the independence between dW_l and $dW_h^{'}$. From (A9),

$$E_t^Q\left\{\exp\left[-\int_t^u \left(h_t + \sigma_h \int_t^s \left(\rho dW_l\right)\right) ds\right]\right\} = \exp\left(\frac{\sigma_h^{\ 2}\rho^2 \left(u-t\right)^3}{6} - h_t\left(u-t\right)\right)$$

$$E_t^Q\left\{\exp\left[-\int_t^u \left(\sigma_h \sqrt{1-\rho^2} \int_t^s dW_h^{'}\right) ds\right]\right\} = \exp\left(\frac{\left(1-\rho^2\right)\sigma_h^{\ 2}\left(u-t\right)^3}{6}\right)$$

and it follows that

$$d_{t,u}^{h,\rho} = d_{t,u}^{h} = \exp\left(\frac{\sigma_h^{\ 2}\left(u-t\right)^3}{6} - h_t\left(u-t\right)\right) \tag{A16}$$

which is independent of the correlation parameter ρ. Thus, the discount factor of liquidity and the pricing of CDS are not affected by the correlation between CDS and corporate bond liquidity. Applying (A16) to the CDS pricing formula in (6) in the main text, we obtain the CDS pricing formula in (7).

Appendix B

The pricing formula in (13) can be adjusted for the effects of discount and premium amortization due to differential statutory tax treatments. Also, we need to consider the accrued interest and different coupons in corporate bond pricing. We describe these adjustments in this appendix for both discount and premium bonds. The pricing formulas derived below are an extension of Liu et al. (2007) to include liquidity in the term structure model of defaultable bonds.

Discount bonds

The price function in (10) can be made more general by accounting for the initial coupon payment and accrual interest (A_t). The first coupon payment C_1 could differ from the rest. This depends on the difference between the issue date and the maturity date for the first coupon. The pricing formula can be modified to accommodate accrual interest and difference in the first coupon as follows:

$$P_t + A_t = E_t^Q \left\{ [C_1(1-\tau_i) + A_t\tau_i] \exp\left[-\int_t^{t_1} (r_s + \lambda_s + l_s) ds \right] + C(1-\tau_i) \sum_{m=2}^{M} \exp\left[-\int_t^{t_m} (r_s + \lambda_s + l_s) ds \right] \right.$$
$$\left. + [1 - \tau_g (1-P_t)] \exp\left[-\int_t^{t_M} (r_s + \lambda_s + l_s) ds \right] + \int_t^{t_M} (\delta + \tau_g (P_t - \delta)) \lambda_u \exp\left[-\int_t^{u} (r_s + \lambda_s + l_s) ds \right] du \right\}. \tag{B1}$$

This pricing formula applies to corporate bonds issued prior to July 18, 1984. However, for bonds issued after July 18, 1984, we must amortize the discount over the life of the bond and both the amortized and unamortized portions of the discount are taxed upon sale or maturity. Under the assumption of buy-and-hold, the total amortized amount of the discount, $1 - P_t$, is taxed as ordinary income at maturity if there is no default before maturity. The tax payment is $\tau_i (1 - P_t)$. If there is default, the entire loss from the default is treated as a capital loss. Adjusting (B1) for these differential treatments, we have

$$P_t + A_t = E_t^Q \left\{ [C_1(1-\tau_i) + A_t\tau_i] \exp\left[-\int_t^{t_1} (r_s + \lambda_s + l_s) ds \right] + C(1-\tau_i) \sum_{m=2}^{M} \exp\left[-\int_t^{t_m} (r_s + \lambda_s + l_s) ds \right] \right.$$
$$\left. + [1 - \tau_i (1-P_t)] \exp\left[-\int_t^{t_M} (r_s + \lambda_s + l_s) ds \right] + \int_t^{t_M} (\delta + \tau_g (P_t - \delta)) \lambda_u \exp\left[-\int_t^{u} (r_s + \lambda_s + l_s) ds \right] du \right\}. \tag{B2}$$

We can solve the above equation to obtain the bond pricing formula

$$P_t = \frac{1}{1-\tau_i d^r_{t,t_M} d^\lambda_{t,t_M} d^l_{t,t_M} - \tau_g \int_t^{t_M} d^r_{t,u} d^l_{t,u} \gamma_{t,u} du} \times$$

$$\left\{ -A_t + \left[C_1(1-\tau_i) + A_t\tau_i\right] d^r_{t,t_1} d^\lambda_{t,t_1} d^l_{t,t_1} + C(1-\tau_i)\sum_{m=2}^{M}\left(d^r_{t,t_m} d^\lambda_{t,t_m} d^l_{t,t_m}\right) + \right. \quad \text{(B3)}$$

$$\left. (1-\tau_i) d^r_{t,t_M} d^\lambda_{t,t_M} d^l_{t,t_M} + (1-\tau_g)\delta \int_t^{t_M} d^r_{t,u} d^l_{t,u} \gamma_{t,u} du \right\}.$$

This pricing formula applies to all discount bonds issued after July 18, 1984.

Premium bonds

The tax treatment of premium bonds also varies over time. The tax code allows the holder of a bond to recognize the amount of capital loss (P_t - 1) earlier. For bonds issued prior to September 27, 1985, the linear amortization method applies. For bonds issued after this date, investors need to use the constant yield method for amortization. In the following, we first consider the linear amortization rule and then the constant yield method. We assume that there is no accrued interest and the first coupon is identical to the rest. These adjustments can be easily accommodated later.

The expected net after-tax value of coupon payments now becomes

$$E_t^Q \left\{ \left[C(1-\tau_i) + \tau_i \frac{(P_t - 1)}{t_M - t} \right] \sum_{m=1}^{M} \exp\left[-\int_t^{t_m} (r_s + \lambda_s + l_s) ds \right] \right\}. \quad \text{(B4)}$$

The expected net after-tax value of the principal received is

$$E_t^Q \left\{ \exp\left[-\int_t^{t_M} (r_s + \lambda_s + l_s) ds \right] + \right.$$

$$\left. \int_t^{t_M} \left[\delta + \tau_g \left(P_t - (P_t - 1)\frac{\lfloor u - \hat{t} + 1 \rfloor - t}{t_M - t} - \delta \right) \right] \lambda_u \exp\left[-\int_t^u (r_s + \lambda_s + l_s) ds \right] du \right\} \quad \text{(B5)}$$

where $\hat{t}$ is the end of the first calendar year after time t and $\lfloor x \rfloor$ is the floor function whose value equals the largest integer smaller than or equal to x if $x \geq 0$, and zero if x < 0. This floor function is used to recognize that the premium is adjusted in discrete time at the end of each calendar year. The defaultable coupon bond that pays a dollar at maturity is priced as

$$P_t = E_t^Q\left\{\left[C(1-\tau_i)+\tau_i\frac{(P_t-1)}{t_M-t}\right]\sum_{m=1}^{M}\exp\left[-\int_t^{t_m}(r_s+\lambda_s+l_s)ds\right]+\exp\left[-\int_t^{t_M}(r_s+\lambda_s+l_s)ds\right]\right.$$
$$\left.+\int_t^{t_M}\left[\delta+\tau_g\left(P_t-(P_t-1)\frac{\lfloor u-\hat{t}+1\rfloor-t}{t_M-t}-\delta\right)\right]\lambda_u\exp\left[-\int_t^{u}(r_s+\lambda_s+l_s)ds\right]du\right\}.$$

(B6)

Taking the expectations under the risk-neutral measure Q, and solving for P_t gives

$$P_t = \frac{\left(C(1-\tau_i)-\frac{\tau_i}{t_M-t}\right)\sum_{m=1}^{M}\left(d_{t,t_m}^r d_{t,t_m}^\lambda d_{t,t_m}^l\right)+d_{t,t_M}^r d_{t,t_M}^\lambda d_{t,t_m}^l+\int_t^{t_M}\left[\frac{\tau_g\left(\lfloor u-\hat{t}+1\rfloor-t\right)}{t_M-t}+(1-\tau_g)\delta\right]d_{t,u}^r d_{t,u}^l\gamma_{t,u}du}{1-\frac{\tau_i}{t_M-t}\sum_{m=1}^{M}\left(d_{t,t_m}^r d_{t,t_m}^\lambda d_{t,t_m}^l\right)-\tau_g\int_t^{t_M}\left(1-\frac{\lfloor u-\hat{t}+1\rfloor-t}{t_M-t}\right)d_{t,u}^r d_{t,u}^l\gamma_{t,u}du}.$$

(B7)

The amortization rule changes to the constant yield method for bonds issued after September 27, 1985. The expected net after-tax value of coupon payments becomes

$$E_t^Q\left\{\sum_{m=1}^{M}[C(1-\tau_i)+\tau_i L(m)]\exp\left[-\int_t^{t_m}(r_s+\lambda_s+l_s)ds\right]\right\}, \quad \text{(B8)}$$

where *L(m)* is the amount of premium recognized in period *m* using the constant yield method, and the second term represents the tax reduction resulting from the premium amortization. The expected net after-tax value of the principal payment is

$$E_t^Q\left\{\exp\left[-\int_t^{t_M}(r_s+\lambda_s+l_s)ds\right]+\int_t^{t_M}[\delta+\tau_g(B(m)-\delta)]\lambda_u\exp\left[-\int_t^{u}(r_s+\lambda_s+l_s)ds\right]du\right\}, \quad \text{(B9)}$$

where *B(m)* is the value of the basis in period *m*. The first term is the expected present value of the principal payment and the second term is the expected residual value, including the tax rebate upon default, adjusted for amortization. The price of the premium bond can be written as

$$P_t = E_t^Q\left\{\sum_{m=1}^{M}[C(1-\tau_i)+\tau_i L(m)]\exp\left[-\int_t^{t_m}(r_s+\lambda_s+l_s)ds\right]+\exp\left[-\int_t^{t_M}(r_s+\lambda_s+l_s)ds\right]\right.$$
$$\left.+\int_t^{t_M}[\delta+\tau_g(B(m)-\delta)]\lambda_u\exp\left[-\int_t^{u}(r_s+\lambda_s+l_s)ds\right]du\right\}. \quad \text{(B10)}$$

The constant yield amortization rule stipulates that

$$L(m) = C - yB(m), \tag{B11}$$

where y is the yield to maturity of the bond. The initial basis is simply the purchase price:

$$B(1) = P_t, \tag{B12}$$

and the basis changes according to

$$B(m) = B(m-1) - L(m-1), \tag{B13}$$

where $m = u - \hat{t} + 2$. Substituting (B11)-(B13) into (B10) gives

$$P_t = E_t^Q \left\{ \sum_{m=1}^{M} \left[C(1-\tau_i) + \tau_i (C - yP_t)(1+y)^{m-1} \right] \exp\left[-\int_t^{t_m} (r_s + \lambda_s + l_s) ds \right] + \exp\left[-\int_t^{t_M} (r_s + \lambda_s + l_s) ds \right] \right.$$
$$\left. + \int_t^{t_M} \left[\delta + \tau_g \left(P_t (1+y)^{\lfloor u-\hat{t}+1 \rfloor} - C \sum_{i=1}^{\lfloor u-\hat{t} \rfloor} (1+y)^i - \delta \right) \right] \lambda_u \exp\left[-\int_t^u (r_s + \lambda_s + l_s) ds \right] du \right\}. \tag{B14}$$

Solving (B14) for P_t, we have

$$P_t = \frac{1}{1 + \tau_i y \sum_{m=1}^{M} \left[(1+y)^{m-1} d_{t,t_m}^r d_{t,t_m}^\lambda d_{t,t_m}^l \right] - \tau_g \int_t^{t_M} (1+y)^{\lfloor u-\hat{t}+1 \rfloor} d_{t,u}^r d_{t,u}^l \gamma_{t,u} du} \times$$
$$\left\{ \sum_{m=1}^{M} C\left(1 - \tau_i \left[1 - (1+y)^{m-1}\right]\right) d_{t,t_m}^r d_{t,t_m}^\lambda d_{t,t_m}^l + d_{t,t_M}^r d_{t,t_M}^\lambda d_{t,t_M}^l + \right. \tag{B15}$$
$$\left. \int_t^{t_M} \left[(1-\tau_g)\delta - \tau_g C \sum_{j=1}^{\lfloor u-\hat{t} \rfloor} (1+y)^j \right] d_{t,u}^r d_{t,u}^l \gamma_{t,u} du \right\}.$$

The above pricing formulas can be adjusted for accrued interest and the first coupon payment as in (B3) when the issue date is not aligned with the maturity date. The pricing formulas in (B15), after adjusting for accrued interest and the possible difference in the first coupon, are applied to the premium corporate bonds issued after September 27, 1985 in empirical estimation. For those bonds issued before this date, we apply the pricing formulas in (B7), with a proper adjustment for accrued interest and the first coupon as in (B1).

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Table 1
Summary Statistics of Credit Default Swap Premia, Corporate Yield Spreads and Bond Characteristics

This table summarizes the distribution of credit default swap premia, corporate bond yields, and characteristics for the entire sample and each rating class. Coupon rate and yield spread are in percentage, the size of bond issues is in 10 million dollars, and maturity and age are expressed in years. The sample period is from July 2002 to February 2005.

	CDS	Corporate Bond				
	Premium (bps)	Coupon (%)	Maturity (yrs)	Issuance size (10 M)	Age (yrs)	Yield (%)
			All Bonds			
Mean	43.11	5.49	4.88	56.98	3.02	3.95
Median	30.34	5.52	4.26	30.00	1.83	3.91
Std.	41.39	1.49	2.28	68.93	3.17	1.06
			AAA/AA			
Mean	18.99	5.47	4.71	82.10	3.49	3.52
Median	16.91	5.55	4.06	50.00	1.97	3.43
Std.	6.75	1.53	2.18	84.28	3.37	0.76
			A			
Mean	36.59	5.35	4.99	44.84	2.68	3.95
Median	30.14	5.41	4.50	25.00	1.69	3.93
Std.	14.92	1.48	2.28	47.74	3.01	1.02
			BBB			
Mean	75.37	5.95	4.55	53.13	4.06	4.21
Median	54.06	6.00	3.89	25.00	2.79	4.10
Std.	67.50	1.44	2.34	61.13	3.56	1.27
			BB			
Mean	155.75	6.02	5.32	134.67	1.89	5.05
Median	161.77	6.00	5.02	75.00	1.62	4.99
Std.	61.41	1.30	2.38	159.25	1.61	1.06

Table 2
Ratio of the Credit Default Swap Premium to the Corporate Yield Spread

This table reports average credit default swap premia, corporate yield spreads and the ratio of the CDS premium to the corporate spread. Panel A shows results for each individual firm and Panel B summarizes the results by rating category. The CDS premium and yield spread are in basis points. Ratios with an asterisk are significantly different from 1 at the 5% level. N denotes the number of observations.

Panel A: Results for Individual Firms

Rating	Firm	CDS (bps)	Yield Spread (bps)	Ratio	N
AAA	JOHNSON & JOHNSON	10.23	14.53	0.70	73
AAA	PFIZER INC	11.72	15.44	0.76	73
AAA	TOYOTA MOTOR CREDIT CORP	10.36	25.49	0.41*	53
AA	ABBOTT LABORATORIES	16.91	57.92	0.29*	52
AA	ASSOCIATES CORP NA	30.34	77.76	0.39*	59
AA	BANK OF AMERICA CORP	30.34	66.32	0.46*	83
AA	BANK ONE NA ILLINOIS	16.53	70.26	0.24*	73
AA	CITIGROUP INC	30.41	58.53	0.52*	128
AA	COLGATE-PALMOLIVE CO.	13.63	36.27	0.38*	77
AA	E.I. DU PONT DE NEMOURS	18.65	61.29	0.30*	34
AA	GANNETT CO INC	27.06	48.36	0.56*	91
AA	GILLETTE COMPANY	11.46	33.15	0.35*	61
AA	MERCK & CO INC	15.86	22.45	0.71*	66
AA	PEPSICO INC	16.69	54.73	0.30*	75
AA	PROCTER & GAMBLE CO	15.51	41.81	0.37*	115
AA	SUNTRUST BANK	21.62	69.02	0.31*	57
AA	US BANCORP	20.02	59.77	0.33*	76
AA	WAL-MART STORES	18.88	41.48	0.46*	118
AA	WELLS FARGO COMPANY	24.54	51.31	0.48*	99
A	ALLSTATE CORP	26.37	59.37	0.44*	73
A	AMERICAN EXPRESS	31.65	44.91	0.70*	98
A	ANHEUSER-BUSCH COS INC	21.26	46.53	0.46*	70
A	ARCHER-DANIELS-MIDLAND	20.49	53.85	0.38*	91
A	BANK OF NEW YORK CO INC	20.50	59.88	0.34*	60
A	BB&T CORP	28.16	50.64	0.56*	60
A	BEAR STEARNS CO INC	34.66	92.66	0.37*	126
A	BOEING CAPITAL CORP	58.64	93.38	0.63*	69
A	CATERPILLAR FIN SERV CRP	29.93	56.49	0.53*	91
A	COCA-COLA ENTERPRISES	28.29	54.88	0.52*	65
A	COMERICA BANK	29.91	102.47	0.29*	77
A	CONS EDISON CO OF NY	24.32	70.33	0.35*	25
A	COOPER INDUSTRIES INC	26.15	88.67	0.29*	78
A	COUNTRYWIDE HOME LOAN	64.54	115.58	0.56*	31
A	DOW CHEMICAL	59.99	89.40	0.67*	127
A	EMERSON ELECTRIC CO	23.32	51.27	0.45*	91
A	FLEETBOSTON FINL CORP	31.87	74.91	0.43*	83
A	GOLDMAN SACHS GROUP INC	44.29	67.33	0.66*	56
A	HONEYWELL INTERNATIONAL	32.81	60.60	0.54*	130

A	IBM CORP	26.40	47.02	0.56*	89
A	INTL LEASE FINANCE CORP	60.79	106.94	0.57*	84
A	JOHN DEERE CAPITAL CORP	35.93	54.62	0.66*	102
A	JOHNSON CONTROLS INC	27.57	84.64	0.33*	95
A	JP MORGAN CHASE & CO	30.34	89.68	0.34*	60
A	KRAFT FOODS INC	50.19	68.22	0.74*	31
A	LEHMAN BROTHERS HOLDINGS	47.05	84.76	0.56*	128
A	LOEWS CORP	93.89	142.22	0.66*	130
A	MCDONALD CORP	29.14	74.29	0.39*	54
A	MELLON FUNDING CORP	24.63	71.12	0.35*	102
A	PRUDENTIAL FINANCIAL INC	33.54	48.96	0.69*	49
A	SLM CORP	42.44	51.34	0.83*	60
A	TRIBUNE CO	21.95	90.29	0.24*	85
A	TORONTO DOMINION BANK NY	29.77	82.74	0.36*	63
A	VERIZON COMMUNICATIONS	43.67	68.84	0.63*	59
A	WACHOVIA CORP	23.23	62.32	0.37*	71
A	WASHINGTON MUTUAL INC	59.69	108.53	0.55*	96
BBB	ALCAN INC	36.44	91.79	0.40*	99
BBB	AMERICAN GENERAL FINANCE	47.28	102.96	0.46*	85
BBB	BALTIMORE GAS & ELECTRIC	50.99	122.76	0.42*	76
BBB	CARDINAL HEALTH INC	53.81	86.01	0.63*	92
BBB	COMMONWEALTH EDISON	48.10	80.61	0.60*	92
BBB	DAIMLERCHRYSLER NA HLDG	72.61	86.01	0.84*	30
BBB	GENERAL MILLS INC	54.06	87.42	0.62*	135
BBB	MARSH & MCLENNAN COS INC	59.49	77.79	0.76*	60
BBB	MAY DEPARTMENT STORES CO	57.36	93.48	0.61*	78
BBB	SPRINT CAPITAL CORP	276.37	315.97	0.87*	109
BBB	WALT DISNEY COMPANY	72.61	84.55	0.86*	105
BB	CLEAR CHANNEL COM.	76.01	106.28	0.72*	88
BB	FIRSTENERGY CORP	196.21	240.17	0.82*	78
BB	FORD MOTOR COMPANY	195.03	213.21	0.91*	75

Panel B: Summary CDS and Corporate Yield Spreads by Rating

Rating	CDS (bps)	Yield Spread (bps)	Ratio	N
AAA/AA	18.99	47.68	0.44*	77
A	36.59	74.16	0.50*	79
BBB	75.37	111.76	0.64*	87
BB	155.75	186.55	0.82*	80
ALL	43.11	77.75	0.52*	80

Table 3

Estimates of Liquidity and Default Spreads in CDS

This table reports average liquidity and default spreads and the proportion of each component to the CDS premium. Default and liquidity spread components are in basis points. Panel A reports results for each individual firm and Panel B summarizes the results by rating category.

Panel A: Results for Individual Firms

		Liquidity		Default	
Rating	Firm	Spread	Ratio	Spread	Ratio
AAA	JOHNSON & JOHNSON	1.78	0.17	8.45	0.83
AAA	PFIZER INC	1.61	0.14	10.11	0.86
AAA	TOYOTA MOTOR CREDIT CORP	0.68	0.07	9.68	0.93
AA	ABBOTT LABORATORIES	0.88	0.05	16.03	0.95
AA	ASSOCIATES CORP NA	1.11	0.04	29.23	0.96
AA	BANK OF AMERICA CORP	1.72	0.06	28.62	0.94
AA	BANK ONE NA ILLINOIS	2.17	0.13	14.36	0.87
AA	CITIGROUP INC	1.39	0.05	29.02	0.95
AA	COLGATE-PALMOLIVE CO.	1.43	0.10	12.20	0.90
AA	E.I. DU PONT DE NEMOURS	1.31	0.07	17.34	0.93
AA	GANNETT CO INC	1.69	0.06	25.37	0.94
AA	GILLETTE COMPANY	1.97	0.17	9.49	0.83
AA	MERCK & CO INC	1.83	0.12	14.03	0.88
AA	PEPSICO INC	1.12	0.07	15.57	0.93
AA	PROCTER & GAMBLE CO	2.81	0.18	12.70	0.82
AA	SUNTRUST BANK	1.64	0.08	19.98	0.92
AA	US BANCORP	0.33	0.02	19.69	0.98
AA	WAL-MART STORES	1.53	0.08	17.35	0.92
AA	WELLS FARGO COMPANY	1.11	0.05	23.43	0.95
A	ALLSTATE CORP	2.95	0.11	23.42	0.89
A	AMERICAN EXPRESS	3.57	0.11	28.08	0.89
A	ANHEUSER-BUSCH COS INC	3.32	0.16	17.94	0.84
A	ARCHER-DANIELS-MIDLAND	1.95	0.10	18.54	0.90
A	BANK OF NEW YORK CO INC	5.02	0.24	15.48	0.76
A	BB&T CORP	1.88	0.07	26.27	0.93
A	BEAR STEARNS CO INC	3.10	0.07	39.90	0.93
A	BOEING CAPITAL CORP	10.15	0.17	48.49	0.83
A	CATERPILLAR FIN SERV CRP	1.48	0.05	28.45	0.95
A	COCA-COLA ENTERPRISES	5.35	0.19	22.94	0.81
A	COMERICA BANK	1.37	0.05	28.54	0.95
A	CONS EDISON CO OF NY	1.21	0.05	23.11	0.95
A	COOPER INDUSTRIES INC	1.69	0.06	24.46	0.94
A	COUNTRYWIDE HOME LOAN	6.91	0.11	57.63	0.89
A	DOW CHEMICAL	7.26	0.12	52.73	0.88
A	EMERSON ELECTRIC CO	2.18	0.09	21.14	0.91
A	FLEETBOSTON FINL CORP	3.54	0.11	28.33	0.89
A	GOLDMAN SACHS GROUP INC	2.31	0.05	41.98	0.95
A	HONEYWELL INTERNATIONAL	4.79	0.15	28.02	0.85

A	IBM CORP	5.56	0.21	20.84	0.79
A	INTL LEASE FINANCE CORP	10.19	0.17	50.60	0.83
A	JOHN DEERE CAPITAL CORP	3.84	0.11	32.09	0.89
A	JOHNSON CONTROLS INC	1.84	0.07	25.73	0.93
A	JP MORGAN CHASE & CO	2.67	0.09	27.67	0.91
A	KRAFT FOODS INC	5.80	0.12	44.39	0.88
A	LEHMAN BROTHERS HOLDINGS	4.92	0.10	42.13	0.90
A	LOEWS CORP	12.14	0.15	66.77	0.85
A	MCDONALD CORP	4.65	0.16	24.49	0.84
A	MELLON FUNDING CORP	2.45	0.10	22.18	0.90
A	PRUDENTIAL FINANCIAL INC	1.94	0.06	31.55	0.94
A	SLM CORP	6.73	0.16	35.71	0.84
A	TRIBUNE CO	3.45	0.12	26.32	0.88
A	TORONTO DOMINION BANK NY	3.23	0.15	18.72	0.85
A	VERIZON COMMUNICATIONS	7.99	0.18	35.68	0.82
A	WACHOVIA CORP	1.13	0.05	22.10	0.95
A	WASHINGTON MUTUAL INC	4.48	0.07	57.96	0.93
BBB	ALCAN INC	6.05	0.17	30.34	0.83
BBB	AMERICAN GENERAL FINANCE	6.28	0.13	41.00	0.87
BBB	BALTIMORE GAS & ELECTRIC	3.78	0.07	47.21	0.93
BBB	CARDINAL HEALTH INC	5.99	0.11	47.82	0.89
BBB	COMMONWEALTH EDISON	3.28	0.07	44.82	0.93
BBB	DAIMLERCHRYSLER NA HLDG	10.63	0.15	61.98	0.85
BBB	GENERAL MILLS INC	7.51	0.14	46.55	0.86
BBB	MARSH & MCLENNAN COS INC	7.55	0.13	51.94	0.87
BBB	MAY DEPARTMENT STORES CO	6.71	0.12	50.65	0.88
BBB	SPRINT CAPITAL CORP	41.66	0.15	234.71	0.85
BBB	WALT DISNEY COMPANY	6.22	0.09	66.39	0.91
BB	CLEAR CHANNEL COM.	11.08	0.15	64.93	0.85
BB	FIRSTENERGY CORP	25.92	0.16	135.85	0.84
BB	FORD MOTOR COMPANY	36.21	0.19	158.82	0.81

Panel B: Summary of Average CDS Liquidity and Default Spreads by Rating

	Liquidity		Default	
Rating	Spread	Ratio	Spread	Ratio
AAA/AA	1.48	0.08	17.51	0.92
A	4.25	0.12	32.23	0.87
BBB	9.61	0.13	65.76	0.87
BB	24.40	0.17	119.87	0.83
ALL	5.22	0.13	37.33	0.87

Table 4
The Default Component of Corporate Yield Spreads Estimated from the Models with and without CDS Liquidity: The Case without Taxes

This table reports the average default component of corporate yield spreads estimated from two different models. The first model includes the liquidity process in the CDS pricing but the second model does not. Neither model incorporates taxes in the corporate bond pricing. CDS and corporate bond pricing models are estimated jointly. Panel A reports results for each individual firm and Panel B summarizes the results by rating category. Ratios with an asterisk are significantly different from 1 at the 5% level.

Panel A: Results for Individual Firms

		With CDS liquidity		Without CDS liquidity	
Rating	Firm	Dflt (bps)	Ratio	Dflt (bps)	Ratio
AAA	JOHNSON & JOHNSON	11	0.37*	14	0.47*
AAA	PFIZER INC	9	0.35*	14	0.54*
AAA	TOYOTA MOTOR CREDIT	9	0.38*	10	0.42*
AA	ABBOTT LABORATORIES	15	0.36*	16	0.38*
AA	ASSOCIATES CORP NA	33	0.46*	32	0.44*
AA	BANK OF AMERICA CORP	18	0.26*	19	0.27*
AA	BANK ONE NA ILLINOIS	12	0.26*	13	0.28*
AA	CITIGROUP INC	30	0.42*	32	0.44*
AA	COLGATE-PALMOLIVE CO.	8	0.18*	13	0.29*
AA	E.I. DU PONT DE NEMOURS	22	0.59*	24	0.65*
AA	GANNETT CO INC	26	0.44*	25	0.42*
AA	GILLETTE COMPANY	10	0.37*	13	0.48*
AA	MERCK & CO INC	15	0.39*	21	0.55*
AA	PEPSICO INC	10	0.24*	14	0.34*
AA	PROCTER & GAMBLE CO	10	0.26*	14	0.36*
AA	SUNTRUST BANK	16	0.29*	19	0.34*
AA	US BANCORP	19	0.71*	20	0.50*
AA	WAL-MART STORES	12	0.26*	18	0.39*
AA	WELLS FARGO COMPANY	26	0.42*	32	0.52*
A	ALLSTATE CORP	9	0.12*	23	0.31*
A	AMERICAN EXPRESS	25	0.45*	31	0.55*
A	ANHEUSER-BUSCH COS INC	18	0.38*	22	0.47*
A	ARCHER-DANIELS-MIDLAND	19	0.22*	21	0.25*
A	BANK OF NEW YORK CO INC	6	0.11*	19	0.34*
A	BB&T CORP	30	0.42*	32	0.44*
A	BEAR STEARNS CO INC	32	0.48*	31	0.47*
A	BOEING CAPITAL CORP	44	0.45*	50	0.52*
A	CATERPILLAR FIN SERV CRP	20	0.47*	25	0.58*
A	COCA-COLA ENTERPRISES	19	0.34*	28	0.50*
A	COMERICA BANK	27	0.39*	28	0.40*
A	CONS EDISON CO OF NY	30	0.39*	33	0.43*
A	COOPER INDUSTRIES INC	25	0.31*	26	0.32*
A	COUNTRYWIDE HOME LOAN	49	0.58*	56	0.66*
A	DOW CHEMICAL	65	0.57*	69	0.60*
A	EMERSON ELECTRIC CO	22	0.35*	25	0.40*
A	FLEETBOSTON FINL CORP	27	0.45*	31	0.52*
A	GOLDMAN SACHS GROUP	41	0.45*	45	0.49*
A	HONEYWELL	27	0.36*	36	0.49*

A	IBM CORP	20	0.33*	29	0.48*
A	INTL LEASE FINANCE CORP	49	0.50*	64	0.65*
A	JOHN DEERE CAPITAL CORP	35	0.56*	39	0.62*
A	JOHNSON CONTROLS INC	19	0.32*	23	0.39*
A	JP MORGAN CHASE & CO	29	0.39*	30	0.41*
A	KRAFT FOODS INC	45	0.51*	53	0.60*
A	LEHMAN BROTHERS	43	0.48*	47	0.53*
A	LOEWS CORP	95	0.49*	122	0.63*
A	MCDONALD CORP	17	0.28*	29	0.48*
A	MELLON FUNDING CORP	23	0.61*	25	0.37*
A	PRUDENTIAL FINANCIAL	40	0.53*	42	0.55*
A	SLM CORP	34	0.45*	41	0.55*
A	TRIBUNE CO	22	0.29*	26	0.34*
A	TORONTO DOMINION BANK	31	0.47*	36	0.55*
A	VERIZON	38	1.16*	44	0.47*
A	WACHOVIA CORP	12	0.19*	23	0.37*
A	WASHINGTON MUTUAL INC	45	0.58*	51	0.66*
BBB	ALCAN INC	39	0.43*	46	0.51*
BBB	AMERICAN GENERAL	45	0.56*	49	0.61*
BBB	BALTIMORE GAS &	42	0.47*	46	0.52*
BBB	CARDINAL HEALTH INC	46	0.56*	53	0.65*
BBB	COMMONWEALTH EDISON	47	0.46*	53	0.52*
BBB	DAIMLERCHRYSLER NA	68	0.64*	76	0.72*
BBB	GENERAL MILLS INC	48	0.56*	43	0.51*
BBB	MARSH & MCLENNAN COS	46	0.52*	57	0.64*
BBB	MAY DEPARTMENT STORES	58	0.42*	64	0.46*
BBB	SPRINT CAPITAL CORP	225	0.65*	268	0.78*
BBB	WALT DISNEY COMPANY	69	0.60*	75	0.65*
BB	CLEAR CHANNEL COM.	64	0.60*	80	0.75*
BB	FIRSTENERGY CORP	168	0.71*	194	0.82*
BB	FORD MOTOR COMPANY	156	0.70*	213	0.96

B. Summary of Average Default Component of Corporate Yield Spreads by Rating

	With CDS liquidity		Without CDS liquidity	
Rating	Dflt (bps)	Ratio	Dflt (bps)	Ratio
AAA/AA	16	0.36	19	0.42
A	31	0.41	38	0.49
BBB	67	0.56	75	0.63
BB	129	0.69	162	0.86
ALL	37	0.47	44	0.55

Table 5
Estimates of Liquidity, Tax, and Nondefault Spreads in Corporate Bonds

This table reports the estimates of liquidity, tax, nondefault (sum of liquidity and tax), and default spreads and the proportion of each variable to corporate yield spreads. The estimates are obtained from the generalized models that include liquidity in the CDS pricing and taxes, default, and liquidity in the corporate bond pricing. Corporate yield spread components are expressed in basis points. Panel A reports results for each individual firm and Panel B summarizes the results by rating category.

Panel A: Average Spread Components for Individual Firms

		Liquidity		Tax		Nondefault		Default	
Rating	Firm	Spread	Ratio	Spread	Ratio	Spread	Ratio	Spread	Ratio
AAA	JOHNSON & JOHNSON	2	0.07	17	0.57	19	0.63	11	0.37
AAA	PFIZER INC	10	0.38	7	0.27	17	0.65	9	0.35
AAA	TOYOTA MOTOR CREDIT CORP	6	0.25	9	0.38	15	0.63	9	0.38
AA	ABBOTT LABORATORIES	10	0.24	17	0.40	27	0.64	15	0.36
AA	ASSOCIATES CORP NA	11	0.15	28	0.39	39	0.54	33	0.46
AA	BANK OF AMERICA CORP	9	0.13	43	0.61	52	0.74	18	0.26
AA	BANK ONE NA ILLINOIS	26	0.55	9	0.19	35	0.74	12	0.26
AA	CITIGROUP INC	14	0.19	28	0.39	42	0.58	30	0.42
AA	COLGATE-PALMOLIVE CO.	12	0.27	25	0.56	37	0.82	8	0.18
AA	E.I. DU PONT DE NEMOURS	11	0.30	4	0.11	15	0.41	22	0.59
AA	GANNETT CO INC	15	0.25	18	0.31	33	0.56	26	0.44
AA	GILLETTE COMPANY	8	0.30	9	0.33	17	0.63	10	0.37
AA	MERCK & CO INC	12	0.32	11	0.29	23	0.61	15	0.39
AA	PEPSICO INC	15	0.37	16	0.39	31	0.76	10	0.24
AA	PROCTER & GAMBLE CO	14	0.36	15	0.38	29	0.74	10	0.26
AA	SUNTRUST BANK	16	0.29	24	0.43	40	0.71	16	0.29
AA	US BANCORP	8	0.20	13	0.33	21	0.53	19	0.71
AA	WAL-MART STORES	10	0.22	24	0.52	34	0.74	12	0.26
AA	WELLS FARGO COMPANY	8	0.13	28	0.45	36	0.58	26	0.42
A	ALLSTATE CORP	34	0.45	32	0.43	66	0.88	9	0.12
A	AMERICAN EXPRESS	22	0.39	9	0.16	31	0.55	25	0.45
A	ANHEUSER-BUSCH COS INC	13	0.28	16	0.34	29	0.62	18	0.38
A	ARCHER-DANIELS-MIDLAND	23	0.27	43	0.51	66	0.78	19	0.22
A	BANK OF NEW YORK CO INC	16	0.29	34	0.61	50	0.89	6	0.11
A	BB&T CORP	12	0.17	30	0.42	42	0.58	30	0.42
A	BEAR STEARNS CO INC	10	0.15	24	0.36	34	0.52	32	0.48
A	BOEING CAPITAL CORP	25	0.26	28	0.29	53	0.55	44	0.45
A	CATERPILLAR FIN SERV CRP	15	0.35	8	0.19	23	0.53	20	0.47
A	COCA-COLA ENTERPRISES	19	0.34	18	0.32	37	0.66	19	0.34
A	COMERICA BANK	11	0.16	32	0.46	43	0.61	27	0.39
A	CONS EDISON CO OF NY	14	0.18	33	0.43	47	0.61	30	0.39
A	COOPER INDUSTRIES INC	24	0.30	32	0.40	56	0.69	25	0.31
A	COUNTRYWIDE HOME LOAN	22	0.26	14	0.16	36	0.42	49	0.58
A	DOW CHEMICAL	22	0.19	28	0.24	50	0.43	65	0.57
A	EMERSON ELECTRIC CO	9	0.15	31	0.50	40	0.65	22	0.35
A	FLEETBOSTON FINL CORP	16	0.27	17	0.28	33	0.55	27	0.45
A	GOLDMAN SACHS GROUP INC	13	0.14	38	0.41	51	0.55	41	0.45

A	HONEYWELL INTERNATIONAL	16	0.22	31	0.42	47	0.64	27	0.36
A	IBM CORP	15	0.25	25	0.42	40	0.67	20	0.33
A	INTL LEASE FINANCE CORP	24	0.24	25	0.26	49	0.50	49	0.50
A	JOHN DEERE CAPITAL CORP	9	0.14	19	0.30	28	0.44	35	0.56
A	JOHNSON CONTROLS INC	23	0.39	17	0.29	40	0.68	19	0.32
A	JP MORGAN CHASE & CO	11	0.15	34	0.46	45	0.61	29	0.39
A	KRAFT FOODS INC	14	0.16	30	0.34	44	0.49	45	0.51
A	LEHMANBROTHERS HOLDINGS	14	0.16	32	0.36	46	0.52	43	0.48
A	LOEWS CORP	45	0.23	53	0.27	98	0.51	95	0.49
A	MCDONALD CORP	31	0.52	12	0.20	43	0.72	17	0.28
A	MELLON FUNDING CORP	23	0.34	22	0.32	45	0.66	23	0.61
A	PRUDENTIAL FINANCIAL INC	12	0.16	24	0.32	36	0.47	40	0.53
A	SLM CORP	16	0.21	25	0.33	41	0.55	34	0.45
A	TRIBUNE CO	14	0.18	40	0.53	54	0.71	22	0.29
A	TORONTO DOMINION BANK NY	14	0.21	21	0.32	35	0.53	31	0.47
A	VERIZON COMMUNICATIONS	20	0.21	36	0.38	56	0.60	38	1.16
A	WACHOVIA CORP	12	0.19	38	0.61	50	0.81	12	0.19
A	WASHINGTON MUTUAL INC	23	0.30	9	0.12	32	0.42	45	0.58
BBB	ALCAN INC	11	0.12	40	0.44	51	0.57	39	0.43
BBB	AMERICAN GENERAL FINANCE	25	0.31	10	0.13	35	0.44	45	0.56
BBB	BALTIMORE GAS & ELECTRIC	26	0.29	21	0.24	47	0.53	42	0.47
BBB	CARDINAL HEALTH INC	21	0.26	15	0.18	36	0.44	46	0.56
BBB	COMMONWEALTH EDISON	31	0.30	24	0.24	55	0.54	47	0.46
BBB	DAIMLERCHRYSLER NA HLDG	13	0.12	25	0.24	38	0.36	68	0.64
BBB	GENERAL MILLS INC	19	0.22	18	0.21	37	0.44	48	0.56
BBB	MARSH & MCLENNAN COS INC	19	0.21	24	0.27	43	0.48	46	0.52
BBB	MAY DEPARTMENT STORES CO	18	0.13	62	0.45	80	0.58	58	0.42
BBB	SPRINT CAPITAL CORP	94	0.27	25	0.07	119	0.35	225	0.65
BBB	WALT DISNEY COMPANY	11	0.10	35	0.30	46	0.40	69	0.60
BB	CLEAR CHANNEL COM.	27	0.25	16	0.15	43	0.40	64	0.60
BB	FIRSTENERGY CORP	41	0.17	28	0.12	69	0.29	168	0.71
BB	FORD MOTOR COMPANY	45	0.20	21	0.09	66	0.30	156	0.70

Panel B: Summary of Average Corporate Yield Spread Components by Rating

	Liquidity		Tax		Nondefault		Default	
Rating	Spread	Ratio	Spread	Ratio	Spread	Ratio	Spread	Ratio
AAA/AA	11	0.25	18	0.40	30	0.64	16	0.36
A	18	0.24	27	0.35	45	0.59	31	0.41
BBB	26	0.22	27	0.23	53	0.44	67	0.56
BB	38	0.20	22	0.11	59	0.31	129	0.69
ALL	18	0.23	24	0.30	43	0.53	37	0.47

Table 6
Model Specification Tests

This table reports the likelihood ratio test results of model specifications. Test 1 is to test whether introducing the CDS liquidity component improves the explanatory power of the model. Test 2 is to test whether introducing the tax factor improves the model performance. Test 3 is to test whether introducing both the CDS liquidity and tax factors increases the model power. Test statistics follow the $\chi^2(k)$ distribution with the degree of freedom equal to the number of restricted parameters k. The proportions of the sample firms which have significant *LR* are also reported. The mean *LR* values with triple asterisks are significant at the 1% level.

	Test 1		Test 2		Test 3	
Rating	Restrictions: $\sigma_h = 0$, $h_t = 0$	Proportion of significance	Restrictions: $\tau = 0$	Proportion of significance	Restrictions: $\sigma_h = 0$, $h_t = 0$, $\tau = 0$	Proportion of significance
AAA/AA	49.45***	0.63	58.91***	0.95	108.37***	0.84
A	46.07***	0.78	97.63***	0.89	143.71***	0.86
BBB	126.29***	0.73	138.52***	1.00	264.79***	0.91
BB	44.10***	1.00	22.11***	1.00	66.21***	1.00
ALL	56.53***	0.74	88.81***	0.93	145.35***	0.87

Table 7
Characteristics of CDS liquidity Spreads

Panel A. Cross-sectional correlation between CDS and corporate bond liquidity spreads

	ALL	AAA/AA	A	BBB	BB
	CDS				
Bond	0.82	0.38	0.54	0.92	0.98

Panel B.

1. Summary statistics of bid-ask spreads

	Mean (bps)	Std (bps)	Max (bps)	Min (bps)
CDS B/A	8.45	4.93	24.06	4.01
Corporate Bond B/A	40.13	4.72	51.52	31.02

2. Time series correlation among monthly aggregate CDS liquidity spreads (LS), corporate liquidity spreads, and CDS and corporate bond bid-ask spreads (B/A)

	CDS LS	Corporate Bond LS	CDS B/A	Corporate Bond B/A
CDS LS	1.00			
Corporate Bond LS	0.90	1.00		
CDS B/A	0.86	0.93	1.00	
Corporate Bond B/A	0.52	0.46	0.42	1.00

Panel C. Cross-sectional regression of CDS liquidity spreads on corporate bond liquidity spreads

The rating dummy variable (Rating) equals 1 if firm *i* is rated AAA/AA, and zero otherwise. The financial dummy variable (Financial) equals 1 if the firm belongs to the financial industry, and zero otherwise.

$$LS_{CDS,i}=\beta_0+\beta_1 LS_{Bond,i}+\beta_2 Rating_i+\beta_3 Financial_i+\varepsilon_i$$

Variable	Parameter	*T* value
Intercept	2.74	8.32
LS_{Bond}	0.22	13.32
Rating	-3.68	-10.02
Financial	-1.13	-2.30
Adj R^2	43.96%	

Panel D. Tests of Granger Causality between the CDS and corporate bond liquidity spreads

H1 represents the null hypothesis that the CDS liquidity spread is not Granger-caused by the bond liquidity spread. H2 represents the null hypothesis that the bond liquidity spread is not Granger-caused by the CDS liquidity spread. *,**,*** indicate significance at the 10%, 5% and 1% levels, respectively.

	Lag order				
Hypothesis	p=1	p=2	p=3	p=4	p=5
H1	8.19***	29.27***	41.41***	49.56***	58.13***
H2	9.42***	11.00***	8.82**	30.56***	35.35***

Table 8
Cross-Sectional Regressions of Nondefault, Liquidity and Tax Spreads on Bond Characteristics

This table reports the results for the following cross-sectional regression:

$$\text{Spread}_i = \beta_0 + \beta_1 \text{Coupon}_i + \beta_2 \text{Maturity}_i + \beta_3 \text{Age}_i + \beta_4 \text{Size}_i + \beta_5 \text{Rating}_i + \beta_6 \text{Financial}_i + \varepsilon_i$$

where the dependent variable is the nondefault, liquidity, or tax spread of corporate bonds. The rating dummy variable (Rating) equals 1 if the firm is rated AAA/AA, and zero otherwise. The financial dummy variable (Financial) equals 1 if the firm belongs to financial industry, and zero otherwise. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

	Nondefault spread		Liquidity spread		Tax spread	
Variable	β Coeff.	*t*-statistic	β Coeff.	*t*-statistic	β Coeff.	*t*-statistic
Intercept	1.713	0.35	8.338	3.22***	-12.188	-4.66***
Coupon	4.741	4.48***	2.766	4.59***	3.301	7.65***
Maturity	1.256	2.60***	-0.835	-2.75***	3.435	13.72***
Size	-0.389	-0.33	-1.633	-2.41**	-0.114	-1.51
Age	1.217	2.33**	0.780	4.85***	0.329	0.46
AAA/AA Rating	-4.787	-1.94*	-5.476	-4.67***	-0.505	-0.41
Financial	5.377	2.51**	-2.049	-1.78*	4.880	4.46***
Adj. R^2	23.33%		32.49%		43.39%	

Table 9
Time-Series Regressions

This table reports the results of regressing weekly changes in the nondefault, liquidity, and tax spreads of corporate bond and liquidity spreads of CDS on the lagged spread changes, changes in money market mutual fund assets in billions (ΔMMMF), the total amount of corporate debt issuance in millions, the difference between the yields of on- and off-the-run Treasury bonds in basis points, and/or the Amihud (2002) illiquidity measure (AILLIQ). *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Panel A: $\Delta \text{Spread}_t = \beta_0 + \beta_1 \text{ lagged } \Delta \text{Spread}_t + \beta_2 \, \Delta \text{MMMF}_t + \beta_3 \text{ On/Off-the-Run Spread}_t + \beta_4 \text{ Debt Issuance}_t + \varepsilon_t$

	The generalized model with taxes and CDS liquidity								The Longstaff et al. model	
	Corporate bond						CDS		Corporate bond	
	Nondefault spread		Liquidity spread		Tax spread		Liquidity spread		Nondefault spread	
Variable	Coeff.	*t*-statistic	Coeff.	*t*-statistic	Coeff.	*t*-statistic	Coeff.	*t*-statistic	Coeff.	*t*-statistic
Intercept	-0.480	-0.52	-0.578	-0.93	-0.115	-1.11	-0.095	0.90	-1.380	1.35
Lagged spread change	-0.206	-3.13***	-0.198	-3.09***	0.167	1.99**	-0.260	-3.21***	-0.190	-2.43**
ΔMMMF	0.247	2.61**	0.206	2.31**	0.010	1.28	0.019	2.50**	0.174	1.94*
On/off-the-run spread	0.437	2.05**	0.565	2.73***	0.025	1.45	0.056	2.23**	0.471	1.67*
Debt issuance	0.177	0.35	0.099	0.21	0.061	-0.03	0.064	1.02	0.309	0.57
Adj. R^2	15.73%		16.88%		7.66%		11.96%		12.78%	

Panel B: $\Delta \text{Spread}_t = \beta_0 + \beta_1 \Delta \text{AILLIQ}_t + \varepsilon_t$

	Generalized model with tax and CDS liquidity								Longstaff et al. model	
	Corporate bond						CDS		Corporate bond	
	Nondefault spread		Liquidity spread		Tax spread		Liquidity spread		Nondefault spread	
Variable	Coeff.	*t*-statistic	Coeff.	*t*-statistic	Coeff.	*t*-statistic	Coeff.	*t*-statistic	Coeff.	*t*-statistic
Intercept	-0.408	-0.42	-0.714	0.74	-0.011	-0.24	0.025	0.35	0.243	0.35
ΔAILLIQ	1.047	2.14**	1.212	2.50**	0.048	1.23	0.187	5.37***	0.660	1.88*
Adj. R^2	3.53%		5.03%		1.13%		17.19%		2.74%	

Panel C: $\Delta \text{Spread}_t = \beta_0 + \beta_1$ lagged $\Delta \text{Spread}_t + \beta_2 \Delta \text{MMMF}_t + \beta_3$ On/Off-the-Run $\text{Spread}_t + \beta_4$ Debt $\text{Issuance}_t + \beta_5 \Delta \text{AILLIQ}_t + \varepsilon_t$

	Generalized model with tax and CDS liquidity								Longstaff et al. model	
	Corporate bond						CDS		Corporate bond	
	Nondefault spread		Liquidity spread		Tax spread		Liquidity spread		Nondefault spread	
Variable	Coeff.	*t*-statistic	Coeff.	*t*-statistic	Coeff.	*t*-statistic	Coeff.	*t*-statistic	Coeff.	*t*-statistic
Intercept	-0.339	-0.24	-0.364	-0.27	-0.113	-1.08	0.054	0.45	-0.821	-0.84
Lagged spread change	-0.407	-4.05**	-0.414	-4.24***	0.169	2.01**	-0.278	-3.61***	-0.244	-3.29***
Δ MMMF	0.239	1.92*	0.217	1.79*	0.010	1.34	0.018	2.12**	0.022	0.27
On/off-the-run spread	0.186	0.58	0.124	1.39	0.035	1.43	0.012	0.44	0.205	0.89
Debt issuance	0.068	0.09	0.026	0.03	0.073	1.19	0.015	0.21	0.408	0.74
ΔAILLIQ	0.868	2.07**	1.074	2.32**	0.022	0.62	0.226	5.69***	0.777	2.27**
Adj. R^2	18.65%		20.29%		7.93%		22.77%		14.48%	

Figure 1. Time series of mean liquidity spreads for CDS and corporate bonds

This figure plots the time series of liquidity spreads for CDS and corporate bonds averaged across firms.

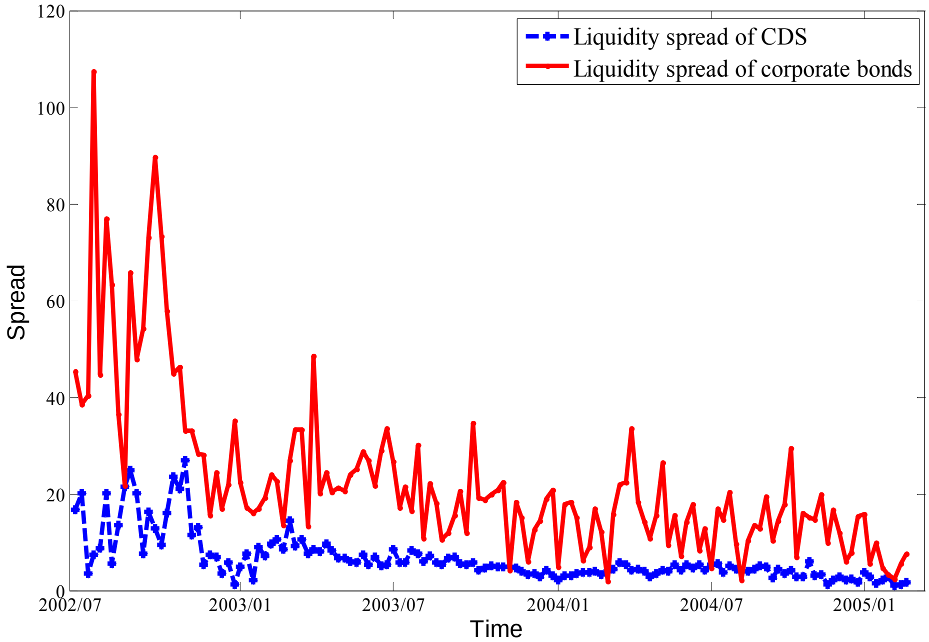

Figure 2. Time series of liquidity, tax and nondefault spreads

This figure shows the time series of the liquidity, tax, and nondefault components of corporate yield spreads averaged across firms.

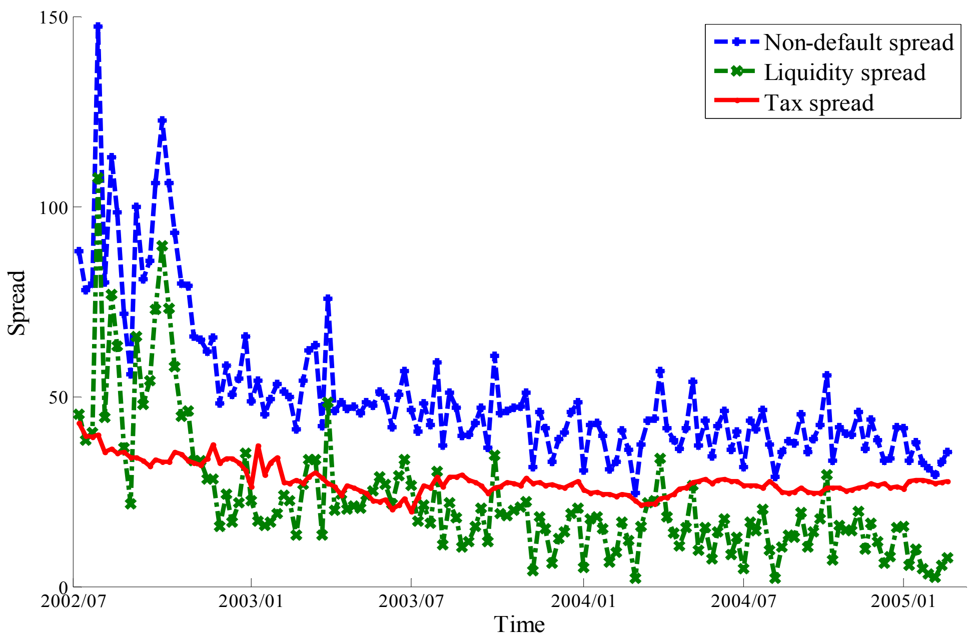

Figure 3. Time series of the Amihud illiquidity measure

This figure plots the time series of the weekly Amihud illiquidity measures over the sample period.