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Investors' Valuation for Asset Liquidity and the Corporate-Treasury Yield Spread

Benjamin Niestroj[1]

[1] Chair of Applied Economics, TU Dortmund University, Dortmund, Germany

Correspondence: Benjamin Niestroj, Chair of Applied Economics, TU Dortmund University, Vogelpothsweg 87, 44221 Dortmund, Germany. Tel: 49-231-755-3441. E-mail: benjamin.niestroj@uni-dortmund.de

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Abstract

The present study seeks to contribute to the explanation of the non-default component within corporate-U.S. Treasury yield spreads. This is done by extending the model by Krishnamurthy and Vissing-Jorgensen (2012), assuming that investors value not only U.S. Treasuries' liquidity but instead value liquidity independently from the underlying asset. For that purpose I modify a standard asset pricing model by allowing certain groups of assets to directly contribute to investor's utility. Empirical tests of the model's implications confirm this view and show that changes in the holdings of most liquid assets cause a stronger impact on corporate-Treasury yield spreads compared to changes in the holdings of least liquid assets. Finding this systematic pattern, points to the existence of a demand function for liquidity. Further, I provide evidence that changes in the holdings of liquid assets are priced separately from commonly used controls for credit default risk, as well as from controls measuring an asset's market liquidity.

Keywords: corporate-treasury bond yield spread, CCAPM, asset pricing, credit risk, liquidity premium

1. Introduction

The study of determinants of corporate-U.S. Treasury bond yield spreads has been the subject of a large number of contributions to the corporate finance literature. Some recent papers by Elton et al. (2001), Delianedis and Geske (2001), Huang and Huang (2003), and Eom, Helwege and Huang (2004) find that variables, i.e. default risk and measures for assets' market liquidity, that should in theory determine spreads between corporate bond yields and U.S. Treasury bond yields, have rather limited explanatory power. Longstaff, Mithal and Neiss (2005) use information from credit default swaps to estimate the share of corporate-Treasury yield spreads being explained by default risk, which they label as the default component. The residual is then labeled as nondefault component. The latter is found to be time-varying and strongly related to macroeconomic measures of bond market liquidity (Note 1). Krishnamurthy and Vissing-Jorgensen (2012) (KVJ) provide evidence that the nondefault component within the corporate-Treasury bond yield spread is to a significant extent driven by the total amount of U.S. Treasuries outstanding. They argue that investors value certain features of U.S. Treasury securities, namely their liquidity and "absolute security of nominal return" as they directly contribute to investors' utility. This affects prices of Treasuries and hence, drives down their yields compared to assets that do not to the same extent share these features.

In this paper I investigate whether investors value liquidity only as a U.S. Treasury-specific feature, or whether investors value in general the liquidity of assets. In particular, I ask whether there is evidence for a systematic pattern in investors' valuation for liquid assets which reflects different degrees in the assets' level of liquidity. Empirical evidence for such a pattern being priced within the corporate-Treasury yield spread would point to the existence of a demand function for liquidity. I follow KVJ by modifying a standard asset pricing model to allow for holdings of a certain group of liquid assets to directly contribute to investors' utility. In a next step the theoretical implications of this asset pricing model are empirically tested. Specifically, I estimate and compare the effects of changes in the aggregate holdings of assets which differ in their degree of perceived liquidity, on alternative yield spread measures, while controlling for commonly employed measures for default risk and assets' market liquidity.

U.S. Treasuries are of high liquidity and are considered to be default-free. From a theoretical point of view this should be reflected in the interest differential between Treasuries and any other debt security with the same maturity length. As pointed out by Collin-Dufresne, Goldstein and Martin (2001) the standard empirical approach to explain corporate-Treasury bond yield spreads is to find suitable controls that should proxy for the spread determinants which are implied by Asset Pricing Theory's Consumption Capital Asset Pricing Model (CCAPM). According to Chen, Lesmond and Wei (2007), these determinants are generally denoted as credit risk factors. Specifically, they are the expected loss in case of default on a corporate bond and the degree to which default states covary with the business cycle, commonly named as "expected default loss" and investors' demanded "risk premium" (Elton et al., 2001). Furthermore, authors like Amihud, Mendelson and Pedersen (2005) and Acharya and Pedersen (2005) use controls which proxy for the securities' level of market liquidity (Note 2). They argue that time-varying differences in an asset's degree of market liquidity contribute to make returns, i.e. future expected payment streams, risky and therefore, induce an additional "liquidity-risk premium". For example, in times when investors would like to sell and the market liquidity of a corporate bond deteriorates, risk averse investors will demand an additional premium for holding these bonds, i.e. a market-liquidity induced risk premium. Chen, Lesmond and Wei (2007) show that measures which control for CCAPM-implied spread determinants as well as for securities' degree of market liquidity can improve the ability of credit spread regressions to explain observed levels and variability of yield spreads. However, explanatory power still remains relatively low (Note 3).

KVJ find for U.S. data a strong negative correlation between corporate-Treasury bond yield spreads and the government Debt-to-GDP ratio (i.e., the ratio of the market value of publicly held U.S. government debt to U.S. GDP) over the period from 1926 to 2008. They argue that this reflects an investors' valuation for certain features of U.S. Treasury securities, i.e., a high degree of liquidity and a high degree of perceived safety. This valuation by the investors is further found to be priced separately from the commonly analyzed spread determinants, such as credit risk and assets' market liquidity. As theoretical rationale for the observed behavior, KVJ assume that the holder of a U.S. Treasury security obtains some services and gains to the subjective level of well-being (Note 4). Those benefits are summarized as "convenience yields" which directly contribute to investors' utility and lead Treasuries to have significantly lower yields than they otherwise would have in a standard asset-pricing framework. The strong negative correlation they find, therefore reflects a Treasury demand curve, or more specifically an investors' demand for a certain feature of Treasuries. If the supply of Treasuries is low, the value that investors assign to the services offered by Treasuries is high. As a result the yields on Treasuries are low relative to the yields on corporate bonds. The opposite applies when the supply of Treasuries is high.

In this study I test the hypothesis whether only U.S. Treasury-specific liquidity services are valued by investors, or whether investors have a general valuation for liquidity services which is independent from the underlying asset. The latter would point to the existence of a demand function for liquidity. For this purpose, I extend the asset pricing model developed by KVJ. Specifically, I employ a representative investor's utility function where not only Treasury holdings contribute directly to utility but also money balances as well as corporate debt security holdings. In particular, by following Poterba and Rotemberg (1986), utility is assumed to be a function of consumption and liquidity services which depend on the level of holdings of the assets under consideration. I analyze the modified asset pricing model's implications with regard to changes in the holdings of liquidity services providing assets on corporate-Treasury yield spreads. These implications are empirically tested by employing regression analysis. In addition to evaluating the effects of variables which should implied by the model drive corporate-Treasury yield spreads, this study is also intended to conduct an exploratory analysis. This is done by regressing bond spreads on measures that capture the investors' perceived market-liquidity risk of corporate debt securities relative to U.S. Treasuries, and so called "flight-to-liquidity" episodes, where I follow Pflueger and Viceira (2011) and Longstaff (2004).

I find a significant negative association between changes in measures for aggregate money balances and near money holdings, measures for U.S. Treasury holdings, as well as measures for the holdings of corporate debt securities and corporate-U.S. Treasury yield spreads. Results indicate that yield spreads react the stronger, the higher the correspondent measure's degree of liquidity. Further, I find that this observation is robust across different model specifications including common measures for credit risk and assets' market-liquidity risk. Results imply a systematic pattern for the investors' valuation for liquidity services which points to the existence of a demand curve for liquidity.

The remainder of this paper is organized as follows. Section 2 describes the model set-up and derives yield spread regression models. Section 3 provides results for empirical tests of the model-implied hypotheses. Section 4 offers concluding remarks.

2. Theoretical Framework

Testable corporate-Treasury yield spread regression models are derived from a theoretical framework which extends the standard asset pricing model by the concept of convenience yields. This approach is proposed by KVJ which is based on a the notion of a money-in-the-utility preference specification. Specifically, it is assumed that convenience yields as a function of Treasuries and some broad measures for the economy's wealth enter the utility function as a separate argument. I extend the asset-pricing model derived by KVJ by allowing for holdings of money, Treasuries and corporate debt securities to contribute to household's utility (Note 5). In a next step a theoretical asset-pricing model is derived from the household's optimization problem.

2.1 Utility Function

Under the assumption that investors value liquidity services a representative agent's utility function, fulfilling the Inada conditions, is of the form:

$$u_t = u\left(c_t, v\left(\Theta_t, X_t, \xi_t\right)\right), \qquad (1)$$
$$\text{with } \Theta_t = \Theta\left(m_t, b_t, s_t\right)$$

The argument c_t is the agent's consumption at date t and $v(\,)$ denotes the agent's gained convenience yield which is a function of a set of macroeconomic factors, denoted as X_t, and $\Theta(\,)$, a yet unspecified aggregator function of the real holdings of money m_t, Treasuries b_t, and corporate debt securities s_t. The term ξ_t is a preference shock which is intended to capture level-effects on the utility derived from asset holdings during times when exogenous shocks like a financial crisis, temporarily changes investors' valuation for liquidity services (Note 6).

Following KVJ the convenience yield function $v(\,)$ is assumed to capture unique services provided by liquid assets and a set macroeconomic factors which are valued by investors, where $v(\,)$ is concave with $v'(\,)>0$, and $v''(\,)<0$. For the purpose of the present study I follow KVJ by assuming that X_t is mainly driven by the U.S. Gross Domestic Product (GDP). Further, $v(\,)$ shall be homogeneous of degree one in GDP_t and Θ_t. Hence, $v(\,)$ can be transformed in the following manner:

$$v\left(\Theta_t, GDP_t, \xi_t\right) \equiv v\left(\frac{\Theta_t}{GDP_t}, \xi_t\right) GDP_t. \qquad (2)$$

For simplicity, I further assume that for the unknown liquidity services aggregator function $\Theta(\cdot)$:

$$\frac{\Theta_t}{GDP_t} = \Theta\left(\frac{m_t}{GDP_t}, \frac{b_t}{GDP_t} \frac{s_t}{GDP_t}\right). \qquad (3)$$

The liquidity services function is concave as well, as I assume that $\Theta(\,)$ is increasing in θ_t/GDP_t, with $\theta_t=\{m_t, b_t, s_t\}$, but the marginal benefit from holding another unit of liquid assets is decreasing in θ_t/GDP_t. This captures the idea that holding more liquidity services providing assets reduces the marginal value of an extra unit of such assets. Further, $v(\,)$ shall have the property of $\lim_{\theta_t/GDP_t \to \infty} v'\left(\Theta_t/GDP_t, \xi_t\right) = 0$. Hence, the marginal value of a unit of θ_t/GDP_t approaches zero if the agent is holding a large amount of liquidity services providing assets. Moreover, under the hypothesis that investors value liquidity, holding one more unit of an asset that is more liquid compared to another asset should c.p. generate more utility than holding one more unit of the latter, therefore:

$$\frac{\partial\Theta(\cdot)}{\partial m_t} > \frac{\partial\Theta(\cdot)}{\partial b_t} > \frac{\partial\Theta(\cdot)}{\partial s_t}$$

KVJ point out that Treasuries with a high maturity length carry a higher interest rate risk and default risk compared to Treasuries with a short maturity length. Further, one could argue that Treasury bonds are less liquid than Treasury bills which is the reason that the interest rate on the latter carries a liquidity premium. Therefore, the investors' perceived benefit in terms of utility from holding "short-term" Treasuries might differ from the benefit of holding "long-term" Treasury bonds. Hence, the marginal liquidity services of holding an additional unit of Treasury bonds will differ from the additional liquidity services of holding an additional unit of Treasury bills. This should be reflected in the true but unspecified parameterizations of $v(\,)$, and $v(\,)$. However, for this study it is sufficient to use this general specification to motivate the empirical analysis.

2.2 Household's Problem

A representative household is assumed to maximize the expected sum of a discounted stream of utilities

$$E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t, v\left(\Theta\left(m_t, b_t, s_t\right), GDP_t, \xi_t\right)\right), \tag{4}$$

subject to the budget constraint

$$P_t c_t + P_t^M m_t + P_t^T b_t + P_t^S s_t \le P_t y_t + P_t^M m_{t-1} + P_t^T b_{t-1} + P_t^S s_{t-1}\left(1-\delta_t\right), \tag{5}$$

where E_0 is the expectation operator conditional on the information set in the initial period and $\beta \in (0, 1)$, is the subjective discount factor. The household earns a real endowment income y_t and can carry wealth into the next period by investing into nominal holdings of money $P_t^M m_t$, Treasuries $P_t^T b_t$, and corporate debt securities $P_t^S s_t$. Assume for simplicity that the agent buys zero coupon discount bonds which pay out one unit of currency when being held to maturity (Note 7). The aggregate price level at date t is denoted by P_t. The nominal prices for one-period investments into money balances, Treasuries, and corporate debt securities are P_t^M, P_t^T, and P_t^S. Note that for the price of one unit of m_t it should hold that $P_t^M = 1$, which is one nominal unit of currency. An investment increases real holdings of convenience assets Θ_t by $\Theta'(\ )P_t^\theta/P_t$, where $P_t^\theta = \{P_t^M, P_t^T, P_t^S\}$. For a corporate debt security with face value of one the expected repayment is $(1-\delta_t)$ where δ_t is the expected default rate, which is $\delta_t = 0$, in the absence of default and $\delta_t > 0$, if there is default on the bond.

Maximizing the objective function (4) subject to the budget constraint (5) leads for given initial values and non-negativity constraints for m_t, b_t, and s_t, to the following first order conditions for consumption c_t, and investments into money balances m_t, Treasuries b_t, and corporate bonds s_t:

$$u'\left(c_t, v(\cdot)\right) = \lambda_t, \tag{6}$$

$$\lambda_t \frac{1}{P_t} = u'\left(c_t, v(\cdot)\right) v'\left(\frac{\Theta_t}{GDP_t}, \xi_t\right) \frac{\partial \Theta(\cdot)}{\partial m_t} \frac{1}{P_t} + \beta E_t\left[\lambda_{t+1} \frac{1}{\lambda_{t+1}}\right], \tag{7}$$

$$\lambda_t \frac{P_t^T}{P_t} = u'\left(c_t, v(\cdot)\right) v'\left(\frac{\Theta_t}{GDP_t}, \xi_t\right) \frac{\partial \Theta(\cdot)}{\partial m_t} \frac{P_t^T}{P_t} + \beta E_t\left[\lambda_{t+1} \frac{P_{t+1}^T}{\lambda_{t+1}}\right], \tag{8}$$

$$\lambda_t \frac{P_t^S}{P_t} = u'\left(c_t, v(\cdot)\right) v'\left(\frac{\Theta_t}{GDP_t}, \xi_t\right) \frac{\partial \Theta(\cdot)}{\partial m_t} \frac{P_t^S}{P_t} + \beta E_t\left[\lambda_{t+1} \frac{P_{t+1}^S}{\lambda_{t+1}}\right], \tag{9}$$

and (5) holding with equality, and the transversality conditions $\lim_{j\to\infty} \beta^j E_t\left(\lambda_{t+j} P_{t+j}^M m_{t+j}\right) = 0$, $\lim_{j\to\infty} \beta^j E_t\left(\lambda_{t+j} P_{t+j}^T b_{t+j}\right) = 0$, and $\lim_{j\to\infty} \beta^j E_t\left(\lambda_{t+j} P_{t+j}^S s_{t+j}\right) = 0$. Define the stochastic discount factor for nominal payoffs as $M_{t+1} = \beta u'\left(c_{t+1}, v(\cdot)\right) / u'\left(c_t, v(\cdot)\right) P_t / P_{t+1}$, so that, similar to KVJ, equations (7)–(9) can be expressed as

$$P_t^M = 1 = \frac{E_t\left[M_{t+1}\right]}{1 - v'\left(\Theta_t / GDP_t, \xi_t\right) \partial \Theta(\cdot) / \partial m_t}, \tag{10}$$

$$P_t^T = \frac{E_t\left[M_{t+1} P_{t+1}^T\right]}{1 - v'\left(\Theta_t / GDP_t, \xi_t\right) \partial \Theta(\cdot) / \partial b_t}, \tag{11}$$

$$P_t^S = \frac{E_t\left[M_{t+1} P_{t+1}^S \left(1-\delta_{t+1}\right)\right]}{1 - v'\left(\Theta_t / GDP_t, \xi_t\right) \partial \Theta(\cdot) / \partial s_t}. \tag{12}$$

Equations (10)–(12) require that under the assumption of liquidity services being an argument of the investor's utility function, increasing the amount of liquidity services providing assets held, will decrease their prices P_t^M, P_t^T, and P_t^S. Specifically, increasing the holdings of liquidity services providing assets will lower the investor's willingness to pay for another unit of such assets. This is basically due to the assumption of $v(\ )$ and $\Theta(\ )$ being concave functions of m_t, b_t, and s_t. Further note, that by assuming $\partial \Theta(\cdot)/\partial m_t > \partial \Theta(\cdot)/\partial b_t > \partial \Theta(\cdot)/\partial s_t$, increasing the amount of m_t held should decrease liquidity services providing assets' prices P_t^M, P_t^T, and P_t^S stronger than increasing the amounts of b_t and s_t held. As a unit of money balances is assumed to provide more liquidity services than a unit of Treasuries or corporate debt securities, increasing the holdings of money lowers the investor's willingness to pay for another unit of liquidity services to a stronger extent, than increasing the holdings of Treasuries and corporate debt securities by the same amount. The same reasoning analogously holds for increasing the amount of b_t compared to increasing s_t. Therefore, one can interpret $\Theta'()$ as a demand function for a certain feature of assets, namely their degree of liquidity. Further, the model implies that $P_t^M = 1 > P_t^T > P_t^S$, if c.p. holdings of m_t, b_t, and s_t are of the same size. Actually one would expect to find exactly this pattern for the assets' prices for most of the observations within the time period under consideration.

2.3 Corporate-Treasury Yield Spread Model

In the following section the asset pricing model which was derived under the assumption that liquidity services are valued by investors is employed to explain spreads between the yields of corporate debt securities and U.S. Treasuries. This is done along the lines of KVJ. The goal is to obtain a model of spread determinants which can be empirically tested for its ability to explain observed corporate-U.S. Treasury yield spreads by using regression analysis.

Following KVJ and Elton (2001) (Note 8) the τ-period yields for U.S. Treasury debt securities $i_{t,\tau}^T$, and for corporate debt securities $i_{t,\tau}^S$ are computed by:

$$i_{t,\tau}^T = -\frac{1}{\tau}\ln P_t^T \text{, and } i_{t,\tau}^S = -\frac{1}{\tau}\ln P_t^S,$$

Where τ is the number of periods to maturity. By this, the price of a zero coupon bond is converted into a continuously compounded zero coupon bond yield. Therefore, for discount bonds with $P_\tau^T = P_\tau^S = 1$, the corporate-Treasury yield spread for securities with any number of periods to maturity τ, can be expressed as:

$$i_{t,\tau}^S - i_{t,\tau}^T = \frac{1}{\tau}\left(\ln P_t^T - \ln P_t^S\right). \tag{13}$$

Now plug in (11) for P_t^T, and (12) for P_t^S

$$\begin{aligned} &= \frac{1}{\tau}\left(\ln\left(\frac{E_t[M_{t+\tau}]}{1-\nu'(\cdot)\partial\Theta(\cdot)/\partial b_t}\right) - \ln\left(\frac{E_t[M_{t+\tau}(1-\delta_{t+\tau})]}{1-\nu'(\cdot)\partial\Theta(\cdot)/\partial s_t}\right)\right) \\ &\approx \frac{1}{\tau}\left(E_t[M_{t+\tau}] + \nu'(\cdot)\partial\Theta(\cdot)/\partial b_t - E_t[M_{t+\tau}(1-\delta_{t+\tau})] - \nu'(\cdot)\partial\Theta(\cdot)/\partial s_t\right) \end{aligned}. \tag{14}$$

This approximation uses that $\ln(1+x)\approx x$, for small x. This approximation is regarded as sufficiently accurate to describe the corporate-Treasury yield spread model. Define the corporate-Treasury yield spread as $\Delta i_{t,\tau} = i_{t,\tau}^S - i_{t,\tau}^T$, and rearrange

$$\Delta i_{t,\tau} = \frac{1}{\tau}E_t[M_{t+\tau}]E_t[\delta_{t+\tau}] + \frac{1}{\tau}\text{cov}_t(M_{t+\tau}, \delta_{t+\tau}) + \frac{1}{\tau}\nu'\left(\frac{\Theta_t}{GDP_t}, \xi_t\right)\left(\frac{\partial\Theta(\cdot)}{\partial b_t} - \frac{\partial\Theta(\cdot)}{\partial s_t}\right). \tag{15}$$

As Collin-Dufresne, Goldstein and Martin (2001) point out, most empirical studies on determinants of corporate-Treasury bond yield spreads seek to find suitable proxies for the first two terms on the right hand side of equation (15). These models are generally derived from the standard approach of the Asset Pricing Theory's CCAPM. The first and the second term on the right hand side of (15) account for the factors that should implied by the CCAPM model drive corporate-Treasury yield spreads. The first term on the right-hand side of (15) reflects the expected losses in case of default on commercial papers and corporate bonds. The common label for this expression is "expected default losses". A higher expected probability of default in the business sector, leads investors to demand a higher premium or discount on prices for corporate debt securities, and hence to a higher yield spread relative to Treasuries. The second term on the right-hand side reflects the so called "risk premium" which is related to variation in default probabilities. This premium investors demand, reflects in how far expected default rates covary with expected levels of the agent's marginal utility of consumption. The third term on the right hand side of (15) appears due to the modification of the standard asset pricing model by the assumption that investors value assets' liquidity services. This term, which captures the marginal utility of holding another unit of money m_t, Treasuries b_t, and corporate bonds s_t, is a spread determinant which is not implied by the CCAPM. Due to the assumption that an additional unit of m_t offers more liquidity services than holding an additional unit of b_t and s_t, and that an additional unit of b_t offers more liquidity services than s_t, increasing the investors' holdings of m_t, b_t, and s_t should decrease bond yield spreads with the following ordering of their marginal impacts

$$\left|\frac{\partial \Delta i_t(\cdot)}{\partial m_t}\right| > \left|\frac{\partial \Delta i_t(\cdot)}{\partial b_t}\right| > \left|\frac{\partial \Delta i_t(\cdot)}{\partial s_t}\right|.$$

For this model I assume that the shock parameter ξ_{t} captures so called "flight-to-liquidity" episodes and a securities' market-liquidity related risk premium. The term "flight-to-liquidity" was coined by Longstaff (2004) who defines this as an episode where one can observe on the markets, that some participants suddenly prefer to hold highly liquid securities, such as U.S. Treasuries rather than less liquid securities like corporate bonds and commercial papers. Therefore, in a flight-to-liquidity episode, investors will have an increased willingness to pay for another unit of b_t which will drive up Treasury prices and in turn decrease their yields and hence, decrease spreads relative to yields on corporate debt securities. Following Amihud, Mendelsen and Pedersen (2005) time-varying changes in an asset's market liquidity, like an increase of the time span of a transaction, as well as increasing bid-ask-spreads, contribute to make future expected payment streams risky. This is denoted as "liquidity risk" which would lead to a market-liquidity induced risk premium. For example, in times when investors would like to sell and the market liquidity of a corporate bond deteriorates, risk averse investors will demand a liquidity-risk premium for holding these bonds. Flight-to-liquidity episodes and market-liquidity related risk premia can therefore be interpreted as temporary shocks affecting investors' marginal convenience yields $v'(\,)$.

2.4 Estimation Strategy

The empirical part of this paper follows the lines of KVJ by estimating regression models derived from equation (15). This is done by using Ordinary Least Squares (OLS) (Note 9). As pointed out by Longstaff, Mithal and Neiss (2005), empirical studies relying on regression models which are derived from the standard CCAPM approach, find an unexplained share within corporate-U.S. Treasury yield spreads, the so called "nondefault" component. The purpose of this analysis is to investigate whether the third term on the right-hand side of equation (15), can contribute to explain the observed nondefault component. Further, the present analysis poses a test of the hypothesis that liquidity services, which are assumed to be provided by a certain group of assets, are valued by investors. Specifically, I investigate whether investors' valuation for liquidity services is priced within corporate-U.S. Treasury yield spreads while controlling for proxies of spread determinants which are commonly used in the literature. On the one hand, these measures are basically intended to proxy for the spread determinants implied by the standard CCAPM model. These are namely the risk premium and the premium required to compensate for expected losses in case of default (Note 10). On the other hand, I employ proxies which have been used in recent studies to capture market-liquidity related risk premia and flight-to-liquidity episodes (Pflueger & Viceira, 2011 and Longstaff, 2004) (Note 11). This is done for different yield spread measures as dependent variables, namely for a spread between yields on corporate debt securities and Treasuries with short maturities and a spread between yields of such securities with long maturities. In the following, I will refer to the former as the short-term spread and to the latter as the long-term spread.

The first part of the empirical analysis employs regression models based on the following specification:

$$\Delta i_t^{s,l} = \alpha + \beta_{1\theta} \log\left(\frac{\theta_t}{GDP_t}\right) + \beta_2 Vola_t + \beta_3 Slope_t + \varepsilon_t. \tag{16}$$

Following KVJ the regression model (16) is estimated for a long-term spread and a short-term spread as dependent variables. The dependent variable $\Delta i_t^{s,l}$ in each of the corporate-Treasury spread regressions, is a monthly yield spread measured in percentage points and ε_t denotes an error term (Note 12). The long-term spread Δi_t^l is the difference between an index number on Aaa-rated long maturity corporate bond yields and an index on long maturity Treasury yields. The short-term spread Δi_t^s is the spread between a commercial paper yield index and a Treasury bills yield index. The third term on the right hand side of (15) is for the regression model (16) captured by the log of θ_t/GDP_t, with $\theta_t = \{m_t, b_t, s_t\}$. The variable m_t/GDP_t is proxied by the empirical measure for the holdings of money balances, which is the monetary base aggregate, scaled by U.S. GDP. The correspondent proxy is denoted as MB_t/GDP_t. Following KVJ the variable b_t/GDP_t is proxied by the face value of the outstanding stock of U.S. Treasuries, which is scaled by U.S. GDP, and is named as $Debt_t/GDP_t$. The face value of corporate bonds and commercial papers outstanding, scaled by U.S. GDP, is the proxy for s_t/GDP_t. It is denoted as CD_t/GDP_t. Following KVJ a log functional form is used because it provides a good fit and requires estimation of only one parameter (Note 13). Further, the interpretation of a regression coefficient for a log independent variable, which is expressed as a share, on a dependent variable denoted in percentage points is more convenient.

To control for the premium associated with the expected default losses, which is captured by the first term on the right-hand side of (15), I follow KVJ and use a measure for stock return volatility, named *Vola*. The volatility measure for a given month is computed as the standard deviation of weekly log returns on the value-weighted S&P 500 index up to the end of a month. Then, this is multiplied by the square root of 4 to derive the standard deviations on a monthly basis. The proxy *Vola* is commonly used in the corporate finance literature as a measure for aggregate expected default losses as Collin-Dufresne, Goldstein and Martin (2001) point out. An increased stock market volatility is generally regarded as implying an increasing probability of defaults in the economy's private firms sector. Hence, investors will demand a higher premium for holding corporate debt securities. Therefore, one can expect corporate-Treasury yield spreads to increase with *Vola*.

To proxy for the risk premium, which is captured by the second term on the right-hand side of (15), I follow KVJ by employing the slope of the yield curve. The proxy *Slope* is measured as the spread between the 10-year U.S. Treasury yield and the 3-month U.S. Treasury yield. As Collin-Dufresne, Goldstein and Martin (2001) point out, the slope of the yield curve is regarded as a measure for the state of the business cycle. KVJ assert that the slope of the yield curve is known to predict the excess returns on stocks and captures time-varying risk premia on corporate bonds. For example, if investors are more risk averse in a recession, when *Slope* is high, they will demand a higher risk premium for holding corporate bonds. Thus, the slope of the yield curve serves as a measure for the variation in the risk premium component of the bond spread, i.e., the term involving $cov_t()$ in (15). Further, KVJ note that to the extent that corporate default risk is likely to vary with the business cycle, the Slope variable can furthermore contribute to control for the default risk in the yield spread.

By estimating (16) the present study is intended to test the following hypotheses:

Hypothesis 1.

The yield spread model (15) requires that an increase in the proxies for the holdings of liquidity services providing assets, MB_t/GDP_t, $Debt_t/GDP_t$, and CD_t/GDP_t decreases the observed spread measures.

Hence, the regression results would provide support in favour of the yield spread model (15) if point estimates for the coefficients would imply that $\beta_{1\theta}<0$.

A priori, one can assume that the three groups of assets under consideration can be ordered in the following manner, by their postulated degree of liquidity services provision:

MB_t/GDP_t most liquid

$Debt_t/GDP_t$

CD_t/GDP_t least liquid

Hypothesis 2.

Further, the yield spread model (15) implies that c.p. increasing the proxy for the holdings of the most liquid asset will decrease spreads to a larger extent than increasing the proxy for the holdings of the least liquid asset. Therefore, empirical evidence in favour of the yield spread model (15) would require $|\beta_{1m}|>|\beta_{1b}|>|\beta_{1s}|$.

Testing both hypotheses is done by estimating whether changes in the aggregate holdings of assets that are presumed to bear less or more liquidity services than Treasuries will drive spreads in the predicted way. Therefore, I test whether an increase in the holdings of assets that are more (less) liquid than Treasuries reduces observed spreads to a stronger (weaker) extent than an increase in the holdings of Treasuries.

The second part of the empirical analysis employs regression models based on the following specification:

$$\Delta i_t^{s,l} = \alpha + \beta_{1\theta} \log\left(\frac{\theta_t}{GDP_t}\right) + \beta_2 Vola_t + \beta_3 Slope_t + \beta_4 ASW_t + \beta_5 Agency_t + \varepsilon_t \cdot \tag{17}$$

Longstaff (2004) provides evidence for a "flight-to-liquidity" premium in the prices for U.S. Treasuries. This is captured by the spread between yields of bonds issued by Resolution Funding Corporation (Refcorp), a U.S. government agency which is guaranteed by the Treasury, and U.S. Treasury bonds. By full repayment being guaranteed, Refcorp bonds therefore have literally the same default risk as Treasuries. Since Treasuries are more liquid and more popular than Refcorp bonds, a widening (deterioration) of this yield spread reflects investors' preference to hold more (less) highly liquid assets. The reason behind such changes in preferences lies in changing conditions of financial markets, e.g. financial market turmoil would suddenly increase investors' preference for highly liquid assets. Therefore, I use the spread between Refcorp bond yields and U.S. Treasury bond yields to control for flight-to-liquidity episodes. This variable is named *Agency*.

To proxy for market-liquidity related risk premia I follow Pflueger and Viceira (2011) by employing the difference between asset-swap spreads (*ASW*) for corporate debt securities and Treasury securities. Consider an investor owning a bond and entering into an asset swap contract. The payer of the bond cash flows can hedge by holding the bond and financing the position on the short term debt market. Hence, the asset-swap spread reflects the current and expected financing costs of holding the long bond position. Therefore, the difference between the asset-swap spreads for corporate bonds, and commercial papers resp., and Treasuries, is a measure for the relative cost of financing a long position in the corporate debt securities market versus financing a long position in the Treasuries market. A widening of this difference indicates a decreasing relative liquidity of corporate debt securities. Hence, an increase in *ASW* should have a positive impact on corporate-Treasury yield spreads.

Inclusion of those two proxies to the estimation model is actually not backed by the theoretical yield spread model (15). Both covariates are intended to measure an asset's degree of market liquidity. Therefore, they are in a certain way different from the proxies for the holdings of liquidity services providing assets which are employed for the present asset pricing model. The purpose of including these two new controls into the regression model is to investigate whether estimations are robust across the specifications (16) and (17), specifically with regard to the coefficients on the measures for the holdings of liquidity services providing assets. If Hypothesis 1 and Hypothesis 2 are not rejected for estimation model (17) this would provide further support in favour of the modified asset pricing model which assumes investors to value liquidity services. Hence, the following hypothesis can be derived:

Hypothesis 3.

Adding proxies to the estimation model which control for securities' market-liquidity risk and flight-to-liquidity premia (ASW, Agency), will not change the model-implied restrictions on the estimated coefficients and their required ordering: $\beta_{1\theta} < 0$ *and* $|\beta_{1m}| > |\beta_{1b}| > |\beta_{1s}|$.

To retain comparability of empirical results, the same data as in KVJ are used for the construction of model variables (Note 14). Differently from KVJ, for the present study I use data at a monthly frequency. Increasing the number of observations within the data set will make regression results more precise and more sound. Further, the use of monthly data is expected to lead to a stronger emphasis of coefficients measuring market volatility. Therefore, if the estimated impact of the U.S. Debt-to-GDP ratio on corporate-Treasury yield spreads is robust across annual and monthly data, this would pose evidence in favor of the present approach. Further to note is that short-term and long-term spreads might not be in the same way affected by changes of the proxies described above. Hence, estimated coefficients on the logs of θ_t/GDP_t might differ between the regression models with Δi_t^s and Δi_t^l as dependent variables. Note that short-term and long-term spreads are different price measures. Therefore investors might have a different valuation for the spread determinants when pricing long-term and short-term assets. Therefore, different estimated coefficients on the logs of θ_t/GDP_t for short-term and long-term spreads, point to the existence of a differently priced value of short-term and long-term liquidity services. Note that the present asset pricing model still leaves open the possibility for such a specification of $v(\ )$ and $\Theta(\ )$.

3. Empirical Results

Since data on the securities' market-liquidity related risk measure *ASW* and on the measure for flight-to-liquidity episodes *Agency* are only available from 1987 onwards, the empirical results are split into two parts: In the first part the standard CCAPM implied credit spread regression model is augmented by the measures for the holdings of liquidity services providing assets. The dependent variables are long-term and short-term bond yield spreads. For that estimation monthly time series data are employed ranging from April 1971 to September 2008. This data sample is chosen for the estimation as it covers a period with a presumably constant pattern in investors' tastes, and as it leaves out the recent financial market turmoil. In the second part of the empirical study the covariates *ASW* and *Agency* are included where only a short-term yield spread is the dependent variable (Note 15). To derive monthly GDP data I used a cubic spline interpolation on the time series of quarterly U.S. GDP.

Further note that for Tables 1-4 I report t-statistics with adjusted standard errors, after finding an AR(1), AR(2), and AR(3) error structures in most regressions. Following KVJ the AR(n) structure is motivated by a standard Box-Jenkins analysis of the autocorrelation function and partial autocorrelation function of the error terms. The first-order AR coefficients for each estimation are presented in the correspondent tables. Serial correlation is especially pronounced in the long-term spread regressions. I use the Newey-West estimator to correct the t-statistics and standard errors for autocorrelation in the error terms.

3.1 Impact of Liquid Asset Supply Changes on Price Measures

Table 1 presents results for estimating (16) with the long-term spread and the short-term spread being regressed on the measure for Treasury holdings, log($Debt_t/GDP_t$), the measure for expected default losses, *Vola*, and the proxy for the risk premium, *Slope*. A constant term is included as well. This estimation model basically reproduces KVJ. However, the present study uses monthly data. Panel A summarizes the coefficient estimates for the long-term spread as dependent variable, which is in this case the spread between the yields on Aaa-rated corporate bonds and the yields on U.S. Treasury bonds. The mean value of the Aaa-Treasuries spread is at 96 basis points (bp) for the period from April 1971 to September 2008. The coefficient of -0.784 on the log($Debt_t/GDP_t$) variable implies that a decrease of one standard deviation in the Debt-to-GDP ratio, from its mean value of 0.498 to 0.364, increases the Aaa-Treasury spread on average by 25 bp. This is consistent with Hypothesis 1 and statistically significant. From the perspective of the asset pricing model (15) one would argue that such a decrease in liquid asset holdings increases the investors' valuation, or willingness to pay, for liquidity services. Note that KVJ find for the same time period with annual data an average increase of 22 bp. Further, Vola is found to be significantly related to the spread. The magnitude of the correspondent regression coefficient β_2 implies that expected default losses are an important driver of long term bond spreads. While KVJ estimate for a one standard deviation increase in their default risk measure, an increase of 10 bp in the Aaa-Treasuries spread, the present study implies an increase by 13 bp and a regression coefficient of 5.588 (Note 16). Though, evidence presented in Panel A of Table 1 indicates that Slope does not exhibit a significant impact on the Aaa-Treasuries spread.

In Panel B of Table 1 results are shown for estimating the regression model (16) with a short-term bond spread as dependent variable. This spread is the difference between the yields of highest rated commercial paper and Treasury bills, both with 3-month maturity length. Changing holdings of liquidity services providing assets might be priced differently within short-term and long-term spreads. Hence, it should not be expected to find estimated coefficients on log($Debt_t/GDP_t$) to be the same across the two panels. Nonetheless, the effect of changes in aggregate Treasury holdings on the short-term spread is estimated to be of fairly similar magnitude as the effect on long-term spreads. The mean value of the commercial paper-Treasury bills spread is at 62 bp for the period from April 1971 to September 2008. A decrease of one standard deviation in the Debt-to-GDP ratio from its mean, is found to increase the commercial paper-Treasury bills spread on average by 22 bp. Compared to that KVJ estimate an average increase of 23 bp. Further, this study finds evidence for a statistically significant impact of Vola on short-term spreads. An increase of *Vola* by one standard deviation increases the spread by 13 bp. KVJ however, find no significant effect of their default risk measure on short-term spreads for annual data within the period from 1969 to 2007. Panel B further shows that the measure for the risk premium *Slope* exhibits a significant but rather small impact on the commercial paper-Treasury bills spread (Note 17).

Table 1. Impact of Treasury supply on corporate-U.S. treasury yield spreads

Period	Apr 1971–Sep 2008	
	Panel A: Aaa-Treasury	Panel B: CP-Bills
log(Debt/GDP)	-0.784	-0.620
	[-7.596]	[-8.732]
Volatility	5.588	5.819
	[4.005]	[6.567]
Slope	0.006	-0.136
	[0.327]	[-8.825]
Intercept	0.387	0.156
	[5.319]	[2.790]
R^2	0.419	0.350
Durbin-Watson	0.282	0.536
ρ	0.646	0.658
N	453	453

Note. t-statistics with adjusted standard errors are reported in the brackets. AR(n) structures are found by a standard Box-Jenkins analysis of the autocorrelation function and partial autocorrelation function of the error terms. The first-order AR coefficients for each OLS estimation are denoted as ρ. The Newey-West estimator is employed to correct the t-statistics and standard errors for autocorrelation in the error terms.size.

The estimation results presented in Table 1 imply that Hypothesis 1 can not be rejected. This poses evidence in favor of the predictions made by the theoretical pricing model (16). Prior results by KVJ can therefore be regarded as confirmed. Increasing the number of observations, by changing the data frequency from an annual basis to a monthly basis, leads for the same sample period to similar results regarding the estimated coefficients on log($Debt_t/GDP_t$), and *Vola*. Note that for monthly data the nondefault component proxied by the Debt-to-GDP ratio, as well as the default risk component proxied by stock market volatility, play a more pronounced role compared to the estimation with annual data.

Table 2 presents results for estimating (16) with the long-term spread as the dependent variable. In the first column estimated coefficients for the regression of the AAA-Treasury yield spread on log(CD_t/GDP_t), *Vola* and *Slope* are shown. In the second column estimation output is shown for the regression model where the log($Debt_t/GDP_t$) regressor replaces the proxy for the holdings of corporate debt securities. Note that for reasons of comparability of results, here the same information as in Table 1, Panel A is provided. Results presented in the third column refer to the estimation where the proxy for money balances, log(MB_t/GDP_t), replaces the former proxies for liquidity services providing assets. The corporate-Treasury yield spread model described in Section 2 implies that under the hypothesis of liquidity services being a priced attribute, estimated coefficients should in absolute terms be ordered by $|\beta_{1m}|>|\beta_{1b}|>|\beta_{1s}|$. This is basically outlined by Hypothesis 2.

Table 2. Impact of MB/GDP, Debt/GDP, CD/GDP on Aaa-Treasury yield spread

Period	Apr 1971–Sep 2008			Apr 1971–Jan 2006
	(1)	(2)	(3)	(4)
log(MB/GDP)			0.303	
			[1.122]	
log((M3-M2)/GDP)				-1.718
				[-4.018]
log(Debt/GDP)		-0.784		
		[-7.596]		
log(CD/GDP)	-0.277			
	[-4.369]			
Volatility	6.544	5.588	6.337	5.879
	[4.803]	[4.005]	[4.596]	[4.007]
Slope	-0.017	0.006	-0.027	-0.038
	[-0.799]	[0.327]	[-1.309]	[-1.767]
Intercept	-0.741	0.387	1.846	1.399
	[-1.902]	[5.319]	[2.329]	[2.352]
R^2	0.288	0.458	0.140	0.240
Durbin-Watson	0.287	0.282	0.225	0.239
ρ	0.589	0.646	0.611	0.615
N	453	453	453	418

Note. *t*-statistics with adjusted standard errors are reported in the brackets. AR(n) structures are found by a standard Box-Jenkins analysis of the autocorrelation function and partial autocorrelation function of the error terms. The first-order AR coefficients for each OLS estimation are denoted as ρ. The Newey-West estimator is employed to correct the *t*-statistics and standard errors for autocorrelation in the error terms.size.

In Table 2 the coefficient on the proxy for the aggregate holdings of corporate debt securities is estimated to be in absolute terms smaller than the coefficient on the proxy for the aggregate Treasuries holdings. This result is in line with Hypothesis 2. The coefficient implies an increase of 7 bp in the Aaa-Treasuries yield spread due to a decrease of the corporate debt-to-GDP ratio by one standard deviation from its mean value. However, the coefficient on log(MB_t/GDP_t) is found to be insignificant while the regression model has a relatively low R^2. Finding an insignificant coefficient on the proxy for money balances does not seem to support the model implication that changes in the holdings of assets that should deliver more liquidity services than Treasuries will cause a stronger impact on long-term bond spreads than changes in holdings of the latter. However, with regard to their long runtime, Treasury bond holdings and corporate bond holdings are generally motivated by matching investor's long-term objectives. In contrast to that the investor's decision regarding holdings of money balances is affected by short-term investment objectives. Hence, for these two groups of assets there are different underlying investment motives. As pointed out by KVJ, assets do not only may provide liquidity services to a different degree, there might also be a difference between short-term and long-term liquidity services. Therefore, it should not be surprising that the estimated effect of changing money holdings on the long-term spread is insignificant. Including a different measure for the most liquid assets, namely the difference of M3-M2 scaled by GDP, instead of monetary base scaled by GDP, yields a regression coefficient which is in line with Hypothesis 2. Column 4 of Table 2 reports an estimated coefficient of -1.718 on the measure $\log((M3_t\text{-}M2_t)/GDP_t)$ which implies an average increase in the Aaa-Treasuries spread by 75 bp following a decrease in the M3-M2-to-GDP ratio by one standard deviation from its mean value (Note 18). Note that M3-M2 covers the positions of large time deposits, institutional money market funds, repurchase agreements and other larger liquid assets. Investors hold these highly liquid near money assets mostly for long-term investments horizons. Hence, the insignificance of $\log(MB_t/GDP_t)$ seen against the background of evidence presented in the fourth column of Table 2, points to a difference between long-term and short-term liquidity services. Further, this would imply the existence of market segmentation for long-term and short-term liquidity services providing assets. All other variables included in the regression models, but the four discussed here, provide roughly the same evidence as explained in the paragraph above.

Table 3 presents results for estimating (16) with the short-term spread as the dependent variable. In Column 1 of Table 3 output is reported for the regression of the short-term spread on the $\log(CD_t/GDP_t)$, *Volatility* and *Slope* measures. In Column 2 the proxy for the aggregate holdings of corporate debt securities is replaced by the proxy for the holdings of Treasury debt, $\log(Debt_t/GDP_t)$, and in Column 3 by the proxy for money balances, $\log(MB_t/GDP_t)$. Results presented in Table 3 are in line with Hypothesis 1 and Hypothesis 2. Further, the results are statistically significant. Specifically, it is found that $|\beta_{1m}|>|\beta_{1b}|>|\beta_{1s}|$. Expressed in terms of basis points, coefficients imply a 26 bp, 22 bp, and 5 bp increase of the commercial paper-Treasury bills spread by decreasing the correspondent asset-to-GDP ratios by a one standard deviation from their means. Further, comparing the magnitudes of the coefficients on the proxies for money holdings in column 3 and 4 with the accordant results from Table 1, there is further support for the implication of market segmentation and differently priced short-term and long-term liquidity services. Coefficients on $\log((M3_t\text{-}M2_t)/GDP_t)$ and $\log(MB_t/GDP_t)$ imply that changes in the holdings of long-term near money assets do not cause such a strong impact on short-term yields as changes in the base money measure. All other variables included here, again provide the same evidence as explained in the paragraphs above.

Table 3. Impact of MB/GDP, Debt/GDP, CD/GDP on CP-Bills yield spread

Period	Apr 1971–Sep 2008			Apr 1971–Jan 2006
	(1)	(2)	(3)	(4)
log(MB/GDP)			-1.267	
			[-4.216]	
log((M3-M2)/GDP)				-0.254
				[-4.096]
log(Debt/GDP)		-0.620		
		[-6.101]		
log(CD/GDP)	-0.198			
	[-4.672]			
Volatility	6.581	5.819	7.339	5.748
	[3.828]	[3.482]	[4.202]	[2.799]
Slope	-0.155	0.136	-0.158	-0.177
	[-5.941]	[-5.709]	[-5.856]	[-6.139]
Intercept	-0.607	0.156	-3.085	0.132
	[-2.456]	[2.462]	[-3.509]	[1.120]
R^2	0.288	0.350	0.308	0.295
Durbin-Watson	0.521	0.536	0.566	0.486
ρ	0.646	0.658	0.624	0.674
N	453	453	453	418

Note. *t*-statistics with adjusted standard errors are reported in the brackets. AR(n) structures are found by a standard Box-Jenkins analysis of the autocorrelation function and partial autocorrelation function of the error terms. The first-order AR coefficients for each OLS estimation are denoted as ρ. The Newey-West estimator is employed to correct the *t*-statistics and standard errors for autocorrelation in the error terms.size.

Table 4 reports results for estimations of (17) which include the market-liquidity risk measure and the measure for flight-to-liquidity episodes. The dependent variable is the short-term spread. The data sample covers the period from April 1987 to September 2008. In Column 1 estimated coefficients of the commercial paper-Treasury bills yield spread regression on log($Debt_t/GDP_t$), *Vola*, *Slope* and a constant are shown. Column 2 reports results for an estimation where the covariates *Agency* and *ASW* are added to the regression model. In the same manner, regressions are estimated for specifications of (16) and (17) that employ log(CD_{t}/GDP_{t}) and log(MB_{t}/GDP_{t}) instead of log(Debt_{t}/GDP_{t}). Accordant results are summarized in Columns 3 and 4, and Columns 5 and 6.

Table 4. Impact of MB/GDP, Debt/GDP, CD/GDP on CP-Bills yield spread

Period	Apr 1987 – Sep 2008					
	(1)	(2)	(3)	(4)	(5)	(6)
log(MB/GDP)			-2.313	-0.953		
			[-8.713]	[-4.356]		
log(Debt/GDP)	-1.495	-0.379				
	[-5.077]	[-3.436]				
log(CD/GDP)					-1.029	-0.068
					[-6.908]	[-1.430]
Volatility	2.862	2.104	4.007	2.459	5.216	2.737
	[1.916]	[3.266]	[3.711]	[3.822]	[4.671]	[4.646]
Slope	-0.050	0.077	-0.045	-0.054	-0.069	0.079
	[-2.734]	[5.240]	[-3.156]	[3.549]	[-4.788]	[5.342]
ASW		1.095		0.945		1.146
		[9.094]		[9.658]		[13.609]
Agency		-0.209		-0.161		-0.227
		[-12.144]		[-8.190]		[-13.331]
Intercept	-0.301	-0.175	-6.204	-2.534	-1.170	-0.198
	[-2.064]	[-1.320]	[-8.192]	[-4.092]	[-4.977]	[-0.716]
R^2	0.287	0.671	0.505	0.715	0.402	0.684
Durbin-Watson	0.396	0.762	0.610	0.862	0.547	0.816
ρ	0.762	0.602	0.685	0.566	0.679	0.535
N	258	258	258	258	258	258

Note. t-statistics with adjusted standard errors are reported in the brackets. AR(n) structures are found by a standard Box-Jenkins analysis of the autocorrelation function and partial autocorrelation function of the error terms. The first-order AR coefficients for each OLS estimation are denoted as ρ. The Newey-West estimator is employed to correct the t-statistics and standard errors for autocorrelation in the error terms.size.

Comparison of estimated coefficients on the proxies for money balances, Treasury holdings and the holdings of corporate debt securities in columns 1, 3, and 5, indicates that the ordering of $|\beta_{1m}|>|\beta_{1b}|>|\beta_{1s}|$ is preserved for the shorter data sample. Including the liquidity-risk proxy *ASW*, and the proxy for flight-to-liquidity episodes *Agency*, yields for all regression models statistically significant regression coefficients β_4, and β_5, with the expected signs. For the regression results reported in Column 2 of Table 4, where log($Debt_t/GDP_t$) is included as a covariate, an increase of *ASW* by one standard deviation from its mean of 0.441 to 0.644, increases the short term yield spread on average by 22 bp. This confirms the view that an investors' demanded market-liquidity related risk premium is an important driver of the commercial paper-Treasury bill spread. Further, if the measure *Agency* increases by one standard deviation from its mean of 1.054 to 1.997, the short-term spread decreases by 20 bp, which provides evidence for a flight-to-liquidity premium in the commercial paper-Treasury bill spread. The corresponding estimated effects implied by the regression output presented in the fourth column of Table 4 are 23 bp and 21 bp, and for the output depicted in Column 6 I calculate 20 bp and 15 bp. Compared to the results shown in columns 1, 3, and 5, coefficients of the proxies for Treasury holdings, money balances and the holdings of corporate debt securities decrease sharply. The sizes of coefficients now imply that decreases of the correspondent measure by one standard deviation from its mean value, increase spreads by only 3, 8, and 1 bp (Note 19). This implies that in regression models which exclude measures for securities' market-liquidity risk and flight-to-liquidity episodes, the coefficients on the proxies for liquidity services providing assets capture sizeable information which should actually be attributed to the former measures. However, seen against the background of the commercial paper-Treasury bills spread's mean being at 46 bp for the period of April 1987 to September 2008, still priced liquidity services can be regarded as a significant driving force. In addition to that, the model-implied ordering of estimated coefficients is still preserved with $|\beta_{1m}|>|\beta_{1b}|>|\beta_{1s}|$, while controlling for market-liquidity risk and flight-to-liquidity episodes. Hence, one can regard Hypothesis 3 to be not rejected. Further, R^2 measures for all three regression models rise to values of roughly 0.8, and Durbin-Watson statistics increase significantly by including market-liquidity risk measures and measures for flight-to-liquidity episodes. This points to a better model fit and a lager share of the spread's variance being explained by the regression models. Therefore, one can argue that the present study yields a significant contribution to explain the nondefault component which appears to be found within corporate-Treasury yield spreads.

4. Conclusion

This paper provides evidence which supports the notion that the nondefault component within the corporate-Treasury bond yield spread is to a significant extent driven by the investors' valuation for liquid assets. Estimation results imply that changes in the aggregate holdings of assets that are presumed to provide less or more liquidity services than U.S. Treasuries will affect corporate-Treasury yield spreads in the way predicted by an asset pricing model which allows for holdings of liquid assets to contribute to investors' utility. Specifically, results imply that investors have a general valuation for asset's liquidity. Finding this systematic pattern points to the existence of a demand function for liquidity attributes. Several regression model specifications are estimated using different data samples and datasets where results are found to be robust. Estimation results show that investors price liquidity services separately from measures for credit risk, market-liquidity related risk, and flight-to-liquidity episodes. Moreover, results imply market segmentation for long-term and short-term assets as a difference in the valuation for long-term and short-term liquidity services points to the existence of different investment motives. Compared to commonly employed corporate-Treasury bond yield spread regression models, the present study uses model specifications which yield a better empirical fit and explain a lager share of the observed yield spreads' variation. Further, finding empirical evidence that liquidity services provision is priced by investors, poses a challenge to standard asset pricing theory models.

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References

Acharya, V. V., & Pedersen, L. H. (2005). Asset Pricing with Liquidity Risk. *Journal of Financial Economics, 77*(2), 375–410. http://dx.doi.org/10.1016/j.jfineco.2004.06.007

Amihud, Y., Mendelson, H., & Pedersen, L. H. (2005). Liquidity and Asset Pricing. *Foundations and Trends in Finance, 1*(4), 269–364. http://dx.doi.org/10.1561/0500000003

Bansal, R., & Coleman, W. (1996). A Monetary Explanation of the Equity Premium, Term Premium, and Risk-free Rate Puzzles. *Journal of Political Economy, 104*(6), 1135–1171. http://dx.doi.org/10.1086/262056

Chen, L., Lesmond, D., & Wei, J. (2007). Corporate Yield Spreads and Bond Liquidity. *Journal of Finance, 62*(1), 119–149. http://dx.doi.org/10.1111/j.1540-6261.2007.01203.x

Collin-Dufresne, P., Goldstein, R., & Martin, J. (2001). The determinants of credit spread changes. *Journal of Finance, 56*(6), 2177–2207. http://dx.doi.org/10.1111/0022-1082.00402

Cortes, F. (2003). Understanding and modeling swap spreads. *Bank of England Quarterly Bulletin*, Winter.

Delianedis, G., & Geske, R. L. (2001). *The components of corporate credit spreads: Default, recovery, taxes, jumps, liquidity, and market factors*. Working Paper. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=306479

Duffie, D., & Singleton, K. J. (1999). Modeling Term Structures of Defaultable Bonds. *The Review of Financial Studies, 12*(4), 687–720. http://dx.doi.org/10.1093/rfs/12.4.687

Duffie, D., & Singleton, K. J. (1997). An econometric model of the term structure of interest-rate swap yields. *Journal of Finance, 52*(4), 1287–1321. http://dx.doi.org/10.1111/j.1540-6261.1997.tb01111.x

Elton, E. J., Gruber, M., Agrawal, D., & Mann, C. (2001). Explaining the rate spread on corporate bonds. *The Journal of Finance, 56*(1), 247–277. http://dx.doi.org/10.1111/0022-1082.00324

Eom, Y. H., Helwege, J., & Huang, J. (2004). Structural models of corporate bond pricing: An empirical analysis. *Review of Financial Studies, 17*(2), 499–544. http://dx.doi.org/10.1093/rfs/hhg053

Gomes, F., & Michaelides, A. (2008). Asset Pricing with Limited Risk Sharing and Heterogeneous Agents. *Review of Financial Studies, 21*(1), 415–448. http://dx.doi.org/10.1093/rfs/hhm063

Gorton, G. (2010). *Slapped by the Invisible Hand: The Panic of 2007*. Oxford University Press.

Greenwood, R., & Vayanos, D. (2013). *Bond Supply and Excess Bond Returns*. Working Paper. Retrieved from http://personal.lse.ac.uk/vayanos/Papers/BSEBR_RFSf.pdf

Heaton, J., & Lucas, D. (1996). Evaluating the Effects of Incomplete Markets on Risk Sharing and Asset Pricing. *Journal of Political Economy, 104*, 443–487. http://dx.doi.org/10.1086/262030

Huang, J., & Huang, M. (2003). How much of the corporate-Treasury yield spread is due to credit risk? *Review of Asset Pricing Studies, 2*(2), 153–202. http://dx.doi.org/10.1093/rapstu/ras011

Krishnamurthy, A., & Vissing-Jorgensen, A. (2012). The Aggregate Demand for Treasury Debt*. Journal of Political Economy, 120*(2), 233–267. http://dx.doi.org/10.1086/666526

Krishnamurthy, A., & Vissing-Jorgensen, A. (2011). The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy. *Brookings Papers on Economic Activity, 43*(2), 215–287. http://dx.doi.org/10.1353/eca.2011.0019

Liu, J., Longstaff, A., & Mandell, R. (2006). The market price of risk in Interest Rate Swaps: The roles of default and liquidity risk. *Journal of Business, 79*(5), 2337–2360. http://dx.doi.org/10.1086/505237

Longstaff, F. A. (2004). The Flight-To-Liquidity Premium in U.S. Treasury Bond Prices. *The Journal of Business, 77*(3), 511–526. http://dx.doi.org/10.1086/386528

Longstaff, F. A., Mithal, S., & Neis, E. (2005). Corporate Yield Spreads: Default risk or Liquidity? New Evidence from the Credit Default Swap Market. *The Journal of Finance, 60*(5), 2213–2253. http://dx.doi.org/10.1111/j.1540-6261.2005.00797.x

Longstaff, F. A., & Schwartz, E. (1995). A simple approach to valuing risky fixed and floating rate debt. *Journal of Finance, 50*, 789–821. http://dx.doi.org/10.1111/j.1540-6261.1995.tb04037.x

Pflueger, C. E., & Viceira, L. M. (2012). *An Empirical Decomposition of Risk and Liquidity in Nominal and In.ation-Indexed Government Bonds*. Working Paper.

Poterba, J. M., & Rotemberg, J. J. (1986). *Money in the Utility Function: An Empirical Implementation*. NBER Working Paper 1796. Retrieved from http://www.nber.org/papers/w1796

Rocheteau, G. (2009). *A Monetary Approach to Asset Liquidity.* Working Paper. Retrieved from http://www.clevelandfed.org/research/workpaper/2009/wp0901.pdf

Sidrauski, M. (1967). Rational Choice and Patterns of Growth in a Monetary Economy. *American Economic Review, 57*(2), 534–544.

Swanson, E. (2011). A High-Frequency Event-Study Analysis of Operation Twist and Its Implications for QE2. *Brookings Papers on Economic Activity*, 151–188. http://dx.doi.org/10.1353/eca.2011.0006

Vayanos, D., & Villa, J. (1998). Equilibrium Interest Rate and Liquidity Premium With Transaction Cost. *Economic Theory, 13*, 509–539. http://dx.doi.org/10.1007/s001990050268

Notes

Note 1. For example flows into money market mutual funds.

Note 2. Following Amihud, Mendelson and Pedersen (2005) market liquidity refers not only to the ease of trading an asset but also to an asset's ability to be sold without having to accept a considerably large drop in the price or value. Therefore, in empirical studies bid-ask spreads are the commonly employed measures for an asset's degree of market liquidity.

Note 3. For an overview of regressions including standard controls see Collin-Dufresne, Goldstein and Martin (2001).

Note 4. The assumption of an asset's feature providing specific services which are valued by investors is reminiscent of the money-in-the-utility-function model. For a complete elaboration of the rationale for investors' valuation for liquidity see KVJ.

Note 5. This idea is based on Poterba and Rotemberg (1986) who use a utility function where so called liquidity services directly contribute to household's utility. The function's argument "liquidity services" is assumed to be a CES aggregate of demand deposits plus currency, short term savings deposits, and Treasury bill holdings.

Note 6. Longstaff (2004) finds evidence for what he calls „flight to liquidity/quality" premium episodes by examining the spread between government agency bonds and U.S. Treasury bonds. In a flight to liquidity episode market participants suddenly prefer highly liquid securities, such as Treasuries, rather than less liquid securities.

Note 7. Derivation of pricing expressions takes place for zero-coupon Treasury bonds and corporate bonds. In the empirical part coupon bonds are examined. However, KVJ argue that the impact of Treasury supply on coupon bond spreads is qualitatively similar to the effect on zero-coupon bond spreads.

Note 8. This is a simplified version of Duffie and Singleton (1999). Specifically, I neglect the "recovery of market value" in case of default. Therefore, I do not account for losses in case of default as a fractional reduction of the bond's market value. Further, KVJ point out that the method of Duffie and Singleton (1999) reflects the standard approach in the corporate bond pricing literature.

Note 9. OLS estimations are the common approach to analyze determinants of credit spreads in the empirical finance literature. See e.g. Collin-Dufresne, Goldstein and Martin (2001), Chen, Lesmond and Wei (2007), Eom, Helwege and Huang (2004), Longstaff (2004), Longstaff, Mithal and Neiss (2005).

Note 10. For the choice of proxies for the risk premium and the expected default losses I follow KVJ and the survey of Collin-Dufresne, Goldstein and Martin (2001).

Note 11. Note that due to data availability for these proxies the empirical study has to be divided into two parts.

Note 12. See Appendix A for data description.

Note 13. For quarterly and monthly time series data the Debt-to-GDP ratio is non-stationary but the log of the variable is stationary.

Note 14. Except for MB_t/GDP_t, CD_t/GDP_t *Agency*, and *ASW* as those proxies do not appear in KVJ.

Note 15. The covariates *Agency* and *ASW* are expected to capture effects which only affect asset prices in the short-run. In fact, regression results do not imply a significant impact on long-term spreads.

Note 16. For the 1971-2008 sample this study finds a mean value of 0.035 and a standard deviation of 0.023 for Volatility.

Note 17. These regressions were also conducted for quarterly data but are not provided for reasons of brevity. Results imply that a decrease in the Debt-to-GDP ratio by one standard deviation increases the long term spread by 26 bp and the short-term spread by 21 bp. An increase in Volatility by one standard deviation increases the long-term spread by 14 bp and the short-term spread by 17 bp.

Note 18. The last available observation on the M3 aggregate is January 2006.

Note 19. For the time period April 1987 to September 2008 the mean of $Debt_t/GDP_t$ is 0.603 with a standard deviation of 0.051. For the same period MB_t/GDP_t has a mean of 0.056 and a standard deviation of 0.005. The mean of CD_t/GDP_t is 0.225 and the standard deviation is 0.031.

Appendix A

Regression Variables

Aaa-Treasury yield spread: This variable is constructed as the monthly spread between Moody's Aaa-rated long maturity corporate bond yield and the average yield on long term Treasury bonds measured in percentage points. The Moody's Aaa index is constructed from a sample of long maturity ($\geq$ 20 years) industrial and utility bonds (industrial only from 2002 onward). The yield on long maturity Treasury bonds is the average yield on long-term government bonds. The Treasury bonds included are due or callable after 10 years for the period 1971–1999. For 2000–2008 the yields on 20-year maturity Treasuries are used. All three data series are from the Federal Reserve's FRED database (series AAA, LTGOVTBD, and GS20). Monthly data for April 1971 up to September 2008 is used leaving out the sub prime crisis market turmoil and fiscal and GDP response.

CP-Bills yield spread: The yield spread between commercial paper and Treasury bills measured in percentage points. For the whole period 1971–2008 the commercial paper yield is from the FRED database. The period 1971–1996 is covered by the series CP3M (the average of offering rates on 3-month commercial paper placed by several leading dealers for firms whose bond rating is AA or equivalent) and for 1997–2008 by the series CPN3M (the 3-month AA nonfinancial commercial paper rate). The Treasury bill yield is for 3-month Treasury bills from 1971–2008 (FRED series TB3MS).

Debt/GDP: This variable is intended to proxy the holdings of Treasuries scaled by GDP. This variable is calculated from April 1971 until September 2008. I use time series data on the total amount of Treasury securities outstanding from Datastream (series USSECMNSA). Quarterly GDP data is from Federal Reserve's FRED database (series GDP). To derive monthly GDP data I used a cubic spline interpolation on the time series of quarterly U.S. GDP. Unlike KVJ I do not calculate Debt/GDP at market value. However, KVJ show that over the period 1949–2008 the correlation between Debt/GDP at face value and Debt/GDP at market value is 0.992.

MB/GDP: This variable is intended to proxy for the holdings of money and close to money substitutes scaled by GDP. From FRED I use the series BOGAMBSL, "Board of Governors Monetary Base, Adjusted for Changes in Reserve Requirements". Therefore, notes and coins (currency) in circulation (outside Federal Reserve Banks, and the vaults of depository institutions), currency in bank vaults, and Federal Reserve Bank credit (minimum reserves and excess reserves) are included which is widely interpreted as base money or total currency. MB/GDP hence, is derived from the most liquid measure of money supply actually leaving out close to money assets like demand deposits and savings deposits.

(M3-M2)/GDP: This variable is intended to proxy for the holdings of long-term close to money substitutes, and long-term assets with the highest possible degree of liquidity, scaled by GDP. M3-M2 covers the positions of large time deposits, institutional money market funds, repurchase agreements and other larger liquid assets. Data on the two empirical measures for aggregate money supply M3, and M2 are from FRED (series M3SL and M2SL). Data for M3 is only available until February 2006. Hence, this variable is calculated for the period April 1971 until February 2006.

CD/GDP: This variable is intended to proxy for the holdings of corporate debt securities scaled by GDP. I use the FRED series CPLBSNNCB, "Commercial Paper-Liabilities-Balance Sheet of Nonfarm Nonfinancial Corporate Business", for the face value of outstanding commercial paper and the series CBLBSNNCB, "Corporate Bonds-Liabilities-Balance Sheet of Nonfarm Nonfinancial Corporate Business", for the face value of outstanding corporate bonds. The sum of both series is assumed to measure the total holdings of corporate debt securities.

Volatility: This measure is based on standard deviations of weekly log stock returns on the S&P 500 index. Weekly returns are calculated on the value-weighted S&P 500 index based on daily returns obtained from Federal Reserve's FRED database (series SP500). As a volatility measure for a given month, the standard deviation of the weekly log returns are calculated up to the end of the month. The standard deviation of weekly log returns is then multiplied by the square root of 4.

Slope: The slope of the Treasury yield curve measured as the spread between the 10-year Treasury yield and the 3-months Treasury bill yield. The interest rate on Treasuries with 10 year maturity is from FRED (series GS10). The interest rate on Treasuries with 3 month maturity is from FRED as well (series TB3MS).

ASW: The measure for the difference in asset-swap spreads between corporate debt securities and Treasury securities. From Datastream the time series ICUSS2Y is used which captures the asset-swap rate of benchmark securities over the 2-year Treasury rate.

Agency: This is the measure for the spread between yields of Refcorp and Treasury securities. Time series data on yields of Freddie Mac securities due after one year and yields on Treasuries with the same maturity length are from Datastream (series USMIA1 and FRTCM1Y).