Measuring Euro Area Government Bond Market Liquidity and its Asset Pricing implications

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Abstract

We study the contribution of liquidity to time-series dynamics and cross-sectional variations of Euro area sovereign bond yield spreads. We consider a large sample period covering both the global financial crisis and the European sovereign crisis. Using intraday trade and quote data we construct several alternative liquidity measures and study their contribution to yield spreads. When we control for standard risk factors, such as credit and term, liquidity does not provide a significant incremental explanatory contribution to the time-series dynamics of yields before the crisis period. Liquidity however becomes an important explanatory factor during the crisis period. In the cross-sectional analysis liquidity plays an important role in explaining yield spreads both before and during the crisis period. Amongst the various liquidity proxies the bid-ask spread consistently provides the largest incremental contribution to models for yield spreads.

JEL Classification: G01, G12, G15.

Keywords: Market Microstructure, Asset Pricing, Liquidity, Sovereign Debt Crisis.

1. Introduction

The price impact of liquidity during financial crises captured the attention of researchers, practitioners and policy makers alike. This paper studies the liquidity of the Euro zone government bond market using a comprehensive database, MTS Time Series, and a long sample covering a period of relative calm with converging Euro zone yields as well as the period of the financial and sovereign bond crises. We address the following questions: Does the role of liquidity in explaining government bond yields changes during crisis periods? How do we measure government bond liquidity? Is liquidity risk priced in government bond yield spreads?

Despite the strong agreement on the importance of liquidity in explaining the cross-section of equity returns (Pastor and Stambaugh (2003), Acharya and Pedersen (2005) and Sadka (2006)), bond yields (Flaming and Remolona (1999), Chordia, Sarkar, and Subrahmanyam (2005), Green, Li, and Schürhoff (2010), Bao, Pan, and Wang (2011), and Dick-Nielsen, Feldhütter and Lando (2012)) as well as carry trade returns in the foreign exchange market (Mancini, Ranaldo and Wrampelmeyer, 2012), there is no clear consensus on how to measure liquidity.

Liquidity has many dimensions such as breadth, depth and resilience and hence numerous liquidity proxies have been proposed in the literature (Fleming 2003). Some are indirect measures, constructed from bond characteristics, and some are direct measures, constructed using trade and quote data. We study bond's characteristics such as *bond's age, number of market participants, number of committed market makers* and we employ transaction level data to compute a series of additional liquidity measures such as *bid-ask spread, depth, order book slope, number of quote revisions, trade frequency, trade volume* and *Amihud's liquidity*. After controlling for standard bond market factors, we identify the liquidity measures that best explain both time-series and cross-sectional variations in bond yield spreads.

We also investigate whether there is a common component underlying all liquidity proxies (Korajczyk and Sadka (2007) and study whether the first *principal component* (PC) extracted from all our liquidity proxies is priced in the bond yield spreads.

This paper makes an important contribution by evaluating the relative importance of aforementioned liquidity measures in explaining both the time series dynamics and cross sectional variation of bond yield spreads before and during crisis periods. For the time-series analysis, we use the Fama and French (1993) two-factor bond market model (FF2, here onwards) in order to control for other sources of risk such as default risk and interest rate risk.

Even though the FF2 model is widely used in pricing defaultable corporate bonds, we apply it to sovereign bonds because of the heightened default risk in the Euro area during the sovereign debt crisis. Following Houwelling, Mentink and Vorst (2005), we augment the FF2 model with liquidity proxies and study the incremental contribution of each liquidity proxy in explaining the variation of bond excess yields over time after controlling for standard risk factors and bond characteristics. However, instead of including bond characteristics in the model as in Houwelling et al. (2005), we construct *rating-duration* sorted portfolios as suggested in Gebhardt *et al.* (2005) in order to simultaneously control for credit rating, maturity and coupon. The methodology of portfolio formation is explained in detail in the later sections.

The key empirical findings of our paper are as follows. Prior to the 2007 crisis, we find no clear evidence of pricing effect for our liquidity proxies across all the bond portfolios. This can be explained by the highly liquid markets and converging yields enjoyed by many countries in the Euro area from 2000 to 2007. The situation changes sharply during the debt crisis with liquidity drying up due to growing concerns of solvency risks in Greece, Portugal, and Ireland. Liquidity becomes an important priced factor during the crisis period for AA and A rated bonds but not for the high rated, AAA bonds. In spite of the growing fears about the liquidity contagion amongst the institutional investors, high rated bonds retain the tag of *'safe-havens'*. Two liquidity proxies, the *bid ask spread* and *Amihud's liquidity*, are consistently important for explaining the variation of yield spreads of AA and A rated bonds. The bid ask spread has an incremental contribution to the adjusted R-squared of the model for the short-term yield spreads of 17% for the A rated and 36% for the AA rated bonds, respectively. Similarly, *Amihud's liquidity* has an incremental contribution to the adjusted R-squared of the model for the short term yield spreads of 16% for the AA rated and 25% for the A rated bonds, respectively.

In order to test the importance of liquidity at an individual bond level we perform cross sectional regressions of individual bond yield spreads on liquidity proxies after controlling for bond characteristics such as rating/CDS spreads, age and duration as in Bao *et al* (2011). Seven out of eleven liquidity proxies are able to explain the cross sectional variation of bond yield spreads both before and during the crisis periods. During the crisis period, the *Bid-Ask Spread* emerges as the clear winner, exhibiting the highest explanatory power across all the duration shorted bond portfolios, with time series adjusted R-squared of 56% for short term, 67% for medium term and 77% for long term bonds. *Depth, order book slope, Amihud liquidity, number of quote updates, number of market participants* follow *bid ask spread* in the liquidity horse race. Using evidence from the sovereign crisis in the Euro area bond markets, our results help researchers and policy makers to better understand the impact of bond market microstructure on yield spreads and guide effective liquidity management programmes.

This paper is organized as follows. Section 2 presents the literature on liquidity measurement and its asset pricing implications. Section 3 describes the microstructure of MTS trading platform. Section 4 describes the data and the filters used while constructing various liquidity proxies. Section 5 briefly introduces the liquidity proxies. Section 6 explains the empirical methodology of portfolio construction, provides summary statistics, and stylized facts on the variables used in the empirical analysis, introduces the model and discusses the estimation results for portfolio time series and individual cross sectional regressions of bond yields on various liquidity proxies. Section 7 concludes.

2. Related Literature

Measuring liquidity

Liquidity is the ease with which securities can be bought and sold without affecting prices. Investors demand higher compensation to bear the transaction costs that arise when it is difficult to search for the buyers/sellers in the market, when there is no sufficient trading volume available at the desired price level (Demsetz (1968), Amihud and Mendelson (1986)). Unlike in equities, liquidity in fixed income markets traditionally has been measured in terms of bond characteristics such as *Issue Size* (Garbade and Silber (1976)), and *Age* (Sarig and Warga (1989)). The literature[1] proposes an additional liquidity indicator based on bond yield differential. Bond yields in excess of the risk-free rate can be explained as the sum of credit and liquidity components. The credit component compensates the bond investor for the risk of default of the bond's issuer. The liquidity component compensates the investor for the risk of being unable to liquidate a position in the bond. Researchers have developed methods for estimating the liquidity component of bond yields. The most popular approach (Goldreich, Hanke and Nath (2005), Pasquariello and Vega (2009)) relies on comparing the yields of two bonds with the same credit component as on-the-run and off-the-run government bonds issued by the same country or government and quasi-government bonds with government guarantees.[2]

Liquidity and asset pricing

Favero *et al.* (2010) advance a brief overview of different channels of impact of liquidity on asset returns. 1) *Transaction cost view*: Investors demand more compensation to hold illiquid stocks that have high transaction costs. In other words, the liquidity level, as a proxy for transaction costs is priced in the expected stock returns 2) *Liquidity Risk View*: Illiquidity

[1] See for example Amihud and Mendelson (1991), Kamara (1994), Krishnamurthy (2002), Pasquariello and Vega (2009).
[2] Longstaff (2004) and Schwarz (2010).

itself is a source of risk due to the uncertainty in the transaction costs over time. Investors fear holding illiquid securities due to high price sensitivity of these securities to a drop in market wide liquidity whose timing is unpredictable. In this paper we closely follow transaction cost view in explaining the importance of liquidity. Advocating the *Transaction cost view*, Amihud (2002) shows that liquidity helps explain the cross section of stock returns once controlling for market beta, size, dividend yield and stock return volatility. Brennan and Subrahmanyam (1996) find positive and significant relationship between required rate of stock returns and illiquidity costs after adjusting for Fama and French (1993) factors. Gebhardt *et al.* (2005) adopt a similar portfolio methodology in corporate bond markets to note that default betas are significantly related to the cross section of bond returns even after controlling for bond characteristics such as duration and rating. Houweling, Mentink and Vorst (2005) follow Gebhardt *et al.* (2005) in investigating the relative importance of various liquidity measures. Bao, Pan and Wang (2011) find that illiquidity of corporate bonds is substantial and significantly greater than what can be explained by bid-ask spreads. Instead of using indirect noisy measures of liquidity we construct liquidity measures directly from transaction data. Dick-Nielsen, Feldhutter and Lando (2012) evaluate the relative importance of liquidity level and liquidity risk in explaining the expected corporate bond returns before and after the subprime crisis. Our study also focuses on evolution of liquidity before and after the crisis periods (subprime and sovereign debt).The aforementioned studies on liquidity and asset pricing are all based on corporate bond markets but surprisingly very few papers are based on Euro area sovereign bond markets. Beber, Brandt and Kavajecz (2009) analyse the Euro area sovereign yield spreads and find that both liquidity and credit quality are important but in times of market stress investors chase liquidity more. Favero, Pagano and von Thadden (2010) find that the impact of liquidity on yield differentials is less in the absence of investment opportunities as investors' demand for liquidity is eclipsed by the perceived aggregate investment risk. Both papers study yield spreads before the crisis and the state of the market changed to a great extent especially after 2007. Our paper covers a more recent and larger data set from 2004 to 2010.

3. Microstructure of Euro area government bond markets: MTS

MTS market is the largest electronic fixed income interdealer wholesale market in Europe. MTS (*Mercato dei Titoli di Stato*) was created in 1988 by the Bank of Italy and the Italian Treasury as an electronic platform for the secondary trading of Italian government securities. In 1999, a platform for trading benchmark fixed-income securities, EuroMTS, was created. As of 2012 MTS trades bonds of the following countries: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, the Netherlands, Portugal, Slovenia, Spain, the United Kingdom as well as Israel. The microstructure of the European government bond market is presented in Cheung, de Jong and Rindi (2005), Dunne, Moore and Portes (2006). Traders with access to both local and EuroMTS platforms ensure there are no price discrepancies between two parallel platforms trading the same bond. For bonds trading in parallel on a local MTS market and the EuroMTS market, market makers can post quotes simultaneously to both platforms. MTS operates a centralized limit order book for each platform. Once a proposal is received, MTS sorts buy and sell proposals according to price/time priority and then publishes the best quotes on either side of the market. Trades are executed when proposals are either hit by incoming orders or matched with opposite-side proposals.

Each MTS platform has two types of participants: market makers and market takers. Institutions must satisfy strict requirements about traded volumes and net asset values to qualify as market makers. Market makers are assigned a subset of securities for which they have to post two-sided quotes called *proposals.* Market makers must commit to provide firm quotes for a minimum time during the trading day, for a maximum spread, and for minimum quantities ranging from €2.5 to €10 million, depending on the maturity and benchmark status of the instrument. Market makers can post quotes for any other security trading on a particular platform. In this case, they are not subject to quoting obligations. For bonds trading in parallel on a local MTS market and the EuroMTS market, market makers can post quotes simultaneously to both platforms. Besides posting proposals, or limit orders, market makers can also submit liquidity-consuming market orders. Market takers must use market orders and trade against the best available quotes. They have no obligation to buy or sell at the posted quotes. Before execution of a trade, MTS keeps identities of traders anonymous. Once the trade has been executed, MTS reveals the counterparty for clearing and settlement purposes. Counterparties will never know each other if a centralized counterparty is used.

4. Data

We use a large sample of Euro-area sovereign fixed-coupon bearing bonds for the period from January 2004 to July 2010. We exclude inflation linked, quasi government and covered bonds from our sample. The data are extracted from the MTS Time Series database, which provides quote and trade data and records every change to the best three bids and ask quotes. The sample covers 11 countries (Austria, Belgium, Germany, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal, and Spain). Table 4.1 provides the distribution of bonds across the various countries and years. France and Italy have the largest number of bonds throughout the sample. Finland and Ireland have the lowest number of bonds. The number of bonds available in each year of the sample has grown from 260 bonds in 2004 to 310 bonds in 2010. For each bond in the sample we compute the yield from the daily mid-price of the best bid and ask prices observed at the end of day (5:00 PM CET).

Table 4.1 Distribution of Number of bonds across Euro area from 2004 to 2010

	No of Bonds						
	2004	2005	2006	2007	2008	2009	2010*
Total #bonds	260	285	289	283	295	306	310
Austria	13	14	15	16	16	17	17
Belgium	22	23	22	22	23	23	25
Germany	28	35	39	42	45	46	46
Spain	29	29	28	26	28	31	33
Finland	9	9	10	9	9	10	10
France	48	50	52	51	54	50	51
Greece	22	25	25	27	27	28	28
Ireland	5	5	5	6	7	11	11
Italy	54	51	50	49	49	52	51
Netherlands	25	27	26	24	21	22	22
Portugal	5	17	17	16	16	16	16
Total #Obs(millions)	727.30	656.45	627.22	679.19	897.26	913.13	227.04

Empirical market microstructure studies commonly require a series of preliminary steps to prepare the data for analysis. Coluzzi et al. (2008) and Dufour and Nguyen (2008) provide guidelines for using MTS data, and Fleming and Mizrach (2009) carefully describe U.S. government bond data. The sample data employed for the analysis presented in this chapter are prepared using the following steps.

- First, consider only quotes recorded during the regular trading hours from 8:15 AM until 5:30 PM Central European Time (CET).
- Second, assign the same time stamp to quotes simultaneously submitted to parallel platforms for the same bond, with the same price, and recorded within 3 milliseconds of each other to account for latency issues.
- Third, compute the best bid and ask quotes across parallel platforms by constructing a consolidated order book.
- Fourth, discard quotes with either negative or extremely large bid-ask spreads Negative spreads appear with consolidated quotes when prices of parallel platforms

temporarily diverge from each other. No trades are executed when spreads are extremely large.

To determine the maximum tradable spread within a year, we conduct a thorough empirical analysis of tick-by-tick bid ask spreads of all the bonds in the data sample. First, we group bonds for each country into different maturity categories (1.5y to 2.5y, 2.5y to 3.5y, 4.5y To 5.5y, 6.5y to 7.5y, 9.5y to 10.5y, 14.5y to 15.5y and finally 25.5y to 31.5y). The rationale behind such a granular maturity structure is to closely examine even the minor discrepancies in the bid-ask spreads of the bonds of various maturities. Every year for each group of bonds, we observe the empirical frequency distribution of the tradable spreads, defined as the bid ask spreads that are recorded immediately before a trade. For each year, and for each maturity group we construct 10 bins of tradable spreads(bps) ranging from [0 10],[10 20],[20 50],[50 70],[70 100],[100 500],[500 1000],[1000 2000],[2000 10000],[>10000]). The maximum tradable spread is the bid-ask spread within which 99.9% of the trades are executed for a maturity group in a year. Spreads larger than the maximum tradable spreads are classified as extremely large and discarded. The maximum tradable spreads of all the bonds below 10years are significantly lower than that of all the bonds above 10 years. Also, within each of the two groups (maturities below 10 years and above 10 years), we find little cross sectional variation of the maximum tradable spreads of individual bonds and hence we use only use two groups for employing the data filtering: 1) **S**: Short and Medium term bonds (all bonds with maturity below 10 years) and 2) **L**: Long term bonds (all bonds with maturity above 10Y). The year-wise, maturity-wise and country-wise maximum tradable spreads are provided in table 8.3 enclosed in the appendix. The maximum tradable bid ask spread of all the bonds in our sample from 2004 to 2006 is 50bps above which removes less than 0.1% of executed trades. However, with the onset of the subprime crisis in 2007, the maximum tradable spread reaches 70bps for the long term bonds. The period from 2008 to 2010 that covers both the Lehman

Brothers bankruptcy and the Euro sovereign debt crisis, reports maximum tradable spreads ranging from 100bps to 500bps. However the bid ask spreads in AAA rated countries such as Germany, Finland, France, Netherlands remain relatively small, ranging from 50bps to 150bps. During the crisis period, the bonds of the low rated countries such as Portugal, Ireland, Greece and Spain feature maximum tradable spreads ranging from 200bps to 500bps. Italy is the only exception with bid ask spreads remaining within 150 bps even during the crisis period and despite being a low rated country. The filters implemented in this paper never discard more than 0.1 percent of best quote updates.

5. Liquidity Measures

Our paper proposes an extensive list of liquidity proxies that capture the breadth, depth and resiliency aspects of liquidity to a large extent. We use *bid-ask spread*, a widely accepted illiquidity proxy associated with breadth (Fleming (2003), Beber et al. (2009), Dufour and Darbha (2012)) is calculated as the difference between the best ask quote and the best bid quote divided by the mid-point of the bid and ask quotes posted by liquidity providers. Market makers cover the transaction costs arising due to adverse selection, inventory risk, competition, search costs by quoting wide bid-ask spreads. We also use d*epth,* defined as the average of best bid and ask quantities available on the limited order book. Engle *et al.* (2012) model the dynamics of depth in US treasury markets to study the relationship between liquidity and volatility.

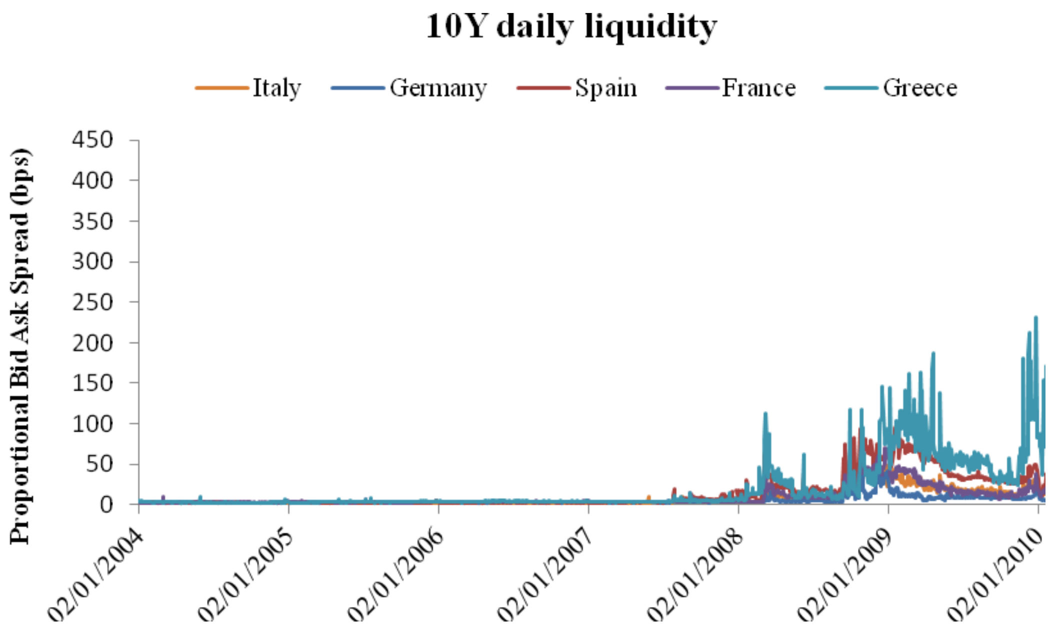
We also use *order book slope, a* hybrid measure that captures the joint effect of breadth and depth aspects of liquidity. *Order book Slope* is a precise estimate of the elasticity, $\frac{\partial q}{\partial p}$, defined as ratio of change in quantity supplied q, to the changes in prices p at all levels of the order book as suggested by Naes and Skjeltorp (2006). Our next proxy for liquidity is the *Number of quote updates*, calculated as the number of changes within a day for the best mid-quote. Market Makers with subjective evaluations of the true price of the asset indicate their interest in trading by continuously revising the bid-ask quotes submitted to the limit order book (Kavajecz and Odders-White, 2001; Chung et al., 2004). The impact of Number of quote updates on bond yields can be attributed to 1) high participation of liquidity providers leading to frequent quote revision and subsequently competitive bid and ask quotes improving liquidity and 2) information asymmetry.

Our liquidity proxies *trade volume* and *trade frequency* that are constructed from the actual trade data have been widely used in the literature (Benston and Hagerman (1974), Stoll (1978)). Trading volume indicates trading activity and has direct relationship with liquidity in the market. However, the only drawback with trade volume is that it also increases with volatility, which adversely affects liquidity. Markets with low transaction costs attract more and more trades and traders find it profitable to execute small trades by breaking a huge trade into many small trades, leaving a minimal market impact. Hence, in addition to trading volume, we also observe trade frequency. In order to address the resiliency aspect of liquidity we include in our list of liquidity proxies, *Amihud liquidity*, a measure of price impact of trade. *Amihud* (Amihud, 2002) is constructed by taking the ratio of absolute change in the stock price after a trade to the trade size. Acharya and Pederson (2005) use this measure to price the impact of level of liquidity and liquidity risk in asset returns.

We also use the bond characteristic, *age*, as another proxy for liquidity. Sarig and Warga (1986) propose that the most recently issued bonds are more desirable because they have higher liquidity than other bonds in the same maturity category. The main explanation for this effect is the liquidity of a particular issue decreases with the age of the bonds as increasingly buy and hold investors place the bonds in their portfolios with the aim of holding them until maturity, which effectively reduces the bonds available for trading in the secondary market. Dufour and Nguyen (2012) show that on-the-run bonds provide a greater contribution to the price discovery process. We identify a pair of liquidity proxies: *number of market participants* and *number of committed market makers* associated with the institutional structure of MTS in Euro area bond markets. These proxies capture the effect of competition faced by liquidity providers. *Committed Market makers* not only can provide liquidity by posting quotes but also can take liquidity by trading against prevailing quotes posted by their competitors where as *Market participants* (or price takers) can only hit prevailing quotes.

We investigate the presence of a single underlying fundamental liquidity measure common to the above described liquidity proxies. We follow Korajczyk and Sadka (2007) and extract the first *principal component* of all the 10 liquidity proxies to investigate the pricing impact of the composite liquidity measure. The implementation details of all the above liquidity proxies are enclosed in the Appendix 8.1. We plot the long term (10Y) daily liquidity time series for Germany, France, Greece, Italy and Spain in the Figure 6.2.1. Prior to 2007, the long term bonds of the above mentioned countries, having residual time to maturities near to 10Y, exhibit minimal differences and remain highly liquid. With the onset of credit crisis in 2007-2008, the long term bonds in Spain and Greece become relatively illiquid with respect to Germany, France and Netherlands. We present the portfolio liquidity analysis conducted at a monthly level, in the later sections.

Figure 6.2.1 Daily Liquidity series for long term bonds (10Y).



6. Empirical Methodology

We present two models for estimating the impact of liquidity on excess bond yields. First, we investigate how much variation of bond yields is explained by each liquidity measure in time series after controlling for default and interest rate risk, using the Fama and French two factor model (1993). Second, we perform cross sectional regressions of individual bond yields on each liquidity measure as suggested by Fama and Macbeth (1973).

For investigating the dynamic interaction between excess yields and liquidity proxies we take a portfolio approach recommended by Gebhardt *et al.* (2005). Since Gebhardt *et al.* (2005) find significance of factor loadings even after controlling for bond characteristics, we sort bond portfolios by specific bond characteristics and perform time series regressions of portfolio excess yields on the two common risk factors. We first construct bi-variate characteristic sorted portfolios by grouping individual bonds into buckets according to credit rating and modified duration as described in the next sub section.

6.1 Portfolio construction

For constructing *rating* sorted bond portfolios, we use credit ratings supplied by *Fitch* for the 11 countries in the Euro area. We transform the credit ratings from AAA to BBB- into a numerical scale of 1 to 9 in the same order. A high numerical value maps to low credit rating and vice versa. Sovereign bonds of Euro area countries exhibit heterogeneity in credit rating even though they all have a common currency. Prior to the subprime-crisis, the majority of the bonds in Euro area are rated either AAA or AA/AA- as reported by *Fitch*. During the debt crisis, Greece, Ireland experience downgrades in credit ratings ranging from A- to BBB-. However Germany, Finland, Netherlands and France retained the AAA rating. Thus every month we sort the bonds into three rating groups 1) AAA and 2) AA(includes AA+/AA/AA-) and 3) A (includes A+/A/A-/BBB+/BBB-) This method of sorting bonds with similar default probabilities into three groups controls for the credit risk. Another important bond characteristic is bond's modified duration (duration) that serves as a good proxy for term or interest rate risk. Bonds within each *rating* sorted portfolio are again grouped into three portfolios, Short, Medium and Long, by first sorting the bonds using the previous month's average modified duration and then grouping the sorted bonds into three baskets with an equal number of bonds in each duration sorted portfolio. The yields of bonds that are near maturity tend to be noisy. So we include only those bonds which have at least 6 months of time to maturity. As a result, we attain 9 *rating-duration* sorted portfolios which are re-balanced every month. Prior to the crisis, on average, each portfolio contains 35 bonds for AAA, 19 bonds for AA, 6 bonds for A *rating-duration* sorted portfolios. The number of bonds available in each *rating-duration* sorted portfolio drops significantly during the crisis, with 30 bonds in AAA, 11 bonds in AA and 4 bonds in A categories. For each individual bond, yield spread is obtained by taking the difference between monthly bond yield (observed at end of the month to avoid endogeneity of yields with liquidity proxies) and monthly 3-month Euro bench mark zero coupon yield published by European Central bank (ECB). To obtain portfolio level liquidity proxies, every month we first compute the time series average of daily liquidity proxy for each individual bond. We then compute the equally weighted cross sectional average of individual average liquidity proxy (computed in the previous step) within each rating-duration sorted portfolio separately. Similarly the portfolio level yield spreads are obtained by taking the equally weighted cross sectional average of monthly yield spreads of each individual bond within a portfolio.

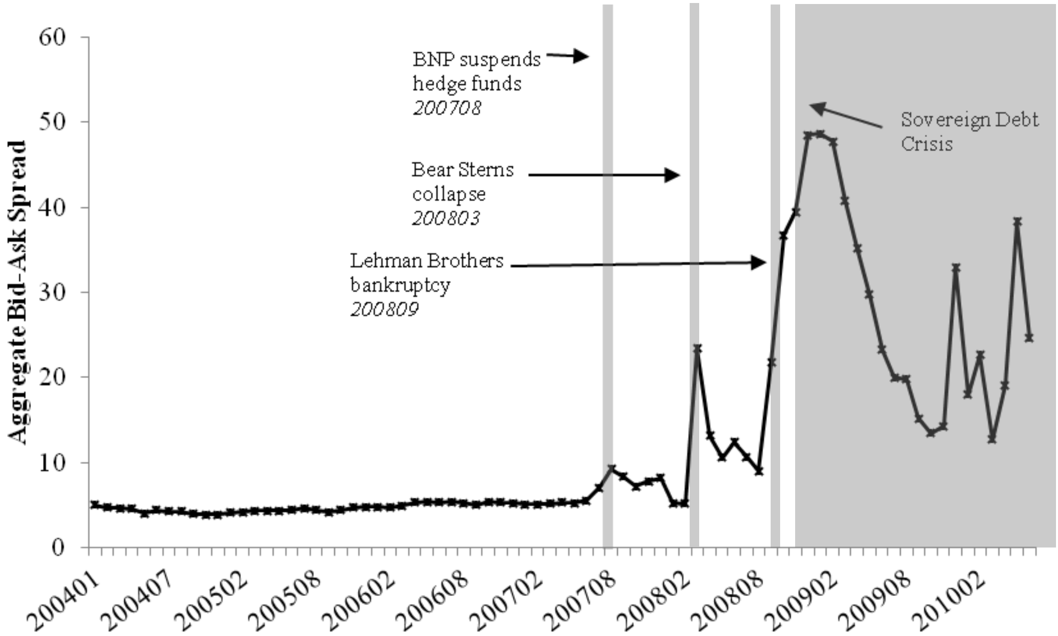
6.2. Stylized facts and Summary Statistics

We compute the average bid-ask spread, average depth and average bond price volatility[3] by taking respective cross sectional averages across 9 *rating-duration* sorted portfolios every month and plot these in Figure 6.2.2 to uncover the evolution of aggregate Euro area sovereign bond market liquidity before and during the subprime crisis and sovereign debt crisis. The plots in the Figure 6.2.2 contain jumps that coincide with the timing of the events during the subprime crisis and debt crisis. The beginning of sub-prime crisis is widely believed to be dated on 9th August 2007 when the French investment bank, BNP Paribas announced the suspension of valuation of three of its major hedge funds that invested in subprime mortgage debt. Surprisingly the Euro area bond yield spreads remain moderate until September 2008. This may be the result of market makers who have extrapolated the state of low macroeconomic volatility that was prevalent prior to the crisis. The impact of subprime crisis on liquidity and Euro area bond yield spreads intensifies in the later stages of the crisis with the collapse of Bear Sterns in March 2008 followed by the bankruptcy of Lehman Brothers in September 2008 and Sovereign debt crisis in early 2009. Bid-Ask spreads rose from on an average of 9bps in August 2008 to 21bps in September 2008 reaching an unprecedented high of 36bps in October 2008. Similar dynamics can also be observed in average depth in Panel B showing a large decline of €14 million after the Bear Sterns collapse in March 2008 and €11 million in September 2008 followed by further decline in early 2009. The average bond price volatility in Panel C rises to 20bps in March 2008 and peaks to an unprecedented high of 50bps in early 2009 during the onset of debt crisis. The Average yield spread of A rated bonds rises from 60bps in August 2008 to 100bps in September 2008 reaching the peak at 450bps in early 2010 as shown in Panel D.

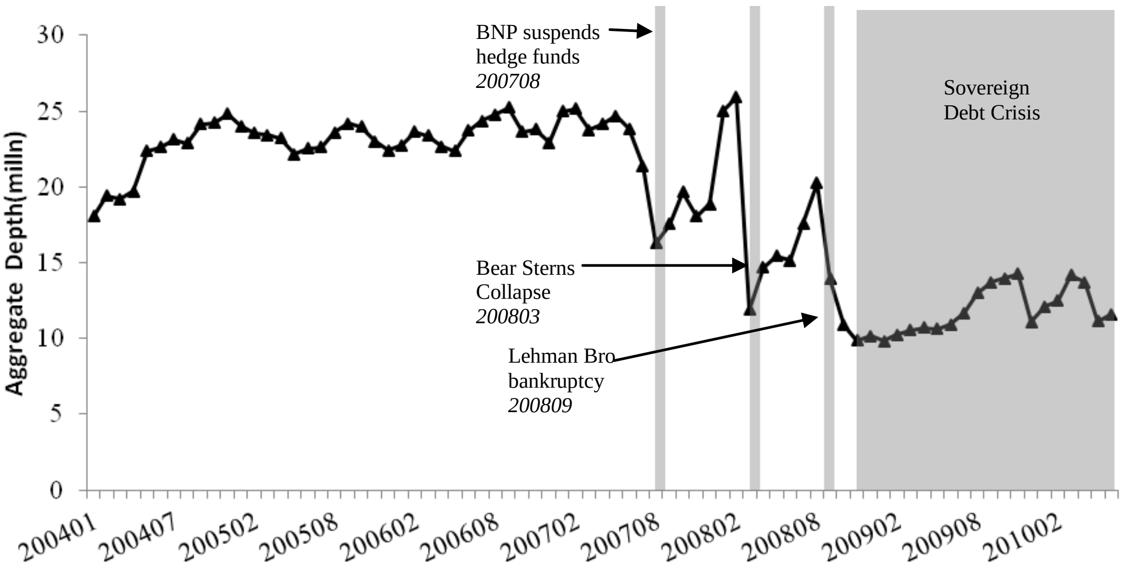
[3] The implementation details of bond volatility are enclosed in the appendix.

Figure 6.2.2 Average Liquidity and Portfolio Yield spread before and during crises.

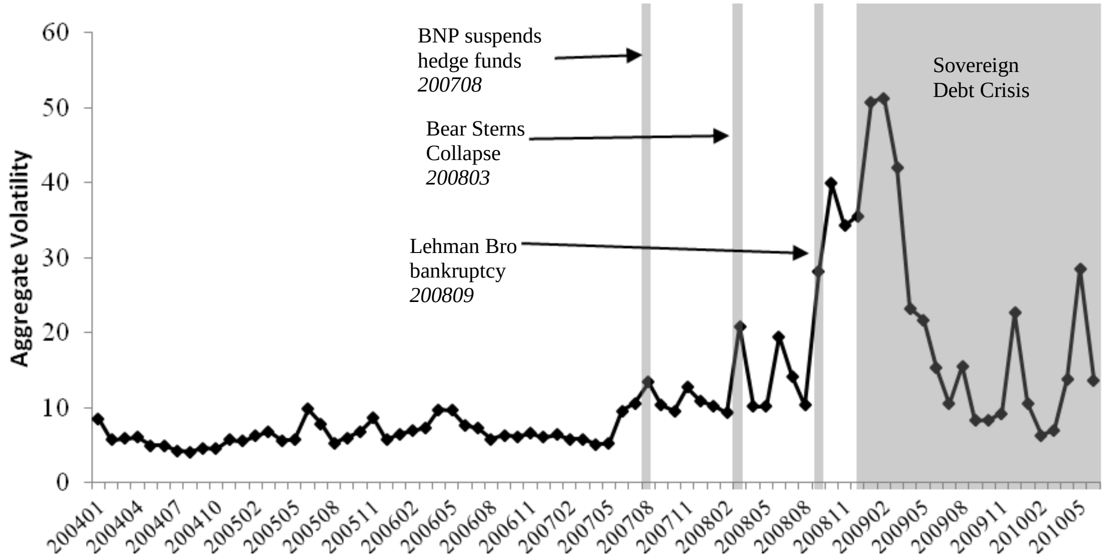
<u>Panel A: Average Bid-ask spreads</u>



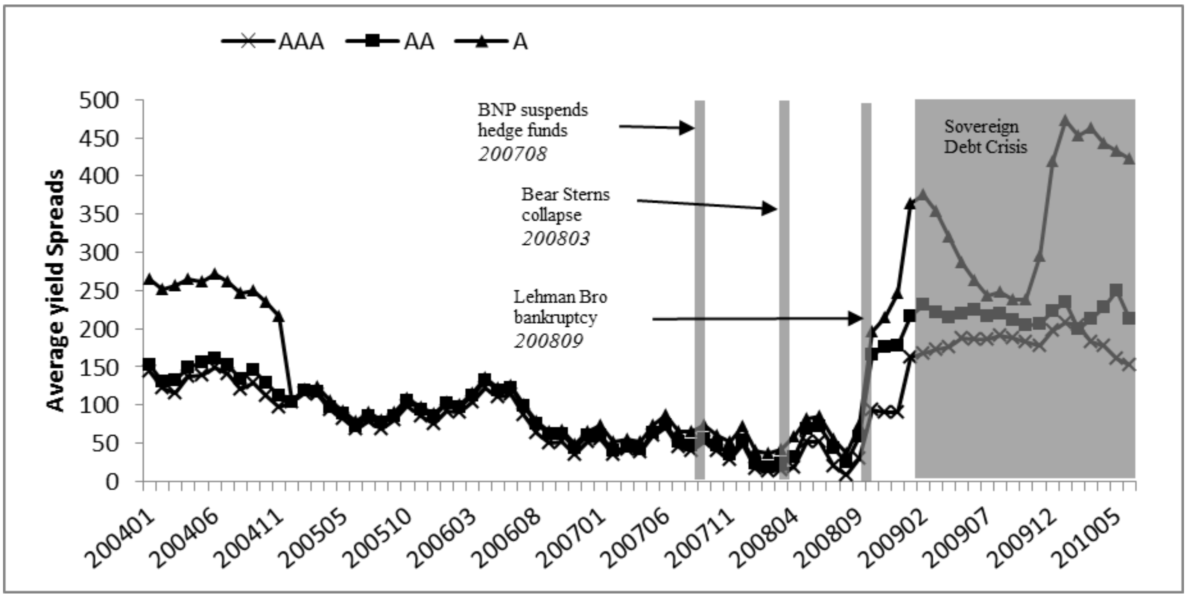
<u>Panel B: Average Depth</u>



Panel C: Average Bond volatility



Panel D: Rating-Duration sorted Portfolio yield spreads



Similar trend is also seen in average yield spreads of AA and AAA rated bonds. Since we observe a substantial change in the dynamics of liquidity measures after the subprime crisis in August 2007 we partition our data set into two sub periods for further empirical analysis: pre-crisis(Jan 2004 – July 2007) and crisis(August 2007 to July 2010).

Table 6.1 Summary statistics of Portfolio liquidity and bond characteristics.

Panel A

This table presents the pre-crisis (January 2004 to July 2007) summary statistics(mean and *standard deviation*) of daily *BA Spread, Depth, Order book slope, Bond Volatility, Number of Quote updates, Number of trades, Trade Volume, Amihud Liquidity, Age, Maturity and Yield spreads* within each *rating-duration* sorted portfolio. The summary statistics for the *Number of market participants* and *Number of committed market makers* are computed using monthly data as these details are only available on monthly basis.

Rating	Duration	BA Spread (bps.)	Depth (€milln.)	Orderbook slope	Bond Volatility (bps.)	Number of Quote Updates	Number of Trades	Trade Volume (€milln.)
AAA	Short	2.16 *0.22*	28.33 *2.03*	498.23 *76.19*	0.82 *0.26*	220.53 *30.13*	2.79 *0.58*	28.33 *5.71*
	Medium	2.99 *0.39*	27.07 *1.87*	309.76 *74.13*	2.88 *0.75*	318.85 *49.09*	2.31 *0.33*	23.00 *4.56*
	Long	7.28 *1.52*	16.32 *1.73*	283.67 *80.47*	10.76 *3.47*	463.76 *49.15*	2.50 *0.78*	19.20 *6.29*
AA	Short	1.64 *0.14*	36.94 *6.31*	623.38 *194.58*	0.72 *0.21*	217.33 *33.19*	10.95 *3.92*	82.26 *20.88*
	Medium	2.51 *0.25*	33.10 *3.87*	317.24 *72.79*	2.67 *0.59*	334.02 *47.74*	7.28 *1.35*	59.28 *11.02*
	Long	6.29 *0.76*	16.00 *1.75*	345.47 *57.33*	10.70 *2.76*	506.73 *59.32*	9.21 *1.85*	64.38 *15.37*
A	Short	1.84 *1.22*	17.21 *11.11*	366.31 *243.97*	0.70 *0.66*	167.59 *107.59*	1.67 *1.07*	14.35 *9.25*
	Medium	2.51 *1.56*	17.72 *10.78*	246.61 *149.79*	2.09 *1.49*	230.47 *142.70*	2.08 *1.49*	19.04 *13.68*
	Long	4.21 *2.72*	12.61 *7.78*	229.14 *147.31*	6.47 *4.36*	334.34 *204.08*	2.95 *2.07*	23.95 *16.70*

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Rating	Duration	Amihud Liquidity	Age (yrs.)	Number of market participants	Number of committed market makers	Yield spreads (bps.)	Maturity (yrs.)	Number of Bonds
AAA	Short	0.69 *0.38*	4.31 *0.48*	59.45 *2.53*	13.95 *2.07*	49.41 *18.39*	2.48 *0.38*	35.4
	Medium	1.24 *0.58*	4.19 *0.48*	59.96 *5.63*	12.91 *2.31*	86.09 *31.93*	5.74 *0.82*	36.4
	Long	2.95 *1.47*	3.83 *0.23*	61.05 *4.41*	15.49 *2.03*	135.08 *59.78*	15.99 *2.04*	37.9
AA	Short	0.77 0.10	4.81 0.31	89.60 6.02	20.45 5.41	49.43 17.98	2.25 0.19	19.7
	Medium	1.26 *0.30*	4.75 *0.52*	77.78 *3.81*	18.55 *4.36*	91.10 *33.14*	5.56 *0.59*	20.3
	Long	3.74 *0.77*	3.77 *0.23*	88.77 *1.61*	20.68 *4.72*	155.60 *65.32*	16.75 *1.00*	21.6
A	Short	0.66 *0.57*	2.10 *1.68*	33.99 *20.51*	11.03 *6.88*	42.73 *30.25*	2.10 *1.53*	5.3
	Medium	1.04 *0.70*	4.26 *1.87*	34.84 *21.01*	11.35 *7.01*	62.59 *43.29*	4.26 *2.67*	6.0
	Long	1.99 *1.31*	10.48 *1.47*	35.67 *21.51*	10.10 *6.21*	92.75 *65.09*	10.48 *6.42*	6.4

Panel B

This table presents the crisis (August 2007 to July 2010) summary statistics(mean and *standard deviation*) of daily *BA Spread, Depth, Order book slope, Bond Volatility, Number of Quote updates, Number of trades, Trade Volume, Amihud Liquidity, Age, Maturity and Yield spreads* within each *rating-duration* sorted portfolio. The summary statistics for the *Number of market participants* and *Number of committed market makers* are computed using monthly data as these details are only available on monthly basis.

Rating	Duration	BA Spread (bps.)	Depth (€milln.)	Orderbook slope	Volatility (bps.)	Number of Quote Updates	Number of Trades	Trade Volume (€milln.)
AAA	Short	10.80	14.53	391.65	4.00	414.19	1.86	18.96
		6.89	*3.93*	*146.97*	*3.24*	*89.64*	*1.29*	*13.59*
	Medium	17.21	14.32	252.63	9.49	526.30	1.69	16.29
		10.73	*4.02*	*72.25*	*6.21*	*110.38*	*1.13*	*11.07*
	Long	22.54	12.62	220.29	21.01	643.98	1.91	16.71
		13.59	*3.02*	*60.90*	*12.15*	*88.79*	*1.23*	*11.39*
AA	Short	12.49	17.56	588.29	5.24	421.13	5.69	50.93
		11.15	*8.54*	*252.26*	*7.39*	*124.39*	*3.18*	*28.47*
	Medium	19.34	16.84	296.53	12.06	611.62	5.34	44.62
		14.51	*6.56*	*80.90*	*10.26*	*191.07*	*3.33*	*28.52*
	Long	21.92	14.35	275.12	21.54	736.63	8.35	62.65
		13.36	*4.11*	*73.57*	*12.82*	*125.50*	*5.68*	*49.94*
A	Short	17.24	6.50	116.07	13.99	174.57	0.93	6.89
		27.06	*8.54*	*133.41*	*31.08*	*187.46*	*1.16*	*9.21*
	Medium	21.55	5.90	81.42	23.31	209.64	1.11	8.80
		32.20	*7.09*	*111.58*	*47.06*	*224.47*	*1.24*	*10.64*
	Long	30.07	9.39	167.21	43.29	448.83	1.97	14.67
		31.42	*6.93*	*155.90*	*66.71*	*244.27*	*1.60*	*13.78*

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Rating	Duration	Amihud Liquidity	Age (yrs.)	Number of market participants	Number of committed market makers	Yield spreads (bps.)	Maturity (yrs.)	Number of Bonds
	Short	1.36	5.03	59.29	11.38	56.15	2.29	30.7
		1.49	*0.67*	*3.45*	*2.47*	*36.06*	*0.34*	*1.49*
AAA	Medium	2.30	4.68	62.06	11.68	110.85	4.68	32.1
		2.31	*0.61*	*6.71*	*2.85*	*78.37*	*0.71*	*2.31*
	Long	3.53	3.26	62.70	12.55	170.37	10.06	33.9
		3.77	*0.81*	*4.97*	*2.94*	*112.61*	*3.50*	*3.77*
AA	Short	2.62	5.26	72.94	12.83	78.81	1.91	11.4
		2.67	*0.64*	*10.97*	*3.68*	*50.85*	*0.24*	*2.67*
	Medium	3.62	4.95	75.12	14.03	142.83	4.81	11.1
		3.55	*0.58*	*16.96*	*3.89*	*89.66*	*0.46*	*3.55*
	Long	5.33	2.84	77.06	15.58	210.41	9.96	12.0
		3.27	*0.68*	*12.19*	*3.92*	*123.76*	*2.34*	*3.27*
A	Short	4.19	1.32	20.71	5.81	75.82	1.32	3.5
		10.14	*2.72*	*21.67*	*6.39*	*101.32*	*1.54*	*10.14*
	Medium	5.71	2.36	21.04	6.52	114.73	2.36	4.5
		10.51	*2.07*	*22.04*	*6.95*	*150.30*	*2.65*	*10.51*
	Long	8.53	5.84	35.63	12.22	171.70	5.84	3.9
		10.81	*2.68*	*18.14*	*7.07*	*176.39*	*5.28*	*10.81*

We describe the daily summary statistics of all the liquidity measures[4] and bond characteristics for the 9 *rating-duration* sorted portfolios in Table 6.1. The Panel A presents the summary statistics over the pre-crisis period from January 2004 to July 2007. We identify a significant variation in the bond yield spreads before and during the crisis periods. However, prior to the crisis, many liquidity proxies do not exhibit significant variation across the portfolios. This indicates that the price impact of liquidity prior to crisis is only trivial. The same phenomenon can be spotted in the liquidity/yield graphs with portfolio yields displaying significant movements while average bid-ask spread staying stable. Based on the

[4] For the liquidity proxies, *Number of market participants* and the *Number of committed market makers*, the data is available only on monthly basis and hence we compute the averages and standard deviations using monthly data.

summary statistics, we expect our liquidity proxies to have trivial price impact before crisis across all the portfolios. The Panel B presents the summary statistics of liquidity measures and bond characteristics during the crisis period (August 2007 to July 2010). In the middle of 2009 we observe a significant variation in most of the liquidity proxies across many portfolios. This can be explained by the fact that MTS dealers are under pressure and are no longer willing to maintain tight spreads. The MTS market agrees to lift and relax market making obligations resulting in a sharp decrease in liquidity across all markets and securities with larger bid-ask spreads, lower depths and increased priced volatility. More specifically such an effect is visible in the low rated portfolios with countries such as Greece, Ireland, Portugal and Spain that have experienced frequent downgrades in credit outlook due to increased fear of solvency risk. From the above trend, we expect to find significant impact of liquidity risk on bond excess yields in the crisis period. The above summary statistics that describe the evolution of various (il)liquidity proxies before and during the crisis motivate us to establish the relationship between liquidity proxies and bond yield spreads using more formal econometric procedures that are described in the later sections.

6.3 Portfolio level time series regression

We adopt the Fama and French (1993) two factor model with two business cycle variables default risk (DEF) and interest rate risk (TERM) as our bench mark model to explain the time series dynamics of the bond portfolio yield spreads.

Variable construction: Fama and French two factor model(1993).

We use Markit's iBoxx daily indices to compute the two Fama and French factors *TERM* and *DEF*. To construct the risk factor *TERM* (interest rate risk) we first obtain the daily yield spread of the iBoxx Eurozone sovereign index of bonds with minimum 10 years of maturity and 3-month German Treasury Bill rate. We then compute the time series average TERM over a month. A similar approach is adopted by Li et al (2009) in constructing the TERM factor that features as an important risk factor in explaining the excess returns of US treasury bonds using the Fama French bond market model. They also include in the model, additional risk factors such as size factor, SMB and the book-to-market factor, HML from the stock market. Instead of using risk factors from stock market, we introduce the sovereign default risk factor *DEF* (default risk) computed as the average of daily yield spread between iBoxx Eurozone BBB sovereign bonds and AAA sovereign bonds indices. The underlying intuition is to highlight the growing importance of default risk within the Euro area sovereign bond markets especially during the debt crisis periods. Therefore it is sensible to construct the DEF using bond yields from sovereign bond market rather than from corporate bond markets or interest rate swap markets. We use 3 month Euro area bench mark zero coupon yield as a risk free rate for computing the excess yields. The European Central bank publishes the daily zero coupon yield curve using the most credit worthy AAA rated bonds that are traded on the Euro MTS platform.

We estimate time-series regression of Fama and French (1993) two factor model for each of the *rating-duration* sorted portfolios (*i=1,…9*).

$$Z_i = \alpha_i + \beta_{1i}\, DEF + \beta_{2i}\, TERM + \epsilon_i,$$

where $\alpha_i$is the intercept, Z_i is a (T $\times$ 1) vector of portfolio yield spreads constructed by subtracting ECB 3 month benchmark zero coupon yield from the monthly portfolio yield, *TERM* and *DEF* are (T $\times$ 1) vector of business cycle factor rewards, β_{1i} and β_{2i} are corresponding factor loadings, ϵ_i is the disturbance. We present the results of the above time series regression for both pre-crisis and Crisis periods in Table 6.2. The factor loadings are significant and positive for most of the portfolios. The insignificant intercepts and significant factor loadings justify the correct choice of the risk factors DEF and TERM in explaining the yield spreads.

In order to test the importance of our liquidity proxies, we augment the above time series regression with each *rating-duration* sorted portfolio liquidity measures L_{ki},

$$Z_i = \alpha_i + \beta_{1i}\ DEF + \ \beta_{2i}\ TERM + \ \beta_L L_{ki} + \epsilon_i,$$

where L_{ki} is the (il)liquidity proxy for *k=1,…11.* For simplicity we report estimated values for only the liquidity proxy coefficient, β_L. We report both the Adjusted R-squared and the Incremental Adjusted R-squared to evaluate the marginal explanatory power of each liquidity proxy in explaining the yield spreads after controlling the credit and term factors. The results are presented separately for the pre-crisis (Table 6.3) and the crisis (Table 6.4) periods. During the pre-crisis period most of the liquidity proxies remain trivial in explaining the excess yields. This behaviour can be explained by the fact that many of the Euro area countries prior to the crisis exhibited homogeneity in liquidity and yields. The only liquidity proxy that is statistically significant in explaining the portfolio yield spreads is the *Age*. The AAA rated bonds are in relatively larger circulation than that of AA and A rated bonds due to the high issue frequency implemented in AAA rated countries such as Germany and France. As a result, AAA rated bonds loose the on-the-run status more quickly than low rated bonds. Since the bond portfolios consist of both on-the-run and off-the-run bonds, age becomes an important liquidity risk factor in explaining the yield spreads.

During the crisis periods the yields and the liquidity proxies of Euro zone bonds exhibit much greater volatility as shown in Figure 6.1 (Panel A,B,C,D). Liquidity is an important explanatory factor as many liquidity proxies succeed in explaining the portfolio yields of low rated bonds. Liquidity however, has no incremental explanatory power for the yield spread dynamics of AAA rated bonds. Nevertheless, the AAA rated long term bond portfolio yield spreads are impacted by the liquidity proxies *depth, age, number of market participants*. Majority of the liquidity proxies remain insignificant in explaining yield spreads for the AAA rated bond portfolios. The growing concerns of solvency risk in Greece, Portugal, and Ireland during the debt crisis pushed investors to rebalance their portfolios and increase their holdings of safer AAA rated bonds, a phenomenon called flight to quality. Consequently, AA and A rated bonds became illiquid and hence investors incurred high impact of liquidity. The liquidity proxies *bid ask spread, depth, order book slope, Amihud liquidity* and the *principal component* are successful in explaining the yield spreads of AA and A bond portfolios and the respective marginal explanatory power decreases(increases) with the bond duration(credit rating). The positive regression coefficient of the *bid ask spread* confirms the expected relationship between the bond yields and illiquidity. The incremental adjusted R-Squared of *bid ask spread* varies from 36% to 3% (short term to long term) for the A rated and 17% to 1 %(short term to long term) for AA rated bonds. The liquidity proxy, *depth* has a negative regression coefficient as expected and has a marginal explanatory power of 8% for the A rated and 3% for the AA rated medium term bonds. The *order book slope* is also inversely related to the yield spreads and consistently prices the AA and A rated portfolios. The proxy for resilience, *Amihud liquidity,* has a positive regression coefficient and has a significant marginal explanatory power in explaining the low rated bond yield spreads. The principal component measure, *PC,* which is a fundamental characteristic underlying all the liquidity proxies has a positive slope coefficient since all the liquidity proxies appear as illiquidity measures in the factor decomposition. *PC* precisely estimates liquidity impact across the AA rated bond portfolios.

6.4 Individual level cross-sectional regressions

To test the importance of 11 liquidity proxies in explaining the cross-sectional variation of excess yields at an individual level, we conduct cross sectional regressions by controlling bond characteristics such as *rating*[5] and *duration* as in Bao *et al* (2011). Most of our liquidity measures exhibit strong term structure and hence controlling for maturity and liquidity simultaneously induces multicollinearity problems in the model (as indicated by a strong pairwise correlation of around 80% between liquidity proxies and modified duration. To overcome quasi multicollinearity we classify all the bonds according to the previous month's modified duration and form 3 portfolios: Short, Medium and Long. We control the bond characteristics such as *rating* and *age* by including them as additional explanatory variables in the cross section.

Finally we augment the above model with the individual liquidity measures and conduct the cross-sectional regressions for each duration group separately.

$$Z_{i,t}^{d} = \alpha_i + \gamma_{n,t}^{d} \sum_{n=1}^{N} C_n + \beta_{L,t}^{d} L_{i,t}^{d} + \epsilon_i ,$$

where $Z_{i,t}^{d}$ are the individual excess yields of bonds ($i=1,..N$), belonging to a duration group ($d=\{Short, Medium, Long\}$), observed at the end of month t, and $L_{i,t}^{d}$ are the individual liquidity measures, belonging to duration group d, computed in month t. The endogeneity problem is addressed by recording excess yields at the end of month and by computing averages of daily liquidity measures over a month.

[5] For robustness we repeat the cross sectional regression with sovereign CDS spreads replacing the credit ratings. Results are enclosed in appendix 8.5. We obtain the Euro area sovereign CDS spreads from CMA (Bloomberg).

We present the time series averages of the slope coefficients and adjusted R-squared obtained from the monthly cross sectional regression of individual bond yield spreads on bond characteristics and each liquidity proxy, conducted separately for the three duration groups, for both the pre-crisis (Jan 2004 to July 2007) and the crisis (August 2007 to July 2010) periods in Table 6.6. We estimate the t-statistics using Fama-Macbeth standard errors with serial correlation corrected using Newey and West (1987). Due to space constraints we drop intercepts and coefficients of rating and age (we observe little change in the characteristic slope coefficients after adding liquidity measures) from the table and only report liquidity slope coefficients estimated for each liquidity proxy. Prior to the crisis, we find 8 out of 10 liquidity proxies are successful in explaining the cross sectional variation of individual bond yield spreads. Bid ask spread leads the table with highest adjusted R-squared of 77% for the long term bonds and 31% for the short term bonds. This result indicates the presence of heterogeneous transaction costs in the cross section of individual bonds even before the crisis period. The strong significance of the regression coefficient of depth also indicates the discrepancies in the market depth offered by different Euro area countries for different bonds prior to the crisis. During the crisis only 6 out of the 11 liquidity proxies remain significant in explaining the cross sectional variation of individual bond yields. With the onset of sovereign debt crisis in early 2009, markets across the Euro area experienced high transaction costs and low trading activity. Consequently the impact of liquidity on bond yields had gone up significantly as indicated by relatively high adjusted R-squared reported by almost all the liquidity proxies during the crisis period. The bid ask spread leads the liquidity horse race with the largest average adjusted R-squared of 56% for the short term and 77% for the long term bonds. The liquidity proxies *depth, Amihud liquidity* and *order book slope* also emerge as good liquidity proxies in pricing the cross section of bond yields. The number of quote updates remains relevant in affecting the bond yields during the crisis. We find that number of market participants is inversely related to yield spreads. This result indicates that the market competition in the form of high participation improves market liquidity and consequently drives down the yields. However the number of market makers who have commitment to post two way proposals on the order book are adversely impacting the bond yields before and during the crisis for the long term bonds. This finding could be driven by the Italian bonds which are characterised by relatively higher yields and a large number of committed market makers. Our evidence suggests that the number of market participants is more important than the number of committed dealers for explaining the cross-section of yields. For robustness we include in the appendix 8.4, the results of cross sectional regression with credit rating replaced by Euro area sovereign CDS spreads. We achieve similar results as we obtained while controlling credit risk with credit ratings. The results of the above regression suggest that liquidity is an important priced factor in explaining the cross sectional variation of individual bond yield spreads.

7. Conclusion

The main objective of the paper is to measure liquidity in Euro area sovereign bond markets before and during the crisis period. Our liquidity measures precisely capture the market conditions that are prevalent during the crises periods. We find a substantial deterioration in liquidity, represented by wide bid-ask spreads, thin trading volumes, high bond volatility and large price impact during the crises periods. We also evaluate the importance of each liquidity measure by comparing 11 liquidity proxies in explaining the time series dynamics and cross sectional variation of bond yield spreads. Prior to the crisis, many countries in the Euro area enjoyed highly liquid markets and hence we find liquidity to be trivial in explaining bond excess yields. However during the crisis, at a portfolio level, liquidity is found to be a significantly priced factor. Liquidity is more important for explaining low rated (AA, A) bond yields than high rated bond yields (AAA). The *bid ask spread* and *Amihud liquidity* emerge as a winners in explaining the time series dynamics of AA and A rated bonds during the crisis. *Bid Ask spread* leads the liquidity proxy table in the cross sectional regressions. A greater number of market participants is important liquidity factor especially during the crisis. Our empirical findings have serious implications to liquidity management and market design.

Table 6.2 Time-series *rating-duration* sorted portfolio regression results

This table presents the time series regression results of the bench mark model(Fama French 2-factor model) estimated for 6 rating-duration sorted portfolios: short, medium and long term for AAA, AA and A rated portfolio bonds before(January 2004 to July 2007) and during the crisis periods(August 2007 to July 2010). The dependent variable is the portfolio yield spread, calculated as the equally weighted average of monthly yield spreads (bond yield – 3M ECB zero coupon yield) of bonds within each portfolio separately. The independent variable *DEF* (default risk) is the average yield spread between iBoxx Eurozone BBB sovereign bonds and AAA sovereign bonds indices. The independent variable TERM (interest rate risk) is the difference between daily average yield of the iBoxx Eurozone sovereign index of bonds with minimum 10 years of maturity and 3-month German Treasury Bill rate. The slope coefficients β_{1i} and β_{2i} represent the factor loadings associated with *DEF* and *TERM* respectively. The t-statistics are presented right below the slope coefficients. Slope coefficients that are statistically significant at 5%level are represented in bold characters. $Adj\,R^2$ is presented in the corner against each portfolio.

		Pre-Crisis				Crisis			
		α_i	DEF	$TERM$	$Adj\,R^2$	α_i	DEF	$TERM$	$Adj\,R^2$
AAA	Short	-5.43	**49.35**	**16.03**	30%	**23.69**	**-4.37**	**22.42**	82%
		-0.43	4.14	3.62		4.01	-1.64	11.08	
	Med	-8.97	**40.07**	**50.93**	82%	**21.57**	-3.82	**50.97**	93%
		-0.80	3.78	12.96		2.67	-1.05	18.41	
	Long	2.55	14.12	**92.25**	96%	**36.55**	-7.78	**76.82**	93%
		0.25	1.44	25.41		3.12	-1.40	19.27	
AA	Short	-4.40	**49.48**	**15.21**	31%	**26.16**	0.26	**27.97**	73%
		-0.36	4.26	3.53		2.56	0.06	8.01	
	Med	-12.59	**45.90**	**54.44**	86%	4.05	**18.27**	**49.89**	89%
		-1.22	4.72	15.08		0.34	3.29	12.50	
	Long	-2.32	**28.65**	**103.90**	97%	**36.35**	**11.00**	**76.04**	91%
		-0.24	3.19	31.14		2.42	1.55	14.92	
A	Short	12.52	**42.34**	**13.28**	24%	20.02	21.59	**33.68**	59%
		0.87	3.23	1.65		0.64	1.12	1.99	
	Med	-1.81	**36.68**	**58.65**	76%	20.04	24.85	**62.49**	79%
		-0.17	3.71	9.64		0.62	1.24	3.56	
	Long	6.83	**21.18**	**102.48**	94%	27.75	7.27	**101.09**	91%

0.79	2.72	21.40	1.24	0.61	11.32

Table 6.3 Time series *rating-duration* sorted portfolio regressions augmented with liquidity measures for the Pre crisis period (January 2004 to July 2007).

This table presents the time series regression results of 9 *rating-duration* sorted portfolios: short, medium and long term for AAA, AA and A rated bonds. The dependent variable is the portfolio yield spread, calculated as the equally weighted average of monthly yield spreads (bond yield – 3M ECB zero coupon yield) of bonds within each portfolio separately. The independent variables consist of 11 liquidity proxies averaged within each bond portfolio and added in the model in exclusion of the others. The slope coefficients β_L are presented for each portfolio against each liquidity proxy. The intercept and the coefficients of DEF and TERM are dropped from the table to save the space. The t-statistics, adjusted R-squared and incremental adjusted R-squared are presented right below the slope coefficients. Slope coefficients that are statistically significant at 5% level are represented in bold characters.

Pre Crisis (January 2004 to July 2007)										
		AAA			AA			A		
		Short	Medium	Long	Short	Medium	Long	Short	Medium	Long
BA	β_L	**29.70**	1.63	**-5.37**	28.59	-3.49	**-6.16**	7.19	**3.42**	-2.99
		2.58	0.20	-3.13	1.43	-0.32	-1.95	1.29	0.55	-1.71
	$Adj\ R^2$	*39%*	*81%*	*96%*	*32%*	*85%*	*97%*	*25%*	*75%*	*94%*
	$Incr\ AdjR^2$	*9%*	*0%*	*1%*	*2%*	*0%*	*0%*	*2%*	*0%*	*0%*
Depth	β_L	1.91	-1.14	0.40	**1.10**	0.50	-1.51	**1.27**	2.37	0.34
		1.61	-0.94	0.30	2.38	0.55	-0.99	1.92	1.55	0.30
	$Adj\ R^2$	*33%*	*82%*	*95%*	*38%*	*85%*	*97%*	*30%*	*77%*	*94%*
	$Incr\ AdjR^2$	*3%*	*0%*	*0%*	*7%*	*0%*	*0%*	*7%*	*1%*	*0%*
Slope	β_L	**-9.77**	1.45	-2.79	-1.01	-3.68	0.69	**-6.00**	-7.47	1.92
		-3.00	0.49	-1.12	-0.83	-1.34	0.20	-2.34	-0.70	0.65
	$Adj\ R^2$	*42%*	*81%*	*96%*	*30%*	*86%*	*97%*	*34%*	*75%*	*94%*
	$Incr\ AdjR^2$	*12%*	*0%*	*0%*	*0%*	*0%*	*0%*	*11%*	*0%*	*0%*
Quote Updates	β_L	5.41	6.52	**11.31**	3.28	2.55	**5.37**	7.71	**12.02**	9.73
		0.67	1.52	2.81	0.39	0.55	1.69	1.08	1.65	1.62
	$Adj\ R^2$	*29%*	*82%*	*96%*	*29%*	*85%*	*97%*	*24%*	*77%*	*94%*
	$Incr\ AdjR^2$	*0%*	*1%*	*1%*	*0%*	*0%*	*0%*	*0%*	*1%*	*0%*
Number Of Trades	β_L	-5.36	6.50	3.40	-0.11	2.22	-0.70	-3.30	-1.49	2.45
		-0.81	0.84	1.29	-0.14	1.40	-0.65	-0.33	-0.42	1.03
	$Adj\ R^2$	*29%*	*82%*	*96%*	*29%*	*86%*	*97%*	*21%*	*75%*	*94%*
	$Incr\ AdjR^2$	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Trade Volume	β_L	-0.29	-0.33	0.36	0.08	0.28	-0.14	-0.64	-0.19	0.24
		-0.46	-0.48	1.13	0.59	1.57	-1.00	-0.56	-0.50	0.90
	$Adj\ R^2$	*29%*	*81%*	*96%*	*29%*	*86%*	*97%*	*22%*	*75%*	*94%*
	$Incr\ AdjR^2$	*0%*	*0%*	*0%*	*0%*	*1%*	*0%*	*0%*	*0%*	*0%*
Amihud	β_L	6.42	3.05	0.35	-7.65	9.04	-1.01	7.36	-1.42	**-6.27**
		0.96	0.79	0.24	-0.29	1.25	-0.37	1.16	-0.20	-2.33
	$Adj\ R^2$	*30%*	*82%*	*95%*	*29%*	*86%*	*97%*	*25%*	*75%*	*95%*
	$Incr\ AdjR^2$	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*1%*	*0%*	*1%*
Age	β_L	**28.27**	**15.87**	-7.69	5.59	-4.06	19.64	**7.31**	3.57	-1.35
		3.53	2.37	-0.90	0.69	-0.89	1.53	1.99	1.07	-0.88
	$Adj\ R^2$	*46%*	*84%*	*96%*	*30%*	*86%*	*97%*	*31%*	*76%*	*94%*
	$Incr\ AdjR^2$	*16%*	*2%*	*0%*	*0%*	*0%*	*0%*	*7%*	*0%*	*0%*
Number Of Market participants	β_L	-0.46	**2.30**	**1.37**	**-2.43**	0.36	0.35	-0.11	-3.57	3.31
		-0.43	2.91	2.00	-3.33	0.39	0.29	-0.03	-0.86	1.20
	$Adj\ R^2$	*29%*	*85%*	*96%*	*45%*	*85%*	*97%*	*21%*	*75%*	*94%*
	$Incr\ AdjR^2$	*-1%*	*3%*	*0%*	*14%*	*0%*	*0%*	*0%*	*0%*	*0%*
Number of market makers	β_L	-0.03	1.14	0.93	0.48	0.77	**0.89**	1.64	**3.38**	1.50
		-0.03	1.08	0.90	1.01	1.58	2.39	1.11	3.03	1.17
	$Adj\ R^2$									

		28%	*82%*	*96%*	*31%*	*86%*	*97%*	*24%*	*81%*	*94%*
	Incr AdjR^2	*-2%*	*0%*	*0%*	*0%*	*1%*	*0%*	*1%*	*6%*	*0%*
PC	β_L	**2.96**	-0.60	-0.34	0.21	0.44	0.17	**3.73**	**4.02**	-0.32
		2.64	-0.85	-1.14	0.19	1.31	0.28	2.10	1.87	-0.44
	Adj R^2	*39%*	*82%*	*96%*	*29%*	*86%*	*97%*	*32%*	*78%*	*94%*
	Incr AdjR^2	*9%*	*0%*	*0%*	*-2%*	*0%*	*0%*	*8%*	*2%*	*0%*

Table 6.4 Time series *rating-duration* sorted portfolio regressions augmented with liquidity measures for the Crisis period (August 2007 to July 2010).

This table presents the time series regression results of 9 *rating-duration* sorted portfolios: short, medium and long term for AAA, AA and A rated bonds. The dependent variable is the portfolio yield spread, calculated as the equally weighted average of monthly yield spreads (bond yield – 3M ECB zero coupon yield) of bonds within each portfolio separately. The independent variables consist of 11 liquidity proxies averaged within each bond portfolio and added in the model in exclusion of the others. The slope coefficients β_L are presented for each portfolio against each liquidity proxy. The intercept and the coefficients of DEF and TERM are dropped from the table to save the space. The t-statistics, adjusted R-squared and the incremental adjusted R-squared are presented right below the slope coefficients. Slope coefficients that are statistically significant at 5% level are represented in bold characters.

Crisis (August 2007 to July 2010)										
		AAA			AA			A		
		Short	Medium	Long	Short	Medium	Long	Short	Medium	Long
BA	β_L	-0.27	-0.20	0.45	**1.81**	**1.51**	**1.68**	**2.56**	**2.62**	**1.57**
		-0.47	-0.35	0.72	7.24	3.95	2.63	10.72	9.61	3.55
	Adj R^2	*82%*	*93%*	*93%*	*90%*	*93%*	*92%*	*96%*	*97%*	*94%*
	Incr AdjR^2	*0%*	*0%*	*0%*	*17%*	*3%*	*1%*	*36%*	*19%*	*3%*
Depth	β_L	-1.03	-1.78	**-4.72**	**-2.57**	**-3.95**	**-5.47**	-5.9	**-18.8**	**-13.7**
		-0.85	-0.98	-2.70	-2.71	-3.61	-3.32	-1.03	-3.08	-2.51
	Adj R^2	*82%*	*93%*	*94%*	*78%*	*92%*	*93%*	*59%*	*87%*	*93%*
	Incr AdjR^2	*0%*	*0%*	*1%*	*5%*	*3%*	*2%*	*0%*	*8%*	*2%*
Slope	β_L	3.47	3.21	-17.7	**-5.03**	**-24.74**	**-37.8**	**-90.4**	**-135.3**	**-55.2**
		0.80	0.34	-1.46	-2.85	-3.22	-3.53	-6.27	-4.81	-3.08
	Adj R^2	*82%*	*93%*	*93%*	*78%*	*92%*	*93%*	*89%*	*92%*	*94%*
	Incr AdjR^2	*0%*	*0%*	*0%*	*5%*	*2%*	*2%*	*30%*	*13%*	*2%*
Quote Updates	β_L	-9.87	-9.71	-2.09	6.41	5.39	-1.87	-2.47	**-73.73**	**-19.6**
		-2.24	-1.89	-0.24	1.21	0.95	-0.24	-0.07	-3.43	-2.05
	Adj R^2	*84%*	*94%*	*93%*	*74%*	*89%*	*91%*	*56%*	*88%*	*92%*
	Incr AdjR^2	*2%*	*1%*	*0%*	*0%*	*0%*	*0%*	*-3%*	*9%*	*1%*
Number Of Trades	β_L	-3.22	-2.88	-0.86	-0.12	-2.64	-0.72	-2.00	-36.49	4.51
		-1.19	-0.66	-0.16	-0.05	-1.37	-0.54	-0.09	-0.96	0.49
	Adj R^2	*82%*	*93%*	*93%*	*72%*	*90%*	*91%*	*56%*	*79%*	*91%*
	Incr AdjR^2	*0%*	*0%*	*0%*	*-1%*	*0%*	*0%*	*-3%*	*0%*	*0%*
Trade Volume	β_L	-0.26	-0.32	-0.51	-0.17	-0.36	-0.21	-0.73	**-6.76**	-0.05
		-1.04	-0.72	-0.90	-0.69	-1.60	-1.44	-0.21	-1.83	-0.04
	Adj R^2	*82%*	*93%*	*93%*	*73%*	*90%*	*91%*	*56%*	*82%*	*91%*
	Incr AdjR^2	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*-3%*	*3%*	*0%*
Amihud	β_L	0.59	0.39	0.50	**6.88**	**7.19**	**8.27**	**3.59**	**5.10**	**3.36**
		0.34	0.23	0.36	6.44	5.50	4.24	4.79	7.59	3.49
	Adj R^2	*82%*	*93%*	*93%*	*89%*	*94%*	*94%*	*84%*	*96%*	*94%*
	Incr AdjR^2	*-1%*	*0%*	*0%*	*16%*	*5%*	*3%*	*25%*	*17%*	*3%*
Age	β_L	**12.00**	1.93	**26.50**	-4.94	5.14	-2.40	-16.9	-39.98	3.65
		2.09	0.22	2.89	-0.62	0.54	-0.21	-0.39	-1.18	1.63
	Adj R^2	*84%*	*93%*	*95%*	*73%*	*89%*	*91%*	*56%*	*79%*	*92%*
	Incr AdjR^2	*2%*	*0%*	*1%*	*-1%*	*0%*	*0%*	*-3%*	*1%*	*1%*
Number Of Market participants	β_L	-0.91	-2.80	**-14.6**	**-1.44**	-1.06	-0.36	-13.0	-25.1	3.39
		-0.37	-1.45	-5.92	-2.67	-1.61	-0.30	-0.56	-1.16	0.28
	Adj R^2	*82%*	*93%*	*97%*	*78%*	*90%*	*91%*	*57%*	*79%*	*91%*
	Incr AdjR^2	*-1%*	*0%*	*3%*	*5%*	*1%*	*0%*	*-2%*	*1%*	*0%*
Number of market makers	β_L	0.84	0.61	1.19	**-2.43**	-1.58	-2.87	-1.70	-6.55	-2.4

		0.81	0.50	0.69	-1.83	-1.24	-1.68	-0.25	-0.77	-0.75
	$Adj\ R^2$	*82%*	*93%*	*93%*	*75%*	*90%*	*91%*	*56%*	*78%*	*91%*
	$Incr\ AdjR^2$	*0%*	*0%*	*0%*	*2%*	*0%*	*0%*	*-3%*	*-1%*	*0%*
PC	β_L	2.04	1.19	-1.50	**8.70**	**10.24**	**9.83**	3.08	**-30.39**	6.98
		1.30	0.54	-0.57	7.54	4.70	3.39	0.20	-2.13	0.97
	$Adj\ R^2$	*82%*	*93%*	*93%*	*91%*	*94%*	*93%*	*56%*	*83%*	*91%*
	$Incr\ AdjR^2$	*0%*	*0%*	*0%*	*18%*	*4%*	*2%*	*-3%*	*4%*	*0%*

Table 6.5. Cross sectional regression of individual bond excess yields on liquidity proxies.

This table presents the results of monthly cross sectional regressions of individual bond yield spreads on liquidity proxies along with the control variables rating, duration and age for the periods Pre-Crisis(January 2004 to July 2007) and Crisis(August 2007 to Jul 2010). The regressions are conducted separately for three groups sorted by the individual bond duration: short, medium and long term. The dependent variable is the individual monthly bond yield spread (bond yield – 3M ECB zero coupon yield). The independent variables consist of individual bond liquidity proxies added in the model in exclusion of the others. The time series average of slope coefficients β_L are presented for each group against each liquidity proxy.The intercept and the coefficients of rating and age are dropped from the table to save the space.The t-statistics are estimated using Fama-Macbeth standard errors with serial correlation corrected using Newey and West (1987). The time series average Adjusted R-squared is presented right below the slope coefficients. Slope coefficients that are statistically significant at 5% level are represented in bold characters.

		Pre Crisis			Crisis		
		Short	Medium	Long	Short	Medium	Long
BA Spread	β_L	**5.61**	**10.36**	**5.13**	**1.5**	**1.16**	**1.7**
		3.65	6.24	9.8	7.4	12.39	8.40
	$Adj\ R^2$	*31%*	*40%*	*77%*	*56%*	*67%*	*77%*
Depth	β_L	**0.31**	**-0.31**	**-1.83**	**-1.51**	**-1.09**	**-1.86**
		5.73	-5.09	-9.24	-2.47	-3.13	-3.27
	$Adj\ R^2$	*23%*	*35%*	*73%*	*43%*	*57%*	*67%*
Slope	β_L	**-0.40**	**-2.63**	**-4.61**	**-5.90**	**-4.32**	**-11.01**
		-3.95	-4.27	-2.99	-2.44	-1.54	-4.62
	$Adj\ R^2$	*25%*	*34%*	*31%*	*48%*	*55%*	*59%*
Quote updates	β_L	**2.17**	**15.38**	**19.02**	**8.79**	**-0.89**	**3.94**
		2.30	9.19	12.66	4.95	4.97	2.38
	$Adj\ R^2$	*25%*	*65%*	*65%*	*52%*	*65%*	*60%*
Trade Frequency	β_L	0.09	**-0.17**	**0.11**	**-2.46**	**-1.26**	**0.48**
		1.14	-2.64	2.18	-2.33	-1.09	2.07
	$Adj\ R^2$	*20%*	*31%*	*29%*	*45%*	*55%*	*56%*
Trade Volume	β_L	**0.02**	**-0.02**	**-0.07**	**-0.22**	-0.16	**0.07**
		2.13	-2.24	-6.27	-1.86	-0.90	2.2
	$Adj\ R^2$	*20%*	*31%*	*31%*	*45%*	*54%*	*56%*
Amihud	β_L	**7.22**	**4.81**	**5.52**	**1.76**	**0.85**	**1.15**
		3.75	5.66	6.85	5.44	3.30	3.64
	$Adj\ R^2$	*22%*	*34%*	*55%*	*44%*	*55%*	*62%*
Number of market participants	β_L	0.00	-0.00	**0.22**	**-0.31**	**-0.52**	**-0.55**
		0.14	-0.11	12.6	-4.45	-6.80	-7.47
	$Adj\ R^2$	*20%*	*31%*	*34%*	*45%*	*60%*	*60%*
Number of committed market makers	β_L	**0.46**	**-0.10**	**0.48**	-0.06	**-0.48**	**0.40**
		5.49	-3.02	5.02	-0.49	-2.92	2.30

	$Adj\ R^2$	*21%*	*31%*	*33%*	*41%*	*54%*	*54%*
PC	β_L	**5.24**	-0.39	**-2.56**	-1.36	**-3.02**	-1.09
		6.82	-1.28	-4.73	-1.80	-2.85	-0.83
	$Adj\ R^2$	*28%*	*36%*	*73%*	*50%*	*63%*	*65%*

8. Appendix

8.1 *Implementation of liquidity measures*

We provide the implementation details of some of the liquidity proxies used in our empirical analysis. The liquidity proxies such as Number of market participants and Number of committed Market Makers are observed on monthly basis whereas the other liquidity proxies such as Bid-Ask spread, Depth, Slope, Trade Frequency, Trade Volume, and Amihud are computed as monthly averages using tick-by-tick data.

Bid-Ask Spread

The daily average bid-ask spread is computed from the Time weighted Bid-Ask spreads that are calculated using tick-by-tick data. Market makers on MTS have a mandate to provide two-sided quotes for most of the trading day, yet quote updates are irregularly spaced in time with periods of frequent quote updating followed by periods of slow quote updating. Therefore, instead of using simple averages of intraday spreads, time-weighted averages are used. Intraday spreads are weighted by the proportion of the trading day they remain available in the market before the next update.

$$\mathrm{TWBAS_d} = \frac{1}{\mathrm{T}}\sum_{t=1}^{Q} \frac{(\mathrm{Ask_t} - \mathrm{Bid_t})}{(\mathrm{Ask_t} + \mathrm{Bid_t})/2} * (\mathrm{T_{t+1}} - \mathrm{T_t})$$

Time-weighted bid-ask spread $TWBAS_d$ is a daily liquidity measure computed with all the intraday updates to the best bid and ask quotes; T_t is the time stamp of the t^{th} quote update measured in seconds; Q is the number of quote revisions in a day; and T is the length of the trading day measured in seconds.

Depth

Depth is computed as a daily average of the Time weighted Average Depth calculated using tick by tick average depth available on the top of the book.

$$TWQD_d = \frac{1}{T}\sum_{t=1}^{Q}\frac{(bidQty1_t + askQty1_t)}{2} * (T_t - T_{t-1}),$$

Where $bidQty1_t$ and $askQty1_t$ are the quantities available for trading at best bid and ask prices. T_t is the time between successive mid-quote revisions.

Order book Slope

The information content of limit orders has been extensively investigated by many researchers (Irvine, Benston, and Kandel, 2000; Kalay, Wei, and Wohl, 2002; Harris and Panchapagesan, 2005; Foucalt, Moinas, and Theissen, 2007; Cao, Hansch, and Wang, 2009). These studies analyse the relationship between the shape of the limit order book and future volatility. In a market with informed and uninformed traders, liquidity providers widen the bid-ask spread to avoid being picked off by the traders with superior information. In other words, market makers act more cautiously as the probability of informed trading increases due to the increase in the scope of speculation during volatile periods. As a result, the quoted depth being offered by the market makers is also distributed away from the best quotes.

Slope is estimated using 10 snapshots of the order book sampled every 30 minutes during the most active part of the trading day from 11:00 AM to 3:30 PM because the order book outside these hours tends to be depleted of depth and prices at lower levels. The total volume supplied (demanded) on each side of the book recorded at each snapshot, at every price level is calculated by accumulating the aggregate number of bonds supplied/demanded at each price level or lower (higher). The local slope at each price level is calculated by taking the ratio of percentage change in the quantity supplied from the previous level to percentage price change from the previous level. The local slopes are averaged across all price levels for bid and ask separately at each snapshot to get bid slope (Demand slope) $DE_{i,t}^{s}$ and ask slope (Supply slope) $SE_{i,t}^{s}$ at each snapshot. (Calculation for only the ask slope is described below as the process is similar for bid slope).

$$SE_{i,t}^{s} = \frac{1}{N_A}\left\{\frac{q_1^A}{\frac{p_1^A}{p_0^A}-1} + \sum_{\tau=1}^{N_A}\frac{\frac{q_{\tau+1}^A}{q_\tau^A}-1}{\frac{P_{\tau+1}^A}{P_\tau^A}-1}\right\},$$

For each bond *i*, on each day *d*, we average the Supply and Demand slopes across the 10 snapshots to obtain one daily average slope as given below,

$$SLOPE_{i,d} = \frac{1}{N_A}\sum_{s=1}^{10}\left\{\frac{SE_{i,t}^{s} + DE_{i,t}^{s}}{2}\right\}$$

The daily slopes are averaged every month to get a final Slope.

Amihud

We measure the daily price impact of trade as the ratio of absolute change in the mid-price for a unit dollar volume traded during the day.

$$Amihud_d = \frac{1}{T}\sum_{t=1}^{T}\frac{|\Delta MidQuote_m|}{P_t * Q_t},$$

$$\Delta MidQuote_m = MidQuote_m - MidQuote_{m-1},$$

where $\Delta MidQuote_m$ is the difference between the mid-price observed immediately preceding and following a trade at t ($m-1 < t < m$), P_t is the traded price and Q_t the traded volume at *t.* Finally for each bond we compute the daily average of daily Amihud measure implemented above.

<u>*Principal Component of liquidity proxies (PC)*</u>

We extract the first principal component from the 10 liquidity proxies by using the principal component analysis (PCA) with missing values as in Korazcjyk and Sadka(2007) using the Expectation Maximization algorithm(EM) suggested in Stock and Watson(1998). We perform factor decomposition across our 10 liquidity proxies, whose units can vary by several orders of magnitude leading to over-weighting because of the scale. Also some liquidity proxies measure liquidity and while other measure illiquidity. To maintain consistency of sign, we multiply the liquidity proxies such as depth, order book slope, trade volume, trade frequency, number of market participants/market makers by -1 before we proceed to the standardization. We standardize our liquidity proxies to have a zero mean and unit variance. Define L^{i*} to be the $n\ X\ T$ matrix of observations and μ^i to be the time series mean and σ^i to be the standard deviation of the i^{th} liquidity proxy (i=1,…10). Let L^i be the $n\ X\ T$ matrix of observations on the i^{th} standardized liquidity measure where $L_t^i = (L_t^{i*} - \mu^i)/\sigma^i$, we apply the factor decomposition as

$$L^i = B^i F^i + \varepsilon^i,$$

where F^i is $k\ X\ T$ matrix of factors and $B^i$is an $n\ X\ k$ vector of factor loadings and ε^i is an $n\ X\ T$ vector of idiosyncratic shocks specific to liquidity proxy *i*. With an unbalanced panel with missing values, quasi-MLE estimates are obtained through an iterative procedure that maximizes, at each step, the complete data likelihood. Under the assumption that ε_t^i is i.i.d the missing values are replaced by the fitted value of the factor model from the previous iteration. In other words $L_t^{i*} = L_t^i$, when data are observed and $L_t^{i*} = \widehat{B^i}\widehat{F^i}$ when data are missing. The factor estimates are obtained from the eigen vectors of

$$\pi^{i,*} = \frac{L^{i*\prime}L^{i*}}{n}$$

This process is repeated by maximizing the objective function using the EM algorithm. The full details of the EM algorithm can be obtained from Stock and Watson(1998).

8.2 Bond Volatility

We estimate the daily bond volatility as the sum of squared log returns computed by using tick-by-tick mid prices (average of best bid and ask prices) during the day.

$$Bond\ Volatility_d = \sum_{t=1}^{T} (\log(Mid\ Price_t) - \log\,(Mid\ Price_{t-1}))^2$$

Table 8.3 Maximum Tradable Spreads (bps)

This table reports the maximum tradable bid ask spreads(basis points,*bps*), below which ,99.9% of trades are executed from 2004 to 2010 for a) bonds with remaining time to maturity below or equal to 10 years,(**S**, Short) and b) bonds with remaining time to maturity above 10 years,(**L**, Long)

	2004	**2005**	**2006**	**2007**		**2008**		**2009**		**2010**	
	S/L	S/L	S/L	S	L	S	L	S	L	S	L
Austria	50	50	50	50	70	50	300	100	300	50	150
Belgium	50	50	50	50	70	100	100	50	150	50	150
Germany	50	50	50	50	70	50	150	50	150	50	70
Spain	50	50	50	50	70	100	100	50	150	100	200
Finland	50	50	50	50	70	50	50	50	150	50	50
France	50	50	50	50	70	50	100	50	150	50	70
Greece	50	50	50	50	70	150	200	200	400	400	500
Ireland	50	50	50	50	70	50	100	150	200	70	300
Italy	50	50	50	50	70	50	150	50	100	50	70
Netherlands	50	50	50	50	70	50	150	50	100	50	100
Portugal	50	50	50	50	70	70	70	70	300	70	300

Table 8.4. Cross sectional regression of individual bond excess yields on liquidity proxies.

This table presents the results of monthly cross sectional regressions of individual bond yield spreads on liquidity proxies along with the control variables cds spreads, duration and age for the periods Pre-Crisis(January 2004 to July 2007) and Crisis(August 2007 to Jul 2010). The regressions are conducted separately for three groups sorted by the individual bond duration: short, medium and long term. The dependent variable is the individual monthly bond yield spread (bond yield – 3M ECB zero coupon yield). The independent variables consist of individual bond liquidity proxies added in the model in exclusion of the others. The time series average of slope coefficients β_L are presented for each group against each liquidity proxy.The intercept and the coefficients of rating and age are dropped from the table to save the space.The t-statistics are estimated using Fama-Macbeth standard errors with serial correlation corrected using Newey and West (1987). The time series average Adjusted R-squared are presented right below the slope coefficients. Slope coefficients that are statistically significant at 5% level are represented in bold characters.

		Pre Crisis			Crisis		
		Short	Medium	Long	Short	Medium	Long
BA Spread	β_L	**7.37**	**11.23**	**5.17**	**2.75**	**1.60**	**1.33**
		4.52	6.75	10.24	10.13	12.12	9.77
	$Adj\ R^2$	*29%*	*32%*	*76%*	*59%*	*69%*	*68%*
Depth	β_L	**0.31**	**-0.35**	**-1.85**	0.20	**-2.73**	**-1.01**
		5.57	-5.78	-9.65	0.58	-1.58	-1.51
	$Adj\ R^2$	*18%*	*27%*	*72%*	*35%*	*56%*	*66%*
Slope	β_L	**-0.48**	**-3.12**	**-7.98**	**-3.14**	2.44	**-9.28**
		-4.64	-5.38	-4.71	-4.46	0.22	-2.83
	$Adj\ R^2$	*22%*	*24%*	*31%*	*53%*	*56%*	*59%*
Quote updates	β_L	**2.13**	**15.23**	**18.65**	**3.32**	**12.69**	**7.40**
		2.26	8.85	11.62	4.13	4.73	3.38
	$Adj\ R^2$	*20%*	*53%*	*60%*	*36%*	*62%*	*63%*
Trade Frequency	β_L	-0.00	**-0.25**	**-0.15**	-0.09	-0.08	**0.85**
		-0.08	-4.00	-2.55	-0.12	-0.13	2.11
	$Adj\ R^2$	*15%*	*20%*	*28%*	*36%*	*55%*	*56%*
Trade Volume	β_L	0.01	**-0.03**	-0.09	-0.02	-0.00	**0.15**
		1.48	-2.67	-7.64	-0.19	-0.06	2.60
	$Adj\ R^2$	*15%*	*21%*	*31%*	*36%*	*56%*	*57%*
Amihud	β_L	**7.30**	**5.08**	**5.35**	**5.27**	**1.27**	**0.77**
		3.73	5.67	6.70	5.24	3.66	1.89
	$Adj\ R^2$	*18%*	*23%*	*51%*	*42%*	*56%*	*61%*

Number of market participants	β_L	-0.02	**-0.03**	**0.13**	**-0.10**	0.37	**-0.28**
		-1.04	-3.17	7.01	-3.02	0.89	-7.12
	$Adj\ R^2$	*16%*	*21%*	*30%*	*34%*	*56%*	*58%*
Number of committed market makers	β_L	**0.47**	**-0.09**	**0.37**	**-0.69**	1.37	**-0.87**
		5.48	-2.17	3.66	-4.23	1.35	-5.15
	$Adj\ R^2$	*16%*	*21%*	*31%*	*35%*	*55%*	*58%*
PC	β_L	**5.54**	-0.38	**-3.01**	-0.71	**-3.16**	-0.73
		6.82	-1.23	-7.02	-1.42	-3.62	-0.57
	$Adj\ R^2$	*24%*	*29%*	*75%*	*56%*	*67%*	*71%*

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