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A Study on Yield Spreads and Liquidity Measures in the Indian Bond Market

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Abstract

This paper studies the effect of liquidity and other trading activities on yield spreads in the Indian bond market. The wholesale debt market (WDM) and corporate bond market segments are both examined in our paper. We have used the study of Subrahmanyam *et al.* (2009) as a reference tool and adapted their study for the Indian bond market[1]. We use time series data for the last 10 years for the Wholesale Debt Market, and the last 4 years for the Corporate Bond Market[2]. To our knowledge this is the first time this data has been used to study bond market liquidity in India, in recent times. Our search indicated that the last significant work was in 2003.[3] This was a study of the imperfections in the Indian corporate bond market and the relationship between yields and market measures like liquidity, ratings, frequency of trading. We have used wider, more recent datasets and enlarged the scope to consider Government securities as well. Our dataset also allows us to consider the impact of the recent crisis in the financial markets worldwide.

We test the hypothesis that liquidity measures and trading activity explain yield spreads. The explanatory power of the variables considered, provide an insight into the Indian bond market. We find good evidence regarding the significance of liquidity measures on yield spreads.

Keywords: Liquidity, Bond Rating, Yield Spread

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[1] Marti Subrahmanyam, Nils Friewald and Rainer Jankowitsch, 2009

[2] We gratefully acknowledge the historical data provided by the National Stock Exchange, Mumbai for the Wholesale Debt Market segment

[3] Sucshismita Bose, Dipankar Coondoo, 2003

Introduction

The inspiration for this study came from an important paper published by Subrahmanyam *et al.* (2009) where they have studied the US fixed income market and tried to glean patterns regarding credit deterioration and illiquidity.[4] The study tries to capture which of the two causes, credit deterioration or illiquidity, have a more significant effect on bond yields. They have also compared the effect across different time periods when the environment was different. They have considered both speculative and investment grade bonds in their study. Recent events in financial markets worldwide, which began with the sub-prime crisis in the USA, have thrown up several interesting questions concerning liquidity, pricing, and credit rating. We will address these questions in our study.

Their study included more than 20,000 bonds starting from October 2004. The authors identified three different regimes in their sample period. The first period coincided with the GM/Ford crisis in 2005 when the corporate bond market was affected with GM/Ford debt downgraded to junk status. The second period was one of relative calm, which was succeeded by the dramatic crisis in the sub-prime market starting in 2007-2008. Their study also examined how liquidity affected different sub-groups. In particular the sample is subdivided along the following lines:

a) Financial and industrial firms
b) Retail and institutional trades
c) Investment grade and speculative grade bonds

Using the liquidity factors, they have tried to explain the variation in bond yields.

Bond Markets Compared

The US bond market, at $32 trillion, is by far the largest fixed income market in the world (Figure 1). The public sector constitutes only about a third of the US fixed income market.

By comparison, emerging markets like India and China have a much smaller fixed income segment. Yet, the bond market in India, which is estimated to be growing at 6% with Government securities (G-Secs), comprising the main segment of the market, is becoming

[4] Marti Subrahmanyam, Nils Friewald and Rainer Jankowitsch, 2009

sizeable. The outstanding issue size for G-Secs is estimated at $289 billion with a secondary market turnover of $1,200 billion.

The Indian bond market is 1/60th of the US market. The amount raised in the primary market by non-government entities has formed no more than a third of the total raised in recent years. While there is relatively healthy trading in G-secs, the depth of the corporate bond market is singularly shallow (Table 1)

Mortgage backed securities that form almost another third, are completely absent in the Indian market (Figures 4)

Literature Survey

Several authors have studied the relationship between liquidity (or illiquidity) and asset prices. Various proxies for illiquidity have been proposed; most are related to spreads. Amihud *et al, (1986)* measure illiquidity by the premium associated with executing a transaction immediately.[5] The authors make the argument that the spread between bid and ask is a measure of illiquidity. They find evidence of negative correlation between the spread and trading volume (and number of market makers), which is deemed to be a proxy for liquidity. They find asset prices to be negatively related to liquidity – more illiquid assets yield higher expected return; their cheaper price compensates for the illiquidity.

Amihud (2000) proposes a liquidity measure for the equity market making use of the equity return and the trade volume.[6] The study uses the excess market return owing to market illiquidity to suggest a liquidity premium. The illiquidity measure is the ratio of average daily return (absolute value) over trading volume (in dollar terms). Amihud provides evidence for illiquidity affecting *ex-ante* excess stock returns over a year.

Diaz *et al.* (2003) analyze the relationship between yield spreads of Treasury and non-Treasury fixed income assets in Spain.[7] They have postulated that the observable downward sloping term structure of the yield spreads is due to the effect of liquidity. The shape of the term structure, according to them, is the result of both credit and liquidity risks.

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[5] Amihud and Mendelson, 1986
[6] Amihud, 2000
[7] Diaz and Navarro, 2003

Ericcson *et al.* (2005) develop a structural model to capture liquidity and credit risk for bonds, using US corporate bond data for a period spanning 15 years.[8] The effect of illiquidity on yield spreads is felt to be more predominant in those cases where default is more likely to occur. Their model predicts the shape of the term structure of liquidity spreads and the effect of default risk on it. Their model also predicts, in line with earlier work of Amihud and Mendelson (1986), that liquidity spread is a decreasing function of maturity of the bond. They use two liquidity proxies: liquidity risk in Treasury markets and age of the bond.[9]

Mahanti *et al.* (2005) proposed a new measure of liquidity called 'latent liquidity' for corporate bonds to glean information about bonds with higher liquidity.[10] Instead of using traditional transactional information such as trading volume and bid-ask spreads, they have used ownership information to determine 'accessibility'. They were able to correlate the proposed measure with bond characteristics like maturity, amount outstanding etc. They exhibited similar relationship to those given by conventional trade measures like volume etc. Also they were able to use this in the illiquid segment of the market, where conventional trade data is sparsely available, and were able to get results similar to what one would get in the liquid segment.

Chen *et al.* (2005) examine whether liquidity is priced in corporate bond yield spreads.[11] They analyze over 4000 corporate bonds spanning both investment and speculative bond categories and postulate that higher illiquidity earns higher yield spreads. Longstaff (Francis A.Longstaff, 2002) determine whether there is a flight-to-liquidity premium in US Treasury bond prices by comparing them with US Government backed bonds issued by Refcorp.[12]

Bao *et al.* (2008) propose a new measure of illiquidity for corporate bonds based on earlier studies by Grossman and Miller (1988) and Huang and Wang (2007) that illiquidity gives rise to transitory price movements.[13] According to the authors, the negative of the auto covariance in price changes, denoted by Y, provides a robust measure of illiquidity. They have used Y to examine the levels of illiquidity and asset pricing in corporate bonds. Based on a study of

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[8] Ericson and Renault, 2005
[9] Amihud and Mendelson, 1986
[10] George Chacko, Sriketan Mahanti, Gaurav Mallik and Marti Subrahmanyam, 2005
[11] Long Chen, David A. Lesmond and Jason Wei, 2005
[12] Francis Longstaff, 2002
[13] Jack Bao, Jun Pan and Jiang Wang, 2008

corporate bonds between 2003 and 2007, they have found out that bid-ask bounce explains only part of the illiquidity in bonds. They have also found a rise in illiquidity during times of crises.

Lubomir (2009) has studied Yankee bonds (bonds of foreign issuers in US markets) and concluded that liquidity explains 1% of daily changes in yield spreads.[14] In effect, credit risk from the economy has a bigger role to play in affecting yield spreads than liquidity risk.

Hai Lin *et al.* (2009) examine the effect of liquidity risk on yields of muni-bonds and taxable bonds.[15] The evidence for the effect of tax on asset pricing has been mixed. The authors find significant correlation between yield spread of municipal and taxable bonds, and the liquidity premium. Their study attempts to explain the muni puzzle, which is the empirically observed fact that relative to taxable bond yields, long-term yields of tax-exempt bonds are higher. They have added liquidity factors to explain yields of tax-exempt and taxable bonds. Their results suggest that liquidity is a key factor in pricing muni-bonds.

Amihud *et al.* (2010) examine how US Corporate bond returns are correlated to liquidity shocks in equity and Treasury bonds over the period 1973 to 2007.[16] They postulate the existence of time variant liquidity risk for corporate bonds. Any decline in liquidity of treasury bonds or stocks has different effects on speculative and investment grade bonds. While the prices of the latter rise, the prices of the former actually fall. Any unexpected rise in illiquidity for an asset increases expected return causing a decreasing yield and a widening in yield spreads. They have also tested this model out-of-sample for the period 2008-2009 and have reported robust results.

India, like most other emerging markets, is characterized by very little empirical literature on its bond market, in part reflecting the lack of depth in the market. Bose *et al.* (2003) study liquidity in the Indian bond market using volume data of trades.[17] Ajay Shah *et al.* (2008) look at the liquidity crunch in India and the required policy interventions.[18] To the best of our knowledge no previous study of the Indian market has examined the relationship between liquidity and pricing.

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[14] Lubomair Petrasek, 2009
[15] Hai Lin, Sheen Liu, Junbo Wang and Chunchi Wu, 2009
[16] Viral V. Acharya, Yakov Amihud and Sreedhar Bharath, 2010
[17] Suchismita Bose, Dipankar Coondoo and Sumon Kumar Bhaumik, 1999
[18] Jahangir Aziz, Ila Patnaik and Ajay Shah, 2008

Regression Model

To study the above relationship, we use the model used in Subrahmanyam *et al.* (2009) which is presented below.[19]

$$\Delta(\text{Yield Spread})_{i,t} = \alpha_0 + \alpha_1.\Delta(\text{Yield Spread})_{i,t-1} + \beta.\Delta(\text{Rating Dummies})_{i,t} + \gamma.\Delta(\text{Trading activity variables})_{i,t} + \lambda.\Delta(\text{Liquidity Measures})_{i,t} + \varepsilon_{i,t} \quad \text{………(1)}$$

where α_0, α_1, β, γ, λ are the regression coefficients

We use first differences in trading activity variables and liquidity measures along with the lagged values of the yield spread differences. Wherever possible, we have added the rating dummies variable to account for credit risk. This is discussed in detail in the results section**.**

Explanatory Variables

We have used a few variables, suggested through our literature survey, as proxies for liquidity to explain yield measures. We had to discard a few of them for want of relevant data for the Indian bond markets. Similar to the study by Subrahmanyam *et al.* (2009) cited already, we have classified them into bond characteristics, trading activity and liquidity variables. Bond characteristics include coupon and maturity.[20] Trading activity is measured by trading volume reported on a daily basis. We will discuss liquidity proxies in detail below.

Liquidity proxies

We consider five variables as proxies for liquidity. We have considered only four of them in our regression. Bid-ask spread data is not available and we do not use it in our analysis.

Price Dispersion

Price dispersion is a new liquidity measure discussed by Jankowitsch *et al.* (2008) and measures the deviation between the traded price and market value scaled by the daily volume.[21] Price dispersion indicates potential costs of transaction for a trade.

[19] Marti Subrahmanyam, Nils Friewald and Rainer Jankowitsch, 2009
[20] Ibid.
[21] Rainer Jankowitsch, A. Nashikkar and Marti Subrahmanyam, 2008

$$\text{Price Dispersion}(t) = \sqrt{\frac{1}{\sum_{k=1}^{K(t)} vk} \sum_{k=1}^{K(t)} (pk - m(t))^2 vk}$$

Where pk and vk represent the $K(t)$ observed traded prices and volumes on date t and $m(t)$ is the market value on that day.

Amihud ratio

As explained in the literature review section, Amihud ratio is a liquidity measure proposed by Amihud (Amihud, 2000) for the equity markets. It is computed using the absolute daily dollar return over the trading volume (measure in dollars).

$$Amihud(t) = \frac{1}{\text{N(t)}} \sum_{j=1}^{N(t)} \frac{|rj|}{vj}$$

where N(t) is the number of observed returns over a defined period t and rj, vj are returns and trading volumes respectively. A large Amihud ratio denotes a large change in price for a given change in volume, implying higher illiquidity.

Bid-ask spreads

The Bid-ask spread is an accepted measure of liquidity costs. Brokerage fees and bid-ask spreads constitute transaction costs. Since brokerage costs remain constant, difference in bid-ask spreads could be used as a measure of liquidity costs.

Roll Measure

This measure was developed by Roll (1984) where the covariance in price movements is used as a proxy for liquidity.[22]

$$\text{Roll (t)} = 2\sqrt{-Cov(\Delta pt, \Delta pt - 1})$$

Here the Roll measure is taken to be zero if the Covariance between adjacent price data points is positive. Roll measure is a proxy for liquidity because it gives a sense of the round trip costs i.e. the costs of completing a transaction, including commissions and market impact.

[22] Roll R., 1984

Zero Return

Subrahmanyam *et al. (2009)* have suggested the use of zero return as a proxy for liquidity.[23] The zero return is used to track the staleness of price data that we use. It takes the value '1' if the price on 2 consecutive days remains the same and a value '0' otherwise. Zero return is observed when the price over two days remains unchanged and yields a zero return. A value of '1' over a period of time is more likely to be construed as a measure of illiquidity. The intuition is that bond prices that stay constant at a particular value are more likely to do so owing to lack of liquidity.

Methodology

In this paper, we first have a look at the model that we follow for studying yield spreads and define the variables used. Then we look at the sources of our data and describe all approximations and assumptions made in our analysis. Finally we interpret the results that we obtain.

Yield Spread

The yield spread of a corporate bond can be interpreted as the penalty that is added to the yield to maturity of a benchmark Treasury bond. The penalty is added to account for relative illiquidity of a corporate bond as compared to the Treasury bond. We use the yield spread as a proxy for liquidity because a wider spread is associated with a higher credit risk or a higher risk of default. So investors are apprehensive about buying securities with greater yield spread and hence these securities trade below the yield curve. Also as an incentive for the investors, the securities with huge yield spreads usually trade at a discount or else they need to offer huge coupons to counter this.

Explanatory Variables

Both trading activity variables and liquidity indicators are included in the basket of explanatory variables. For instance the volume index would address the impact on yield spread due to increase or decrease in trading volumes. Whereas a liquidity indicator like Price Dispersion Index refers to the impact on yield spread due to change in transaction costs. To ensure that no

[23] Marti Subrahmanyam, Nils Friewald and Rainer Jankowitsch, 2009

two variables have exactly the same characteristics, we have formed the correlation matrix of the explanatory variables. From the correlation matrix (shown in Table 8), we find that almost all the input variables have little correlation with each other. This means their characteristics are also independent. An exception is the high degree of correlation between the Roll Measure and Price dispersion. By definition, the Roll measure is a measure of the bid-ask bounce, as quantified by adjacent price movements. As we argue elsewhere in this paper, Roll measure is economically not significant and this exception that we encountered here can be ignored. An additional point to note is that lack of intra-day data and lack of depth in the market automatically implies a less than accurate picture about the bid-ask bounce.

Linear Regression:

The basic methodology is to regress the change in yield spread against trading activity variables and liquidity indicators. Since the yield spreads are auto correlated, we estimate equation (1) in first differences as repeated below.

$$\Delta(\text{Yield Spread})_{i,t} = \alpha_0 + \alpha_1.\Delta(\text{Yield Spread})_{i,t-1} + \beta.\Delta(\text{Rating Dummies})_{i,t} + \gamma.\Delta(\text{Trading activity variables})_{i,t} + \lambda.\Delta(\text{Liquidity Measures})_{i,t} + \varepsilon_{i,t}$$

Data and Approximations

We have been extremely fortunate to receive directly from the National Stock Exchange (NSE), Mumbai, a data set that is not so commonly used. Owing to the different nature of the Indian debt market we have conducted the analysis in a unique way described below. The data required us to make certain approximations for usability.

The NSE data classifies Government securities under the Wholesale Debt Market (WDM) segment, and provided it to us for a period of 10 years from 1999 to 2009. In the case of corporate bonds, we use two sets of data. The first set of data provided daily credit default swap (CDS) spreads for A+++ rated bonds and A++ rated bonds, obtained from Bloomberg, for the period September 2003 to August 2010. The second set of data involved daily data from NSE for the period June 2007 to September 2010. In its composition, this was similar to the dataset on the WDM segment. A common problem across all datasets was the lack of liquidity, evident in our datasets, with extremely thin values for the periods under consideration.

The first approximation we had to make was due to the fact that we did not have the daily data for volumes traded for each corporate bond from Bloomberg. To overcome this data limitation, we assume the volumes to be proportional to the total volumes of 10 year bonds traded on each day. Since the volume measure always occurs in the numerator and denominator of all the explanatory variables, the proportionality constant is eliminated. The only variable where this does not occur is the Roll measure. In this case, the regression coefficient (slope variable) is a constant of proportionality and it adjusts itself when we actually perform the regression. We are interested in the t-statistic and a proportionality constant on the explanatory variable is not going to affect the regression coefficient. In addition, as we shall see later, the Roll measure is deemed economically insignificant.

In the second case, the corporate debt data from the NSE, we do have data on daily volumes traded. But the corporate debt markets are thin and trades for any particular bond do not happen on a daily basis. So when we calculate the yield spreads of these corporate bonds against a Government security benchmark, the analysis on a daily basis cannot be made without approximations. We have addressed this problem by collating different corporate bonds with similar maturity dates and similar yield to maturity. This collated entity is then compared against a similar maturity Government security benchmark to get the yield spreads on a daily basis.

We did one more approximation to address the following issue: while collating different corporate bonds into a common basket, it is possible for different securities to have different coupons. If this is the case, then the price at which the different bonds would trade would be different. So for consecutive days, the price difference in the same basket might be large. To address this issue, we assume a common coupon for all the bonds in the basket. From this data, we recalculate the price of each bond traded on a daily basis. This provides us with a better price measure.

In the case of comparison of Government securities against their benchmarks, we have taken 3 bonds, each with different time to maturity. This was done to ensure different parts of the yield curve were covered. These bonds would be compared against benchmark securities and the yield calculated on a daily basis.

The basis for the selection of the benchmark security is that the duration of both the to-be-compared bond and the benchmark security should be the same. So based on this condition, we compare 2011, 2017, 2022 maturing bonds against 2015, 2019, 2020 maturing benchmarks respectively. In case of lack of data for either the benchmark or the to-be-compared bond on a particular day, we do not take the trade on that day and accordingly, the adjustments are made in the formula for the lack of data. For instance, while computing the returns on a particular day, say November 3rd 2010, if we do not have data for November 2nd, we use data from November 1st and then adjust the daily returns accordingly

In all the cases, we have assumed the price data to be log-normally distributed. Therefore the returns are normally distributed. We factor in liquidity, by using volume weighted price when computing returns.

In dealing with the first set of corporate bonds data, to calculate Rolls measure and Price Dispersion indicators, different instances of prices and volumes are required on each trading day. (Intra-day prices and volumes). We overcome the non-availability of intra-day data, by replacing the concept of different price and volume instances on each day with the corresponding data for 10 consecutive trading days. This is done for both price and volume. This is the closest approximation to the ideal case. Also since there is not much trading, we assume there would not be appreciable price and volume variation in a few days.

In dealing with the second set of corporate bonds, as mentioned earlier we had data for volumes traded on each day, but were handicapped by the fact that the bonds were not traded on a daily basis and that intra-day data was not available for the bonds. So we chose not to include price dispersion in our analysis for this data, as intra-day data requirement is essential to calculate price dispersion.

Hypothesis and Tests

Based on the methodology presented above, various hypotheses regarding the effect of liquidity in the Indian corporate bond market can be tested. In this section we formulate the hypotheses that we will test. We have two main hypotheses that we test.

Null Hypothesis 1:

$H0_1$: Trading variables and liquidity indicators do not affect the liquidity (or the illiquidity) of a bond in the market.

Test for $H0_{1:}$ Regress the change in yield spread of a bond on the indicators mentioned above (Equation 1). We expect the coefficients of regression to be equal to zero. We test for significance using the t-statistic.

Null Hypothesis 2:

$H0_{2:}$ The credit ratings of a corporate bond do not play a role in determining liquidity.

Test for $H0_{2:}$ Repeat the above process of regressing yield spread change for 2 corporate bonds with credit ratings of A++ and A+++. We have 2 expectations here.

I. The corporate yield spread of A++ may not be greater than that of A+++
II. The margin of difference may not be significant implying smaller effect of credit rating on liquidity.

We test the coefficients of regression for significance using the t-statistic.

Results:

Impact on Liquidity due to bond credit ratings (based on first set of data on corporate bonds)

First we ran the *regression test for A++*. The following are the results obtained.

Coefficient of determination (R-Square):

The value of the coefficient of regression was found to be 0.002 (Table 2). This extremely small value indicates large values of sum of square errors. We will discuss the persistent low values of R^2 in the next section.

From the regression coefficients (Table 2), it can be seen that the value of the regression coefficient of the Roll Measure is negative. This is interesting because we know that Roll Measure is an indicator of round trip costs for a particular bond and greater the trip costs, greater the Roll Measure value and hence greater the yield spread. So we had expected a positive correlation coefficient.

From table 2, we can see that except Amihud number and volume measure to some extent, none of the other variables appear statistically significant. Also the analysis of variance test (ANOVA) provides us with a low F-Value of .4952. This means that the explained variances is only around half of the unexplained variance.

Next, we ran *the regression test for A+++*. The following are the results obtained.

Coefficient of determination (R-Square):

The value was found to be 0.009 (Table 3). This value is highly on the lower side, indicating large values of Sum square errors.

From the regression coefficients, it can be seen that the value of Roll Measure regression coefficient happens to be positive here. But the Price Dispersion regression coefficient happens to be negative. This is interesting because we know that Price Dispersion Measure is an indicator of transaction costs for a particular bond and greater the transaction costs, greater the Price Dispersion Measure value and hence greater yield spread. So we had expected a positive correlation coefficient. But this effect can be explained as follows. We are dealing with relatively liquid bond in corporate bond market. So the transaction costs for this bond would be at a minimum. So a direct correlation regarding yield spread increase with greater transaction costs may not have been possible, which would have resulted in a negative correlation coefficient.

We can see from table 3, that price dispersion, Amihud number, volume measure and lagged value of yield spread, appear statistically significant. This is a very significant improvement over the previous regression in the case of A++ rated bonds (full time period). The analysis of variance test (ANOVA) provides us with F-Value of 1.96. This means that the explained variance is 1.96 times the unexplained variance in the data. This is reasonable and falls within the expected lines.

Impact on Liquidity during Crisis & other Time Periods

Next, we proceed to regress the bond yield spreads against various parameters as indicated before. But the additional point is to see how the yield spreads react for different time periods. For this we have split the 2005-2010 yield spread data into 2 parts. One is during the financial crisis, which extended from Jul 2008 to Mar 2009. The period of non-crisis, 2005-2008 forms the second part of our analysis. We repeat this for both A+++ and A++ rated corporate bonds.

A++ during crisis

Here we analyze the impact on the yield spread of AA+ corporate bond during the financial crisis by performing the regression for the yield spread against the liquidity and trading parameters, as before. It can be seen that R^2 (3.18%) rises significantly when compared to previous cases. This could be explained as follows: Suppose the yield spread for the AA+ bond increased by 5 bps. People expect a further dip in bond pricing or increase in yield by selling these corporate bonds and holding on to treasury bonds during the time of crisis. We also see that the P value for the same has become more statistically significant than before when AA+ yield spread was regressed for the full time series. Likewise Amihud Number also achieves greater statistical significance in this case.

We can see from table 4 that the t-statistics of Amihud number and the lagged value of yield spread appear significant. The F-value also increases implying the greater proportion of explained variance to unexplained variance in the system, which is desirable.

A++ during non-crisis

We consider the A++ bonds during the period of non-crisis, 2005-2008. We perform the regression as before. We can see from table 5 that the t-statistic of Amihud number appears significant. The R^2 value is on the lower side, something that we have observed consistently and which we will discuss in the next section.

A+++ during crisis

Now we repeat the same process with A+++ rated corporate bonds. Significantly, from table 6, the R^2 value is the highest at 5.18%. We see that during the times of crisis, the Amihud measure has a negative regression coefficient on the yield spread change. This can be explained as follows. A+++ is the highest credit rating and therefore the lowest credit risk. During times of crisis people will be more willing to invest in A+++ bonds. This higher demand for these bonds increases liquidity, which lowers the bid ask spread. This logic is further supported by the fact that the trade volumes also have a negative regression coefficient on the yield spread change. This means that as trade volumes increases the yield spread change decreases implying lack of illiquidity. It can also be seen that the regression coefficient of price dispersion shifts from a negative value (Table 3) under full time scale to a positive value during the time of crisis (Table 6). This implies that as the transaction costs (Price dispersion is a measure of transactions costs) increases the yield spread change also increases. Another important point is the coefficient of determination R square improves significantly meaning the sum square errors is on a lesser level as against the value on the full time scale.

A+++ during non-crisis

Finally we consider the A+++ bonds for the period 2005-2008 (period of non-crisis). The trend (Table 7) here is similar to what was discussed under performance of A+++ corporate bond (full time scale, Table 3). Amihud number, price dispersion, volume measure and lagged yield spread all turn out to be statistically significant. The R^2 for this regression is slightly more than 1%.

Impact of Liquidity on Government Securities

The following are the results obtained when we calculated yield spreads for 2011, 2017, 2022 maturing bonds against 2015, 2019, 2020 maturing benchmarks respectively.

Coefficient of determination (R-Square):

In all the 3 cases that we considered, the value of the coefficient of determination was found to be small ranging between 0.01 and 0.11 (Table 9, 10, 11). This value is highly on the lower side, indicating large values of Sum square errors as a percentage of total sum squares. In other words, the expected sum squares as a percentage of total sum squares is very small.

From the regression coefficients, it can be seen that in 2 out of 3 regressions (Table 9, 11: 2022 and 2011 cases), the value of regression coefficient for Roll Measure is negative. This is interesting because we know that Roll Measure is an indicator of round trip costs for a particular bond and greater the trip costs, greater the Roll Measure value and hence greater yield spread. So we had expected a positive correlation coefficient.

From the regression tests, we obtain mixed results. For example, in case of 2011 Vs 2015 security comparison (Table 9), we find the t-statistic to be very high (8.74) at a confidence level of 95% for price dispersion. This is further verified by the very small p-value (which indicates the probability of obtaining a critical value that would lead to a rejection of the null hypothesis). But in the other 2 cases, the t-statistic corresponding to price dispersion was found to be small. This meant that we cannot reject the null hypothesis that the yield spread change does not depend on price dispersion.

Likewise, incase of 2011 Vs 2015 bonds (Table 9) and 2020 Vs 2022 bonds (Table 11) the t-statistic corresponding to the ‘difference in the number of trades between two adjacent days’ variable happen to be higher, which denotes the significance of the difference in number of trades as an explanatory variable.

We can see from table 15 that Amihud number, price dispersion and difference in number of trades between two adjacent days are significant explanatory variables. Although the evidence appears mixed, we can conclude on their significance based on the fact that they have high values, whenever they appear significant. Also zero return and roll measure, which are economically not significant (Marti *et al.,* 2009), are also statistically not significant.

Impact on Liquidity on corporate bonds: (based on second set of data on corporate bonds)

The following are the results obtained when we calculated yield spreads for 2011, 2017, 2022 maturing bonds against 2015, 2019, 2020 maturing benchmarks respectively.

Coefficient of determination (R-Square):

In all the 3 cases, the value was found to be small ranging from 0.008 to 0.03 (Tables 12, 13, 14). This value is highly on the lower side, indicating large values of sum square errors. In other words, the expected sum squares as a percentage of total sum squares are very small.

From the regression coefficients, it can be seen that in 1 out of 3 regression runs (Table 13: 2017 maturing set of corporate bonds), the value of Roll Measure regression coefficient happens to be negative (-0.0024). This is interesting because we know that Roll Measure is an indicator of round trip costs for a particular bond and greater the trip costs, greater the Roll Measure value and hence greater yield spread. So we expected a positive regression coefficient.

From the regression tests, we obtain mixed results. For example, in case of 2014 maturing set of corporate bonds (Table 12), we find the t-statistic to be very high at a confidence level of 95% for 'change in volume between 2 consecutive days' variable and Amihud number parameter. This means that these two are very significant explanatory variable. This is further verified by the very small p-value (which indicates the probability of obtaining a critical value that would lead to a rejection of the null hypothesis) for the above 2 variables.

We can see from table 15 that Amihud number is a significant explanatory variable in the various cases based on the t-statistic values. As we will discuss in the next section, the roll measure and the zero return measure have little economic significance (Marti *et al*, 2009). The impact of volume is mixed as can be seen from table 15. The only reason could be that the impact of volume is felt much higher in the case of longer maturity bonds than the shorter ones.

Conclusion

Thus we see that for Indian bond market (both corporate and Government securities), illiquidity is not that clearly explained by the liquidity parameters and the trading parameters as indicated by the low value of Coefficient of Determination (R square). We will spend a fair amount of time explaining the low R^2 before proceeding to explain other conclusions.

Lubomair's (2009) study of Yankee bonds (foreign issuers traded in US market), highlighted the fact that credit risk from the macro economy played a much more significant role than liquidity risk.[24] His work, which deviated slightly from earlier findings, indicated that utmost 1% of daily changes in yield spread in corporate bonds (Yankee bonds that he considered) could be accounted for by using the broadest liquidity parameters. The conclusion therefore is that aside of liquidity risk, credit risk explain yield spreads better. This is consistent with earlier findings of Covitz and Dowing (2007).[25] Subrahmanyam *et al.* (2009) reported R^2 values in the region of 14% for various cases.[26] Chen *et al.* (2005) reported an R^2 of 7.3% while regressing yield

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[24] Lubomair Petrasek, 2009

[25] Dan Covitz and Chris Downing, 2007

[26] Marti Subrahmanyam, Nils Friewald and Rainer Jankowitsch, 2009

spread of corporate bonds against three liquidity estimates (Note: The three measures are bid-ask spreads, LOT measures and % zero returns).[27] Our regressions, both in the WDM and Corporate bond segments, exhibit similar trends with R^2 values reaching a maximum of 5.2%. We have made, elsewhere in this paper, reference to the lack of depth and breadth in the market and this could be another reason why the coefficient of determination values, R^2, are on the lower side.

The other key aspect relates to the significance of various explanatory variables that we have used. In general from the overall analysis, mixed pattern was seen among the variables in determining liquidity in the market. Lack of data is definitely an important factor affecting liquidity study and that the factor variables have not been able to explain the liquidity as well as we would have expected. Nevertheless, our time series results offer us some interesting insights in the Indian corporate bond market. In case of the corporate bond segment, from the first set of data, it can be seen that among all the variables, Amihud number gave very good indications about illiquidity. From its t statistics and p-value, we conclude that it is statistically significant as well.

In the original paper by Subrahmanyam *et al.* (2009), it was presented that statistically among liquidity proxies, Amihud number and Price dispersion, with their significant t-statistics, and among trading activity variables, changes in volume and trading activity, are the most important.[28] It was also argued that two variables (liquidity proxies), number of trades and zero return, have for different reasons, different signs (than expected) and are not meaningful. The zero return, it was argued, had little economic significance. Similarly, either buy-side or sell-side pressures, could affect the number of trades and hence it can be discarded.

From our analysis, to a large extent, Amihud number, volume and price dispersion appears statistically significant. However it has to be said that the t-statistics are not as high as seen in the original paper (Subrahmanyam *et al.* (2009)) and it could be argued that lack of data could be one of the reasons.[29]

[27] Long Chen, David A. Lesmond and Jason Wei, 2005
[28] Marti Subrahmanyam, Nils Friewald and Rainer Jankowitsch, 2009
[29] Ibid.

Additionally it has to be pointed out that there has been one instance where the t-statistics are not really significant. On a broad scale, these three variables appear statistically significant and this was as expected.

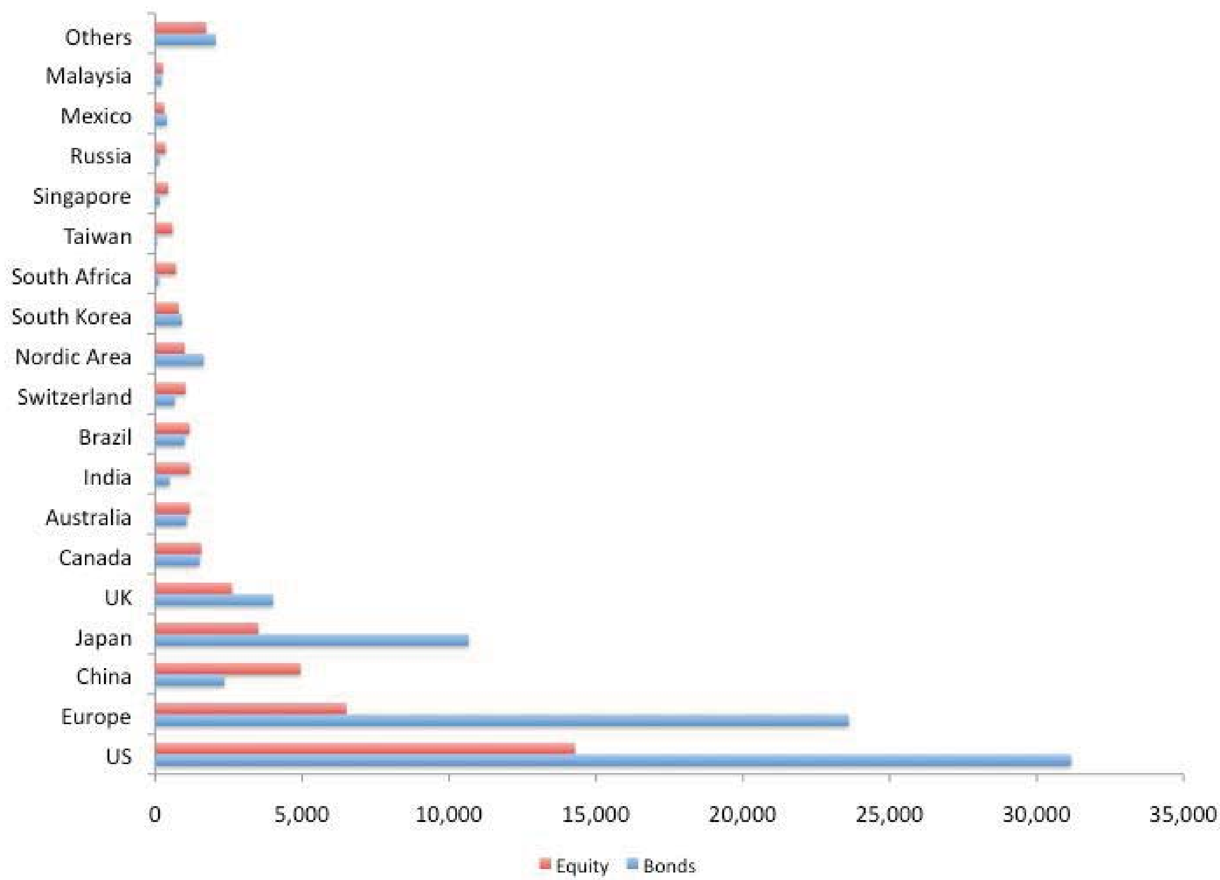
Among other measures, it has been observed that zero-return and roll measure appear statistically insignificant. We have already cited the lack of economic significance of the zero return. Similarly the roll measure, deemed economically insignificant, also provided for very less impact in the original paper (Subrahmanyam *et al.* (2009)).[30]

In conclusion, despite lack of data coupled with the lack of depth in the market, there is a fair amount of support for several of the liquidity proxies that we have used.

[30] Ibid.

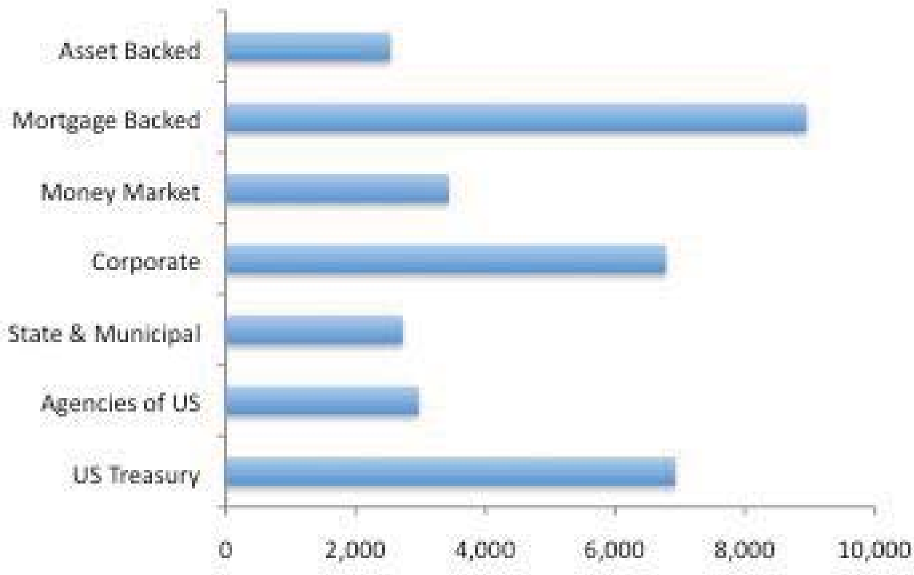
Appendix

Figure 1: *Value of Stock/Bond market worldwide, US$ billions (2009)*



Source: Bank for International Settlements, Asset Allocation Advisor, World Federation of exchanges, 2009

Figure 2: *US Bond Market Outstanding*

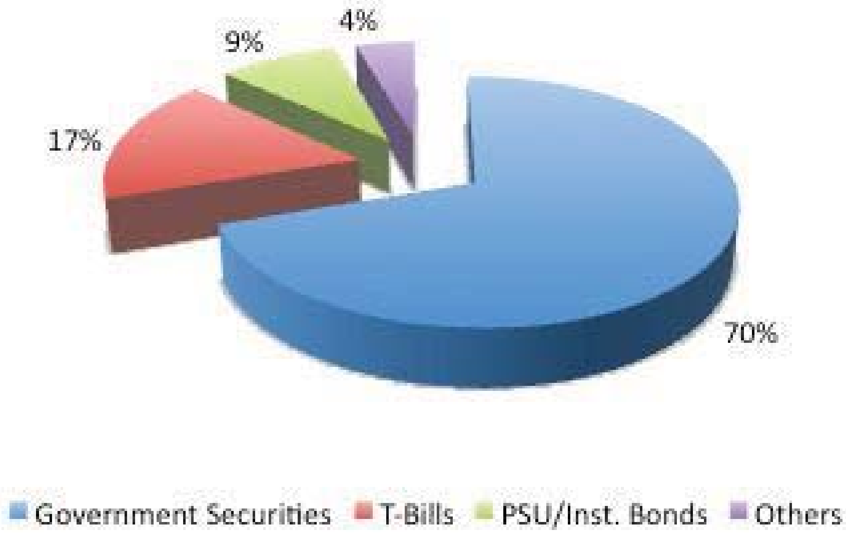


Source: Bank for International Settlements, Asset Allocation Advisor, World Federation of exchanges, 2009

Figure 3: *US Bond Market Composition*

Source: Bank for International Settlements, Asset Allocation Advisor, World Federation of exchanges, 2009

Figure 4: *Indian Debt Market Composition*



Source: National Stock Exchange, India

Table 1: Indian Debt Market Outstanding

Issuer/Securities	Amount raised in Primary market (US$ Mln)		Turnover in secondary market (US$ Mln)	
	2008	2009	2008	2009
Government	64,044	85,709	1,407,893	1,221,872
Corporate/Non-Government	29,088	34,510	5,561	9,011
Total	93,132	120,219	1,413,454	1,230,883

Source: National Stock Exchange, India

Table 2: *Regression statistics for change in yield spreads of A++ 10 yr corporate bond (full time scale)*

	Coefficients	Standard Error	t Stat	P-value
Intercept	0.00081	0.00313	0.25741	0.79690
Price dispersion	0.12468	0.11814	1.05540	0.29145
Roll measure	-0.04537	0.04571	-0.99254	0.32113
Amihud No	0.00195	0.00164	1.19379	0.23278
Zero Return Variable	0.01632	0.02875	0.56757	0.57043
Volume Index	0.00530	0.00679	0.77967	0.43573
Spread (t-1)	-0.00338	0.02826	-0.11961	0.90481

ANOVA

	df	SS	MS	F	Significance F
Regression	6	0.03619	0.00603	0.49325	0.81376
R Square	0.00236				

Table 3: *Regression statistics for change in yield spreads of A+++ 10 yr corporate bond (full time scale)*

	Coefficients	Standard Error	t Stat	P-value
Intercept	0.00117	0.00237	0.49607	0.61993
Price disp	-0.12399	0.08915	-1.39069	0.16457
Roll Measure	0.04238	0.03451	1.22812	0.21963
Amihud Measure	0.00253	0.00124	2.04424	0.04114
Zero Return Measure	-0.01045	0.02170	-0.48160	0.63017
ln(Vol(t)/Vol(t-1))	0.00795	0.00513	1.54966	0.12147
Spread (t-1)	-0.05886	0.02818	-2.08889	0.03692

ANOVA

	df	SS	MS	F	Significance F
Regression	6	0.08213	0.01369	1.96440	0.06778
R Square	0.00932				

Table 4: *Regression statistics for change in yield spreads of A++ 10 yr corporate bond(time of crisis)*

	Coefficients	Standard Error	t Stat	P-value
Intercept	0.00517	0.00505	1.02324	0.30770
Price disp	0.09154	0.63744	0.14361	0.88599
Roll Measure	-0.03311	0.19755	-0.16761	0.86709
Amihud Measure	-0.00385	0.00233	-1.65414	0.10001
Zero Return Measure	0.00922	0.06623	0.13925	0.88942
ln(Vol(t)/Vol(t-1))	0.00479	0.01157	0.41430	0.67920
Spread (t-1)	0.09871	0.07558	1.30596	0.19339

ANOVA

	df	SS	MS	F	Significance F
Regression	6	0.02313	0.00385	0.89801	0.49784
R Square	0.03181				

Table 5: *Regression statistics for change in yield spreads of A++ 10 yr corporate bond(time of non-crisis)*

	Coefficients	Standard Error	t Stat	P-value
Intercept	0.00000	0.00354	0.00002	0.99999
Price disp	0.12726	0.12869	0.98889	0.32294
Roll Measure	-0.04620	0.05202	-0.88803	0.37472
Amihud Measure	0.00317	0.00189	1.67913	0.09342
Zero Return Measure	0.01770	0.03124	0.56650	0.57117
ln(Vol(t)/Vol(t-1))	0.00629	0.00763	0.82500	0.40955
Spread(T-1)	-0.00943	0.03044	-0.30984	0.75674

ANOVA

	df	SS	MS	F	Significance F
Regression	6	0.05580	0.00930	0.69062	0.65727
R Square	0.00382				

Table 6: *Regression statistics for change in yield spreads of A+++ 10 yr corporate bond(time of crisis)*

	Coefficients	Standard Error	t Stat	P-value	
Intercept	0.00918	0.00337	2.72480	0.00713	
Price disp	0.18474	0.42156	0.43824	0.66179	
Roll Measure	-0.07683	0.13074	-0.58763	0.55759	
Amihud Measure	-0.00087	0.00155	-0.55864	0.57717	
Zero Return Measure	-0.01908	0.04379	-0.43581	0.66355	
ln(Vol(t)/Vol(t-1))	-0.00862	0.00767	-1.12395	0.26268	
Spread (t-1)	-0.17224	0.07784	-2.21275	0.02830	

ANOVA

	df	SS	MS	F	Significance F
Regression	6	0.01679	0.00280	1.49547	0.18268
R Square	0.05187				

Table 7: *Regression statistics for change in yield spreads of A+++ 10 yr corporate bond (time of non-crisis)*

	Coefficients	Standard Error	t Stat	P-value	
Intercept	0.00003	0.00268	0.01212	0.99033	
Price disp	-0.15020	0.09762	-1.53864	0.12418	
Roll Measure	0.05792	0.03948	1.46711	0.14264	
Amihud Measure	0.00334	0.00144	2.32166	0.02044	
Zero Return Measure	-0.00887	0.02370	-0.37436	0.70821	
ln(Vol(t)/Vol(t-1))	0.01082	0.00579	1.87011	0.06174	
Spread (t-1)	-0.05470	0.03031	-1.80443	0.07144	

ANOVA

	df	SS	MS	F	Significance F
Regression	6	0.09862	0.01644	2.12167	0.04842
R Square	0.01163				

Table 8: *Correlation Matrix of input variables for regression*

Correlation Matrix	Price disp	Roll Measure	Amihud Measure	Zero Return Measure	Volume Index	SpreadT-1)
Price disp	1	0.94448	0.01493	-0.00573	-0.00506	0.05825
Roll Measure	0.94448	1	0.02504	0.00054	-0.01282	0.05093
Amihud Measure	0.01493	0.02504	1	-0.03292	-0.37159	0.01641
Zero Return Measure	-0.00573	0.00054	-0.03292	1	0.02557	0.00535
Volume Index	-0.00506	-0.01282	-0.37159	0.02557	1	-0.01758
Spread(T-1)	0.05825	0.05093	0.01641	0.00535	-0.01758	1

Table 9: *Regression statistics for change in yield spreads of CG 2011 bond against CG 2015 bond*

	Coefficients	Standard Error	t Stat	P-value
Intercept	0.00031	0.00150	0.20972	0.83395
Change in Daily Vol	0.00000	0.00000	0.16681	0.86757
Daily Diff in no of trades	0.00032	0.00020	1.57525	0.11563
Price Dispersion	0.00950	0.00109	8.74272	0.00000
Roll Measure	-0.00290	0.00485	-0.59707	0.55064
Amihud Measure	0.29579	0.19185	1.54179	0.12355
Zero Return Measure	-0.00322	0.01786	-0.18020	0.85704

ANOVA

	df	SS	MS	F	Significance F
Regression	6	0.09228	0.01538	16.18270	0.00000
R Square	0.11627				

Table 10: *Regression statistics for change in yield spreads of CG 2017 bond against CG 2019 bond*

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.00026	0.00283	-0.09282	0.92610
Change in Daily Vol	0.00000	0.00000	-1.39686	0.16336
Daily Diff in no of trades	0.00017	0.00020	0.89086	0.37363
Price Dispersion	0.00909	0.01851	0.49108	0.62368
Roll Measure	0.00019	0.00859	0.02218	0.98231
Amihud Measure	1.87271	6.54160	0.28628	0.77484
Zero Return Measure	0.00026	0.02885	0.00911	0.99274

ANOVA

	df	SS	MS	F	Significance F
Regression	6	0.00433	0.00072	0.87571	0.51283
R Square	0.01509				

Table 11: *Regression statistics for change in yield spreads of CG 2020 bond against CG 2022 bond*

	Coefficients	Standard Error	t Stat	P-value
Intercept	0.00115	0.00315	0.36487	0.71554
Change in Daily Vol	0.00000	0.00000	1.49716	0.13569
Daily Diff in no of trades	-0.00051	0.00029	-1.75674	0.08026
Price Dispersion	-0.00530	0.01983	-0.26740	0.78939
Roll Measure	-0.00162	0.00930	-0.17393	0.86207
Amihud Measure	0.37244	0.44513	0.83669	0.40362
Zero Return Measure	0.00410	0.00653	0.62772	0.53080

ANOVA

	df	SS	MS	F	Significance F
Regression	6	0.00341	0.00057	0.86335	0.52255
R Square	0.02157				

Table 12: *Regression statistics for change in yield spreads of 8% 2014 maturity set of corporate bonds*

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.00753	0.01825	-0.41277	0.68012
Roll Measure	0.02311	0.10299	0.22441	0.82261
Zero Return Measure	0.00753	0.14343	0.05253	0.95815
Change in Daily Vol	0.00000	0.00000	-2.23965	0.02596
Amihud Measure	-11.26154	5.69707	-1.97673	0.04913

ANOVA

	df	SS	MS	F	Significance F
Regression	4	0.15638	0.03910	1.93169	0.10555
R Square	0.02886				

Table 13: *Regression statistics for change in yield spreads of 10% 2017 maturity set of corporate bonds*

	Coefficients	Standard Error	t Stat	P-value
Intercept	0.00431	0.00931	0.46264	0.64385
Roll Measure	-0.02250	0.03088	-0.72841	0.46676
Zero Return Measure	0.05717	0.07941	0.71997	0.47194
Change in Daily Vol	-0.00001	0.00001	-1.00502	0.31545
Amihud Measure	0.15480	0.13085	1.18303	0.23745

ANOVA

	df	SS	MS	F	Significance F
Regression	4	0.07025	0.01756	0.94040	0.44033
R Square	0.00869				

Table 14: *Regression statistics for change in yield spreads of 10% 2011 maturity set of corporate bonds*

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.01170	0.01431	-0.81760	0.41403
Roll Measure	0.10578	0.07633	1.38576	0.16653
Zero Return Measure	-0.00879	0.12897	-0.06815	0.94569
Change in Daily Vol	0.00000	0.00001	-0.21825	0.82734
Amihud Measure	0.00000	0.00001	0.87375	0.38274

ANOVA

	df	SS	MS	F	Significance F
Regression	4	0.17231	0.04308	0.87321	0.47988
R Square	0.00800				

Table 15: *Summary of t-statistics for various cases*

a. Corporate Bond (A++ & A+++)

Variables	**Period**					
	A++(full dataset)	A+++(full dataset)	A++(crisis)	A++(non-crisis)	A+++(crisis)	A+++(non-crisis)
Intercept	0.257	0.496	1.023	0.000018255	2.272	0.012
Price Dispersion	1.055	-1.3906	0.14	0.9888	0.4382	-1.53
Roll Measure	-0.9925	1.228	-0.167	-0.88	-0.5876	1.46
Amihud no.	1.1937	2.044	-1.654	1.679	-0.5586	2.32
Zero return	0.5675	-0.48	0.139	0.566	-0.4358	-0.37
Volume index	0.7797	1.549	0.414	0.825	-1.1239	1.87
Spread	-0.1196	-2.088	1.305	-0.309	-2.212	-1.804

b. Corporate Bond

Variables	**Period**		
	8%2014	10% 2017	10%2011
intercept	-0.41	0.46	-0.82
roll measure	0.22	-0.72	1.35
zero measure	0.05	0.71	-0.068
change in vol	-2.23	-1	-0.21
amihud no	-1.97	1.19	0.97

c. Government Securities

Variables	**Period**		
	2011vs2015	2017vs2019	2020vs2022
Intercept	0.2097	-0.0002	0.36
vol change	0.1668	-4.38	1.49
diff in #trades	1.5753	0.0001	-1.75
price dispersion	8.7427	0.009	-0.26
roll measure	-0.5971	0.0001	-0.17
amihud	1.5418	1.872	0.93
zero return	-0.1802	0.0002	0.62

Table 16: *Sample data (yield curve change for A++ corporate bond full time series scale)*

Yield Spread Change (T)	Price disp	Roll Measure	Amihud Measure	Zero Return Measure	Daily Vol Change	Yield Spread Change(T-1)
0.00000	0.00000	0.00000	0.00000	1	0.00000	0
-0.01860	0.00000	0.00000	0.76614	0	-0.08019	0
0.08280	0.00000	0.00000	-0.38241	0	0.00000	-0.01860
-0.00410	0.00000	0.00000	0.27129	0	0.02446	0.08280
-0.01350	0.00000	0.00000	2.83079	0	-0.02658	-0.00410
0.05070	0.00000	0.00000	-3.37228	0	-0.17789	-0.01350
0.01450	0.00000	0.00000	0.53704	0	0.12701	0.05070
-0.02170	0.00000	0.00000	0.66846	0	0.55456	0.01450
0.15020	0.00000	0.00000	-0.99504	0	-0.12605	-0.02170
-0.01970	0.00000	0.00000	0.21245	0	-0.03383	0.15020
0.09950	-0.02003	-0.08511	7.34610	0	-0.45875	-0.01970
-0.07360	-0.02003	-0.08511	-7.32195	0	0.84296	0.09950
-0.01970	-0.02003	-0.08511	2.36524	0	-0.25154	-0.07360
0.01870	-0.02003	-0.08511	-0.18708	0	-0.25676	-0.01970
-0.02490	-0.02003	-0.08511	-2.22393	0	0.55217	0.01870
-0.01350	-0.02003	-0.08511	-0.48815	0	-0.21575	-0.02490
-0.01860	-0.02003	-0.08511	0.37359	0	0.23433	-0.01350
-0.00420	-0.02003	-0.08511	0.10729	0	-1.23684	-0.01860
-0.02170	-0.02003	-0.08511	0.57066	0	0.67040	-0.00420
-0.42000	-0.02003	-0.08511	-0.81346	0	-0.01462	-0.02170
-0.01240	0.09937	0.33397	0.49187	0	-0.28641	-0.42000
-0.00420	0.09937	0.33397	-0.10370	0	0.53297	-0.01240
-0.09210	0.09937	0.33397	0.73165	0	-0.75170	-0.00420
-0.07460	0.09937	0.33397	-0.16618	0	0.47143	-0.09210

Table 17: *Sample data (yield curve change for AAA (corporate bond full time series scale)*

Yield Spread Change (T)	Price disp	Roll Measure	Amihud Measure	Zero Return Measure	Daily Vol Change	Yield Spread Change(T-1)
0.00000	0.00000	0.00000	0.00000	1	0.00000	0
0.11110	0.00000	0.00000	0.76614	0	-0.08019	0
-0.03970	0.00000	0.00000	-0.38241	0	0.00000	0.11110
0.01030	0.00000	0.00000	0.27129	0	0.02446	-0.03970
-0.00090	0.00000	0.00000	2.83079	0	-0.02658	0.01030
0.01130	0.00000	0.00000	-3.37228	0	-0.17789	-0.00090
0.00000	0.00000	0.00000	0.53704	0	0.12701	0.01130
0.08360	0.00000	0.00000	0.66846	0	0.55456	0.00000
0.00410	0.00000	0.00000	-0.99504	0	-0.12605	0.08360
-0.00820	0.00000	0.00000	0.21245	0	-0.03383	0.00410
-0.06430	-0.02003	-0.08511	7.34610	0	-0.45875	-0.00820
0.00730	-0.02003	-0.08511	-7.32195	0	0.84296	-0.06430
0.17350	-0.02003	-0.08511	2.36524	0	-0.25154	0.00730
-0.10300	-0.02003	-0.08511	-0.18708	0	-0.25676	0.17350
0.05080	-0.02003	-0.08511	-2.22393	0	0.55217	-0.10300
-0.03640	-0.02003	-0.08511	-0.48815	0	-0.21575	0.05080
0.03220	-0.02003	-0.08511	0.37359	0	0.23433	-0.03640
0.03830	-0.02003	-0.08511	0.10729	0	-1.23684	0.03220
-0.02590	-0.02003	-0.08511	0.57066	0	0.67040	0.03830
-0.05120	-0.02003	-0.08511	-0.81346	0	-0.01462	-0.02590
-0.02070	0.09937	0.33397	0.49187	0	-0.28641	-0.05120
-0.09980	0.09937	0.33397	-0.10370	0	0.53297	-0.02070
-0.05070	0.09937	0.33397	0.73165	0	-0.75170	-0.09980
-0.00810	0.09937	0.33397	-0.16618	0	0.47143	-0.05070

Table 18: *Sample data (yield curve change for G-Sec (2011 Vs 2015 Maturity Bonds)*

Change in Yield Spread	Daily Vol Change	Daily Diff in no of trades	Price Dispersion	Roll Measure	Amihud Measure	Zero Return Measure
0	0	0	0	0	0	1
-0.01877	20500	26	0.00865	0	2.769E-06	0
-0.00553	-15500	-19	0.02238	0	2.093E-06	0
0.00837	-4000	-6	-0.02898	0	-1.048E-06	0
0.00846	-10000	-10	-0.00352	0	1.457E-05	0
0.00256	20250	23.5	0.01956	0	-1.795E-05	0
0.02959	-11000	4	0.05844	0	2.419E-05	0
0.01287	6000	6	0.27275	0	6.052E-06	0
-0.06118	-29500	-48	-0.28075	0	5.044E-05	0
0.06556	14000	25	-0.00801	0	-6.307E-05	0
-0.01266	-25000	-41	-0.07108	0	5.772E-05	0
-0.00411	6000	11	-0.00637	0	-7.034E-05	0
0.01786	-1500	-16	0.03753	0	-1.804E-06	0
-0.00531	7000	12	-0.02763	0	1.624E-05	0
-0.00001	2000	14	0.04855	0	-1.038E-05	0
-0.04153	-2000	-16	0.21510	0.52003	4.437E-05	0
0.05908	-13000	-9	0.07359	0.52003	1.211E-04	0
-0.02029	2000	3	-0.08385	0.52003	-1.660E-04	0
-0.00356	14500	10	0.02063	0.52003	1.071E-04	0
0.00849	-8500	-5	0.08734	0.52003	-3.651E-05	0
-0.05109	6000	16	0.20227	0.52003	-2.404E-05	0
0.06229	-16500	-34	-0.18921	0.52003	1.688E-04	0

Table 19: *Sample data (yield curve change for Corporate Bonds (7.75% coupon 2014 maturity)*

Change in Yield Spread	Roll Measure	Zero Return Measure	Daily Vol Change	Amihud Measure
0.1325	0.16642	0	1500	-0.00314
-0.0302	0.16642	0	-1000	-0.00020
0.0343	0.16642	0	3500	0.00007
0.0998	0.16642	0	-3500	0.00026
-0.0859	0.16642	0	-500	0.00308
-0.1204	0.16642	0	500	-0.00355
0.0993	0.16642	0	0	0.00180
0.2022	0.16642	0	500	-0.00174
-0.1036	0.02443	0	-250	-0.00007
0.0391	0.02443	0	0	0.00015
-0.0434	0.02443	0	-250	0.00140
-0.1226	0.02443	0	1000	-0.00023
-0.2724	0.02443	0	-1500	0.00514
0.2501	0.02443	0	4500	-0.00640
0.0112	0.02443	0	-2500	0.00009
-0.0316	0.02443	0	6500	-0.00008
-0.0294	0.02443	0	-7500	-0.00002
0.0659	0.02443	0	0	0.00009
-0.0267	0.02443	0	0	-0.00014
-0.0102	0.02443	0	0	0.00013
-0.0302	0.02443	0	0	-0.00001
0.0095	0.02443	0	-1000	0.00021

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