

A Study of Corporate Bond Liquidity

Supervisor:
Dagfinn Rime

Students:
Marius Loe Heggen
Terje Simarud

Hand-In Date:
01.09.2016

Examination Code and Name:
GRA 19003 – Master Thesis

Programme:
Master of Science in Business - Major in Finance

“This thesis is a part of the MSc programme at BI Norwegian Business School. The school takes no responsibility for the method used, results found and conclusions drawn.”

Acknowledgments

Since data for this thesis was difficult to obtain, our biggest and most time-consuming challenge was to collect, clean and process all the data we needed. This would not have been possible without the help from Professor Bernt Arne Ødegaard, and we would like to thank him for providing us with the data on Oslo Stock Exchange. Further, we also want to thank Stamdata for allowing us access to their database, providing us with valuable bond characteristics and information.

Finally, we wish to thank our supervisor, Professor Dagfinn Rime, for his help and support during the process.

Abstract

In this paper we study the liquidity of the Norwegian corporate bond market. We utilize a methodology closely related to the one developed by Dick-Nielsen, Feldhütter, and Lando (2012), and find that the spread contribution from illiquidity is puzzling to disclose in the Norwegian corporate bond market due to the low trading activity. However, for one of our liquidity proxies, zero trading days, we tend to find a positive relationship with bond spreads. Furthermore, we find indications that the liquidity premium measured by the bid-ask spread exist from the first quarter of 2014 to third quarter of 2014.

Table of Contents

1. Introduction.....	5
2. Literature review.....	7
3. The Norwegian bond market	13
3.1 Size and growth:	14
3.2 Market structure.....	15
4. Liquidity	16
4.2 Variables influencing liquidity	19
5. Regulations	22
6. Data.....	28
7. Methodology.....	28
7.1 Liquidity measures.....	29
7.2 Summary statistics	32
7.3 Corporate bond spread.....	34
7.3.1 Yield to maturity.....	34
7.3.2 Modeling the yield curve and curve fitting.....	36
8. Results	39
9. Conclusion	44
10. References.....	45
Appendix.....	51
Exhibit I – Liquidity measures	51
Exhibit II – Volume traded 1987-2015 from OBI (unfiltered).....	52
Exhibit III – Average interpolated swap rate.....	53
Exhibit IV – Volume traded	53
Exhibit V – Negative spread observations.....	54

GRA 19003 – Master Thesis	01.09.2016
Exhibit VI – Bond prices	54
Exhibit VII – Bid-Ask spread	55
Exhibit VIII – Number of quarterly trades	55
Exhibit IX – Oil price 2004-2015	56
Preliminary	57

Figure 1: Number of bond loans listed on Oslo Stock Exchange and Nordic ABM.	14
Figure 2 : Outstanding value of loans listed on Oslo Stock Exchange and Nordic ABM.	15
Figure 3: Number of issuers on Oslo Stock Exchange and Nordic ABM.	15
Figure 4: High yield and investment grade traded yields	36
Figure 5: Bond spreads	38
Figure 6: Liquidity premium compared to bond spreads	43
Table 1: Principal component loadings on the liquidity variables.....	31
Table 2: Principal component loadings on the liquidity variables.....	31
Table 3: Statistics for liquidity proxies.....	33
Table 4: Correlation matrix for liquidity proxies.....	34
Table 5: Results	39

1. Introduction

The importance of liquidity in fixed income markets have received increased attention from both researchers and market participants over the last twenty years. While yield spreads are assumed to be compensation for the default risk of a corporate bond compared to a risk-free government bond, several papers found that a large and significant proportion of the spreads could not be explained by default risk alone or could be attributed to other variables. Liquidity, or lack thereof, has become one of the main explanations for these spreads differences, and many scholars have studied how much of the spreads that can be attributed to a liquidity premium through different types of liquidity measures and methodologies.

During the financial crisis of 2008-2009 it became evident how vulnerable financial markets are when liquidity deteriorates. This is the case for the bond market in particular, where each bond may have multiple issues, which in turn lowers the probability of matching buyers and sellers, and most of the trading happens over-the-counter. In an attempt to make future financial crisis less likely, we have seen a global effort to improve the safety and robustness of the financial market through intensified banking regulations and a more transparent market in general. These reforms are now being implemented in the U.S. and most of Europe, and while it is still early to draw any conclusions regarding the implications for market liquidity, numerous market participants have already voiced their concerns about some of the effects and consequences of the new regulatory framework. Events in the U.S. like the *taper tantrum* in 2013 and the *flash crash* in October of 2014 have to some extent validated these concerns, yet newly published empirical papers in both the U.S. and in Europe have showed that the liquidity in bond markets actually show signs of improvement.

Since the research conducted up to date almost exclusively has focused on the U.S. or large European markets, little is known about the liquidity of the Norwegian corporate bond market. Utilizing a methodology closely related to the

one developed by Dick-Nielsen, Feldhütter, and Lando (2012) we create a liquidity measure consisting of three liquidity proxies after performing a PCA on seven and nine different proxies, respectively. We then use this liquidity measure to estimate the spread contribution from illiquidity for both investment grade and high-yield bonds in the Norwegian corporate bond market. However, since the only paper that previously has studied this market (Rakkestad, Skjeltnor, and Ødegaard 2012) concluded that there were too few trades to correctly assess the liquidity, our main focus will be on the period 2011-2015. During the last five years the Norwegian corporate bond market has experienced a significant increase in terms of both numbers of loans, issuers and transactions, developments that makes it more feasible to analyze the market liquidity today. The growth and increased relevancy of the Norwegian bond market in a time where fixed income liquidity receives more and more attention internationally makes a new assessment of the liquidity both relevant and important.

Our results show that bond spreads tend to increase when the liquidity measure, Zero trading days, increases. However, our results also show that the Norwegian corporate bond market still is somewhat underdeveloped and is characterized by new issues growth with few trades and low liquidity.

The rest of this paper is organized as follows; in Section 2 we review previous literature on bond market liquidity and liquidity premiums in bond spreads. Section 3 consists of the history, size and structure of the Norwegian fixed income market. Section 4 provides a detailed description of the term *liquidity* and why it is so difficult to measure, while Section 5 looks at the new regulations and how these can affect liquidity. Section 6 describes the data and Section 7 outlines our methodology. In Section 8 we present and discuss our results, while our concluding remarks will be in Section 9

2. Literature review

Bond liquidity and its effect on spreads, yields and pricing have received increased attention in the finance literature over the last 15-20 years, resulting in a rich amount of literature and empirical papers. The general consensus, originated by Amihud and Mendelson (1986), is that investors demand a liquidity premium for buying and holding illiquid securities. However, liquidity can be a rather subjective concept that is hard to define and even harder to measure, and this has led to several proposed measures to approximate the extent to which a bond is liquid or illiquid.

In general, credit spreads are assumed to be compensation for credit risk. Credit spreads are the component of corporate bond yields that are above the yield of comparable Treasuries. Since government bonds are assumed to be free of default risk, while corporate debt is subject to this risk, the spreads should reflect this difference in default risk. Amato and Remolana (2003) showed how the spread on corporate bonds tend to be many times wider than what can be explained by default risk, a phenomenon known as the “credit spread puzzle”.

While credit spreads and liquidity originally were studied from an asset pricing view, see Jones, Mason and Rosenfeld (1984) and Longstaff and Schwartz (1995), or as part of analyzing the swap market, see Grinblatt (1995), Nielsen and Ronn (1996), and Duffie and Singleton (1997), the importance of bond liquidity eventually became clearer. Duffie (1999) found a nondefault component he assumed to be a liquidity component when he tried to estimate the price of default risk of corporate bonds, while Collin-Dufresne, Goldstein, and Martin (2001) used a multi-factor model and showed that changes in the probability of future default and in the recovery rate only could account for about one fourth of the observed credit spread changes. They also performed a principal component analysis on the residuals, and found that one common factor captured 76 percent of the remaining variance, yet they were not able to identify this systemic factor. Similarly, Elton et al. (2001) calculated that while taxes accounted for 36 percent of the differential

between corporate and Treasury spreads, 46 percent of the difference in spreads remained unexplained by taxes or expected default. Taxes, in addition to jumps, liquidity, and market risk, also were considered as the main attributes to credit spreads by Delianedis and Geske (2001, who used a firm value framework and showed that for AAA-rated bonds (BBB) only a small percentage, 5 percent (22 percent), of the credit spreads could be explained by default risk. Like Delianedis and Geske, Huang and Huang (2003) also looked at how credit spreads were affected by bond rating, and found that while credit risk accounted for only a small fraction of the spreads for the highest rated bonds, the spreads of junk bonds consisted of a much larger fraction of credit risk. Tax, liquidity, rating, and other factors received increased attention as explanations for the spread differential between corporate and Treasury bond, and Driessen (2005) estimated that the liquidity premium in corporate bond spreads was as high as 20 percent. However, most of these papers used structural models, and as Eom, Helwege, and Huang (2004) pointed out in their study of five different structural models of corporate bond pricing, most structural models predict spreads that are too high on average. Contrary to previous studies, Longstaff, Mithal and Neis (2005) calculated spreads to be mainly attributed to default risk. Relative to the Treasury curve, the default component represented 51% of the spread for AAA/AA-rated bonds, 56% for A-rated bonds, 71% for BBB-rated bonds, and 83% for BB-rated bonds. Similar to other papers, they found a significant nondefault component that ranged from about 20-100 basis points, but additionally they were also able to show that this nondefault component was strongly related to measures of individual corporate bond illiquidity. They also showed that less liquid bonds tend to have a larger liquidity component embedded within their yield spreads.

Unlike equities, which are more standardized in terms of a market product, bonds may have several issues, which lower the probability of matching buyers and sellers. The secondary market for fixed income securities, such as corporate bonds, is therefore mostly traded over-the-counter (OTC), with direct trading between two parties, often through a dealer network but not on a formal exchange.

Because of this, liquidity measures based on transaction data can be misleading and hard to obtain. With the increased attention towards studying the effect of liquidity on corporate bond spreads, researchers resorted to proxies, or indirect measures based on bond characteristics, for liquidity and turned their attention towards a reduced form modeling approach. Perraudin and Taylor (2003) divided bonds into low and high liquidity based on liquidity proxies (quote frequency, bond age, and issue size), and found spread differences of 10 to 28 basis points for AAA- to A-grade bonds. According to Chen, Lesmond, and Wei (2007), who studied more than 4000 corporate bonds over a 9-year period, liquidity alone could explain 7% of the cross-sectional variation in bond yields for investment grade bonds, and as much as 22% of the cross-sectional variation in bond yields for speculative grade bonds. They also studied bond illiquidity and found a significant positive relation between an increase in bond illiquidity and yields spread increases.

One phenomenon that has received increased attention has been the notion of “flight-to-liquidity”. Historically, several papers (see f.ex. Diamond and Dybvik (1983) and Bernanke and Gertler (1995)) have showed how investors shift their portfolios into safer securities during periods of market turbulence, an effect known as “flight-to-quality”. Longstaff (2004) however, examined whether there exists a flight-to-liquidity premium in the U.S. Treasury bond prices, resulting from some market participants suddenly prefer to hold highly liquid securities such as U.S. Treasury bonds rather than less liquid securities. In his analysis, Longstaff revealed that the liquidity premium in Treasury bonds could be as large as 15% of the value for some Treasury bonds. The recent financial crisis is a prime example of how flight-to-quality and flight-to-liquidity influence yield spreads as the yield spreads on corporate bonds spiked once the credit risk increased and investors shifted their portfolios into safer and more liquid securities. Bao, Pan, and Wang (2011) established a strong link between bond illiquidity and bond prices, both in aggregate and cross-section. They also showed how a substantial part of the time variation in yield spreads of high-rated (AAA

through A) bonds could be explained by changes in the level of illiquidity. Similarly, the liquidity measure used in Dick-Nielsen, Feldhütter and Lando (2012) is also an illiquidity measure, which they proved outperformed that of Bao, Pan, and Wang. Using a methodology we will detail later in this paper, they showed how illiquidity dramatically influenced and contributed to increased spreads during 2005-2009. While the liquidity component for investment grade bonds remained small during the entire sample period, they found that the spreads of speculative grade bonds nearly quadrupled from 58 to 197 basis points, implying support for the hypothesis about “flight-to-quality” and “flight-to-liquidity” during crisis, as investors shifted their investments into safe and liquid AAA-rated bonds.

The U.S. bond market is the biggest and most important in the world, and as a result has received the bulk of attention from scholars and researcher around the world. However, studies on the European market have pointed to similar results and confirmed that conclusions regarding bond liquidity are just as valid in Europe. Houweling, Mentink, and Vorst (2005) used nine different proxies (issued amount, listed, euro, on-the-run, age, missing prices, yield volatility, number of contributors and yield dispersion) in order to measure liquidity in the euro-denominated corporate bond market. According to their results, liquidity risk was priced in eight of the nine proxies, and they obtained liquidity premiums ranging from 13 to 23 basis points. Driessen and de Jong (2012) explored the role of liquidity risk in the pricing of corporate bonds and found very similar evidence for the liquidity risk exposure of corporate bonds for a sample of European corporate bond prices compared to the American corporate bonds. They estimated the liquidity risk premium to be around 0.6 percent and 1,5 percent per annum for long-maturity investment grade bonds and speculative grade bonds, respectively. Baber, Brandt, and Kavajecz (2009) studied the Euro-area government bond market and concluded that in times of distress, investors chase liquidity. This is consistent with Longstaffs (2004) results from the U.S. Treasury market.

Regarding the Norwegian bond market, the amount of literature is very limited. The only paper that to our knowledge have analyzed the liquidity of this market is Rakkestad, Skjeltorp, and Ødegaard (2012). Their paper studied fixed income securities on Oslo Stock Exchange (OSE) from 1999 through 2011, and concluded that “with the low trading activity, any statistical measure that attempt to measure liquidity would be highly unreliable and would in most cases not give an accurate picture of the actual liquidity supply”. However, over the last 10 years, the numbers of bonds, issuers and transactions, as well as the amount of outstanding value in the Norwegian bond market have increased significantly. Later in this paper we will describe this development in depth, but for now we argue that the growth of the fixed income market on Oslo Stock Exchange makes a new analysis of the liquidity both important and relevant. The authors also pointed to how trade-based measures such as the Amihud measure can be an informative liquidity measure for Oslo Stock Exchange, and in our model we use several trade-based measures for liquidity, including the Amihud measure.

All of the abovementioned literature studied the bond market before, during, or shortly after the financial crisis of 2008-2009. However, in order to prevent a repeat of the bankruptcies and the financial turmoil witnessed during the crisis, there has been a global effort to promote a more resilient banking sector by increasing capital requirements and strengthening the transparency of the market in general. These regulatory changes are described in depth later in the paper. Because of the short time-span that has passed since the regulations were agreed upon and later implemented, there are few quantitative papers studying the effects of the new regulatory framework on the fixed-income markets. Still, several market participants, like IMF (2015), International Council of Securities Association (2015), Barclays (2015), PwC (2015), Blackrock (2014), The Economist (2015) and Financial Times (2015) have expressed concerns regarding declining liquidity following the new regulations. Their concerns surround reduced market making and less corporate bonds held as inventories by dealers, increased amount of outstanding bonds and the rise in aggregated value of these

bonds, as well as widening bid-ask spreads. Incidents like the taper tantrum in 2013 when U.S Treasury yields surged after then-Fed Chairman Ben Bernanke indicated an imminent reduction of bond repurchases, and the liquidity flash crash in U.S. Treasuries in October 2014, when the yield on the U.S. 10-year note fell by 34 basis points in just a matter of minutes, have showed have vulnerable the fixed income markets can be if the liquidity dries up. However, most of these publications have only looked at variables that historically have been known to be liquidity drivers, but have not done any empirical research on their concerns. The only empirical paper we were able to find that to some extent supports the claims about deteriorating liquidity in the fixed income market is written by van Loon et.al. (2014), who derived a new liquidity measure they used to extract the liquidity premium. Their result showed that while all rating classes had low liquidity premiums before the financial crisis, the liquidity premiums increased dramatically for lower quality bonds during and after the crisis, and has remained at a higher level in the years following the crisis. The highest rated bonds, however, experienced only small changes in premiums, supporting the theory about flight-to-quality. Little is yet known about the long-term effect of the new regulatory landscape in the financial markets, but Trebbi and Xiao (2015) investigated the relationship between regulations and fixed-income liquidity. They use a statistical method consisting of four different estimation strategies in order to identify structural breaks in both level and latent factors for nine different liquidity measures of U.S. corporate and Treasury bonds. This study is important since it found no systematic evidence of decreasing liquidity levels or structural breaks in dynamic latent factors of the U.S. fixed income market during periods of increased regulatory intervention, a result that is consistent across all four of the estimation strategies. Trebbi and Xiao concluded that there is no statistical evidence of market liquidity decrease after 2010; instead, they actually observed breaks towards liquidity improvement during periods of regulatory interventions. Additionally, a very recent study, published as late as June 2016, actually utilize the same methodology as in our paper in order to analyze the liquidity of the British fixed income market from 2008-2014. The authors, Aquilina and

Suntheim, find no evidence of liquidity deterioration, and also conclude that liquidity does not have a larger effect on bond spreads now than before. In fact, they actually support the result of Trebbi and Xiao and states that markets appear to have become more liquid in recent years. The fact that two studies with different methodology, one covering the U.S bond market and one covering the U.K bond market, concludes contrary to the assumptions of other market participants makes our study of the Norwegian bond market that more interesting.

3. The Norwegian bond market

King Carl Johan signed the first Stock Exchange Act in Norway in 1818, but in the beginning the exchange mainly traded in currencies and it was not until 1881 the first thirty bonds and shares became listed on the exchange. Now, nearly 200 years after the Christiania Exchange opened, the Oslo Stock Exchange (OSE) offers two marketplaces for listing and trading in fixed income instruments: Oslo Stock Exchange and Nordic Alternative Bond Market (Nordic ABM).

The Oslo Stock Exchange has historically been the main venue for listing and trading of bonds, and is a regulated marketplace in relation to MiFID. In order to be listed on the Oslo Stock Exchange, an issuer of a new fixed income security must prepare a prospectus that is inspected and approved by the Financial Supervisory Authority of Norway. Companies are also required to prepare their financial statements in accordance with IFRS, as part of the EU directives that Oslo Stock Exchange is subject to (Oslo Børs 2015).

Nordic ABM is a self-regulated marketplace established in 2005, operated and managed by Oslo Stock Exchange. The marketplace is not subject to the provisions of the Norwegian Stock Exchange Act (Børsloven), and can therefore operate indecently of EU directives. Companies do not need to produce financial statements in accordance with IFRS. This makes the listing process and reporting requirements somewhat simpler and less extensive compared with the traditional market on Oslo Stock Exchange, but also implies that Nordic ABM is an unregulated marketplace according to the MiFID definitions. However, companies

are subject to virtually the same trading rules and disclosure obligations on the two marketplaces.

3.1 Size and growth:

Bank financing has been the traditional source of financing for Norwegian companies. However, as new regulations in the aftermath of the financial crisis of 08-09 forced banks to restrict their lending, companies turned elsewhere for financing, and the bond market became an attractive alternative. This has increased the number of bond loans listed on OSE and Nordic ABM in addition to a significant growth in total outstanding value.

Figure 1: Number of bond loans listed on Oslo Stock Exchange and Nordic ABM. OSE dark grey and Nordic ABM light grey.

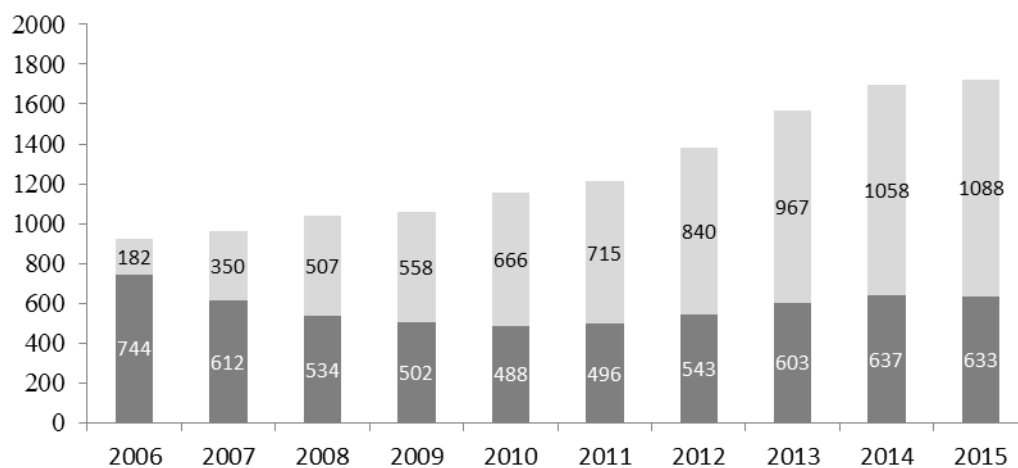


Figure 2 and 3 also shows how the less-regulated Nordic ABM with its simplified listing and reporting requirements has become increasingly important and respected since the marketplace first was introduced in 2005. Nordic ABM actually is the fastest growing Nordic marketplace according to Oslo Stock Exchange (2014), mainly driven by banks and financial institutions, which dominate the Nordic ABM.

Figure 2 : Outstanding value of loans listed on Oslo Stock Exchange and Nordic ABM. OSE dark grey and Nordic ABM light grey. Numbers in billions.

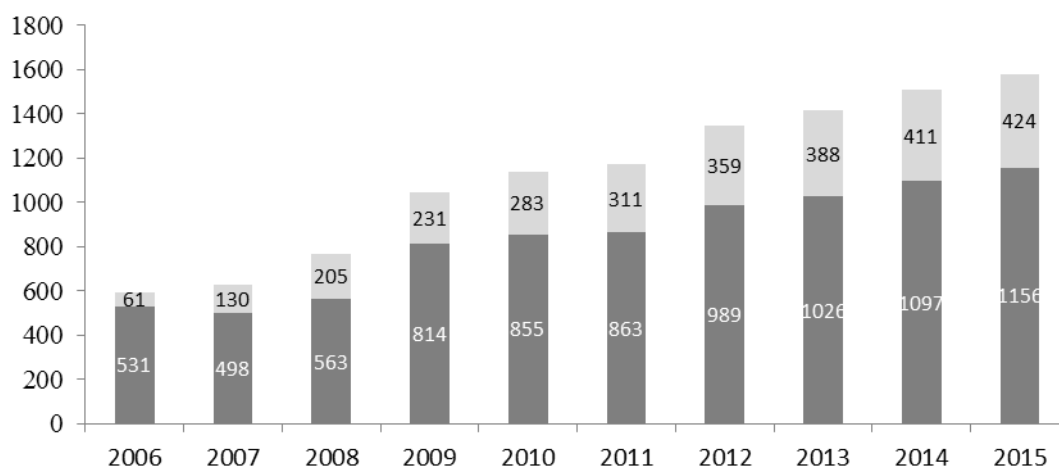
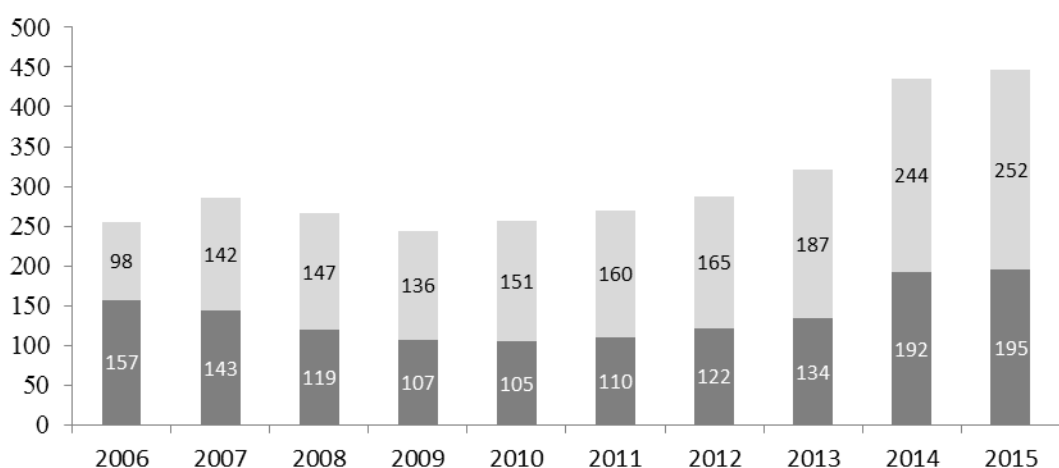


Figure 3: Number of issuers on Oslo Stock Exchange and Nordic ABM. OSE dark grey and Nordic ABM light grey.



3.2 Market structure

From the modest beginning in 1881, bonds were traded through the old auction model for the first 100 years of trading. Bond trading was first revolutionized in October 1989 when the Oslo Stock Exchange moved bonds onto the electronic trading system it had introduced for equities the previous year. This system made trading increasingly decentralized, as it allowed brokers to trade from their own offices by using terminals linked to the stock exchange, instead of trading by physically being at the stock exchange.

The most significant change in the market structure happened in February 1999 when Oslo Stock Exchange launched ASTS; a new decentralized electronic trading system for shares. ASTS used an electronic order book, which provided automatic matching of orders, and by September the system also included bond trading. Since it facilitated for trades over the Internet, ASTS made it possible for foreign firms to participate on the Norwegian exchange.

Oslo Stock Exchange has made a conscious effort to use the same trading platforms as larger markets, which has led to three changes in trading systems since ASTS first was introduced. Yet, the main characteristics of ASTS, like automatic matching of orders and decentralized trading, remain the same.

In 2002, following a Nordic strategic alliance (NOREX), the trading system SAXESS was introduced as a common trading platform for the Nordic countries. This system was replaced by London Stock Exchange's trading system, TradElect, in 2009 when the NOREX alliance ended and Oslo Stock Exchange entered into a strategic partnership with London Stock Exchange. Since then, demand for faster and more powerful trading has coincided with rapid technological development, which resulted in the introduction of a new trading system called Millennium Exchange in 2012. Millennium Exchange, owned by the London Stock Exchange Group, a high-speed and extremely low latency system, is the trading system currently used both in the UK and Norway. There have been several incremental improvements of the system since 2012, and the latest version, Millennium Exchange 9.1, will be implemented on Oslo Stock Exchange in November 2016.

4. Liquidity

The ability to buy and sell securities is a central market functioning and the key to this functioning is liquidity. Liquid markets are desirable because of the benefits they offer in terms of systematic factors such as improved allocation of economic resources and information efficiency (Sarr and Lybek, 2002). However, there are several microeconomic definitions of liquidity and as Baker (1996) states: "there

is no single unambiguous, theoretically correct or universally accepted definition of liquidity”. An easy and often used definition of liquidity is found in Amihud and Mendelson (1991): “an asset is liquid if it can be bought or sold at the current market price quickly and at low cost”, that is, if market participants can buy and sell large amount of financial assets without adversely affecting the price, the asset is perceived as liquid. However, Sarr and Lybek (2002) points out that liquidity characteristics may change over time, such as liquidity mainly is related to transactions cost in a stable market environment but in in periods of market stress and changing fundamentals, prompt price discovery and adjustment to a new equilibrium becomes more important.

It is useful to divide the concept of liquidity into two categories: funding liquidity and market liquidity (Brunnermeier and Pedersen 2009). According to Brunnermeier (2009), “funding liquidity describes the ease with which expert investors and arbitrageurs can obtain funding from (possibly less informed) financiers. Funding liquidity is high when it is easy to raise money. Market liquidity is low when it is difficult to raise money by selling the asset. Market liquidity is equivalent to the relative ease of finding somebody who takes on the other side of the trade “. However, it is important to note that the despite their differences, these concepts are related, and funding liquidity is typically a prerequisite for market liquidity, since market makers also use credit to maintain inventories. For our studies, we will refer to the market liquidity when we use the term liquidity.

In his paper on auctions and insider trading, Kyle (1985) states that: “Market liquidity is a slippery and elusive concept, in part because it encompasses a number of transactional properties of markets. These include tightness, depth and resiliency”. The most complete definition of liquidity, and the definition we most often have seen been referred to is given by Harris (1990). His four dimensions of liquidity; width, depth, immediacy and resilience, are very similar to Kyle’s definition.

Width: Width is the difference between the highest bid price P_B^1 and the lowest ask price P_A^1 , commonly known as the bid-ask spread. The difference between P_A^1 and P_B^1 can be regarded as the price one has to pay in order to acquire liquidity at a given moment. If a seller considers P_A^1 as the fair value of his asset he might be reluctant to sell below this price. But if he needs funds immediately and therefore needs a buyer, he would prefer the one with the highest bid P_B^1 , even though this bid is below what the seller believes is fair value. Hence, the spread $P_A^1 - P_B^1$ reflects the implicit cost of trading immediately and gives an indication on whether the liquidity in the market is high or low, where a more liquid asset typically is characterized by a tighter spread (smaller width).

Depth: The second of Harris' dimensions is depth, which is the volume that can be traded in the market without affecting the price (Hein 2003). Depth reflects how much liquidity is available at various price levels, something that can be of great importance for large investors. When executing a large trade, it is unlikely that the trader obtains the best quotes; represented by P_A^1 and P_B^1 . The trader might need to buy (sell) at the second and third best available price in order to fulfill the trade, and the volume weighted average execution price depends on the depth available at the different ask (bid) levels.

Immediacy: Immediacy is the third of Harris' dimensions and refers to "how quickly trades of a given size can be done at a given cost" (Wuyts 2007). As we will address later, we have seen a decline in banks market making functioning over the last years. This is important because when an intermediary (market maker/dealer) is present in the market, it is generally not a problem to find opposite side trading interest, and the immediacy dimensions therefore vanishes in importance. However, without any market makers, like in a pure limit order market, there can be an unbalanced number of buyers and sellers, thereby affecting how quickly market participants can execute their trade. In general we have that when supply and demand is high it is easier to find a trading partner, and as a result liquid markets typically have a greater number of buyers and sellers than illiquid markets. The decrease in the market-making functioning has to some

extent been offset by the developments in electronic trading platforms, which has made it easier to find a trading partner.

Resiliency: Harris' last dimension is resiliency, which refers to the speed with which prices recover to former levels after a large transaction has taken place. A large order causes a price change if this increased demand exceeds the depth of market supply. Assuming that this order does not affect the underlying value of the asset, the asset price should move back to its equilibrium value. If the market reacts to the large uninformed liquidity demand by quickly replenish the liquidity supply and thus restore the equilibrium level, the market is resilient.

4.2 Variables influencing liquidity

In recent years there have been growing concerns amongst market participants regarding the possible decline in market liquidity and its resilience, especially in the bond market. Events such as the Treasury flash crash in October 2014 have shown how vulnerable markets can be when a liquidity shock occurs. The large number of different variables that to a larger or lesser extent influence liquidity makes liquidity an elusive term that is hard to define and measure. In this section we will look at some of these variables, and explain how they individually affect market liquidity, which hopefully will clarify why it is so difficult to properly measure liquidity.

According to IMF (2015), and following the work of Vayanos and Wang (2012) and Duffie (2012), “drivers of market liquidity levels and resilience comprise three broad categories. These include (1) the risk appetite, funding constraints, and market risks faced by financial intermediaries, all of which affect their inclination to provide liquidity services and correct the mispricing of assets by taking advantage of arbitrage opportunities; (2) search costs, which influence the speed with which buyers and sellers can find each other; and (3) investor characteristics and behavior reflecting different mandates, constraints, and access to information”.

Monetary policies: In the aftermath of the financial crisis of 08-09, we have witnessed unconventional monetary policies that are likely to have both positively and negatively affected market liquidity. Most important in this sense is the quantitative easing (QE) measures, where the central bank increased the money supply by large-scale purchase of financial assets from commercial banks and other financial institutions, leading to higher prices and lower yield on those financial assets. This was done as a result of the economic situation at the time, where historical low rates made the typical expansionary monetary policy - of buying short-term government bonds in order to lower short-term market interest rates in an attempt to stimulate the economy – insufficient. The QE program consisted of buying longer-term government bonds in order to influence interest rates further out on the yield curve. Bank reserves increased as a result of the central banks' purchases, which in turn improved funding liquidity of banks, making it easier to finance their inventories and thereby supporting market liquidity (Brunnermeier and Pedersen 2009).

Outright purchases by central banks can improve the market allocative efficiency, and directly affect the liquidity of the securities being bought by making it easier for investors to find counterparties for trades by reducing search frictions (Lagos, Rocheteau and Weill 2011). However, when certain assets become scarce as a result of central banks' purchases, search costs are raised and those assets' market liquidity is reduced (IMF 2015). IMF also says that the market presence of a central bank as a committed and solvent buyer support market making and enhance market functioning by reducing the illiquidity risk of target assets, which also leads to reduced liquidity premiums. Yet, this improved market functioning and increased liquidity appear to only be sustained for as long as the quantitative easing purchases are ongoing and expected to continue (Christensen and Gillan 2015). In addition, there are concerns over an increasing share of momentum trading activity and the risk of crowded trades based on policy expectations, raising the question of how liquidity conditions will adjust to monetary policy normalization (BIS 2016).

Regulations: It is still too early to fully evaluate the impact of regulatory changes made in the aftermath of the 08-09 crises. It has been argued that regulations have made it more difficult and expensive for banks and large securities dealers to act as market makers (Elliott 2015), leading to changing business model and less securities inventories held for market-making purposes on banks balance sheets. These regulations have forced banks to increase their capital buffers and have put restrictions on proprietary trading that possibly led banks to retrench from trading and market-making activities, which can have a detrimental impact on the level of market liquidity. On the other hand, market liquidity has been positively influenced by regulatory changes that have improved transparency by facilitating the matching of buyers and sellers and reducing uncertainty about asset values (IMF 2015).

Market structure: In addition to the abovementioned changing of banks balance sheets, other changes in market structures - like changes in the investor base - appear to have made market liquidity increasingly fragile. In their report on global financial stability, IMF (2015) states that: “Larger holdings of corporate bonds by mutual funds, and a higher concentration of holdings among mutual funds, and insurance companies, are associated with less resilient liquidity”. There has also been a rise of larger but more homogeneous buy-side institutions, especially investment funds. Proliferation of small bond issuances has probably/likely led to lower liquidity in the bond market, in addition to influence the build-up of liquidity mismatches in investment funds. Changes in the market environment has led to increased importance of mutual funds for financial intermediation, which has made these funds more sensitive to redemption pressures (Barclays 2015) and less likely to absorb order-flow imbalances or to make markets. The growth of open-ended mutual funds that invest in longer-term securities while offering their investors daily redemption has likely increased liquidity risk.

Another interesting aspect of the after-crisis period has been how the easy monetary policies and low interest rates have led to a “search for yield”, where investors invest in less-liquid and more risky bonds in an attempt to attain higher returns (BIS 2015).

Technology: The previous sections have indicated that regulatory changes and changing market structures have negatively affected market liquidity, especially market-making. However, technological improvements have likely compensated for some of this deteriorated liquidity (Menkveld 2013). Improved electronic trading platforms make it easier for buyers and sellers to match without requiring a principal to intermediate between them. This reduces the need for a market maker and helps restore market liquidity. However, these electronic markets depend on securities for which there are a fair amount of demand (Elliott 2015). Investors trading in less liquid markets, compared to government bonds, such as corporate bonds and speculative grade bonds, may have difficulties finding a trading partner quickly, and are unlikely to find a trading partner willing to execute a large block trade. Electronic trading platforms and increased computerized trades may also have made markets less predictable. For instance, several market participants (see BIS 2016) and Roubini (2015)) have pointed to the flash crash of October 2014 to emphasize how automated trading and algorithms have the potential to exacerbate a sudden market downturn.

5. Regulations

Basel III:

The recent financial crisis revealed several market failures and an unsatisfying regulatory framework, leading to increased attention and monitoring towards the global banking sector in the years that have followed. In order to promote a more resilient banking sector the Basel Committee on Banking Supervision built on and strengthened previous regulations, concluding with the introduction of Basel III.

The Basel III framework was agreed upon by the members of the Basel Committee on Banking Supervision (BCBS) in 2010–11, and will be phased in gradually until the changes are fully implemented by March 31st, 2019. Basel III aims to strengthen banks against adverse shocks through increased bank liquidity and decreased bank leverage and short-term funding. In addition it also aim to

improve risk management and governance, as well as strengthen banks' transparency and disclosures (Basel 2011).

The main changes in Basel III compared to the previous two versions are:

- Stricter requirements for risk-weighted assets (RWAs)
- A minimum leverage ratio
- Two new liquidity ratios:
 - The liquidity coverage ratio (LCR)
 - The net stable funding ratio (NSFR).

In Norway, the Basel III recommendations will be implemented in the directive called Capital Requirements Directive (CRD) IV (Europa 2013), a directive applicable to all financial institutions in the European Union, as well as other European member states such as Norway.

Risk-weighted assets:

The BCBS intended to strengthen banks capital requirements in order to assure that banks have a strong funding position by developing previous regulatory framework's view on risk-weighted assets (RWAs). The RWAs are calculated by multiplying the value of a given asset i with its corresponding standardized risk weight:

$$RWAs = \sum_{i=1}^n \text{Value of Asset}_i \times \text{Risk Weight for Asset}_i$$

Different asset classes have different risk weights, prescribed in the banks capital rules and reflecting regulatory judgment regarding the riskiness of the asset. A risk-free asset will have a risk weight of 0%, while a risky asset has a high percentage. Total RWAs for a bank is found by adding up all the individual RWAs, and it is the total RWA that is used in order to calculate the different capital ratios that follows.

The minimum required common equity Tier 1 capital ratio (CET1) is raised to 4,5% of RWAs (formula x), and minimum Tier 1 capital (common equity plus additional Tier 1 capital) is increased to 6%. In addition, banks are required to hold total capital (Tier 1 plus Tier 2 capital) above 8% of RWAs (formula z)

$$\text{Formula x: } CET1 \text{ ratio} = \frac{\text{Common Equity Tier 1}}{\text{Risk-Weighted Assets}} \geq 4,5\%$$

Formula

y:

$$\text{Tier 1 Capital Ratio} = \frac{\text{Common Equity Tier 1 Capital} + \text{Additional Tier 1 Capital}}{\text{Risk-Weighted Assets}} \geq 6\%$$

$$\text{Formula z: } \text{Total Capital Ratio} = \frac{\text{Tier 1 Capital} + \text{Tier 2 capital}}{\text{Risk-Weighted Assets}} \geq 8\%$$

Included in the new regulatory framework are capital buffers that come on top of the minimum common equity requirement (CET1), and increase banks' capacity to absorb losses. The capital conservation buffer will be phased in gradually, starting at 0,625% in 2016 and increase by 0,625% every year until 2019, where it flattens out at 2,5% (BIS 2013). Adding this to the minimum CET1-ratio increases the total common equity standard to 7%.

European banks must also hold a systemic capital buffer of up to 3% of RWAs, and some systemically important financial institutions (SIFIs) in each country might also be subject to hold an additional 1-2,5% of loss-absorbency capital against RWA (BIS 2013). Further, each country is also allowed to individually add a countercyclical capital buffer (CCB) of between 0 and 2,5%. In Norway, the CCB is at 1,5% as of June 2016 (government.no 2016).

The strengthening of banks' capital buffer has undoubtedly made banking safer than before, but there are some possible negative effects as well. Stricter capital requirements have forced banks to either increase their equity capital through retained earnings, or to allocate more of their capital towards less risky assets with low risk weights such as cash, government or covered bonds. According to The

Economist (2015), banks used to “warehouse” lots of bonds and other securities they had bought from one client and hoped to sell to another. But they must now hold more capital and liquid assets to offset the potential losses from trading, and therefore keep much smaller inventories and a larger proportion of less risky papers than before. This might lead to a deterioration of liquidity in riskier papers such as corporate- and speculative grade bonds.

Minimum leverage ratio:

The Basel Committee introduced a new minimum leverage ratio, intended to supplement the risk-based capital requirement and constrain excess leverage in the banking system, thereby enhancing the risk coverage of the regulatory capital framework (BIS 2011). The first leverage ratio was introduced in 2010, while the final standard was released in 2014 and is defined as the capital measure divided by the exposure measure with this ratio expressed as a percentage:

$$\text{Leverage ratio} = \frac{\text{Capital measure}}{\text{Exposure measure}} \geq 3\%$$

The basis of calculation is the average of the monthly leverage ratio over the quarter, where the capital measure should be based on the new definition (given by Basel III) of Tier 1 capital; banks’ core capital, consisting primarily of common shares or retained earnings, while the exposure measure is given by total exposure (BIS 2014). During a parallel run period (from 1 January 2013 to 1 January 2017), the Basel Committee will test a minimum requirement of 3% for the leverage ratio. The leverage ratio may be introduced as a binding measure in 2018, following the Basel Committee review and calibration of leverage ratio requirements in the first half of 2017. However, the introduction of a minimum leverage ratio is by some argued to have had a negative effect on the market as a whole. Stricter leverage ratios have led banks to reduce their repo (repurchase agreement) activities significantly. Repos are a major source of safe, short-term assets for investors looking for cash equivalents, in addition to being an important part of managing a market-maker business. Reduced market-making is likely to

negatively affect the liquidity in the market, as it gets harder for market participants to find a trading partner (Barclays 2015).

The liquidity coverage ratio:

The liquidity coverage ratio (LCR) is a measure of bank's liquid assets introduced in the Basel III regulation. The LCR standard measure banks ability to fund their operations in difficult market-funding environments, and was introduced as a response to the liquidity problems several big banks experienced during the recent crisis due to difficulties of obtaining funding in the market. The LCR is one of the Basel Committee's key reforms, and promotes the short-term resilience of a bank's liquidity risk profile by "ensuring that a bank has an adequate stock of unencumbered high-quality liquid assets (HQLA) that can be converted into cash easily and immediately in private markets to meet its liquidity needs for a 30 calendar day liquidity stress scenario" (BIS 2013). The liquidity coverage ratio is given by:

$$LCR = \frac{\text{Required amount of stable funding}}{\text{Required amount of stable funding}} \geq 100\%$$

HQLA are comprised of Level 1 and Level 2 assets, where different types of assets within HQLA are subject to a range of haircuts. Level 1 assets are typically the most liquid, such as cash, Treasuries, and central bank reserves, and banks have no limit on the extent to which they can hold these assets to meet LCR. Level 2 are comprised of Level 2A and Level 2B assets. Level 2A assets include covered bonds and corporate debt securities, while Level 2B assets include lower rated corporate bonds. Level 2 assets may not account for more than 40% and Level 2B assets may not account for more than 15% of a bank's total stock of HQLA. Clearly, this has the potential to directly affect bank's bond trading, since it forces banks to hold large amounts of liquid bonds such as government bonds. However, since these assets cannot be traded, market liquidity can be reduced (Financial Times 2014).

The LCR will be implemented gradually in Europe in 2015-2019, where the minimum requirement started at 60% in 2015 and will be rising in equal annual steps of 10 percentage points to reach 100% on 1 January 2019.

Net stable funding ratio:

The net stable funding ratio (NSFR) is another key component of the Basel III framework and is designed to complement the LCR. The 2007-2009 financial crisis exposed the vulnerability of large banks to liquidity shocks, and many banks experienced severe contractions in the supply of funding, which led to the possibility of default and failure. NSFR is a longer-term structural ratio designed to address liquidity mismatches by requiring banks to fund their activities with sufficiently stable sources of funding and thereby reduce funding risk over a longer period of time. The NSFR is calculated as follows:

$$NSFR = \frac{\text{Available amount of stable funding}}{\text{Required amount of stable funding}} \geq 100\%$$

The ratio is defined as a bank's available stable funding (ASF) divided by its required stable funding (RSF), with a minimum ratio of 100%, and the relevant time span is one year. ASF is the portion of a bank's funding structure that is reliable over a one-year time horizon, while the RSF is the portion of a bank's assets and off-balance exposures that are viewed as illiquid over a one-year horizon and hence should be backed by stable funding sources (Gobat, Yanase, and Maloney 2014). The ASF and RSF weights range from 100% to 0% to reflect the stability of funding for liability categories and the liquidity of asset categories. Stable funding sources, like regulatory capital and long-term debt, are attached with a higher ASF weight, while less desirable funding sources have lower ASF weights. Similarly, liquid assets are dedicated a low RSF weight, while risky or illiquid assets are assigned higher RSF weights. In Europe, the NSFR will become a minimum standard by January 2018.

6. Data

From Oslo Børs Informasjon (OBI), provided by Bernt Arne Ødegaard, we get the daily volume for fixed income securities from 2004 to 2015 for all listed securities on Oslo Stock Exchange. The dataset provided gives a list of dates traded and volume with 205.384 observations. We get daily prices and bond information and characteristics for each security from Bloomberg, Datastream and Stamdata. We eliminate all government bonds and limit our study to fixed and floating bonds that are not callable, convertible, puttable or have sinking fund provisions. Bonds issued from non-public companies are disregarded in order to obtain quarterly firm accounting figures. After the filtering we are left with 43.171 daily bond trades and 909 unique ISINs from 80 public companies. The control variables are obtained from Bloomberg and Stamdata. One central aspect of the model we will use in order to analyze bond liquidity is the rating of the different bonds. The original paper by Dick-Nielsen, Feldhütter, and Lando (2012) classify each bond in different rating classes based on information from credit rating bureaus. We use the classification provided by Stamdata to determine whether a bond is high yield or investment grade.

7. Methodology

To determine the liquidity development of corporate bonds in the Norwegian market, we will utilize the method developed by Dick-Nielsen, Feldhütter, and Lando (2012). Consistent with their methodology we use quarterly observations and run separate regressions for each rating class; in our paper this means investment grade and high-yield bonds. The regressions are conducted in the following way:

$$\begin{aligned}
 Spread_{it} = & \alpha + \gamma Liquidity_{it} + \beta_1 Bond\ age_{it} + \beta_2 Amount\ issued_{it} \\
 & + \beta_3 Coupon_{it} + \beta_4 Time\ to\ maturity_{it} + \beta_5 Eq.\ Vol_{it} \\
 & + \beta_6 Operating_{it} + \beta_7 leverage_{it} + \beta_8 long\ debt_{it} \\
 & + \beta_9 Pretax\ dummies_{it} + \beta_{10} 10y\ Swap_t + \beta_{11} 10y - 1y\ Swap_t \\
 & + \beta_{12} Forecast\ dispersion_{it} + \varepsilon_{it}
 \end{aligned}$$

where i is bond issue and t is quarter. The dependent variable is the spread (described in detail in section 7.3), which is the yield spread rate to the swap rate for every bond. The $Liquidity_{it}$ term is a measure for liquidity, which we described in detail in Section 4. We have to control for other factors affecting the spread in order to distinguish the liquidity component. Following the work of Blume, Lim, and MacKinlay (1998) we control for credit risk by adding the ratio of operating income to sales, the long term debt to asset ratio, leverage ratio, equity volatility, and a pretax interest coverage dummy to the regression. The systematic risk variables are included to capture the effects of the general economic environment on the credit risk of firms, and we use the 10-year swap rate and the difference between the 10-year and 1-year swap rate as proxies. In line with Houweling, Mentink, and Vorst (2005), Longstaff, Mithal, and Neis (2005), and Sarig and Warga (1989), we additionally add bond age, time to maturity, coupon size, and amount issued to our regression. Finally, since information regarding firm's credit risk is not perfectly transparent to investors in the secondary corporate bond market, spreads may not reflect the true credit quality of a firm according to Duffie and Lando (2001). Using Guntay and Hackbarth (2010) we address this issue by adding dispersion in earnings forecasts as a measure of incomplete information.

Petersen (2009) outlines how we can correct for time-series effects, firm fixed effects, and heteroscedasticity in the residuals by calculating two-dimensional cluster robust standard errors. This is necessary since we have panel data of yield spreads with issuers potentially having multiple bonds outstanding at any point in time.

7.1 Liquidity measures

As described in the section about liquidity, liquidity is a slippery term, with no universal definition and without a straightforward way of measuring. We therefore include several different measures for corporate bond liquidity, briefly explained below. A more extensive and formative explanation of these liquidity proxies are found in Exhibit I in the Appendix.

We proxy for the price impact of a trade per unit traded by applying Amihud's (2002) illiquidity measure, and estimate a proxy for bid-ask spreads; Imputed Roundtrip Trades (IRT). IRT is a measure of roundtrip cost of trading, assuming that two trades in the same bond, close in time and with same trade size, likely is the result of a dealer matching a buyer and a seller.

Some trading activity measures are also considered, and we find the quarterly turnover of bonds by dividing total trading value in that period by amount outstanding. Since bonds are less liquid than other asset classes like equities, days with no trading activity in a given bond might occur. The variable bond zero-trading days measures the percentage of days during a quarter where a bond does not trade, while firm zero-trading days measures the percentage of days where none of the issuing firm's bonds are traded.

Lastly, we use the standard deviations of the Amihud measure and the Imputed Roundtrip Trades in order to consider liquidity risk. The variability in these measures represents the sum of systematic and unsystematic liquidity risk, and given the sporadic trading of bonds, measuring the systematic part accurately is difficult. Although it is the systematic part that is important for pricing, these difficulties force us to use the total component and address the systematic part later. First we use these seven liquidity measures for the sample period 2004:Q1-2010:Q4. While our main focus in this paper will be the period from 2011, we have included this earlier period out of curiosity and in order to check whether it is possible to learn something about the characteristics of the Norwegian corporate bond market.

For our 2011-2015 sample we use two additional liquidity measures, bid-ask and bid-ask risk, in order to capture the liquidity information contained in the bid-ask spreads of the securities. The difference between the prices quoted for an immediate sale (bid) and an immediate purchase (ask) for securities is the bid-ask

spread. The security is frictionless if the spread is zero, where the size of the spread is one measure of liquidity. The bid ask spread is the amount the ask price exceeds the bid price for a security

We perform a principal component analysis (PCA) on these potential liquidity proxies in order to identify the factors with the most relevant information. Table 1 below presents our results for the period 2004:Q1-2010:Q4.

Table 1: Principal component loadings on the liquidity variables.
This table shows the PCA loadings on each of the seven liquidity variables along with the cumulative explanatory power of the components. The liquidity variables are measured quarterly for each bond in the sample. The data are Norwegian corporate bond transaction data from and the sample period is from 2004:Q1 to 2010:Q4.

Principal component loadings, financial crisis (2004:Q1-2010:Q4)

	1PC	2PC	3PC	4PC	5PC	6PC	7PC
Amihud	0.19	-0.49	0.40	0.17	0.68	0.02	0.27
Amihud risk	0.22	-0.25	0.63	0.15	-0.67	0.16	0.02
Firm zero	0.24	0.56	0.39	-0.37	0.26	0.47	-0.21
Bond zero	0.50	0.39	0.12	-0.05	-0.03	-0.68	0.33
Turnover	0.16	0.36	-0.10	0.88	0.06	0.22	-0.03
IRC	0.57	-0.29	-0.20	-0.01	0.05	-0.14	-0.73
IRC risk	0.50	-0.14	-0.47	-0.18	-0.13	0.46	0.49
Cum. % explained	25%	42%	57%	70%	83%	93%	100%

From the table 1 we see that the first component explains 25% of the variation in the liquidity variables and is close to an equally weighted linear combination of the bond zero measure and the IRC measures and its associated liquidity risk measure. Table 2 includes the new liquidity measures, and is based on the period 2011:Q1-2015:Q

Table 2: Principal component loadings on the liquidity variables.
Principal component loadings on the liquidity variables. This table shows the PCA loadings on each of the nine liquidity variables, including our two new liquidity measures bid-ask and bid-ask risk, along with the cumulative explanatory power of the components. The liquidity variables are measured quarterly for each bond in the sample. The sample period is from 2011:Q1 to 2015:Q4.

Principal component loadings, new variables (2011:Q1-2015:Q4)

	1PC	2PC	3PC	4PC	5PC	6PC	7PC	8PC	9PC
Amihud	0.12	0.69	0.06	-0.01	-0.01	0.06	-0.68	0.19	0.02
Amihud risk	0.09	0.69	0.16	-0.02	0.00	-0.02	0.69	-0.11	0.01
Firm zero	0.01	-0.10	0.60	0.05	0.71	0.33	-0.03	-0.04	0.04
Bond zero	0.34	-0.11	0.47	-0.18	-0.05	-0.78	-0.07	0.03	-0.03
Turnover	-0.01	-0.10	0.59	0.21	-0.69	0.36	-0.01	0.02	0.01
IRC	0.49	-0.01	-0.11	0.42	0.03	0.05	-0.09	-0.53	-0.53
IRC risk	0.38	-0.06	-0.12	0.65	0.09	-0.06	0.13	0.50	0.38
Bid-ask	0.47	-0.10	-0.06	-0.45	-0.02	0.30	0.14	0.53	-0.42
Bid-ask risk	0.51	-0.07	-0.10	-0.35	-0.07	0.22	-0.05	-0.39	0.63
Cum. % explained	29%	47%	61%	74%	83%	90%	95%	98%	100%

Now, using our two new liquidity measures, the first component is close to an equally weighted linear combination of bid-ask, bid-ask risk, and the IRC measure. The first PC explains 29% of the variation in the liquidity variables, a small improvement compared to the first sample period. The second PC explains 18% and is an Amihud illiquidity measure, the third PC explains 14% and is a combination of bond zero trading days and turnover, while the fourth PC explains 13% and is an IRC measure. The last five PCs explain approximately 25%.

Using the first PC in Table 1 and Table 2 we create our liquidity measure, denoted λ_1 and λ_2 , respectively. λ_1 is based on the PCA in Table 1, and loads evenly on bond zero, IRC, IRC risk, and omit the other liquidity proxies by not loading on these. This measure will be used to look at the period 2004:Q1 to 2010:Q4. λ_2 is based on the PCA in Table 2, and loads evenly on bid-ask, bid-ask risk, and IRC. We will use this measure to study the period from 2011:Q1 to 2015:Q4. By doing this, we get a factor that retains the properties and is a close approximation of the first PC, extracted among several potential liquidity proxies. This new liquidity measure, λ , is then added to our liquidity proxies in our analysis.

7.2 Summary statistics

Summary statistics for our liquidity proxies are presented in Table 3. The median bond zero trading days is 97 percent, in line with the common perception that the corporate bond market is an illiquid market. This result supports Rakkestad, Skjeltorp and Ødegaard (2012) who found the Norwegian bond market to be illiquid. The amount of trading is also low compared to the results of a median bond zero trading days of 60,7 percent found in the U.S. market by Dick-Nielsen, Feldhütter, and Lando (2012) and 76 percent in the U.K. market (Aquilina and Suntheim 2016). The firm zero trading days contributes to the notion that the Norwegian bond market is less liquid with a median of 71 percent, which shows that on a firm level there is also fairly low trading activity. Seen from a turnover standpoint, it takes approximately one to one and half year to turn over once. To put the Norwegian market in perspective, the U.S. market uses on average five to

six years to turn once. This indicates that there is a lower average issue size in Norway given the trading activity in the U.S. market.

Table 3: Statistics for liquidity proxies.

The proxies are calculated quarterly for each bond for the entire sample period from 2004:Q1 to 2015:Q4. Bid-Ask and lambda 2 measures is only available for 2011:Q1 to 2015:Q4.

	λ_1	λ_2	Amihud	IRC	IRC Risk	Amihud Risk	BID-ASK	BID-ASK risk	Turn over	Zero	Firm Zero
0,99	2,83	3,55	0,0317	0,1258	0,00	0,00	0,0336	0,0070	1,11	0,98	0,98
0,95	1,10	0,56	0,0079	0,0396	0,00	0,00	0,0154	0,0022	0,71	0,98	0,95
0,75	0,22	-0,12	0,0015	0,0099	0,00	0,00	0,0064	0,0007	0,33	0,98	0,85
0,50	-0,02	-0,33	0,0005	0,0046	0,00	0,00	0,0036	0,0003	0,18	0,97	0,71
0,25	-0,15	-0,47	0,0002	0,0020	0,00	0,00	0,0021	0,0004	0,11	0,95	0,56
0,05	-0,26	-0,51	0,0001	0,0009	0,00	0,00	0,0004	0,0005	0,07	0,94	0,41
0,01	-0,29	-0,51	0,0001	0,0007	0,00	0,00	0,0001	0,0005	0,06	0,92	0,36

The median Amihud of 0,005 shows that an average bond trade moves the bond price 1,16 percent given the average trade size of 23 million NOK. We can compare the price impact with the U.S. market and Dick-Nielsen, Feldhütter, and Lando, who found that with a trade size of 0,3 million USD in an average bond moves prices by, approximately 0,13 percent.

The IRC measure shows that the median roundtrip in percentage of the price is 0,46 percent, while the roundtrip cost is less than 0,009 percent for the 5 percent most liquid. The IRC measure can be seen as proxy for the bid-ask spread, due to interpretation of the IRC measure that a dealer matches buyer and seller and collects difference. This is also visible with correlations of 38 percent between bid-ask spread and IRC in Table 4. The median bid-ask spread paid for a liquidity demander is 0,36 percent, which is 10 basis point lower than the IRC measure. The fairly low transaction cost for the modest part of the corporate bond market could indicate that the market is somewhat transparent. With a correlation of 69 percent between IRC and IRC risk, 55 percent correlation between Amihud and Amihud Risk and 74 percent correlation between bid-ask and bid-ask risk shows that there is high correlation between liquidity and liquidity risk. This is consistent with findings in Acharya and Pedersen (2005), Jong and Driessen (2012) and Dick-Nielsen, Feldhütter, and Lando (2012).

Table 4: Correlation matrix for liquidity proxies.

This table shows the correlation among the proxies. Panel A shows the result for the full sample, while Panel B shows the period from 2011:Q1 to 2015:Q4. The data are Norwegian corporate bond transactions.

Panel A: Full sample

	AMIHUD RISK	AMIHUD	FIRM ZERO	IRC	IRC RISK	TURNOVER	ZERO
AMIHUD RISK	1,00						
AMIHUD	0,55	1,00					
FIRM ZERO	0,00	- 0,03	1,00				
IRC	0,06	0,15	- 0,01	1,00			
IRC RISK	0,01	0,03	0,01	0,69	1,00		
TURNOVER	- 0,00	- 0,03	0,07	0,01	0,01	1,00	
ZERO	0,05	0,01	0,23	0,26	0,16	0,14	1,00

Panel B: 2011:Q1-2015:Q4

	AMIHUD RISK	AMIHUD	FIRM ZERO	IRC	IRC RISK	TURNOVER	ZERO	BID ASK	BID ASK RISK
AMIHUD RISK	1,00								
AMIHUD	0,59	1,00							
FIRM ZERO	0,00	-0,04	1,00						
IRC	0,06	0,14	-0,02	1,00					
IRC RISK	0,01	0,03	0,00	0,70	1,00				
TURNOVER	-0,01	-0,05	0,12	-0,01	0,01	1,00			
ZERO	0,05	0,02	0,20	0,26	0,16	0,19	1,00		
BID ASK	0,02	0,04	-0,01	0,38	0,18	-0,07	0,35	1,00	
BID ASK RISK	0,02	0,09	-0,07	0,49	0,25	-0,07	0,37	0,74	1,00

7.3 Corporate bond spread

Spread is measured as the difference between yield to maturity for a given bond and a comparable risk free rate. Thus the spread is based on two variables which will be presented separately below.

7.3.1 Yield to maturity

The yield to maturity for a bond is defined by Bodie, Kane and Marcus (2014) as the interest rate that makes the present value of a bond's payments equal to its price. If the bond is bought now and held to maturity, the yield to maturity is interpreted as a measure of the internal rate of return. The yield to maturity when the price is known is given by:

$$Price = \sum_{t=1}^n \frac{C_n}{(1+ytm)^t} + \frac{par\ value}{(1+ytm)^t}$$

Where C_n is the coupon paid every period which can be fixed or floating and par value is the value that the investor is promised at maturity. Floating coupons is

linked to an underlying reference interest rate, such as 3 month NIBOR (Norwegian interbank offering rate). Furthermore, the coupons paid are the sum of the floating rate plus a spread or premium. The pricing of floating bonds is based on the on the following equality:

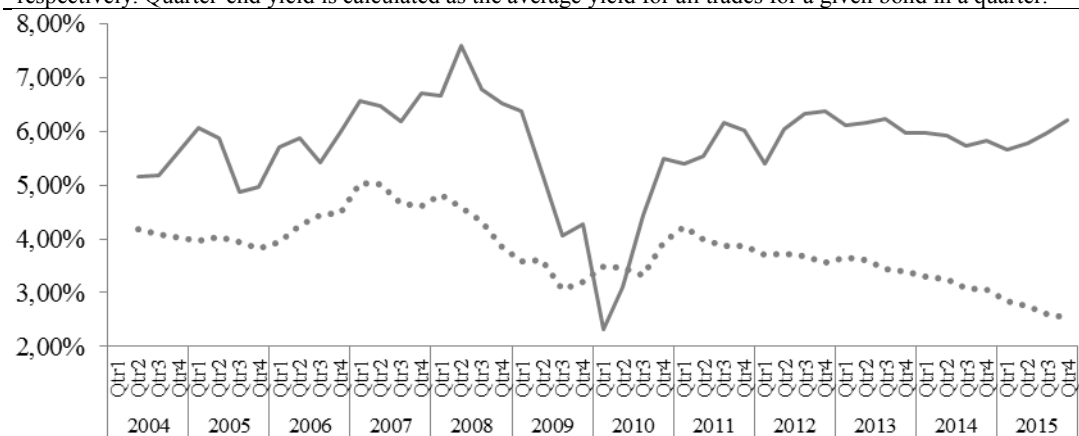
$$\text{Floating coupon with spread } s = \text{Floating coupon with zero spread} + \text{Fixed coupon } s$$

The value of each component above can be solved independently, hence the price of a sequence of payments equal to s is $\sum_{t=0,5}^n \frac{s_n}{(1+r)^{(0,t)}}$ and the ex-coupon price of a floating coupon bond with zero spread on any coupon date is equal to the bond par value. The coupon for a floating bond with zero spread at time $t = 0,5$ depends on today's interest rate, and the coupon at time $t = 1$ depends on the rate on $t = 0,5$, which is not known today. This will continue until the bond matures at time $t = T$. At time $t = 0,5$ the bondholder knows the cash flow provided by the bond at time $t = 1$, since the bondholder knows the rate at time $t = 0,5$. Consequently, the present value of the cash flow for a bond at $t = 0,5$ is equal to par value of the bond. As an example, if $r_2(0,5) = 3\%$ then price at $t = 0,5$ is $P_{(0,5)} = \frac{Par+1,5\%}{1+3\%/2} = Par$. For a semi-annual Floating rate bond with maturity T is a bond whose coupon payments $c(T_i)$ at date $T_1 = 0,5, T_2 = 1, T_3 = 1,5 \dots, T_n = T$ are determined by the formula $c(T_i) = 100 * (r_2(T_i - 0,5) + s)/2$ where $r_2(T_i - 0,5)$ is the annualized 6-month underlying rate at t , and s is the spread. Each date is called the reset date as it is the time when the new coupon is reset.

The yield to maturity for a floating bond is given by the same formula for a floating as for a fixed coupon bond, but any calculations is only valid up to the next coupon payment. Moreover, the future coupons rates have to be predicted. An objective assumption according to ISMA (International Securities Market Association) is to assume that the current rates will not change in future.

We calculate the yield to maturity for every bond trade. The quarter-end yield is then obtained as the average yield for all trades for a given bond in a quarter. Figure 4 displays YTM for high yield bonds and investment grade bonds traded in the secondary market throughout the period of 2004 to 2015. Traded yields for high yields grade bonds rise towards and in the year of the financial crisis and, before dropping in the first quarter in 2010. The subsequent post-crisis period is defined by a shift in average traded yields to around six percent. The drop in the first quarter could indicate an increased risk appetite for high yield bond. Exhibit IV in appendix illustrates a significant increase in volume traded in the first quarter in 2010, which could signal a search for yield in a low interest environment. A noteworthy observation in the graph is that investment grade traded yields are less volatile compared to high yield and that yields are trending downwards. However, from third quarter 2005 to first quarter 2007 investment grade traded bonds shows a positive trend, indicating that holders need a higher compensation.

Figure 4: High yield and investment grade traded yields
 High yield and investment grade traded yields are represented by the solid line and the dotted line, respectively. Quarter-end yield is calculated as the average yield for all trades for a given bond in a quarter.



7.3.2 Modeling the yield curve and curve fitting

The term structure of interest rates is the relationship between interest rates at different point in time is known as the yield curve. Yield interpolation is finding an interest point between to different maturities in the yield curve. To find the comparable risk-free rate for a bond that mature between two risk-free maturities

we have used two techniques of yield interpolation, linear interpolation and the Nelson Siegel method.

Linear interpolation is an average of two rates, and is a simple method that assumes a straight line between the rates in a yield curve. For maturities under a year, we have used the linear method since there is less curvature to take under consideration. The unknown rate R_n between to known interest rates is

$$r_n = r_1 + \frac{r_2 - r_1}{t_2 - t_1} \times (t_n - t_1)$$

Where r_1 and r_2 is the known rate with short maturity and long rate respectively. Number of days to maturity for r_1 is given by t_1 and t_2 for r_2 . The number of days to cash flow at time n is given by t_n .

In order to find the rates between the time steps in the yield curve for given trade date, the standard Nelson-Siegel model is utilized:

$$y(\tau) = \beta_0 + \beta_1 X_1 + \beta_2 X_2$$

Where X_1 is given by:

$$X_1 = Z_1 = \frac{(1 - \exp(-\frac{\tau}{m}))}{\tau/m}$$

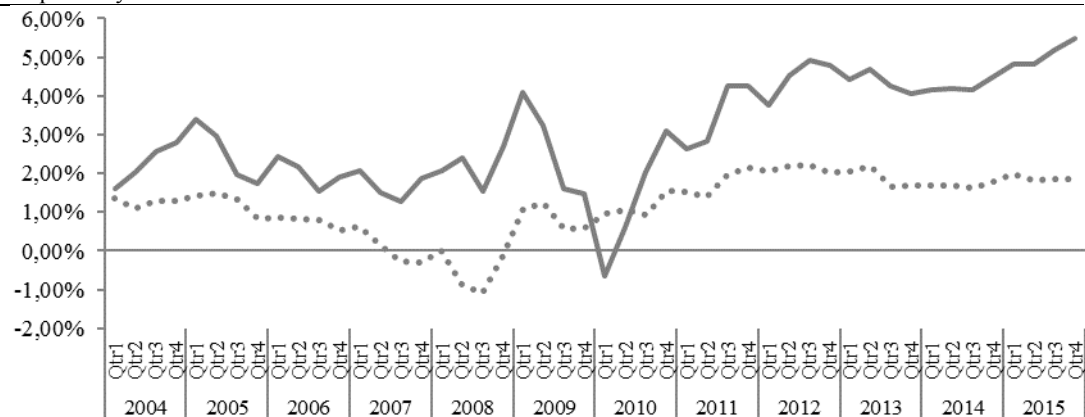
And X_2 is given by:

$$X_2 = Z_2 = \exp(-\tau/m)$$

The spread is then calculated as the difference between traded yield and the interpolated maturity matched swap rate calculated at the same day as the yield is measured. Figure 5 displays the spread for high yield bonds and investment grade bonds traded in the secondary market throughout the period of 2004 to 2015. The interest market rate in exhibit III in appendix discloses a turbulent period for the interest rate market which encounters bond spreads directly. In the ramp-up to financial crisis spreads for high yield bonds are trading around an average of two percent before spiking during the financial crisis. A noticeable observation is that the potential search for yield in the recovery years after the financial crisis pushed

yields into negative territory. Furthermore, the graph indicates that the compensation bondholder gets from holding risky bonds such as high yield bond has stabilized on a higher level from 2011 throughout the sample period. Seen together with the increased number bonds in the same period, the increased average spread can indicate that more risky firms have accessed the high yield market.

Figure 5: Bond spreads
 High yield and investment grade traded yields are represented by the solid line and the dotted line, respectively.



The investment grade spread is trending on average around one percent, where the biggest movements occurs during the financial crisis. The investment grade spread enters negative terrain much earlier than high yield, which may be a signal for a flight-to-quality. In the later years, traded bond spreads for investment grade has stabilized at a relative stable level. To get a deeper understanding of negative spreads, Exhibit IV in Appendix shows the number of observations where the spread is negative by industry. When this occurs, the bond traded delivers a negative risk premium where the non-risky investment pays a higher premium than the riskier investment. The dominant group, with 76 percent of the negative spread observations, is banking. It appears that investors are considering Norwegians banks as safe investments and of high quality during this period of turmoil.

8. Results

In this part, we aim to present empirical evidence for the importance of liquidity for Norwegian listed corporate bonds through different time periods. We look at three different periods: 2004:Q1-2007:Q4, 2004:Q1-2010:Q4, and 2011:Q1-2015:Q4. The period 2004:Q1-2010:Q4 is split in the subsample 2004:Q1-2007:Q4 in order to look at how the period in the years leading up to the financial crisis compares to our results from the years in the aftermath. We run regression for the full sample before we run regressions for subsamples for high yield and investment grade. Our results are presented in Table 5.

Table 5: Results

For each rating class R and each liquidity variable L a pooled regression is run with credit risk controls. $Spread_{it}^R = \alpha^R + \gamma^R L_{it} + Credit\ risk\ controls_{it} + \varepsilon_{it}$, where I is for bond rating R and t is time measured in quarters. The proxies are described in Section 7. The data are Norwegian corporate bond transactions provided by OBI. We use liquidity measure λ_1 when we regress for the periods 2004:Q1-2007:Q4, 2004:Q1-2010:Q4 and 2011:Q1-2015:Q4 while we use λ_2 only for the period 2011:Q1-2015:Q4. Panel A shows the coefficients using data for the entire sample, Panel B shows the coefficients of investment grade bonds, and Panel C shows the coefficients for high-yield bonds. Standard errors are corrected for time series effects, firm fixed effects, and heteroscedasticity, and significance at 10% level is marked *, at 5% marked **, and at 1% marked ***.

Panel A: Full sample

	2004:Q1-2007:Q4	2004:Q1-2010:Q4	2011:Q1-2015:Q4
λ_1	0.0004** (2.03)	0.0002** (2.58)	0,0001** (2.58)
λ_2			0.0003** (2.10)
Amihud	-0.73*** (-9.14)	-0.13* (-1.92)	0.019** (2.18)
Amihud risk	-26.59*** (-4.45)	-47.16*** (-2.95)	-29.65 (-0.15)
Bond zero	0.03*** (5.99)	0.031*** (6.20)	0.046*** (35.86)
Turnover	0.0054*** (5.64)	-0.0002 (-0.52)	-0.0013 (-3.29)
Firm zero	0.006*** (12.82)	0.010*** (12,22)	0.008*** (21.23)
IRC	-0.44*** (-10.97)	-0.32*** (-8.27)	0.099*** (11.03)
IRC risk	-17.81*** (-3.78)	-15.21*** (-5.30)	30.84*** (4.13)
Bid-ask	-	-	0.71*** (24.15)
Bid-ask risk	-	-	1.90*** (22.25)

Panel B: Investment grade bonds

	2004:Q1-2007:Q4	2004:Q1-2010:Q4	2011:Q1-2015:Q4
λ_1	0.0002** (2.08)	0.00014* (1.84)	0.0003 (1.28)
λ_2			0.00004*** (4.99)
Amihud	-0.75*** (-8.26)	-0.24*** (-3.50)	-0.066 (-1.12)
Amihud risk	-34.42*** (-3.39)	-63.47** (-2.56)	-35.30*** (-3.03)
Bond zero	0.034*** (4.86)	0.034*** (9.45)	0.022*** (8.82)
Turnover	0.0089*** (5.53)	0.0019** (2.23)	-0.0007*** (-2.66)
Firm zero	-0.0014** (-2.09)	-0.0047*** (-9.36)	-0.0018*** (-3.90)
IRC	-0.58*** (-10.91)	-0.33*** (-7.47)	0.030 (0.95)
IRC risk	-13.90*** (-2.93)	-20.47*** (-5.30)	10.75 (0.39)
Bid-ask	-	-	-0.68*** (-6.45)
Bid-ask risk	-	-	-1.53*** (-3.92)

Panel C: High-yield bonds

	2004:Q1-2007:Q4	2004:Q1-2010:Q4	2011:Q1-2015:Q4
λ_1	-0.0004*** (-2.74)	-0.0004** (-2.35)	0.000 (1.28)
λ_2			0,00003*** (4,99)
Amihud	-0.47 (-0.65)	0.078*** (5.08)	-0.0044 (-0.76)
Amihud risk	-24.84 (-0.03)	26.96 (0.63)	-26.38*** (-6.21)
Bond zero	0.005 (0.95)	0.017 (1.27)	0.0007*** (2.82)
Turnover	-0.002 (-1.27)	-0.0003*** (-3.14)	0.0002 (0.17)
Firm zero	0.005*** (3.20)	0.0054 (1.63)	0.0023** (2.36)
IRC	-0.044 (-1.00)	0.024 (1.56)	0.027** (2.20)
IRC risk	-8.01 (-0.65)	30.16 (1.11)	51.03 (1.21)
Bid-ask	-	-	0.28*** (3.77)
Bid-ask risk	-	-	0.97*** (7.20)

One important finding is the positive coefficient for zero trading days, both when measured by the full sample and subsample divided between high yield and investment grade bonds. The consistent positive relationship between zero trading days and bond spreads indicates that bond spreads narrows when the bond trading activity increases. This is in line with Chen, Lesmond, and Wei (2007) findings.

For the full sample, the coefficient is increasing through the different time periods which can be interpreted as bond spreads may be more reliant about bond activity in the time period from 2011 to 2015. However, the similar finding does not appear when we divide between investment grade and high yield. Investment grade tends to be more dependent on the trading activity pre-crisis and during crisis, compared to the later years. High yield bonds show a different pattern, since the highest coefficient appears when the financial crisis is included. Nevertheless, the coefficient for high yield bonds in 2004-2007 and 2004-2010 is not significant making the zero trading days' impact on bond spreads for those years inconclusive. For 2011 to 2015 the bond zero trading days has smaller impact on bond spread compared to investment grade bonds. The low impact on spreads could be the result of splitting up trades in smaller orders according to Huberman and Stanzl (2005). This theory is supported by Exhibit VIII in appendix, where number trades increases considerably in the period 2011 to 2015 and Exhibit IV in appendix which shows traded volume is fairly stable from mid-2011 to 2015.

The turnover coefficient is negative five out of nine times and only significant for all of the subsamples for investment grade bonds. Surprisingly, for investment graded bond traded between 2004 to 2007 and 2004 to 2011, a higher turnover tends to increase bond spreads. For 2011 to 2015, turnover indicates a decrease in bond spreads.

For high yield and investment grade bond spreads, the impact of transaction cost on liquidity is indicated to be higher before the financial crisis than after when the Amihud measure is utilized. However, the coefficients are not significant making the results inconclusive. The IRC measure contributes with an inconsistent result due to the fact that an increased IRC in some cases decreases bond spread. Moreover, the IRC coefficient is only positive in three out nine regressions. The bid-ask measure signals a positive relationship with bond spreads without when bond credit rating is not specified. This is consistent with Chen, Lesmond, and

Wei (2007) findings when they use bid-ask spread from Bloomberg. However, when we divide between high yield and investment grade, the results are somewhat mixed. The bid-ask spread has lower impact for high yield bond spreads compared to the full sample, and bid-ask spread for investment grade has decreased bond spreads. This contradicts with Chen, Lesmond, and Wei (2007) findings of higher relationship between bond spreads and bid-ask spread for high yield bonds.

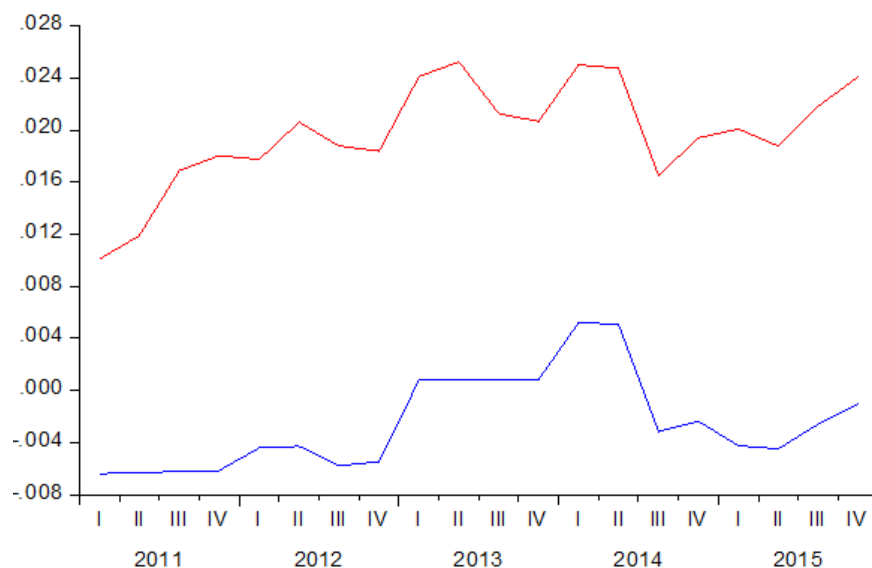
Table 5 also displays that the liquidity measure λ is significant for ten out of twelve regressions. For the full sample, the coefficients decrease which indicates that investors require less compensation for holding an illiquid bond in the years 2011 to 2015 compared to 2004 to 2007. The expected compensation needed for holding a high yield bond compared to investment bond is not evident from the results. Furthermore, the measure has small impact on bond spreads compared to the results found by Chen, Lesmond, and Wei (2007) and Dick-Nielsen, Feldhütter, and Lando (2012).

The noisy and inconclusive results for our liquidity measure λ , Amihud, IRC and turnover between our time-subsamples may be a result of the low trading activity, which can be supported by the findings in Rakkestad, Skjeltnor, and Ødegaard (2012). However, from Exhibit VIII in appendix the number of trades increases considerably from 2011 to 2015. Due to the development and the results for our liquidity measure λ , we will use the bid-ask spread and only look at the time span from 2011 to 2015 for further investigation.

The Dick-Nielsen, Feldhütter, and Lando (2012) methodology is used to measure the fraction of the liquidity component to the total bond spread. Instead of using our liquidity measure λ as Dick-Nielsen, Feldhütter, and Lando (2012) we use the Bid-Ask spread. Figure 6 displays how the liquidity premium evolves with total spreads. Liquidity premium measured by the bid-ask spread is only existent from the first quarter 2014 to third quarter 2014 and the co-movement between spread

and liquidity premium is somewhat similar to the findings to Dick-Nielsen, Feldhütter, and Lando (2012). The presence of liquidity premium occurs during the quarter when oil price starts to tumble mid-2014 and the price for high yield par value start drop which can be observed in Exhibit VI and Exhibit IX in appendix.

Figure 6: Liquidity premium compared to bond spreads
 Liquidity premium measured by bid-ask spread (blue line) and total spread for full sample (red line). We estimate quarterly variations in liquidity and bond spreads by regressing the liquidity measure on bond spreads, after controlling for credit risk. Furthermore, the contribution of illiquidity of total spread is found by multiplying the fraction with the median yield spread. The fraction is calculated as $\beta_t(BA_{it} - BA_{5t})/spread_{it}$, where BA_{it} is the bid-ask spread for every bond where i refers to bond and t is time measured by quarters.



9. Conclusion

Yield spreads are assumed to be compensation for the default risk of a corporate bond compared to a risk-free government bond, and several papers have found that a large and significant proportion of the spreads cannot be explained by default risk alone or can be attributed to other variables. Chen, Lesmond, and Wei (2007) concluded that liquidity is priced in corporate yield spreads and Dick-Nielsen, Feldhütter, and Lando (2012) found that the spread contribution from illiquidity increases dramatically during the financial crisis. In the later years, bond liquidity is a subject that has been debated in the financial media¹ and by market participants².

In this paper we are the first to explicitly analyze the liquidity components of corporate bond spreads during 2004 – 2015 using Norwegian data. By utilizing a methodology closely related to Dick-Nielsen, Feldhütter, and Lando (2012) we show that the internationally documented spread contribution from illiquidity is puzzling to disclose in the Norwegian corporate bond market due to the low trading activity. However, from one of our liquidity proxies, zero trading days, we tend to find a positive relationship with bond spreads. Furthermore, we find indications that the liquidity premium measured by the bid-ask spread exist from the first quarter of 2014 to third quarter of 2014.

¹ The Economist. 2015. “Frozen”. 29.04.2015 and Financial Times. 2015. “Liquidity pitfalls threaten parched market”. 18.06.2015

² BlackRock. «The Liquidity Challenge», June 2014 and Barclays, “The decline in the financial market liquidity”

10. References

- Acharya, Viral V., and Lasse Heje Pedersen. 2005. "Asset Pricing With Liquidity Risk". *Journal of Financial Economics* 77(2): 375-410.
- Amato, Jeffrey D., and Eli M. Remolona. 2003. "The Credit Spread Puzzle". BIS Quarterly Review.
- Amihud, Yakov, and Haim Mendelson. 1991. "Liquidity, Asset Prices and Financial Policy." *Financial Analysts Journal* 47(6): 56-66
- Aquilina, Matteo, and Felix Suntheim. 2016. "Liquidity in the UK corporate bond market: evidence from trade data". *Social Science Research Network*.
- Baker, Kent. H. 1996. *In Trading Location and liquidity- An Analysis of US dealer and Agency Markets for Common Stocks*. Blackwell Pubs.
- Bodie, Zvi, Kane, Alex, Marcus, Alan J, "Investments", Tenth global edition
- Bao, Jack, Jun Pan, and Jiang Wang. 2011. "The Illiquidity of Corporate Bonds." *The Journal of Finance* 66(3): 911-946
- Barclays. 2015. "Mutual Funds and Credit Liquidity: Nobody Move". Barclays Research. Accessed February 20, 2016.
<http://www.thebondbeat.com/bondbeat/wp-content/uploads/2015/09/barcap1.pdf>
- Beber, Alessandro, Michael W. Brandt and Kenneth A. Kavajecz. 2009. "Flight-to-Quality or Flight-to-Liquidity? Evidence from the Euro-Area Bond Market". *Review of Financial Studies* 22(3): 925-957
- Bernanke, Ben S., and Mark Gertler. 1995. "Inside the Black Box: The Credit Channel of Monetary Policy Transmission". *Journal of Economic Perspectives* 9 (4): 27-48.
- BIS (Bank of International Settlements). 2014. "Basel III leverage ratio framework and disclosure requirements". Basel: BIS. Accessed February 20, 2016. <http://www.bis.org/publ/bcbs270.pdf>
- BIS (Bank of International Settlements). 2013. "Basel III phase-in Arrangements". Basel: BIS. Accessed February 20, 2016.
http://www.bis.org/bcbs/basel3/basel3_phase_in_arrangements.pdf

BIS (Bank of International Settlements). 2013. “Global systemically important banks:

updated assessment methodology and the higher loss absorbency requirement”. Basel: BIS. Accessed February 20, 2016.

<http://www.bis.org/publ/bcbs255.pdf>

BIS (Bank of International Settlements). 2013. ” Basel III: The Liquidity CoverageRatio and liquidity risk monitoring tools”. Basel: BIS. Accessed February 20,2016. <http://www.bis.org/publ/bcbs238.htm>

BIS (Bank for International Settlements). 2016. ”Fixed Income Market Liquidity”. Basel: BIS. Accessed March 20, 2016. <http://www.bis.org/publ/cgfs55.pdf>

BIS (Bank for International Settlements). 2015. ”Annual Report 2015”. Basel: BIS. Accessed January 07, 2015. <http://www.bis.org/publ/arpdf/ar2015e.pdf>

BlackRock. 2014. ”The Liquidity Challenge – Exploring and Exploiting (Il)liquidity”. BlackRock Investment Institute

Blume, Marshall E., Felix Lim, and A. Craig MacKinlay. 1998. “The declining credit quality of U.S. corporate debt: Myth or reality?”. *Journal of Finance* 53 (4):1389–1401

Brunnermeier, Markus. K. 2009. “Deciphering the Liquidity and Credit Crunch 2007–08.” *Journal of Economic Perspectives* 23 (1): 77-100

Brunnermeier, Markus K., and Lasse Heje Pedersen. 2009. “Market Liquidity and Funding Liquidity.” *Review of Financial Studies* 22 (6): 2201–38

Chen, Long, David A. Lesmond and Jason Wei. 2007. "Corporate Yield Spreads and Bond Liquidity". *Journal of Finance* 62 (1): 119-149.

Christensen, Jens, and James Gillan. 2015. “Does Quantitative Easing Affect Market Liquidity?” Federal Reserve Bank of San Francisco Working Paper 26, San Francisco.

Collin-Dufresne, Pierre, Robert S. Goldstein and J. Spencer Martin. 2001. ”The Determinants of Credit Spread Changes” . *The Journal of Finance*, Vol. 56 (6): 2177-2207.

Diamond, Douglas W., and Philip H. Dybvig. 1983. “Bank Runs, Deposit Insurance, and Liquidity”. *The Journal of Political Economy* 91 (3): 401-419

Duffie, Darrell and Kenneth J. Singleton. 1997. "An Econometric Model of the Term Structure of Interest-Rate Swap Yields". *The Journal of Finance* 52 (4): 1287-1321.

Duffie, Darrell. 2012. Market making under the proposed Volcker Rule. Public comment to Federal Reserve Board. *Rock Center for Corporate Governance at Stanford University Working Paper No. 106*

Driessen, Joost. 2005. "Is Default Event Risk Priced in Corporate Bonds?". *Review of Financial Studies* 18 (1): 165-195.

Driessen, Joost, and Frank de Jong. 2012. "Liquidity Risk Premia in Corporate Bond Markets". *Quarterly Journal of Finance* 2 (2)

Elliott, Douglas J. 2015. "Market Liquidity: A Primer". The Brookings Institution. <http://www.brookings.edu/~media/research/files/papers/2015/06/market-liquidity/market-liquidity.pdf>

Elton, Edwin J., Martin K. Gruber, Deepak Agrawal, and Christopher Mann, 2001. "Explaining the Rate Spread on Corporate Bonds". *The Journal of Finance* 56 (1): 247–277.

Eom, Young Ho, Jean Helwege, and Jing-zhi Huang, 2004, Structural models of corporate bond pricing: An empirical analysis, *Review of Financial Studies* 17 (2), 499–544.

EU. 2013. "CRD IV/CRR – Frequently Asked Questions". European Union. Accessed February 20, 2016. http://europa.eu/rapid/press-release_MEMO-13-272_en.htm

Financial Times. 2014. "Banks blame bond volatility on tighter regulation". ft.com. Accessed February 21, 2016.

<http://www.ft.com/intl/cms/s/0/1a456bc6-54d9-11e4-bac2-00144feab7de.html#axzz4AdEzLhFM>

Geske, Robert L., and Gordon Delianedis. 2001. "The Components of Corporate Credit Spreads: Default, Recovery, Taxes, Jumps, Liquidity, and Market Factors". UCLA Anderson Working Paper No. 22-01

Gobat, Jeanne, Mamoru Yanase, Joseph Maloney (2014). “The Net Stable Funding Ratio: Impact and Issues for Consideration”. IMF Working Paper.

<https://www.imf.org/external/pubs/ft/wp/2014/wp14106.pdf>

Government.no. 2016. “Countercyclical buffer unchanged”. Accessed April 03, 2016.

<https://www.regjeringen.no/en/aktuelt/countercyclical-buffer-unchanged/id2480319/>

Grinblatt, Mark. 1995. “An Analytical Solution for Interest-rate Swap Spreads”. Working Paper, UCLA, Anderson Graduate School of Management

Güntay, Levent, and Dirk Hackbarth. 2010. “Corporate bond credit spreads and forecast dispersion”. *Journal of Banking and Finance* 34: 2328–2345

Harris, L. 1990. “Liquidity, Trading Rules, and Electronic Trading Systems.” *New York University Salomon Center Monograph Series in Finance*.

Hein, Jesper. 2003. “Likviditet og knapphet i det norske Statsobligasjonsmarkedet”. *Penger og Kreditt* 31 (2): 101-109.

http://www.norges-bank.no/Upload/import/publikasjoner/penger_og_kreditt/2003-02/hein.pdf

Houweling, Patrick, Albert Mentink, and Tom Vorst. 2005. Comparing possible proxies of corporate bond liquidity. *Journal of Banking and Finance* 29: 1331–1358.

Huang, Jing-zhi, and Ming Huang, 2003. “How Much of the Corporate-Treasury Yield Spread is Due to Credit Risk?” Working paper, Stanford University.

Huberman, G., Stanzl, W., 2005. Optimal liquidity trading. *Review of Finance* 9, 165-200

Yield Spread is Due to Credit Risk?” Working paper, Stanford University.

ICSA (International Council of Securities Associations). 2015. “Bond Market Liquidity”. International Council of Securities Associations

IMF (International Monetary Fund). 2015. “Global Financial Stability Report: Vulnerabilities, Legacies, and Policy Challenges: Risks Rotating to Emerging Markets” - Chapter 2. Accessed March 01, 2016.

<http://www.imf.org/external/pubs/ft/gfsr/2015/02/pdf/c2.pdf>

ISDA (The International Swaps and Derivatives Association). 2006. Accessed 15 April, 2016. http://www.isda.org/c_and_a/pdf/Linear-interpolation7-10-06.pdf

Jones, E. Philip, Scott P. Mason, Eric Rosenfeld. 1984. "Contingent Claims Analysis of Corporate Capital Structures: An Empirical Investigation". *The Journal of Finance* 39 (3): 611-625.

Lagos, Ricardo, Guillaume Rocheteau, and Pierre-Olivier Weill. 2011. "Crises and Liquidity in Over-the-Counter Markets." *Journal of Economic Theory* 146 (6): 2169–2205.

Longstaff, Francis A., and Eduardo S. Schwartz. 1995. "A simple approach to valuing risky fixed and floating rate debt". *The Journal of Finance* 50 (3), 789–819

Longstaff, Francis. 2004: "The Flight-to-Liquidity Premium in U.S. Treasury Bond Prices," *Journal of Business* 77, 511–526

Longstaff, Francis A, Sanjay Mithal and Eric Neis. 2005. "Corporate Yield Spreads: Default Risk or Liquidity? New Evidence from the Credit Default Swap Market". *Journal of Finance* 60 (5): 2213-2253.

Menkveld, Albert J. 2013. "High Frequency Trading and the New Market Makers". *Journal of Financial Markets* 16: 712–740.

Nielsen, Soren S., and Ehud I. Ronn. 1996. "The Valuation of Default Risk in Corporate Bonds and Interest Rate Swaps" Social Science Research Network.

Oslo Stock Exchange. 2015. "Issuing corporate bonds in Oslo – an efficient, flexible and mature market for raising debt capital". Oslo Børs publikasjoner. Accessed March 13, 2016.

Oslo Stock Exchange. 2016. "The history of Oslo Børs". Accessed March 13, 2016.

http://www.oslobors.no/ob_eng/Oslo-Boers/About-Oslo-Boers/The-history-of-Oslo-Boers

Oslo Stock Exchange. 2014. "Fastest-growing Nordic marketplace now has over 1,000 securities listed". Accessed March 13, 2016.

http://www.oslobors.no/ob_eng/Oslo-Boers/About-Oslo-Boers/News-from-Oslo-Boers/Fastest-growing-Nordic-marketplace-now-has-over-1-000-securities-listed

- Perraudin, William, and Alex P. Taylor. "Liquidity and Bond Market Spreads". EFA 2003 Annual Conference Paper No. 879
- Petersen, Mitchell A. 2009. "Estimating Standard Errors in Finance Panel Data Sets: Comparing Approaches". *Review of Financial Studies* 22 (1): 435–480.
- PwC. 2015. "Global Financial Markets Liquidity Study".
PricewaterhouseCoopers
- Rakkestad, Ketil, Johannes A. Skjeltop, and Bent Arne Ødegaard. 2012. "The Liquidity of the Secondary Market for Debt Securities in Norway". Unpublished paper
- Roubini, Nouriel. 2015. "The Liquidity Time Bomb". Project Syndicate.
- Sarig, Oded, and Arthur Warga. 1989. "Bond price data and bond market liquidity". *Journal of Financial and Quantitative Analysis* 24 (3): 367–378.
- The Economist. 2015. "Frozen". *The Economist*. Accessed May 10, 2015
<http://www.economist.com/news/finance-and-economics/21648673-regulators-have-made-banking-safer-has-made-markets-riskier-frozen>
- The White House. 2010. "Remarks by the President on Financial Reform". Accessed March 04, 2016.
<https://www.whitehouse.gov/the-press-office/remarks-president-financial-reform>
- Trebbi, Francesco and Kairong Xiao. 2015. "Regulation and Market Liquidity." *The National Bureau of Economic Research Working Paper* No. 21739
- van Loon, Paul R.F., Andrew J.G. Cairns, Alexander J. McNeil, and Alex Veys. 2014. "Modelling the Liquidity Premium on Corporate Bonds". Actuarial Research Centre, Heriot-Watt University.
- Vayanos, Dimitri, and Jiang Wang. 2012. "Market Liquidity – Theory and Empirical Evidence". NBER Working Paper No. 18251. doi: 10.3386/w18251.
- Veronesi, Pietr, "Fixed income securities: valuation, risk, and risk management" 2010
- Wuyts, Gunther. 2007. "Stock Market Liquidity: Determinants and Implications". *Tijdschrift voor Economie en Management* 7 (2): 279-316.

Appendix

Exhibit I – Liquidity measures

Amihud:

Using a slightly modified version of Amihuds (2002) measure of illiquidity, we measure the price impact of a trade per unit traded. For each (corporate) bond, the measure is the daily average of absolute returns r_j divided by the trade size Q_j (in million \$) of consecutive transactions:

$$Amihud = \frac{1}{N_t} \sum_{j=1}^N \left| \frac{P_j - P_{j-1}}{P_{j-1}} \right| \frac{1}{Q_i}$$

where N_t is the number of returns on day t . A quarterly Amihud measure is defined by taking the median of daily measured within the quarter, and we require at least two transactions on a given day to calculate the measure.

Imputed roundtrip costs:

Corporate bonds can often trade multiple times within a short time horizon after a longer period with no trades. This is probably the result of a dealer matching a buyer and a seller, where the dealer carries out a trade with both the seller and the buyer, collecting the bid-ask spread as fee. If multiple trades in a particular bond with the same trade size take place on the same day, and no other trades with the same size occurs on that day, the transaction is a part of an alternative measure of transaction costs developed by Feldhütter (find reference) called Imputed Roundtrip Trades (IRT). For an IRT the imputed roundtrip cost (IRC) is defined as:

$$IRT = \frac{P_{max} - P_{min}}{P_{max}}$$

where P_{max} and P_{min} are the largest and the smallest price in the IRT, respectively. We estimate the quarterly roundtrip cost by averaging over daily estimates, which in turn is found as the average of roundtrip costs on that day for the different trade sizes.

Turnover:

We use the quarterly turnover of bonds, defined as:

$$Turnover_t = \frac{Total\ trading\ volume}{Amount\ outstanding}$$

where t is the quarter. We can interpret the inverse of the turnover as the average holding time of the bond.

Variability of Amihud and imputed roundtrip costs:

The variability of both Amihud and IRC may influence the liquidity spreads because investors are likely to consider the current level of bond liquidity in addition to the possible future levels in case the investor needs to sell the bond. Therefore, we include the standard deviations of the daily Amihud measure and IRC measure in our regression.

Exhibit II – Volume traded 1987-2015 from OBI (unfiltered)

Graph 4: Government bonds(left axis) represented by solid line and non-government bonds(right axis)

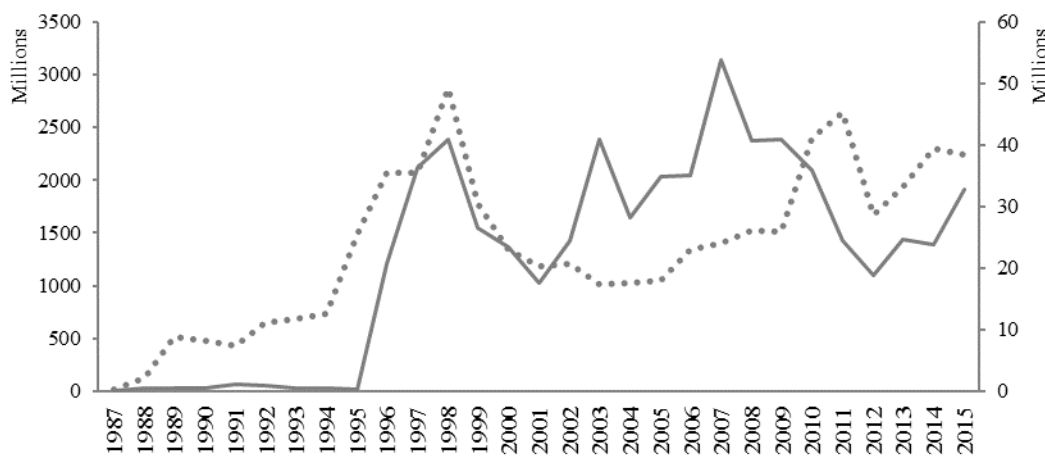


Exhibit III – Average interpolated swap rate

Average interpolated swap rate

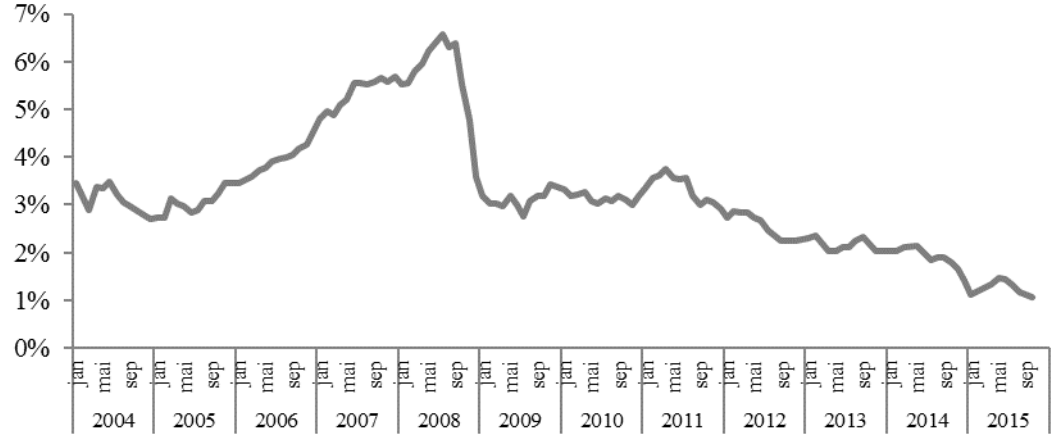


Exhibit IV – Volume traded

High yield and investment grade traded yields are represented by the solid line and the dotted line, respectively.

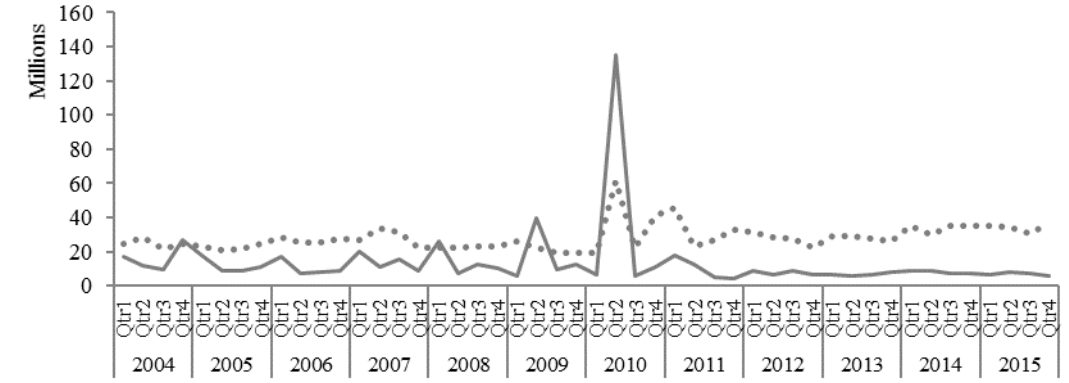


Exhibit V – Negative spread observations

Table 1
 This table shows the number of observation where the spread is negative by industry group.

Industry Group	Count	Percentage
Bank	893	76,00 %
Industry	59	5,02 %
Convenience Goods	50	4,26 %
Utilities	44	3,74 %
Telecom/IT	30	2,55 %
Shipping	28	2,38 %
Pulp, paper and forestry	22	1,87 %
Transportation	12	1,02 %
Insurance	11	0,94 %
Media	8	0,68 %
Real Estate	8	0,68 %
Oil and gas services	5	0,43 %
Oil and gas E&P	4	0,34 %
Finance	1	0,09 %
Grand Total	1175	100,0 %

Exhibit VI – Bond prices

Par value: High yield and investment grade traded yields are represented by the solid line and the dotted line, respectively.

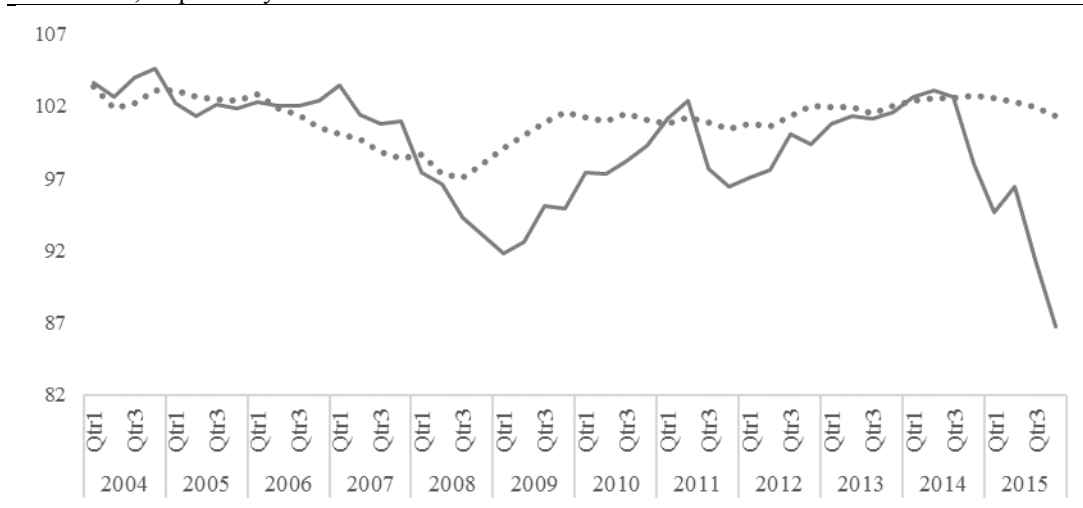


Exhibit VII – Bid-Ask spread

Bid ask spread: High yield and investment grade traded yields are represented by the solid line and the dotted line, respectively.

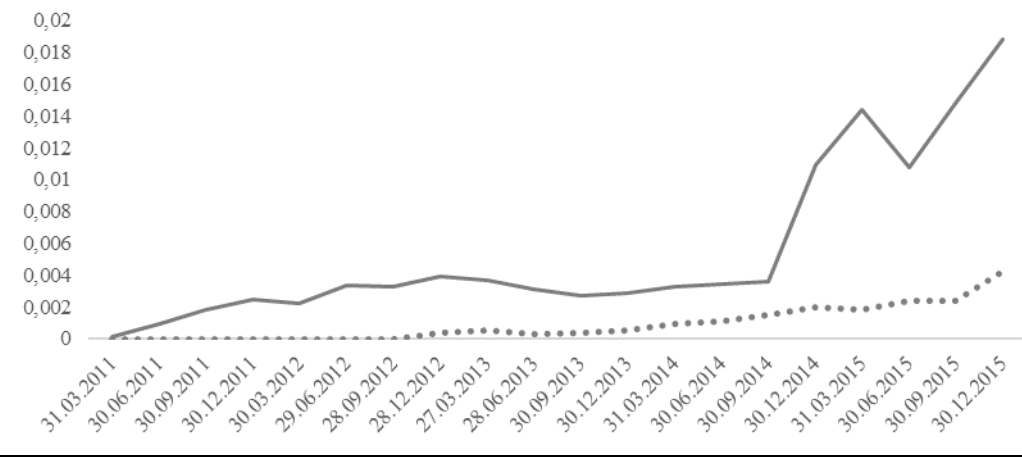


Exhibit VIII – Number of quarterly trades

Bid ask spread: High yield and investment grade traded yields are represented by the solid line and the dotted line, respectively.

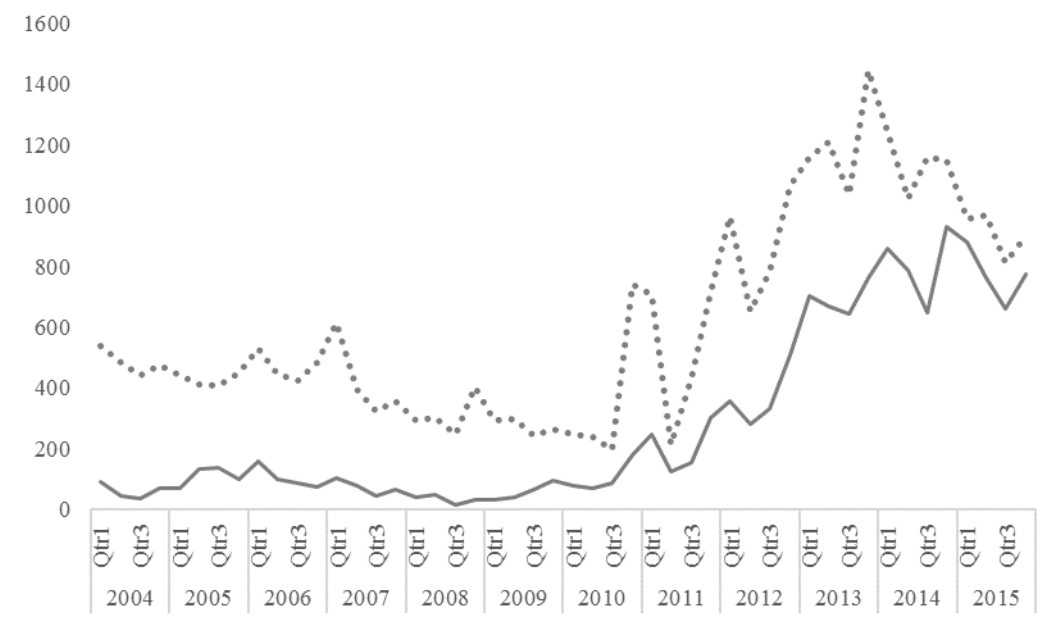
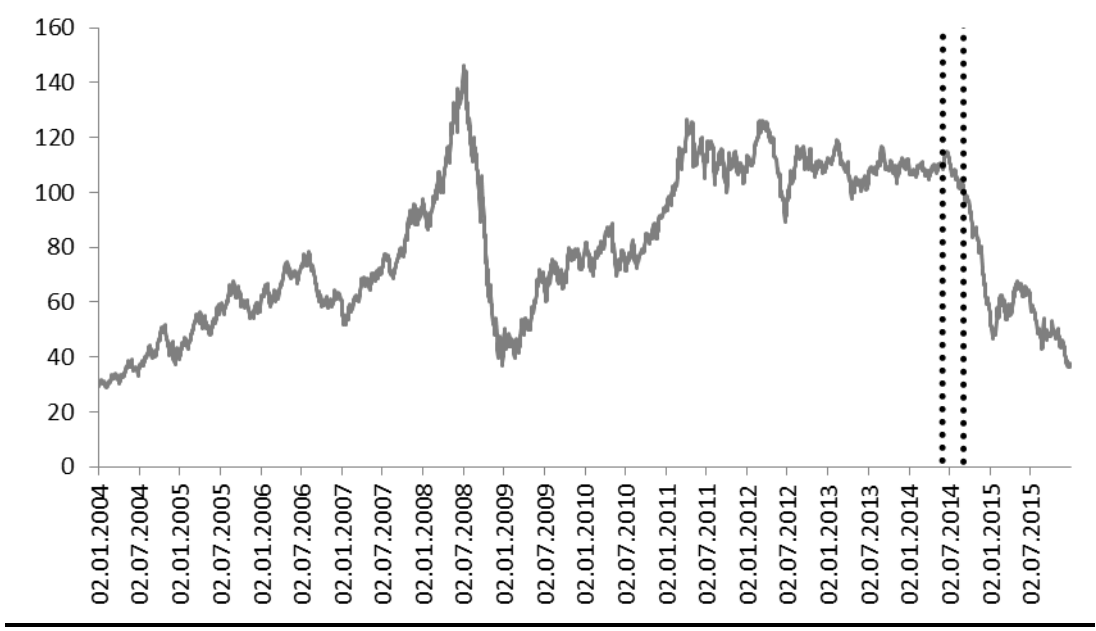


Exhibit IX – Oil price 2004-2015

Oil price: Brent crude oil future (Solid line). Dotted line shows the slide off for oil price mid 2014



Preliminary

- A Study of Corporate Bond Liquidity -

Supervisor:
Dagfinn Rime

Students:
Marius Loe Heggen
Terje Simarud

Hand-in date:
15.01.2016

Campus:
BI Oslo

Examination code and name:
GRA 19003 Preliminary Thesis Report

Programme:
Master of Science in Business - Major in Finance

Introduction

The financial crisis of 2008-09 led to a series of new regulations and requirements towards the financial industry. In the aftermath of the near collapse of the financial system we have seen a global effort to improve the safety and robustness of the financial market through intensified banking regulations in order to make future financial crisis less likely.

According to The Economist (2015), new regulations have made banks more reluctant to lending, forcing borrowers to the bond market instead. This, and in part as a natural response to low interest rate, have made the value of outstanding bonds increase to record levels. Simultaneously, the number of market makers and inventories of securities in banks have fallen, forcing banks to change their capital structure and business models as a response to the new regulations regimes such as Basel III, Dodd-Frank Act and its corollary parts like the Volcker Rule.

Unlike equities, which are more standardized in terms of a market product, bond may have several issues, which lowers the probability of matching buyers and sellers. The secondary market for fixed income securities, such as corporate bonds, is therefore traded over-the-counter (OTC), thus impacted by the lack of market making from financial intuitions.

In this study we will explore the liquidity components of corporate bond spreads for bonds with different ratings in the American and Norwegian bond markets. We will explore how liquidity can explain some of the credit spread puzzle previous studies have found, and how the liquidity components affected bond spreads before, during and after the financial crisis. A point of emphasis will be to study to what extent regulatory changes in recent years have affected the liquidity components of corporate bond spreads. We will use the methodology outlined by Dick-Nielsen, Feldhutter and Lando (2012), but use an extended sample size in order to get the effects of the years following the financial crisis. In addition we

will do the same for the Norwegian market, something that to our knowledge have not been done before.

Literature review

The relationship between bond liquidity and financial regulation is a subject that has been debated in the financial media³ and by market participants⁴ in recent years. However, quantitative papers studying the liquidity effect of the new financial regulations on fixed-income markets are limited. This is a result of the difficulty of measuring liquidity, in addition to the short time-span that has passed since the regulations were agreed upon and later implemented.

The only empirical publication that actually investigates the relationship between regulations and fixed-income liquidity is the paper “*Regulation and Market Liquidity*” by Trebbi and Xiao. In their article, published as late as December 2015, they investigate the effect of the Dodd-Frank Act of 2010 and its corollary Volcker Rule on the market liquidity of the U.S. fixed income market. Despite that the Volcker Rule does not cover the U.S. Treasury market directly, some observers have ascribed recent trading episodes, such as the flash crash in 2014, to liquidity depletion. As a result the authors studies Treasuries in addition to the more regulated U.S. corporate bond market. Trebbi and Xiao use a statistical method consisting of four different estimation strategies in order to identify structural breaks in both level and latent factors for nine different liquidity measures of corporate and Treasury bonds. This study is important since it finds no systematic evidence of decreasing liquidity levels or structural breaks in dynamic latent factors of the U.S. fixed income market during periods of increased regulatory intervention, a result that is consistent across all four of the estimation strategies. Trebbi and Xiao conclude that there is no statistical evidence of market liquidity decrease after 2010; instead, they actually observe breaks towards liquidity *improvement* during periods of regulatory interventions.

³ The Economist. 2015. “Frozen”. 29.04.2015 and Financial Times. 2015. “Liquidity pitfalls threaten parched market”. 18.06.2015

⁴ BlackRock. «The liquidity Challenge», June 2014 and Barclays, “The decline in the financial market liquidity”

The fact that the only empirical paper that has studied the effect of financial regulations on fixed-income liquidity concludes that liquidity has not deteriorated as a result of regulatory intervention is very interesting because of the amount of literature that has the opposite conclusion.

There is a number of studies and articles that have expressed concern regarding liquidity in the increased regulatory landscape. These concerns were a fact already before the Volcker Rule was finalized, as Duffie (2012) states: “The Agencies’ proposed implementation of the Volcker Rule would reduce the quality and capacity of market making services that banks provide to U.S. investors. Investors and issuers of securities would find it more costly to borrow, raise capital, invest, hedge risks, and obtain liquidity for their existing positions. Eventually, non-bank providers of market-making services would fill some or all of the lost market making capacity, but with an unpredictable and potentially adverse impact on the safety and soundness of the financial system”

In August 2015 PricewaterhouseCoopers (PwC) published a study of the global financial markets liquidity, requested from the Global Financial Markets Association (GFMA) and the Institute of International Finance (IIF). The goal of the study was to investigate the impact of regulatory developments on market liquidity. The study identified several ways in which regulatory reform have impacted or will impact financial market liquidity. Firstly, when banks are adapting to the new regulatory environment, they seek a more efficient use of capital and liquidity resources, consequently reducing markets they serve and streamlining their operations. Secondly, the study identified a reduction in market-making activity in capital and funding intensive areas such as fixed income, credit, derivatives and commodities. In dealer-led markets where market making provides a key source of liquidity, the study pointed out that this could lead to reduction in liquidity. The study also showed that the changes in capital regulation have greatly increased both capital charges across banks’ business areas and the

cost of financing those businesses. Further, a shift in trading pattern was identified towards central clearing and electronic trading platforms. For standardized centrally cleared trades this may improve liquidity, but for OTC traded securities, such as corporate bonds that are not suited for central clearing or trade reporting, this might reduce the liquidity. The study also showed that a contraction in repo markets and other bank funding has impacted liquidity provisions by market makers across capital markets. Finally, an increased demand for and hoarding of liquid asset was recognised. The new regulations are forcing banks to hold high quality liquid assets, which reduces their availability to support other transactions.

The International Monetary Fund (IMF) publishes a global financial stability report which is updated twice a year. Chapter two of this report that was published in October 2015 was dedicated to financial market liquidity. The chapter examines the factors that influence the level of market liquidity with focus on bond markets and those that affect its resilience. The researchers find that cyclical factors, including monetary policy, play an important role. By using a Markov Regime-Switching Model⁵ they find that factors such as business conditions, financial volatility, and risk appetite (as measured by the VIX); the price of credit risk; and, to some degree, monetary policy measures, can predict liquidity resilience in the corporate bond market to some extent. In terms of the changes in risk appetite, the study finds that market liquidity compared to changes in the VIX over time does not suggest that liquidity now is more sensitive to financial volatility compared to the period before the crisis. The chapter also finds evidence towards a higher probability that aggregate liquidity is likely to drop sharply when inventories at dealers are low or when dealer's 'ability to make markets are reduced. The result shows that dealers' inventory or their ability to make markets are associated with liquidity regimes, and are significant at a 1 percent level. Furthermore, the chapter emphasises that a change in market structure where

⁵ Lecture note on markov switching model. "Lecture on the markov switching model", Chung-Ming Kuan, 19.04.2002

mutual funds have built up a significant holdings of bonds, appear to have increased the fragility of liquidity. The chapter concludes that underlying risk toward liquidity may be camouflaged by extraordinarily benign cyclical factors under the current monetary policy, and it might be the case that when a normalization of monetary policy occurs could reveal the underlying fragilities and consequently produce a sudden drop in market liquidity.

The possible consequences of a deterioration of fixed income liquidity have received increasing attention in the last couple of years because of the rapid growth in investment in bond mutual funds. Corporate bond funds tend to hold quite illiquid assets, and also have been shown to have no convexity, or even a concave shape, meaning that their outflows are more sensitive to bad performance than their inflows are sensitive to good performance (Goldstein, Jiang and Ng 2015). The same study raises concerns that the illiquidity of corporate bonds may generate a first-mover advantage among investors in corporate-bond funds, amplifying their response to bad performance or other bad news.

Corporate bond liquidity is a topic that has been frequently studied in relation to the financial crisis and methodologies to measure liquidity. Houweling, Mentink and Vorst (2005) shows that eight of their total nine proxies can measure corporate bond liquidity and studies whether liquidity risk is priced in the euro-denominated corporate bond market. Secondly, they showed that liquidity proxies are significant explanatory variables for credit spreads. In the paper they used Brennan and Subrahmanyam (1996) methodology to test whether bond market liquidity is priced based on liquidity proxies such as issued amount, listed, age, missing prices, yield volatility, number of contributors, yield dispersion, euro and on-the-run. To control for other risk factors than liquidity they use the Fama and French (1993) two-factor bond-market model. The difference in this paper from other papers that examines bond liquidity is that Houweling, Mentink and Vorst uses a portfolio based approach instead of testing each individual bond. However, a comparison test shows limited differences between the liquidity proxies.

In contrast to Houweling, Mentink and Vorst (2005) Bao, Pan, and Wang (2011) uses corporate bonds on an individual and aggregate level to examine the illiquidity. The paper finds evidence that bond illiquidity is related to age and maturity of the bond, but decreases with size of the bond issuance. The changes in the liquidity measure used in the paper have a positive association with the VIX index, indicating that illiquidity of bonds increases with market stress.

Dick-Nielsen, Feldhutter and Lando (2012) examine the liquidity component of corporate bonds spread during the financial crisis by providing a new measure of liquidity. The measure is a result of a principal component analysis where the measure is an index of four liquidity measures; Amihud, Imputed round trip cost (IRC), and the variability of each of these variables. The paper finds evidence towards an increase in the liquidity component for all rating classes except AAA during the financial crisis, which is consistent with the theory of flight-to-quality (Acharya, Amihud, and Bharath 2013). For speculative bonds the liquidity component in the bond spread increased dramatically, from 58bp pre crisis to 197bp. Dick-Nielsen, Feldhutter and Lando also addresses that they could not find differences in liquidity between bonds issued from financial institutions and industry, except in periods of extreme market stress, where bonds issued from financial institutions became very illiquid. In recent years we have seen an increased attention towards corporate bond spreads, where researchers have focused on the credit spread, that is, the component of corporate bond yields that is above the yield of comparable Treasuries. Studies have concluded that the spread on corporate bonds are larger than what can be explained by default risk, a phenomenon known as the “credit spread puzzle”.

Theory

The ability to buy and sell securities is a central market functioning and the key to this functioning is liquidity. Liquid markets are desirable because of the benefits they offer in terms of systematic factors such as improved allocation of economic

resources and information efficiency (Sarr and Lybek, 2002). However, there are several microeconomic definitions of liquidity and as Baker (1996) states: "there is no single unambiguous, theoretically correct or universally accepted definition of liquidity". An easy and often used definition of liquidity is found in Amihud and Mendelson (1991): "an asset is liquid if it can be bought or sold at the current market price quickly and at low cost", e.g. if market participants can buy and sell large amount of financial assets without adversely affecting the price, the asset is perceived as liquid. However, Sarr and Lybek (2002) points out that liquidity characteristics may change over time, such as liquidity mainly is related to transactions cost in a stable market environment but in in periods of market stress and changing fundamentals, prompt price discovery and adjustment to a new equilibrium becomes more important.

It is useful to divide the concept of liquidity into two categories: funding liquidity and market liquidity (Brunnermeier and Pedersen 2009). According to Brunnermeier (2009), "funding liquidity describes the ease with which expert investors and arbitrageurs can obtain funding from (possibly less informed) financiers. Funding liquidity is high when it is easy to raise money. Market liquidity is low when it is difficult to raise money by selling the asset. Market liquidity is equivalent to the relative ease of finding somebody who takes on the other side of the trade". For our studies, we will refer to the market liquidity when we use the term *liquidity*.

In his paper on auctions and insider trading, Kyle (1985) states that: "Market liquidity is a slippery and elusive concept, in part because it encompasses a number of transactional properties of markets. These include tightness, depth and resiliency". The most complete definition of liquidity, and the definition we most often have seen been referred to is given by Harris (1990). His four dimensions of liquidity; *width*, *depth*, *immediacy* and *resilience*, are very similar to Kyle's definition. *Width* is the bid-ask spread, in other words the difference between the lowest ask price and the highest bid price. *Depth* refers to the volume that can be

traded in the market without affecting the price. Immediacy is given by the time needed to successfully trade a certain amount at a given cost. Resiliency refers to how fast prices will return to normal following an uninformed and unbalanced order flow.

Market makers are a financial institution that accepts the risk of holding a certain number of shares of a particular security in order to facilitate trading in that security. The market maker acts as an intermediary through the usage of their balance sheet, and thereby generates revenues through facilitation and warehousing. Facilitation revenues refers to selling securities to a higher price than it was originally bought for, whereas the warehouse/inventory revenues is the revenues that the market maker earns during the ownership of an asset, such as an coupon payment from bond etc. Market-makers and proprietary traders have some similarities in the fact that they both in principle are market participant that contribute to market liquidity. Both can absorb temporary market imbalances and their activities are often tied together within the same institution. The distinction between a market maker and proprietary trading is associated with their objectives, where market-makers are serving objectives towards client relationships, whereas a proprietary trader does not take such consideration.

Prior to the recent financial crisis, capital standards were given by Basel I and II which were largely based on risk-weighted assets (RWAs) that facilitated active proprietary risk-taking and inflated balance sheets. The financial crisis uncovered problems with the regulations at the time, and prompted a change, which lead to the introduction of Basel III. This framework was agreed upon by the members of the Basel Committee on Banking Supervision in 2010–11, and will be phased in gradually until they are fully implemented by March 31th, 2019. Basel III aims to strengthen banks against adverse shocks through increased bank liquidity and decreased bank leverage and short-term funding. The main changes in Basel III compared to the previous two versions are stricter requirements in terms of capital held against RWAs, the introduction of a minimum leverage ratio, and two new

liquidity ratios; the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR). The LCR requires banks to hold sufficient high-quality liquid assets to cover its net cash outflows over a thirty-day horizon, while the NSFR requires the available amount of stable funding to exceed the required amount of stable funding over a one-year horizon (Basel 2011).

The most important change in the financial regulatory landscape was the passing of the Dodd-Frank Act and particularly section 619 of it, known as the Volcker Rule. The Volcker rule refers to the former Federal Reserve chairman Paul Volcker that argued that speculative activity such as short-term proprietary trading and investments in hedge funds and private equities was among the reasons for the financial crisis. This new reform prohibited banks from proprietary trading, but still allowed banks to act as market-makers. However, the Volcker Rule took years of hammering out, and anticipation of stricter regulations led many banks to retreat from businesses such as proprietary trading well before the Rule was finalized. By prohibiting proprietary trading, the Volcker Rule also effectively reduced banks and other financial institutions willingness and ability to act as market makers in the fixed income market and discouraged the use of market making discretion since banks would frequently find that meeting a client's demands for immediacy would be unattractively risky relative to the expected profit (Duffie 2012). These claims have later been supported by other publications which show how the corporate bond inventories in banks have declined over the last years, leading to concerns about reduced market liquidity in the corporate bond market.

Methodology

To determine the liquidity development of corporate bonds in the US and Norway, we will utilize the method used by Dick-Nielsen, Feldhutter and Lando (2012). To break down the liquidity effect on corporate bonds, a disaggregation of credit risk and liquidity risk contributions to observed yields, is conducted in the following way;

$$\begin{aligned}
\text{Spread} = & \alpha + \gamma \text{Liquidity} + \beta \text{Bond age} + \beta \text{Amount issued} + \beta \text{Coupon} \\
& + \beta \text{Time to maturity} + \beta \text{Eq. Vol} + \beta \text{Operating} + \beta \text{leverage} \\
& + \beta \text{long debt} + \beta \text{Pretax dummies} + \beta \text{10y Swap} + \beta \text{10y} - \text{1y Swap} \\
& + \beta \text{Forecast dispersion} + \varepsilon
\end{aligned}$$

Where spread is the dependent variable which is the yield spread rate to the swap rate for every bond. The liquidity term is a measure for liquidity which will be commented in detail below. In order to lop out the liquidity component, we have to control for other factors that affect the spread. In line with Houweling, Mentink and Vorst (2005) findings, a variable for bond age, time to maturity, and amount issued is included. The remaining variables are credit risk and systematic risk control variables. In terms of credit risk variables, ratio of operating income to sales, ratio of long term debt to assets, leverage ratio, equity volatility, and a pretax interest coverage dummy is added to the regressions. The systematic risk variable is included in order to capture the economic environment, where we will use the 10-year swap rate and the difference between the 10-year and 1-year swap rate as a proxy. The last term, forecast dispersions, is added since spread may not reflect the true credit quality of a firm according to Duffie and Lando (2001). They argue that credit risk and yield spreads are not perfectly transparent to investors in the secondary corporate bond market. Guntay and Hackbarth (2010) address this issue by adding a variable of forecast dispersion on earnings among analysts.

As described earlier, the liquidity measure consists of Amihud and IRC and the variability related to these two variables is a result of a principal component analysis (PCA). The goal of the PCA analysis is to find the combination of variables that can account for the highest share of total variation of the dependent variable. In our study we will start out with different measures liquidity that is applicable to our data sets.

Following Dick-Nielsen, Feldhutter and Lando approach, we will apply the Amihud (2002) measure of liquidity to estimate the price impact of trades. Amihud is given by:

$$Amihud = \frac{1}{N_t} \sum_{j=1}^N \left| \frac{P_j - P_{j-1}}{P_{j-1} Q_i} \right|$$

Where N is the number return on day t, and measure is the daily average of absolute returns divided by the trade size Q.

Since bonds are traded over-the-counter bid-ask spreads are difficult to obtain for the full sample period. To address this issue we will also use the Roll measure and Imputed Roundtrip Trades (IRT) as proxies. IRT is defined as:

$$IRT = \frac{P_{max} - P_{min}}{P_{max}}$$

Where P_{max} is the largest price in the IRT and P_{min} is the smallest price in the IRT. The roll measure is defined as:

$$Roll_t = 2 \sqrt{-cov(R_i, R_{i-1})}$$

Roll (1984) finds that under certain assumptions, the percentage bid–ask spread equals two times the square root of minus the covariance between consecutive returns. The last liquidity measure we will use is the turnover ratio:

$$Turnover_t = \frac{Total\ trading\ volume}{Amount\ outstanding}$$

Turnover ratio can be interpret as the inverse of the average holding time of the bond.

Data

We will obtain price, yield and volume data for the US market from trade reporting and compliance engine (TRACE). So far we have only tested the availability of the data, since we did not earn access to the database until a few days before the hand-in date. Due to the complexity of the data will also use Dick-Nielsen, Feldhutter and Lando approach to filter the data. Bloomberg will provide us with data regarding the credit and systematic control variables for both the US

and Norwegian bond market. For the Norwegian market we will gather price and yield data from Bloomberg. In order to get volume data we have contacted Oslo Stock Exchange for input. By following Dick-Nielsen, Fieldhutter and Lando calculation of the spread term, we will use daily data to calculate the quarter-end yield as the average yield for all trades on the last day in the quarter where the bond traded.

References

- Acharya, Viral V., Yakov Amihud, and Sreedhar T. Bharath. 2013. “Liquidity risk of Corporate Bond Returns: Conditional Approach.” *Journal of Financial Economics 110*: 358–386
- Amihud, Yakov. 2002. “Illiquidity and Stock Returns: Cross-Section and Time-Series Effects.” *Journal of Financial Markets 5*(1), 31–56.
- Amihud, Yakov, and Haim Mendelson. 1991. “Liquidity, Asset Prices and Financial Policy.” *Financial Analysts Journal 47*(6): 56–66
- Baker, Kent. H. 1996. In *Trading Location and liquidity- An Analysis of US dealer and Agency Markets for Common Stocks*. Blackwell Pubs.
- Bao, Jack, Jun Pan, and Jiang Wang. 2011. “The Illiquidity of Corporate Bonds.” *The Journal of Finance 66*(3): 911–946
- Basel Committee on Banking Supervision. 2011. *Basel III: A global regulatory framework for more resilient banks and banking systems*. Basel: Basel Committee on Banking Supervision..
- Brennan, M. J. and Subrahmanyam, A. 1996, “Market microstructure and asset pricing: On the compensation for illiquidity in stock returns”. *Journal of Financial Economics 41*(3): 441–464.
- Brunnermeier, Markus. K. 2009. “Deciphering the Liquidity and Credit Crunch 2007–08.” *Journal of Economic Perspectives 23*(1): 77–100.
- Brunnermeier, Markus K., and Lasse Heje Pedersen. 2009. “Market liquidity and funding liquidity”. *Review of Financial Studies 22*(6): 2201–2238.
- Dick-Nielsen, Jens, Peter Feldhütter, and David Lando. 2012. “Corporate bond liquidity before and after the onset of the subprime crisis.” *Journal of Financial Economics 103*: 471–492.

- Duffie, Darrell. 2012. Market making under the proposed Volcker Rule. Public comment to Federal Reserve Board. *Rock Center for Corporate Governance at Stanford University Working Paper No. 106*
- Duffie, Darrell and David Lando. 2001. “Term structures of credit spreads with incomplete accounting information.” *Econometrica* 69(3): 633-664.
- Fama, Eugene and Kenneth French. 1993. “Common risk factors in the returns on stocks and bonds”. *Journal of Financial Economics* 33: 3-56.
- Goldstein, Itay, Hao Jiang and David T. Ng. 2015. “Investor Flows and Fragility in Corporate Bond Funds.” Working paper, Wharton School, University of Pennsylvania
- Guntay, Levent and Dirk Hackbarth. 2010. “Corporate Bond Credit Spreads and Forecast Dispersion.” *Journal of Banking and Finance* 34(10): 2328-2345.
- Harris, L. 1990. “Liquidity, Trading Rules, and Electronic Trading Systems.” *New York University Salomon Center Monograph Series in Finance*.
- Houweling, P., A. Mentink, and T. Vorst (2005). “Comparing Possible Proxies of Corporate Bond Liquidity.” *Journal of Banking and Finance* 29(6): 1331–1358.
- IMF. 2015. “Global Financial Stability Report - Vulnerabilities, Legacies, and Policy Challenges”. *The International Monetary Fund*
- Kyle, Albert S. 1985. “Continuous Auctions and Insider Trading.” *Econometrica*, Vol. 53, No.6, 1315-1335.000
- Roll, Richard. 1984. “A Simple Implicit Measure of the Effective Bid-Ask Spread in an Efficient Market.” *Journal of Finance* 39(2): 1127–1139.
- PwC. 2015. “Global Financial Markets Liquidity Study.” *PricewaterhouseCoopers*
- Sarr, Abdourahmane, and Lybek, Tonny. 2002. “Measuring liquidity in financial markets.” *IMF Working Paper*, No. 02/232,
- The Economist. 2015. “Frozen”. *The Economist*. Accessed May 10, 2015. <http://www.economist.com/news/finance-and-economics/21648673-regulators-have-made-banking-safer-has-made-markets-riskier-frozen>
- Trebbi, Francesco and Kairong Xiao. 2015. “Regulation and Market Liquidity.” *The National Bureau of Economic Research Working Paper No. 21739*