OBSERVATOIRE DE L'EPARGNE EUROPÉENNE

First Glance into Patterns of Liquidity in the Eurozone Bond Market

May 2017

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A briefing paper commissioned by the Observatoire de l'Epargne Européenne (OEE) and written for the benefit also of its sister company INSEAD OEE Data Services (IODS).

ROTTERDAM	2 May 2017

Erasmus University Rotterdam

Foreword

The Observatoire de l'Epargne Européenne (OEE) commissioned the writing of this briefing paper with a view on gaining more insights into the topic of liquidity in the European bond markets through high frequency data. Since MTS data from the INSEAD OEE Data Services (IODS) is used for the paper, the methods and results shown in this paper are also of interest for this sister company of OEE.

About the authors

Mary Pieterse-Bloem is Assistant Professor in the section Finance of Erasmus School of Economics (ESE) and member of Erasmus Research Institute of Management (ERIM) since 2011, where she is responsible for the educational and research program on fixed income. Dr. Pieterse-Bloem is also Global Head of Fixed Income Strategy & Portfolio Management at the International Private Bank of ABN AMRO since 2015. In November 2016, dr. Pieterse-Bloem was appointed Chairman of the Rente Gilde, the society of Dutch financial professionals working in fixed income markets.

Dr. Pieterse-Bloem has spent her entire professional career in fixed income. Starting in 1993 upon the completion of her MSc in Economics at the London School of Economics, she worked the first thirteen years in the dealing rooms of Paribas, Dresdner Kleinwort Wasserstein and Lehman Brothers in London as Euro bond strategist and debt capital markets professional. In 2006 she took time out to write her PhD thesis on the integration of European corporate bond markets. She obtained her doctorate in 2011 at Tilburg University, following which she resumed her career in the Netherlands in asset management. She first worked for ING Investment Management (now NN IP) and then for APG Asset Management, both as a senior strategist for the fixed income portfolios of respectively the largest life insurer (Nationale Nederlanden) and largest pension fund (Alegmeen Burgelijk Pensioenfonds) in the Netherlands. She joined ABN AMRO PBI in September 2015, where she leads a team of fixed income specialists globally which is responsible for delivering high performing portfolios and investment recommendations to the private clients of ABN AMRO. Part of this Global team are fixed income specialists of Bank Neuflize in France and Bethmann Bank in Germany. ABN AMRO PBI has approximately 190 billion euro assets under management, of which approximately 40% is invested in fixed income.

Boyd Buis is pursuing a PhD in Economics at the VU University on liquidity in the European government bond markets. Prof. dr. W.F.C. Verschoor, dean of the economics and business economics faculty at the VU, is the promotor of this PhD and Prof. dr. Remco Zwinkels and dr. Mary Pieterse-Bloem are daily supervisors. Mr Buis also works a rates trader at ABN AMRO focusing on FX forwards and short term interest rate derivatives.

Prior to working at ABN AMRO, Mr Buis spent his career in financial markets, working as an equities trader at Rabobank and a balance sheet manager at KAS Bank. At ABN AMRO Boyd adds value by managing the G5 currency book and providing pricing to clients via platforms and or by voice. Mr Buis developed an academic and professional interest in bond market liquidity when he wrote his master thesis on this subject in 2013. The essence of this thesis was later published in the International Review of Economics and Finance. Currently Boyd is working on various papers related to European sovereign bond market liquidity. Mr Buis holds an MSc in Quantitative Finance, a MSc in Economics, a BSc in Econometrics and a BSc in Philosophy.

Content

1. Introduction

Liquidity in the bond markets is an important issue, for asset managers and other market participants on the buy-side such as banks, issuers and policy makers. These various parties have different goals and objectives, but really also have one interest in common and that is that liquidity is high. Few investors prefer a large sizeable liquidity premium. These tend to be large institutional investors like for example insurance companies who manage buy-and-hold portfolios to match their liabilities. With the exception of those, market participants generally prefer a liquid market so that they can switch and trade at low transaction costs. Issuers, whether corporate or sovereign also prefer liquid markets so that they can access when needed for their funding. Policy makers prefer liquid markets because the recent global financial crisis has taught that illiquidity can be a strong transmission channel in times of market stress and uncertainty. Central bankers prefer liquidity so that the transmission channel for their monetary policy works better.

In Europe, liquidity is already at a disadvantage compared to the US, because of the fragmentation of the structure of our markets. In recent years, market participants bring much anecdotal evidence that liquidity in the European bond markets has been waning. Generally the finger is pointed at the burden of regulation which has grown considerable since the global financial crisis. This regulation has put pressure on the market making function of banks, making it more costly on them to act as an intermediary in capital markets. The fear is that when the bond market is suddenly shifting and funds need to convert their investments to cash, they may face difficulties with managing large redemption flows.

For all its importance, liquidity is a scarcely studied phenomenon in bond markets. If it is studied at all, then typically US bond markets are the subject of academic research (e.g. Fontaine and Garcia, 2012; Bouwman et al., 2015). We know from academic work on the determinants of European government bonds yields, from for instance Abad et al. (2010) that liquidity risk matters, and interacts with credit risk, especially in times of market stress. It also plays a role in contagion during the Eurozone sovereign debt crisis (e.g.: Gómez -Puig, 2014).

European bond markets are rarely the subject of liquidity studies. When liquidity is incorporated as an explanatory variable, it is typically on a price bid-ask or a size measure. These are very crude indicators for bond liquidity. Out of the two, the bid-ask is preferred but because the data source for this is typically price indications rather than tradeable quotes, it is not very reliable. The reason why there are so few studies on liquidity for the European bond markets is because of the data. Trading price information is virtually non-existent for the European corporate bond market as this is still large OTC market dominated by voice broking. It is available for European government bonds but the fact that this market is dominated by electronic trading and the trading platform (MTS) is not well known by academics.

The market making for European government bonds is concentrated on certain recognized electronic trading platforms. Inter-dealer platform, and particularly MTS, were the first platforms to emerge and capture market share from traditional voice broking. Recently, we have seen the emergence of dealer-to-client platforms, as the electronification in this market has come passed an inflection point. Despite the larger number of electronic platforms, MTS is still one of the leading ones in terms of daily volume traded on the platform. With the high frequency data from this platform that ESE has obtained through IODS for the years from 2008 to 2012, we can look through the entire Eurozone government bond market in a period which crucially also contains the Eurozone sovereign debt crisis.

There is much to learn on the notion of liquidity in this market. The number of academic papers that use MTS data is relatively small given the importance of the subject. Furthermore, they tend to focus mostly on the microstructure of the MTS market. We are rather interested in the long-term trends in liquidity. We therefore construct liquidity factors and look for the first contours of patterns in liquidity on a country level. As we come to realise that the country factor is not the one-and-only factor that determines liquidity, we look at the influence of the age of bonds and market volatility also on liquidity.

2. Our contribution to the existing literature

MTS started to record and store the three best bid and ask quotes on its bond inter-dealer trading platform on 1 April 2003. A separate department was created, MTS Data, to make the data available to interested parties. Dufour and Skinner (2004) describe the database in detail and highlight the relevance and the richness of information contained in set. Our search for academic papers that have used the MTS high frequency data to study liquidity in the Eurozone bond markets yields 22 papers. We stick to those papers in this literature overview and do not add papers that have otherwise been written on this topic, because the uniqueness of the MTS trading platform renders such papers less relevant for the purpose of this briefing paper.

The 22 papers that, according to our knowledge, have been published thus far can be classified into 3 categories.

The first category are the market microstructure studies. In those papers variables that can be observed on the platform are explained by or related to other variables observed on the platform, and qualitatively or formally explained by the way the MTS market is organised. It is by far the largest category. Market microstructure papers are recognised by three traits: they only use MTS data, the research question is very micro, and they typically use very short sample periods. A typical example of such a market microstructure study is Coluzzi et al. (2008) which determines the correlation between the many different liquidity measures (spread, breath, depth, slope etc) through simple regressions and also measures benchmark and quality of order book effects on liquidity. Their study uses information recorded on the platform between January 2004 and December 2006 on 27 Italian medium and long term government bond.

Other market microstructure papers study the size of the order book on yields (Cheung et al., 2004), the effect of maturity and trading intensity on spreads (Cheung et al., 2005), price discovery through liquidity and trading (Caporale et al., 2006), price discovery and benchmark status (Dunne et al., 2007), switches in the order trading book (Caporale et al., 2012), the price impact of trades in individual bonds (Dufour and Nguyen, 2012), the impact of liquidity on yields (Favero et al., 2010; Darbha and Dufour, 2015) and the response to liquidity shocks (Lillo et al., 2016). Occasionally the interconnectedness between the inter-dealer platform MTS and the dealer-customer platform BondVision is studied, as in Dunne et al. (2010) which uses a microstructure model to determine cross-market dealer intermediation.

The second category are papers that use liquidity measures (LMs) constructed from MTS data to place them in a model to study other phenomena with, such as the interplay with credit risk. The typical traits of these papers is that MTS high frequency data is used alongside other data and that the research question is more macro. There are few papers in this category. Gyntelberg et al. (2013) determine whether either bond spreads on MTS or CDS react first during the day. Pelizzon et al. (2016) study the dynamic relation between credit and liquidity. Schwartz (2017) looks at how much of the yield spread can be attributed to liquidity and credit factors. Pelizzon (2016) is border-line with the first category as it studies the lead-lag in price discovery and liquidity discovery between the bond and the futures market with a small sample of Italian government bonds and futures.

The third and last category classify as liquidity determinants of yields or spread studies. This category is a special variant of the second category, whereby liquidity measures (LMs) are constructed from MTS data and then internal variables from the platform and external variables are used to determine their influence on liquidity dynamically. Internal variables are variables observed on the MTS platform itself, such as bond characteristics like for example the age. Again, there have only been a few of such papers until now. We discuss them in the order of the expanding perspective beyond the MTS platform in the search for explanations of liquidity. Ejsing and Sihvonen (2009) look at the liquidity of the German bond market and document that it is not so much the on-the-run characteristic of bonds but their link with the futures market that drives liquidity. Coppola (2013) also look from a very specific angle, namely that of concentration of supply in the issuance calendar, on Eurozone government bonds. Pelizzon (2013) construct Liquidity measures (LMs), then use bond characteristics to see which effects liquidity, and let the LMs interact with credit risk as observed through CDS.

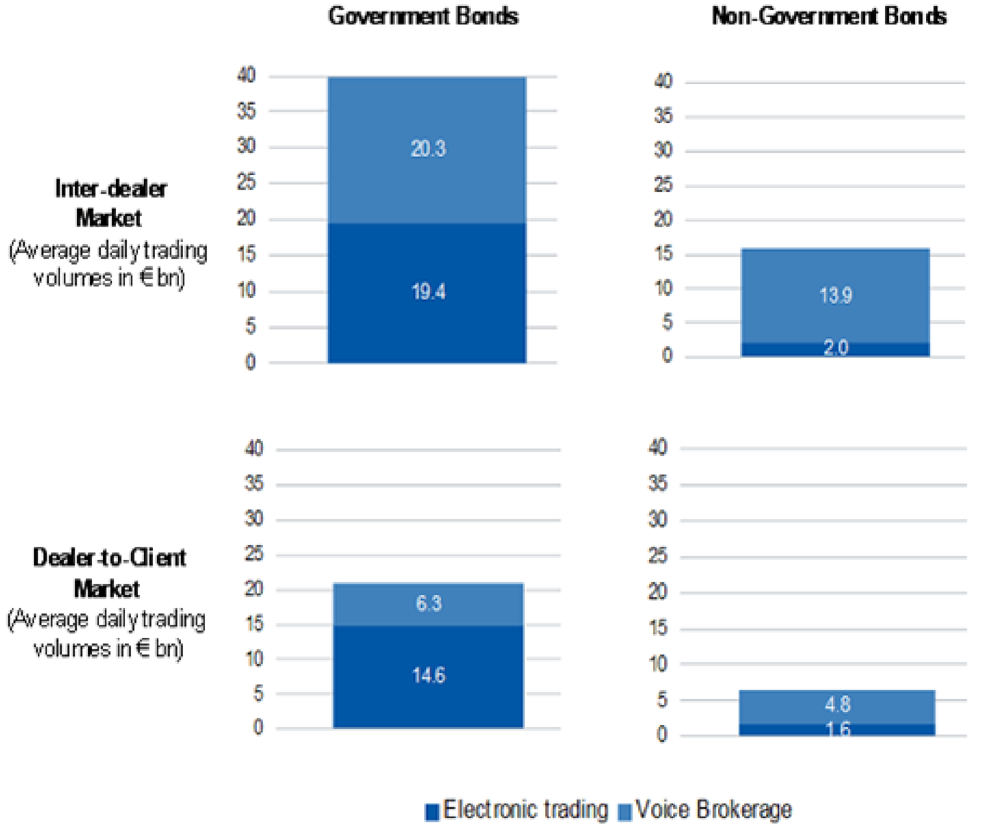
Our briefing paper falls into the third category, for we construct LMs too from MTS high frequency data and use them to explain what determines liquidity in this electronic market for Eurozone government bonds in the years 2008 to 2012. In this briefing paper we give a first glance into patterns of liquidity where, among others, we rank countries over the different forms of liquidity. We also test to what extend the age of the bond and market stress have an effect on liquidity.

3. Trading platforms in the Eurozone government bond market

When bonds are issued in the primary market, they are often listen on a stock exchange. However, when they are traded in the secondary market, they are only occasionally traded through the stock exchange. It is therefore often said that the bond market is an over-the-counter (OTC) market. OTC means that it is a decentralized market, without a central physical location, where market participants trade with one another through various communication modes such as the telephone, email and proprietary electronic trading systems. In an OTC market, dealers act as market makers by quoting prices at which they will buy and sell a security or currency.

In the OTC market trading is done through voice broking and on electronic platforms, which are either inter-dealer-broker (IDB) or inter-dealer-client (IDC) platforms . Various sources document that electronic trading in the European fixed income markets has significantly increased over the last two decades at the expense of voice trading (Celent, ICMA, Greenwich Associates & McKinsey, BIS)[1]. This trend is called the electronification of the European fixed income market. Figure 1 below shows the situation in 2009, which is one year into our sample period. By then, the average daily volume traded electronically is almost equal to that of voice broking in the IDB market of which MTS is part, and more than twice as large in the IDC market. Also trading takes place mostly in the IDB market and the secondary market for non-government bonds is still small compared to government bonds.

Figure 1: Electronic trading in European bond markets



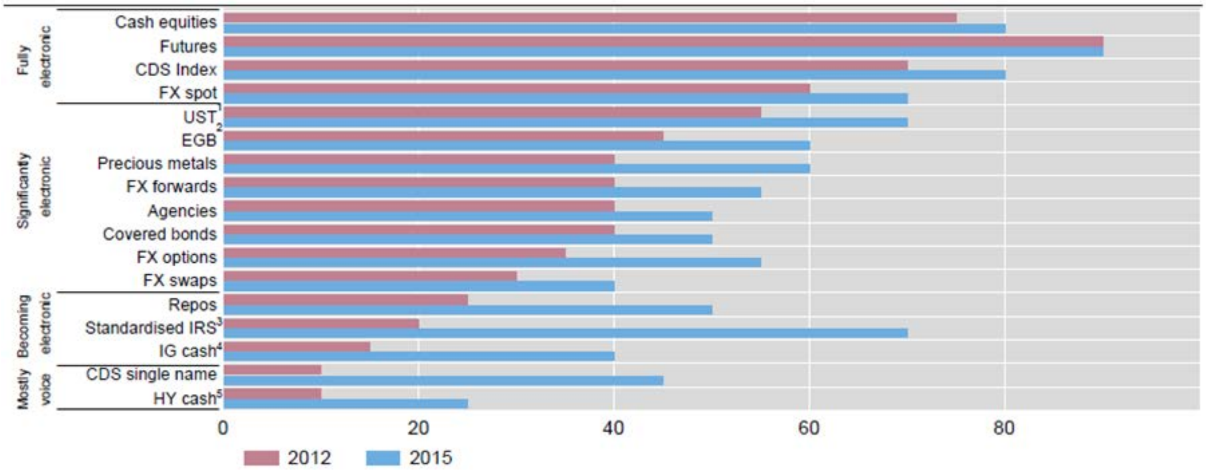
Source: from the press release of Celent 2009, Electronic Trading of Bonds in Europe: Weathering the Storm

Celent reports that the global financial crisis caused trading volumes to drop, by some 20-30% for government bonds. There is reason to believe to that electronic platforms, where quotes can be executable, suffered more from the drop in overall volume than voice trading. However, the bottom was reached towards the end of 2008 and volumes recovered from 2009. Figure 2 below shows that the electronification of the European government bond market is back at 50% in 2012, at average daily volumes which are only slightly below that of 2009 (€52 billion in 2012 compared to €60 billion in 2009, according to Celent). At this point, which coincides with the end of our sample period for this briefing paper, the European government bond (EGB) market

[1] Celent has written several reports on electronic trading in fixed income markets since 2009 and ICMA has produced a mapping of bond platforms in Europe in 2015. Selective information from these reports as well as the charts from Greenwich Associates & McKinsey replicated in this briefing paper is obtained from the internet. The BIS reports on electronic trading in the European fixed income markets are from 2016 and are listed among the references.

classifies as significantly electronic. This classification is on a par with the US Treasury market, which is quite an achievement given that the European bond market before the introduction of the Euro was still highly fragmented. Whereas the global equity, foreign exchange and some derivatives markets are fully electronic in 2012, none of the fixed income markets are at that point.

Figure 2: State of electronification in various asset classes



[1] US Treasuries. [2] European government bonds. [3] Standardised interest rate swaps. [4] Investment grade cash bonds. [5] High-yield cash bonds.

Source: From a McKinsey & Company and Greenwich Associates report of 2013

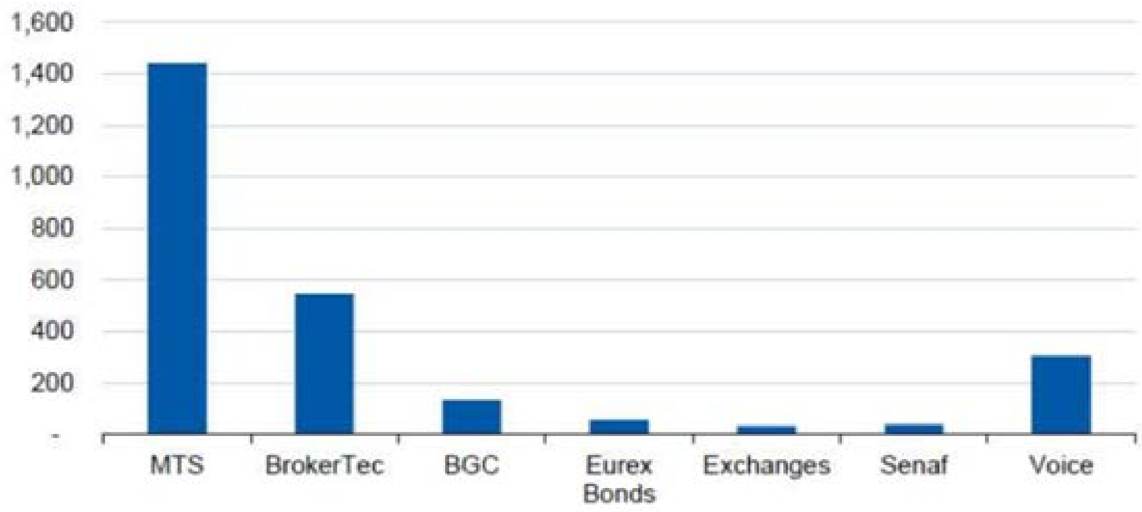
The BIS (2016b) list several factors that have been supporting the rise of electronic trading in fixed income markets. These include the reduction in trading costs due to technological advances. Technological advances, such as the significant rise in computing speed and capacity, have enabled electronic trading platforms to match and process increasingly large numbers of trades. This has contributed to lowering the marginal and average costs of each individual trade as well as to reducing search costs, which in turn raises the incentives for market participants to trade on electronic trading platforms.

Also changes in the demand for liquidity services has contributed to the electronification of fixed income markets. For one, the expansion of primary bond issuance over the past few years and increased bond holdings by market participants that seek to adjust their portfolio allocations at short notice (eg funds that face redemptions) have raised the potential size of secondary bond markets. The greater opportunity for economies of scale to be realised by electronic trading platforms, in particular for standardised products that are traded frequently, have made them attract liquidity. Another trend, as emphasised by many market participants, is an increasing demand for price transparency.

Due to these forces, the market structure shifted from one that was dominated by voice broking in the early 1990's to one that is increasingly dominated by electronic trading. In the early 1990's market participants predominantly negotiated terms of a trade via telephone or electronic chatting systems (i.e. bilaterally). The process of matching buyers and sellers involved significant search costs. A customer needed to contact one or more dealers, asking for currently available prices and quantities to buy or sell a specific security. Within the dealer-to-dealer market, specialised voice brokers helped facilitate and anonymise the matching process by exchanging information on dealers' buy and sell interest.

Fixed income markets experienced a major shift starting in the late 1990s. At that time, electronic trading platforms started to gain traction in the IDB markets for the most actively traded sovereign bonds. MTS was an early entrant. They launched their own proprietary platform in 1992 in selected European government bond markets and launched EuroMTS in 1998 as a pan-European platform for sovereign bonds, agency bonds and repos. With this first-mover advantage, and with their central position in the primary dealership arrangement of many European sovereigns, MTS quickly grew into the largest IDB trading platform. In Figure 3, it is shown how the average number of trades executed daily by IDB platforms in Europe in 2013 was spread.

Figure 3: Average number of trades in Eurozone government bonds executed daily by IDB platforms



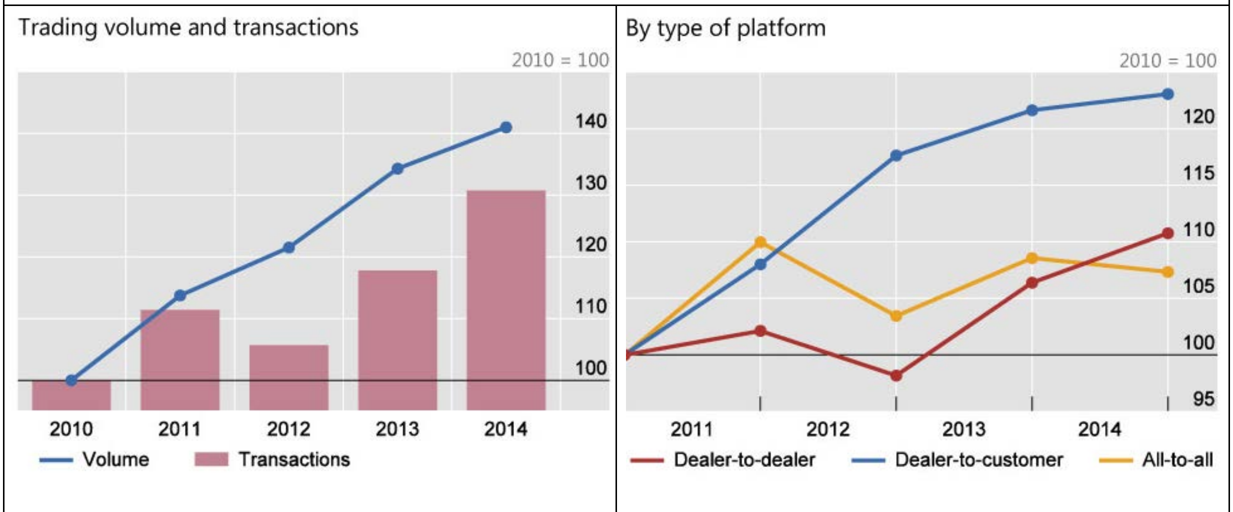
Source: Celent, 10/2013

While the regulatory reforms introduced after the global financial crisis has been another driving force behind the electronification of the fixed income market, it has also shifted where electronic trading takes places in recent years. Ensuring compliance with enhanced pre- and post-trade transparency requirements provides a strong incentive to move trading activity to electronic platforms in general. On IDB platforms mostly banks are active. However, other forms of post-crisis regulation has made it more costly for banks to provide liquidity in fixed income markets.

Therefore, the main growth in electronification has taken place in the IDC market in recent years. This is shown Figure 4. Both charts are from the BIS (2016b) and show that the trading transactions and volume have grown by 30-40% from 2010 to 2014, and that electronic trading activity grew on IDC platforms by more than 20% in this period.

A major difference between the IDB trading platforms is that quoted prices are executable, whereas IDC platforms, whether single or multi dealer platforms, typically work on a request-for-quote basis. An obligation to execute on quotes is not very attractive when the market is very volatile. And we can see indeed that trading activity on the IDB platforms diminishes in 2012, when apparently dealers withdraw as intra-sovereign spreads widen in the Eurozone bond market. Trading activity recovers thereafter and manages to close the period 10% up from 2010. Despite the growth of the IDC platforms, the BIS (2016b) also reports that in 2014, the trading activity on IDB platforms is still twice as large as on IDC platforms.

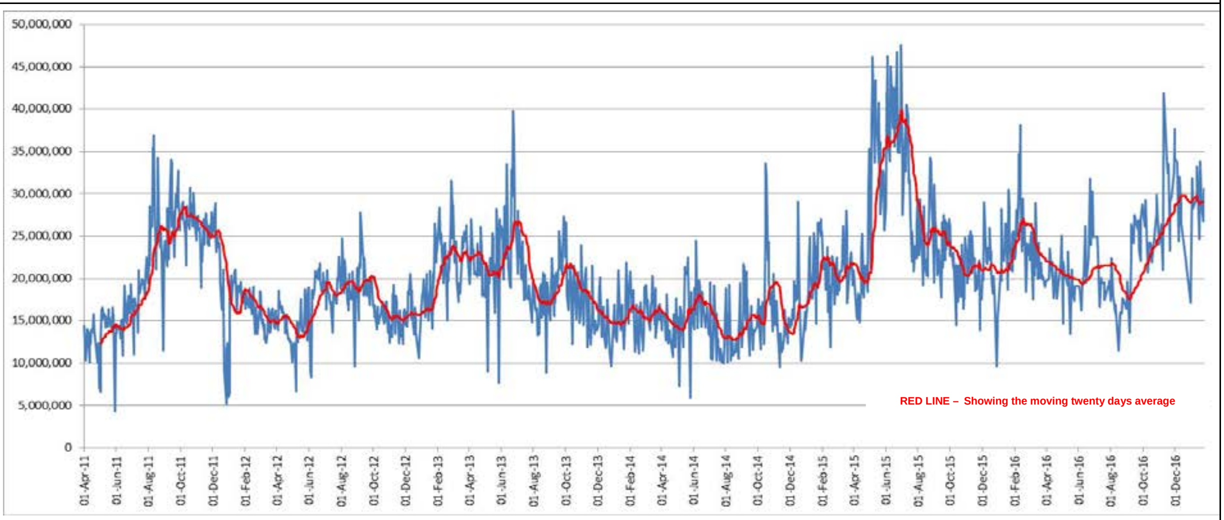
Figure 4: Growth (lhs) and developments (rhs) in electronification of fixed income markets



Source: BIS, March 2016

Also, the growth of IDC platforms is mainly in the non-government bond area. In 2015, Celent writes in their European fixed income market sizing report that the interdealer-broker (IDB) government bond market is still dominated by MTS and BrokerTec. The IDC nongovernment business has grown dramatically and has seen an increase in electronification. In their 2016 report they add that while volumes are stable in the nongovernment bond interdealer market, there are many market share swings between the platforms. They also report that volumes in the IDB government bond market are reducing. This is however not evident from the daily number of cash prices in all MTS markets over since 2011, which is shown in Figure 5. To the contrary, these daily prices are higher on average for 2015-16 than for the proceeding four years.

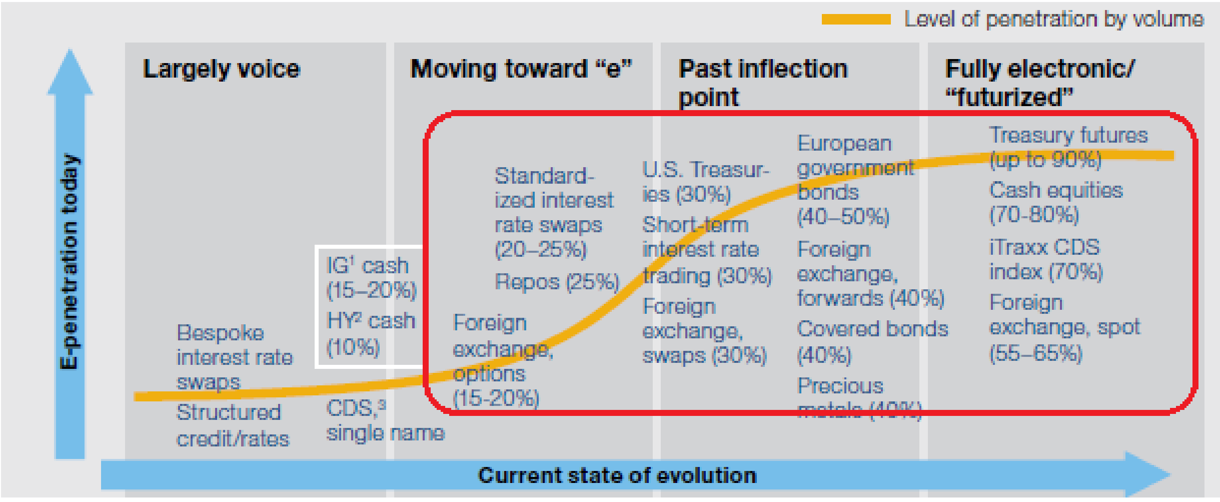
Figure 5: Daily number of cash prices in all MTS markets



Source: MTS at London Stock Exchange group

This is actually not surprising considering that European government bond markets are passed an inflexion point when it comes to electronification, as shown in Figure 6.

Figure 6: Level of electronification of different bond markets



[1] Investment grade corporate bonds; [2] High yield corporate bonds; [3] Credit default swaps; [4] Single-dealer platforms; [5] Mulit-dealer platforms

Source: ICMA study on Mapping of Bond Platforms in Europe, 2015

Another reason why MTS is able to maintain its leading position in the IDB market is because it is the central platform through which the various debt management offices (DMOs) in Europe promote and measure liquidity provision by their primary dealers. With over 500 unique counterparties and average daily volumes exceeding EUR 100 billion, MTS is one of Europe's leading electronic fixed income trading markets.

4. Constructing liquidity factors

The MTS trading platform has real-time tradable prices from the only electronic system offering data across the entire European government, quasi-government and covered bond markets. MTS started to record and store the information from this platform in 2003. The high frequency part of the dataset, called best proposals, contains the three best bid and offer price quotes all complete with related volumes. Three liquidity measures based on high frequency order book data are proposed and constructed for a cross-section of European bonds from the MTS high frequency data of the years 2008-2012.

4.1 The MTS Data

MTS as an interdealer platform is an exchange-like venue which functions as a purely order-driven market. MTS has a minimal order increment p_{incr} of €0.01 per bond and a minimal quoting volume V_{min} of €5 million notional value. The specific high frequency dataset that we use, best proposals, contains the best 3 bid and ask prices (n=3) complete with volumes.

Our dataset contains no information on actual trades, but once a trade takes place the order book is updated accordingly. The order book also updates every time a bid or offer is posted, altered or removed. Every quote posted on MTS is live and firmly tradable.

Our sample period ranges from January 2008 until December 2012 and thus encompasses the global financial crisis which reached its lowest point with the collapse of Lehman Brothers in September 2008 and a significant part of European sovereign debt crisis which truly starts in 2009.

There are thousands of best proposals during the day, but when we create our liquidity measures we aggregate to the daily level. A trading day on MTS spans from 08:00 until 17:30 CET, but preliminary analysis shows that the activity between 08:00 and 09:00 CET is very low. Similarly during the range 17:00 until 17:30 CET there is significantly less activity and bid-ask during these timeslots would be unrealistically and arbitrarily wide for a relatively long period. For these reasons we have omitted these intervals and allow ourselves to focus on the 09:00 until 17:00 CET timeslot.[2]

While the dataset contains price quotes for several non-Euro denominated bonds and sub-sovereign, supranational and agency bonds, we focus on 11 Euro-denominated sovereign bond markets. We also omit inflation-linked bonds and bonds with callable features. Finally, we omit trading days of bonds with less than 50 quote alterations.

4.2 Method for our three liquidity measures

We define $p_{i,\tau,b} = p_{1,\tau,b}, \dots, p_{n,\tau,b}$ as the set of n bid prices at time τ. Where, by virtue of the structure of the order book, it holds that bid prices ranked through i are sequentially $p_{i,\tau,b} > p_{i+1,\tau,b} > p_{n,\tau,b}$. Conversely, the set of ask prices $p_{i,\tau,a} = p_{1,\tau,a}, \dots, p_{n,\tau,a}$ is ordered such that $p_{i,\tau,a} < p_{i+1,\tau,a} < p_{n,\tau,a}$. For an exchange (including MTS markets), the minimal price increment is defined by:

$$p_{incr} = min(abs(p_{i,\tau} - p_{i+1,\tau})) \qquad (1)$$

In the order book every $p_{i,\tau,b}$ and $p_{i,\tau,a}$ is uniquely mapped to their quoted volumes $V_{i,\tau,b}$ and $V_{i,\tau,a}$ respectively via their rank i. Volumes have no restriction other than both $V_{i,\tau,b}$ and $V_{i,\tau,a}$ being larger than the minimal order amount V_{min} determined by the exchange.

Our first liquidity measure $l_{t,\tau,\text{BA}}$ is based on the best bid price and the best ask price and is calculated by:

$$l_{t,\tau,\text{BA}} = (p_{1,\tau,b} - p_{1,\tau,a}) \qquad (2)$$

This measure indicates the cost of crossing the spread. It is a widely used liquidity measure in the literature when from price sources such as Bloomberg the bid and ask quotes can be obtained but not the quoted volumes. With the MTS dataset we also have information on how much can be traded at the point in time of the price quote. We are using this information for our second liquidity measure $l_{t,\tau,\text{V}}$ which is a volume-based measure and is calculated for the bid and the ask side respectively by:

$$l_{t,\tau,\text{V,b}} = \sum_{\text{i=1}}^{\text{n}} V_{i,\tau,b} \qquad (3)$$

[2] It can be argued that the low activity in these timeslots is an actual indication of illiquidity and that the data should be preserved. However, we believe that the actual information content of the data during the most illiquid times of the day is very low. The difference between arbitrarily large bid-ask spreads of e.g. €50 and €80 (on a c. €100 bond) is practically irrelevant as it can be expected that nobody wants to cross that spread), but would bias our results if we allow these quotes in our measurement construction.

$$l_{t,\tau,\mathrm{V,a}} = \sum_{\mathrm{i=1}}^{\mathrm{n}} V_{i,\tau,a} \quad (4)$$

These price and volume measures accentuate the dual nature of liquidity, but they also allow for the limit cases to occur. One such limit is case is a very low spread but virtually no tradable volume, i.e. $l_{t,\tau,\mathrm{BA}}$ being p_{incr} and $l_{t,\tau,\mathrm{V}}$ being V_{min}. Another such limit case is a very large volume when the bid-ask spread is also very wide, i.e. $l_{t,\tau,\mathrm{V}}$ and $l_{t,\tau,\mathrm{BA}}$ being very large. In either limit case our liquidity measures would contradict[3].

For this reason we create a third liquidity measure that encompasses both price and volume information. Akin to Wuyts (2008), we define limit order book slopes (LOS) for the bid and the ask side by:

$$l_{t,\tau,\mathrm{LOS,b}} = \frac{1}{\mathrm{n}} \sum_{\mathrm{i=1}}^{\mathrm{n}} \frac{(\frac{1}{2}(p_{1,\tau,b} + p_{1,\tau,a}) - p_{i,\tau,b})}{(\sum_{\mathrm{k=1}}^{\mathrm{i}} V_{k,\tau,b})} \quad (5)$$

$$l_{t,\tau,\mathrm{LOS,a}} = \frac{1}{\mathrm{n}} \sum_{\mathrm{i=1}}^{\mathrm{n}} \frac{(p_{i,\tau,a} - \frac{1}{2}(p_{1,\tau,b} + p_{1,\tau,a}))}{(\sum_{\mathrm{k=1}}^{\mathrm{i}} V_{k,\tau,a})} \quad (6)$$

We take the average slope of price increments from the midpoint over the cumulative limit order book volume posted $\sum_{\mathrm{k=1}}^{\mathrm{i}} V_{k,\tau}$. A neat feature of these measures is that they form an elasticity of demand and supply respectively.

The difference between bid side liquidity ($l_{t,\tau,\mathrm{V,b}}$ and $l_{t,\tau,\mathrm{LOS,b}}$) and ask side liquidity ($l_{t,\tau,\mathrm{V,a}}$ and $l_{t,\tau,\mathrm{LOS,a}}$) is very relevant from a market microstructure perspective as it is related to important topics such as short-selling restrictions, repo-costs, price discovery and directional shocks. However, the objective here is to create liquidity measures in order to study the cross-sectional differences in liquidity.

For this purpose we define the three liquidity measures as follows:

$$L_{t,\tau,\mathrm{BA}} = -l_{t,\tau,\mathrm{BA}} \quad (7)$$

$$L_{t,\tau,\mathrm{V}} = l_{t,\tau,\mathrm{V,b}} + l_{t,\tau,\mathrm{V,a}} \quad (8)$$

$$L_{t,\tau,\mathrm{LOS}} = -\log(l_{t,\tau,\mathrm{LOS,b}} + l_{t,\tau,\mathrm{LOS,a}}) \quad (9)$$

As such all three liquidity measures have the property that a high relative value of L coincides with the bond being more liquid, whereas lower values of L would coincide with lower liquidity. Since the LOS-measures are initially construed as a ratio, a logarithmic transformation is applied to mitigate the effect of extreme values. The measures $l_{t,\tau,\mathrm{LOS,b}}$ and $l_{t,\tau,\mathrm{LOS,b}}$ are ratios of positive numbers by construction, so that the logarithm of their sum is defined at all times.

When dealing with high frequency data two problems stand out, that is the issue of irregular spacing and intraday seasonality. Since we aggregate our data to the daily level, we do not have to deal with intraday seasonality. Each of the $L_{t,\tau}$ measures currently is a snapshot in time and if we count the unique snapshots in

[3] Another issue with volume based measures is that order book data generally only reveals the top level of the order book (e.g. n=3 in our dataset), thus revealing only a partial amount of the volume available.

an interval t we have Υ_t snapshots (Υ_t can differ across intervals). If we define $\omega_{t,\tau}$ as the length of the period where the order book remains constant (and each of the $L_{t,\tau}$ measures unchanged) then we can create time-weighted measures in interval t by weighting Υ_t by their length $\omega_{t,\tau}$:

$$L_t = \frac{\sum_{\tau=1}^{\Upsilon_t} \omega_{t,\tau} L_{t,\tau}}{\sum_{k=1}^{\Upsilon_t} \omega_{t,\tau}} \qquad (10)$$

Using the weighting method (10) on (7), (8) and (9) we can three create time-weighted liquidity measures $L_{t,\mathrm{BA}}$, $L_{t,\tau,\mathrm{V}}$ and $L_{t,\mathrm{LOS}}$ respectively.

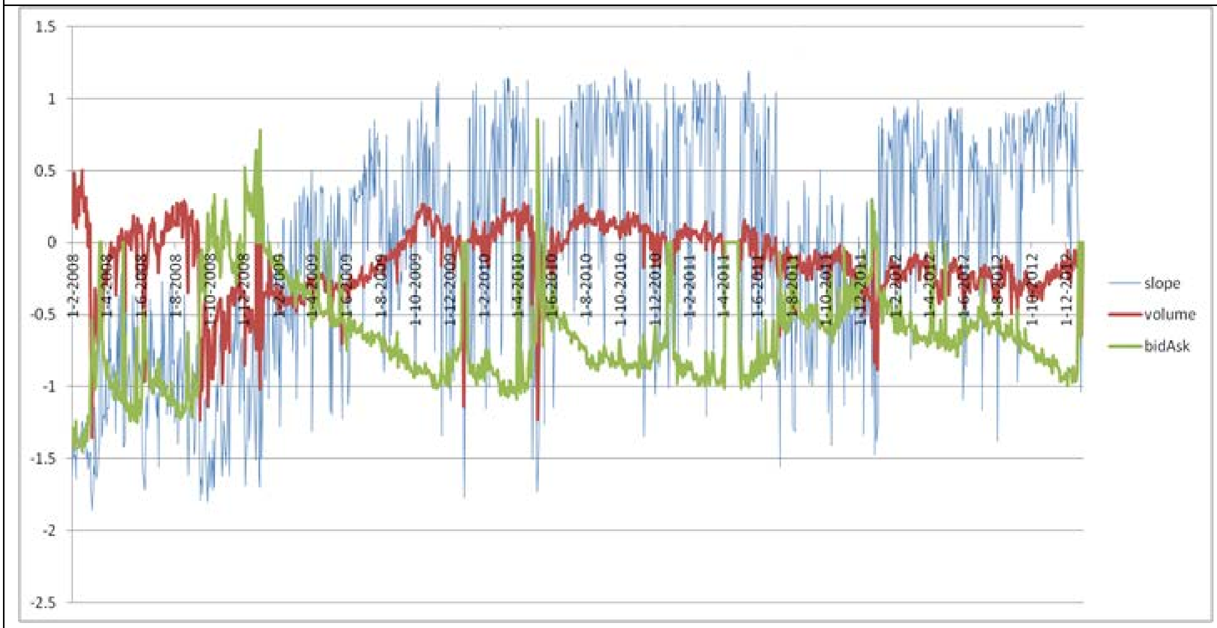
5. First contours of liquidity

With our three liquidity measures of bid-ask in the price quotes, the quoted volumes and the slope thereof, we can look through the Eurozone government bond market over the years 2008 to 2012 to discern patterns of liquidity and to understand the certain key relations. We discuss each, patterns and relations, in turn.

5.1 On patterns

We can plot the three liquidity measures for each country. We have done this in the Figure 7 for Germany by means of illustration.

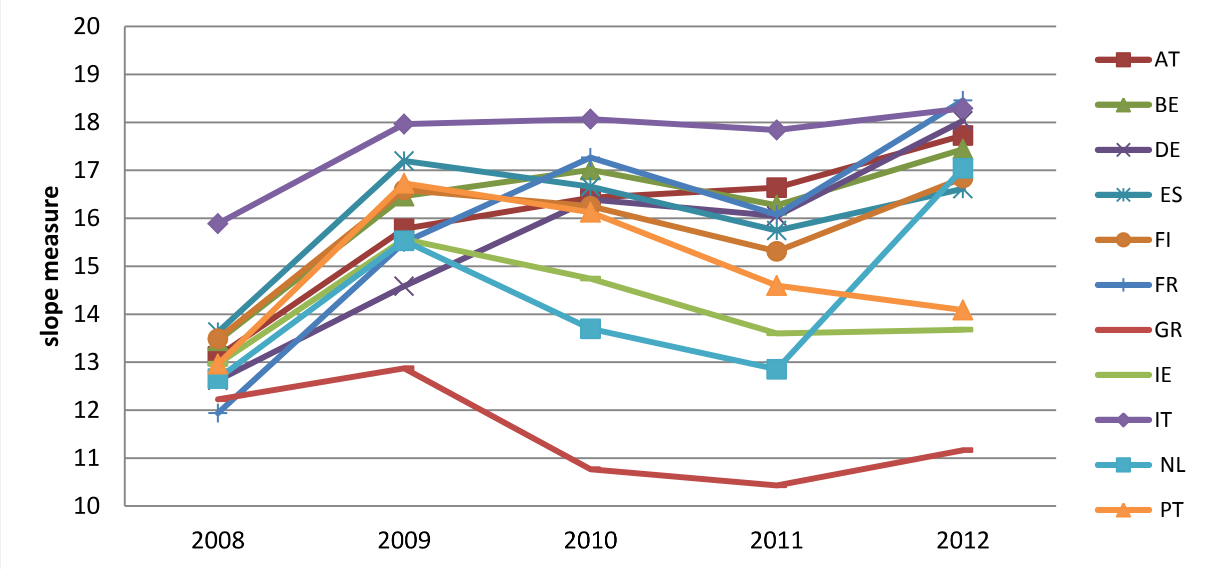
Figure 7: Liquidity measures for Germany



From this plot we observe two things. First, that the bid-ask and the volume measures tend to move in tandem. Note here that we have constructed the liquidity measures such that a higher values coincide with better liquidity. So for the bid-ask, the closer they are to zero, the better the liquidity and when the values become more negative, price liquidity is deteriorating. The co-movement suggests that smaller bid-ask spreads tend to be quoted with larger movements. In other words, when liquidity improves, it improves both in price and in volume. This is also true the other the other way around, when liquidity deteriorates. Secondly, the slope, which combines both price and volume into one measure, is considerably lower in 2008 and 2011 than at other times. A lower reading on the slope indicates poorer liquidity. The years 2008 and 2011 coincide with a lot of stress in the Eurozone government bond market.

The slope measure is informative, but not when it is this noisy. So while we can produce the above chart for all countries[4], we prefer to aggregate the daily data for each country and for each year for further analysis. When we then look at the slope, we get the following picture for the 4-6 year segment of the Eurozone government bond market where the largest volume is quoted, in Figure 8.

Figure 8(a): Annual mean of the slope in the 4-6 year segment



Source: ESE

From this cross-set we can make a number of observations. First of all, in terms of slope, Italy is consistently the most liquid market and Greece consistently the worst. Secondly, over the period, the liquidity of Ireland, Portugal and Greece has decreased from 2009 onwards. Apparently and logically, when a country needs official financial assistance and loses access to the bond markets, this has a dramatic effect on the liquidity of their bonds in the secondary market. Italy and Spain, which did not receive official financial assistance but whose bond spreads widened significantly during times of Eurozone government bond market stress, have held up in terms of liquidity. Thirdly, the pattern for the smaller countries is not consistent. The liquidity for the Netherlands dips after 2009 and recovers quite strongly again in 2012. Austria goes from strength to strength while Belgium and Finland improve from 2008 to 2009 but then fluctuate quite a lot. Fourthly, the slope measure of a number of countries converge to the upper end in 2012. The three countries with the largest slope are Italy, France and Germany and are now nearly perfect substitutes in terms of liquidity.

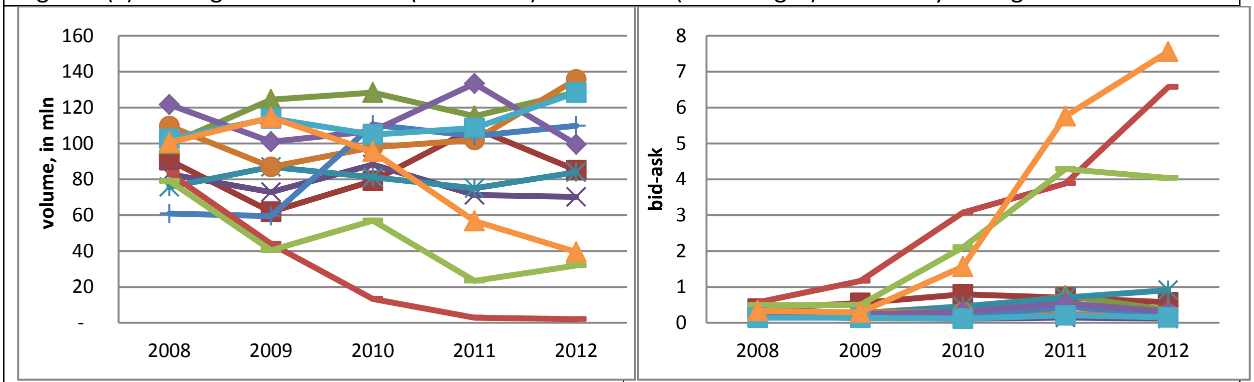
We reproduce the slope charts for two more segments, the 0-2 year and the 8-12 year, in the section More Data. The pattern for these other maturity segments is, with the exception of minor differences, very similar for the slope. The slope disguises a number of patterns with respect to price and volume liquidity which are at least as interesting. We show them in Figure 9(a) below, again for the 4-6 year segment. There is clearly a larger dispersion in volume then there is in terms of the bid-ask. The bid-ask difference is between 0 and 100 cent for all apart from the three countries that required official financial assistance, being Greece, Portugal

[4] The charts are available upon your request.

and Ireland. These countries also trail at the lower end of the volume spectrum, but otherwise volumes range from €60 million of quotes per day to €110 million. This difference in dispersion between the volumes and the bid-ask prices is also evident from the standard deviation among the annual data.[5]

In the section More Data below we show the same charts for two more maturity segments: the 8-12 and the 0-2 year segment. Again, the pattern is pretty similar, the only difference being that volumes are in total a bit lower for the other maturity segment (€831 million for the 0-2 year and €857 million for the 8-12 year versus €938 million for the 4-6 year segment) and that bid-ask spreads increase with maturity.

Figure 9(a): Average annual volume (on the left) and bid-ask (on the right) in the 4-6 year segment



Source: ESE Note that the same legend as in Figure 8(a) applies for the countries

Finally the ranking of countries on quote volume, bid-ask in the price and slope is quite revealing. We provide such a ranking for the average over the years on all three measures in Table 1(a) below, again for the 4-6 year segment.

Table 1(a): Ranking of countries for each measure in the 4-6 year segment

average volume		average bid-ask		average slope	
BE	119	DE	0,141	IT	17,610
IT	112	NL	0,153	BE	16,125
NL	112	FI	0,262	ES	15,969
FI	106	FR	0,298	AT	15,939
FR	89	IT	0,318	FR	15,847
AT	85	BE	0,370	FI	15,697
PT	81	ES	0,531	DE	15,536
ES	81	AT	0,602	PT	14,899
DE	77	IE	2,284	NL	14,357
IE	46	GR	3,053	IE	14,109
GR	29	PT	3,103	GR	11,492

Source: ESE

Italy is the most liquid Eurozone bond market on the slope measure, largely because of the volumes quoted on MTS. Purely on bid-ask difference, Germany is the most liquid market in the Eurozone. The bid-ask of German government bonds is on average half of that of Italian government bonds. Quoted volumes, however, for German bonds are approximately 30% below that of Italian government bonds. This is not surprising given that German bonds are also actively traded on Deutsche Börse's platform. The bid-ask of Dutch government bonds is also quite tight, but whereas the average volume of quotes for German bonds is considerably lower, the

[5] Not reproduced here but available on request.

average volumes for Dutch and Italian government bonds are exactly the same. Still the slope of Italy is higher because the volume is higher at the latter two of the best three proposals. This form of liquidity is often referred to as market depth. On market depth, Belgium, Spain and Austria all rise above France, which is surprising given the benchmark status of France in the Eurozone.

In the section More Data below we show the same table for two more maturity segments: the 8-12 and the 0-2 year segment. Again, the pattern is quite similar. Only now France and Germany rise to third place on slope or market depth in respectively the 0-2 year and the 8-12 year segment. Each time with Belgium in second place after Italy.

Overall, liquidity in the Eurozone bond market is quite dispersed among the countries. The typical division that one might expect beforehand, between the more and the less creditworthy countries of North and Southern Europe is somewhat visible on the bid-ask of quotes prices. This is however quite a narrow perspective on liquidity. When one also considers volumes quoted, any obvious North-South, small – large country or high-low rating division among liquidity disappears. The exception are the three countries that required official financial assistance –Greece, Ireland and Portugal – where liquidity of government bonds on the MTS platform has been severely negatively impacted.

5.2 On relations

Given that the countries themselves only explain differences in liquidity in the Eurozone to some degree, we should also look for other factors that may influence liquidity. We consider two in this briefing paper: the age of the bond, which is a time-varying bond characteristic and the amount stress in financial markets. Both are often shown to influence bond market liquidity elsewhere.

Liquidity is thought to deteriorate with the age of the bond. The reasons for this are that a newly issued bond is often issued at current yield, at a rounded maturity and tends to take over benchmark status from the previously issued bond in that maturity. All of this makes the newer bond more desirable, and hence it should be traded at a tighter bid-ask spread and in larger volumes. With respect to US Treasuries, many academics indeed find such a relation between age and liquidity through the on and off-the-run status of the bonds (e.g. Vayanos and Weill, 2008; Pasquariello and Vega, 2009; Fontaine and Garcia, 2012). The on-the-run bonds are precisely those newly issued bonds that obtain benchmark status and trade at a premium and higher liquidity in the secondary market. Since the US Treasury market is widely regarded as the most liquid government bond market in the world and one where country effects also do not play a role, we are curious if we can observe the same relation between age and liquidity in the Eurozone government bond market.

In order to determine the effect of the age of the bond on liquidity, we run a simple OLS regression of a variable called AGE on each three liquidity measures together with an intercept. We define AGE as the time the bond has been in issue, measured in years. We report the results in Table 2 in the section More Data below.

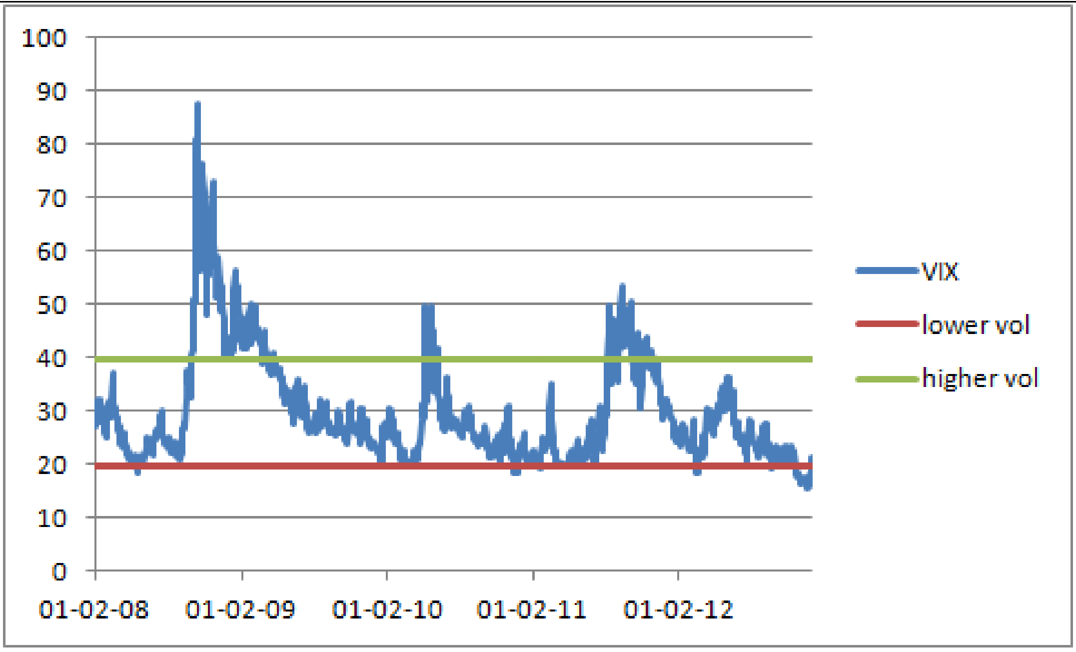
Since we have constructed our liquidity measures in the same direction, we expect the sign of AGE coefficient to be negative, i.e. the older the bond, the lower the liquidity. The AGE coefficients are indeed negative for nearly all countries on the volume measure, for most countries on the bid-ask measure but just for a few countries on the slope measure. This means to say that the age of bond mostly has a reducing effect on the volume that accompanies a price quote. The significance of the results is otherwise not that convincing. The t-statistic of the AGE coefficient may be high in most cases, but the size of the coefficient is very small and the fit of the model, judging from the R^2, is very low.

This result strokes with Eijsing and Sihvonen (2009) who find that not so much the on-the-run feature, but the cheapest-to-deliver (CTD) into the futures contract feature affects the liquidity of German government bonds. Only three government bond markets in the Eurozone have a parallel futures market, being Germany, Italy and France, so the positive effect of CTD status can only possibly play a role in those markets. Our results show that the insignificance of age, or conversely on-the-run status, is more widespread than the Germany in the Eurozone bond market. One likely contributor to this insignificance is the fact that governments in the Eurozone tend to reopen exiting issues. This habit, called tapping, injects new liquidity into old outstanding bonds.

If it not this bond characteristic that influences liquidity, let's consider an external factor instead. Our sample period contains times of considerable stress in the Eurozone government bond market. In 2009, the global sovereign debt crisis washes onto our shores and rolls into the European sovereign debt crisis. In 2012, the Greek bail-in of private bondholders spreads fear to other countries deemed vulnerable to that solution. These periods of stress, which were characterized by heightened volatility in financial markets, are likely to have had an effect on liquidity. We therefore look for a discernable relation between market volatility and liquidity.

We take the Chicago Board of Exchange volatility index, otherwise known by its ticker name VIX, as our universal indicator of market stress. In Figure 10, we show how the VIX has behaved over our sample period.

Figure 10: VIX



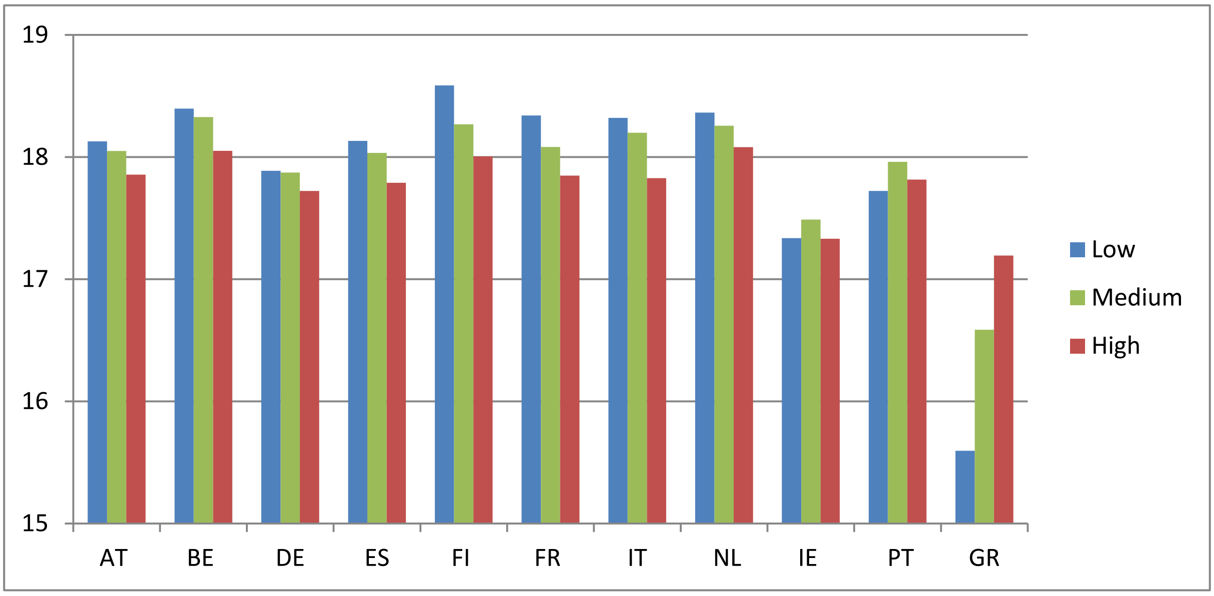
Source: Bloomberg

The chart verifies that the VIX rose significantly in 2009, 2012 and also for a brief period in 2011. Using the levels of the VIX, we can separate periods of low and high volatility where the VIX is more than one standard deviation below and above its mean. A medium volatility period is when the VIX stays between those bands, which are also depicted in Figure 10. From the chart we can see that there have been few periods of really low volatility in our sample period.

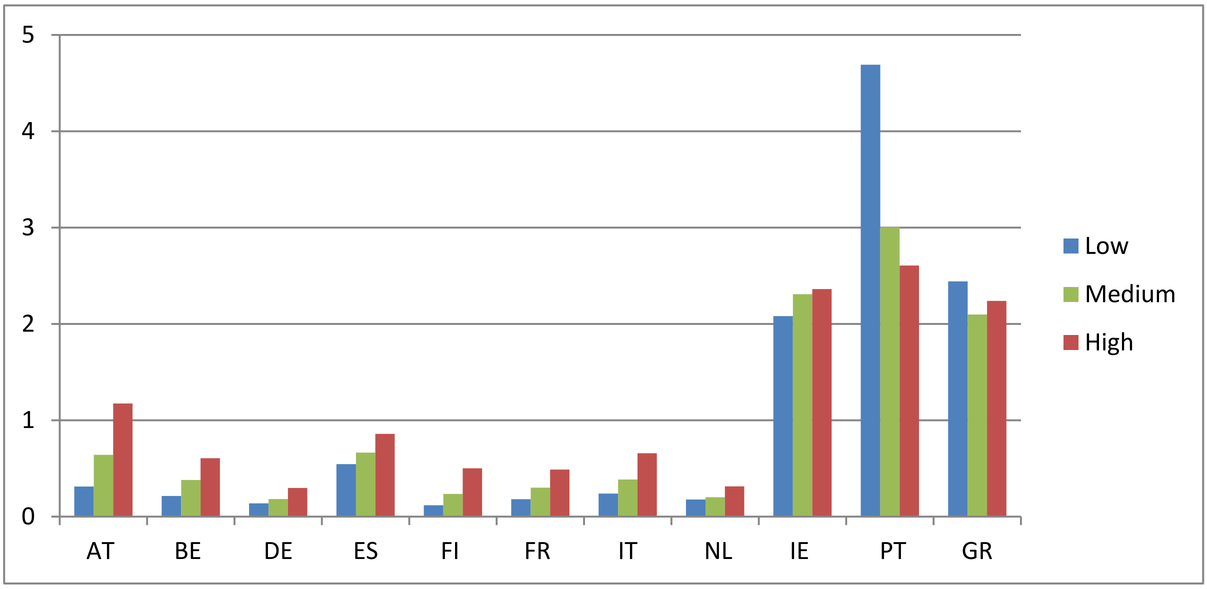
We then calculate the average level of liquidity according to our three measures in each type of volatility period for each country. The results are striking, and depicted in Figure 11 below.

Figure 11: Liquidity measures in Low, Medium and High Volatility Periods

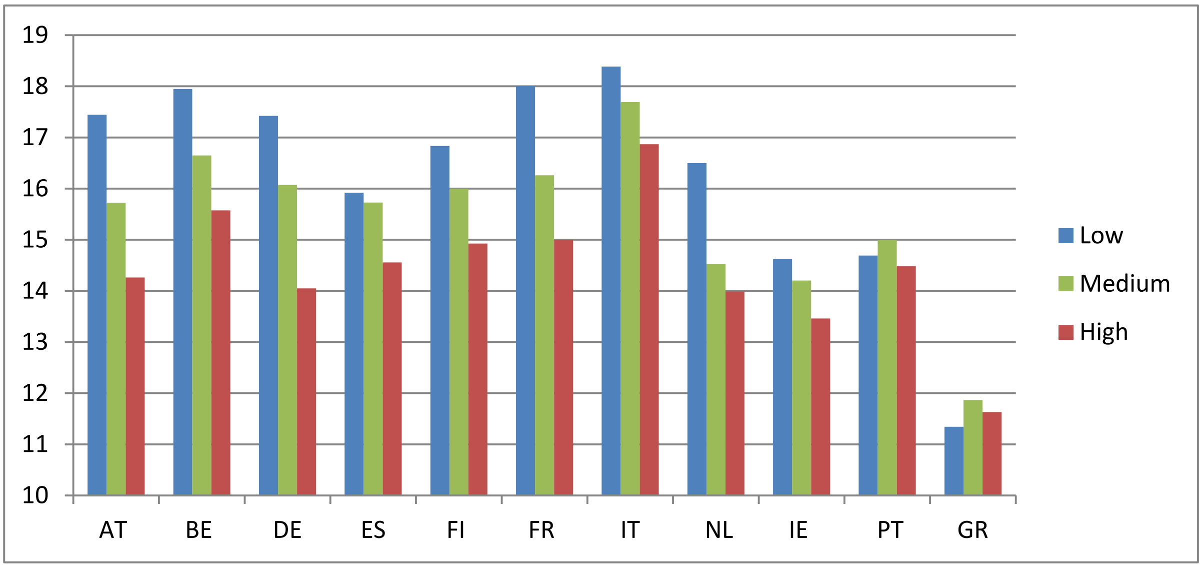
I: volume



II: bid-ask



III: slope



Source: ESE

As can be seen from the chart in panel I of Figure 11, liquidity on volume tends to deteriorate when volatility increases. This is true for all countries, apart from the ones that have needed official financial assistance. In Ireland and Portugal, liquidity on volume is lower in both low and high volatility periods compared to periods with just average volatility. In Greece, liquidity tends to be higher in high volatility periods. The latter can be explained by events in 2012, when both stress and volumes traded in Greek bonds is likely to have been high because of the voluntary exchange program organized for the bail-in of private bond holders. Apart from those three unusual cases, liquidity volume and volatility tends to be a linear and one-directional negative relation, meaning quoted volumes decrease with (extreme) volatility.

The same is true, but now in the opposite direction with the bid-ask spread, as can be seen in panel II of Figure 11. This tends to be a linear and one-directional but positive relation, meaning that the bid-ask spread increases with (extreme) volatility. This is again true for all countries including Ireland, but not in Portugal and Greece. In Greece, the bid-ask spread is wider in both low and high volatility periods. In Portugal, we get the counterintuitive result that the bid-ask spread tightens when volatility rises. The liquidity slope also decreases when volatility rises in all countries apart from Portugal and Greece, as can be seen from panel III in Figure 11.

On the whole, we can conclude that volatility as measured by the VIX has a significantly deteriorating impact on liquidity in the Eurozone government bond market. This result strokes with Biais et al (2004) who find that high volatility reduces yields and increases the value of liquidity offered at auctions of short-dated Treasury bills. The latter is the case, presumably, because the liquidity of those bills in the secondary market is less at times of heightened volatility. The basic premise of Lillo et al. (2016) study of the regular response to shocks and contagion of illiquidity in extremes shocks is also that liquidity decreases in volatility times.

Overall, there is considerable evidence that factors other than country determine liquidity in bond markets. The scant academic research that has been done with MTS data on the Eurozone bond markets provides evidence to this effect. It is therefore imperative to study the relation of different factors with liquidity if one wants to understand the patterns of liquidity in this market. In this briefing paper, we have picked two: age and volatility. We find a weak relation of the age of bonds with liquidity. This suggests that the so-called on-the-run effect hardly exists in the Eurozone, in contrast to the US Treasury market. We find a strong relation between volatility and liquidity. This seems to suggest that volatility is a likely transmission channel for illiquidity. The latter warrants more research on contagion of volatility and liquidity shocks.

6. Conclusion

We are interested in the long term trends of liquidity in the Eurozone government bond markets. Most of the academic papers that have used MTS data so far are market microstructure studies. While interesting, their scope is rather limited. There have been few papers only that analyse the interaction of liquidity with other variables derived from the platform and ever fewer that also related liquidity with external factors. This briefing paper belongs to the last category, as does our academic research.

The purpose of the briefing paper is to provide a first glance into long term patterns of liquidity. For this purpose we construct three liquidity measures (LMs). They are based on the bid-ask spread, the volume accompanying the price bid and offers and the slope from the three best price-volume quotes of the MTS dataset. From the daily pattern of LMs over the different countries, we observe that the size of the bid-ask and the volume tend to move in tandem when liquidity falls: when the bid-ask widens, volumes drop. The reverse is however not always the case: when volumes increase, the bid-ask does not necessarily tighten. The liquidity slope measure is therefore quite volatile on a daily frequency.

When we aggregate the LMs to an annual frequency, it becomes easier to see if there are certain country patterns in the Eurozone. We can also see how liquidity may have shifted as a result of the European sovereign debt crisis as our sample runs over the years from 2008 to 2012. On the most comprehensive LM of the slope, Italy consistently ranks top and Greece bottom of the pack over the years. In between these two, liquidity in the Eurozone bond market is quite dispersed. The typical division that one might expect beforehand, between the more and the less creditworthy countries of North and Southern Europe is somewhat visible on the bid-ask of quotes prices. On that measure, Germany is most liquid bond market. This is however quite a narrow perspective on liquidity. When one also considers volumes quoted, any obvious North-South, small – large country or high-low rating division among liquidity fades. The exception are the three countries that required official financial assistance. The liquidity of Greece, Ireland and Portugal has been severely negatively impacted. In 2012, the situation is that the top 4 markets, which are Italy, Belgium, France and Germany, are almost perfect substitutes in terms of liquidity.

Country factors go some way in explain differences in liquidity but clearly not all the way. It is imperative to look at the influence of other factors too. We consider two factors that are commonly researched in academic papers and look for evidence of their influence on liquidity. The first factor is the age of the bond. Age is thought to influence liquidity negatively. Many papers show that this is case in the US Treasury market, and that a so-called on-the-run effect exists. The evidence that age has an effect from our simple regression analysis in the Eurozone bond market is quite weak. The second factor is volatility. We study whether LMs are significantly different in low and high volatile periods from medium volatile periods as defined by the level of VIX. We find evidence that this is the case. When volatility increases, liquidity tends to deteriorate. This is true for all three measures of liquidity and all Eurozone countries, apart from Greece, Portugal and Ireland.

These are just the first contours and more research is required to obtain a more in-depth understanding of the behavior of liquidity in the Eurozone government bond market and the factors that are influencing it. We believe that there are more factors at play. These include other bond characteristics such as size and whether they are cheapest to deliver in a futures contract. Because of the presence of many sovereigns in the Eurozone bond market, the link with the futures market is much stronger than in the US. Whether a bond is in demand in the repo market may also have an effect on liquidity. Such factors should all be tested in an encompassing regression model. Once we have a good handle on the determinants of liquidity, are we able to study contagion. This will answer important question such as where the shock of the global financial crisis entered into the market, and how it travelled through. Last but not least, we can study to the effects of the ECB's government bond asset purchases under its QE program on liquidity in this market, which we can do if we extend the database to 2015. Future research at ESE is focused on these research questions.

More Data

Figure 8(b): Annual mean of the slope for each country over the years 2008 – 2012 in the 8-12 year segment

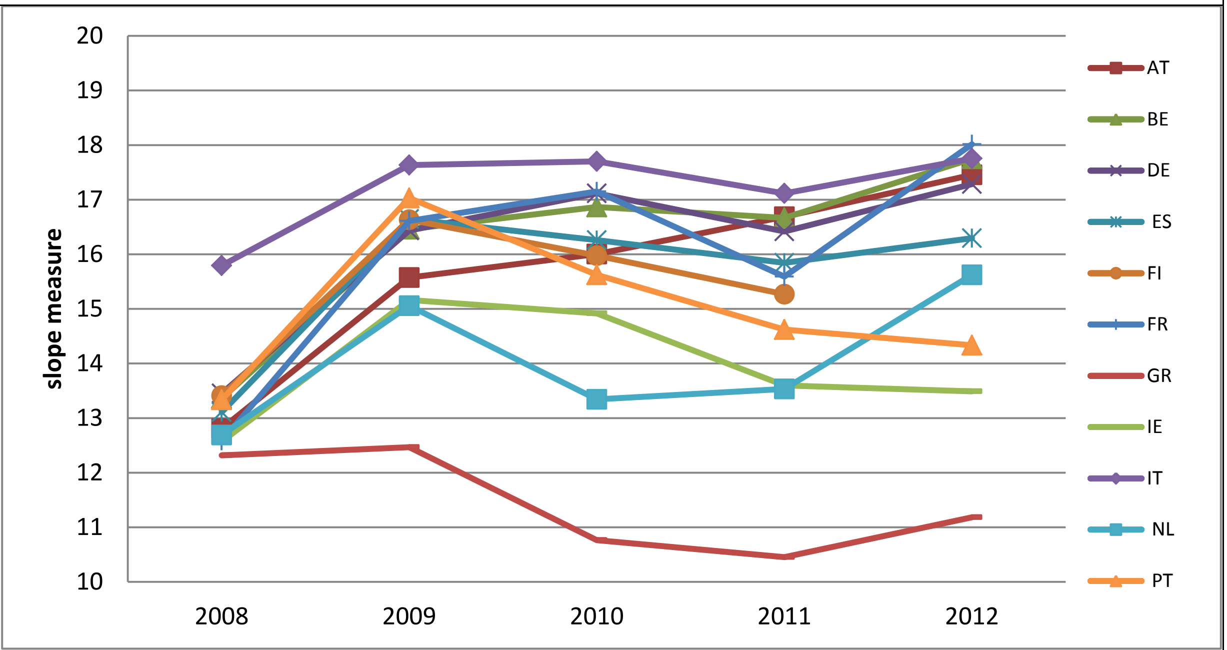


Figure 8(c): Annual mean of the slope for each country over the years 2008 – 2012 in the 0-2 year segment

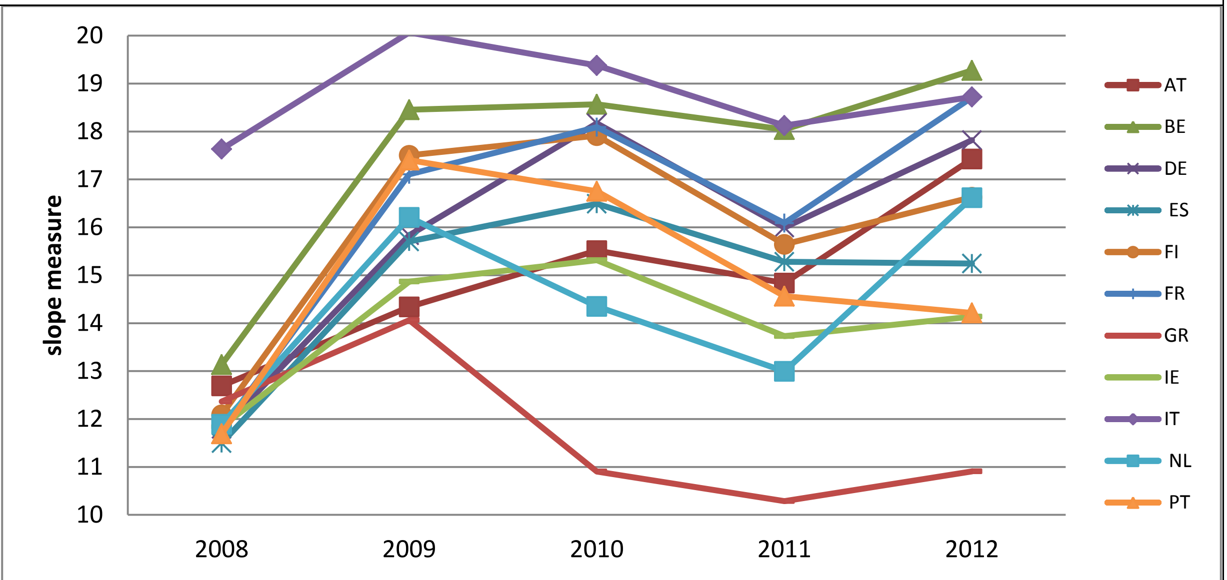
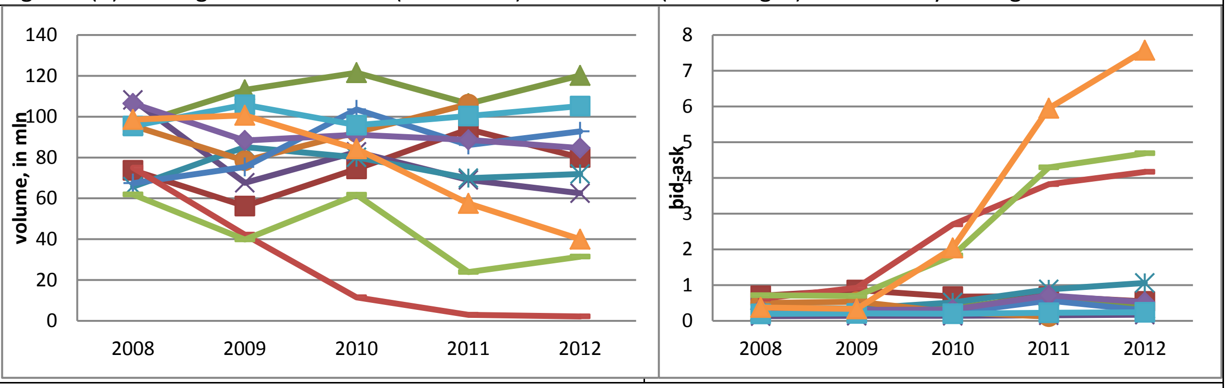
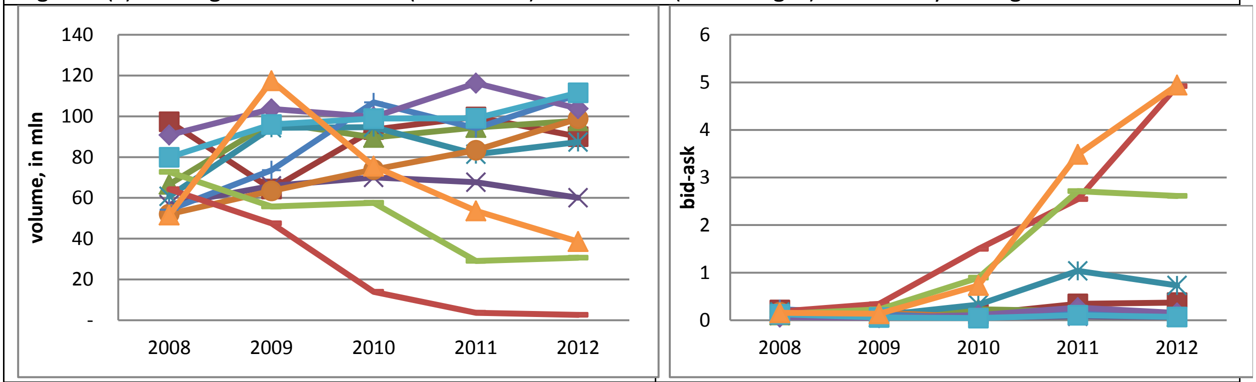


Figure 9(b): Average annual volume (on the left) and bid-ask (on the right) in the 8-12 year segment



Source: ESE. Note that the same legend as in Figures 8 applies for the countries

Figure 9(c): Average annual volume (on the left) and bid-ask (on the right) in the 0-2 year segment



Source: ESE Note that the same legend as in Figures 8 applies for the countries

Table 1(b): Ranking of countries for each measure in the 8-12 year segment

average volume		average bid-ask		average slope	
BE	111	DE	0,1476	IT	17,200
NL	101	NL	0,2130	BE	16,220
FI	93	FR	0,3432	DE	16,142
IT	92	FI	0,3491	FR	15,991
FR	85	BE	0,3960	AT	15,705
DE	78	IT	0,4359	ES	15,631
PT	76	ES	0,6345	FI	15,322
AT	76	AT	0,6938	PT	14,988
ES	75	IE	2,4447	NL	14,050
IE	44	GR	2,4469	IE	13,948
GR	27	PT	3,2522	GR	11,437

Source: ESE

Table 1(c): Ranking of countries for each measure in the 0-2 year segment

average volume		average bid-ask		average slope	
IT	103	DE	0,0771	IT	18,785
NL	97	NL	0,0805	BE	17,495
BE	89	FI	0,1168	FR	16,357
AT	89	IT	0,1285	FI	15,955
FR	88	FR	0,1335	DE	15,923
ES	84	BE	0,1356	AT	14,962
FI	74	AT	0,2483	PT	14,925
PT	67	ES	0,4745	ES	14,844
DE	64	IE	1,3151	NL	14,413
IE	49	PT	1,8900	IE	13,977
GR	26	GR	1,8978	GR	11,705

Source: ESE

Table 2: Results from regression of liquidity measure on AGE with an intercept

Volume

	intercept	standard error	t-value a	beta_coefficent	standard error	t-value b	R-sqrd
AT	-0,048	0,010	-4,684	-0,004	0,002	-2,442	0,0%
BE	0,846	0,010	87,796	-0,076	0,002	-44,529	7,7%
DE	-0,123	0,004	-31,554	-0,058	0,001	-70,486	8,1%
ES	-0,156	0,006	-25,918	0,014	0,001	12,629	0,5%
FI	0,445	0,013	35,027	-0,033	0,002	-14,080	1,9%
FR	0,253	0,008	31,416	-0,024	0,002	-14,880	0,5%
GR	-1,165	0,010	-122,233	0,022	0,002	12,542	0,8%
IE	-0,742	0,007	-108,221	-0,015	0,001	-12,790	1,5%
IT	0,402	0,009	45,576	0,005	0,002	2,385	0,0%
NL	0,558	0,009	63,095	-0,051	0,002	-32,483	5,1%
PT	-0,071	0,013	-5,607	-0,013	0,002	-6,119	0,2%

bid-ask

	intercept	standard error	t-value a	beta_coefficent	standard error	t-value b	R-sqrd
AT	-0,570	0,010	-59,264	0,026	0,001	17,686	1,6%
BE	0,045	0,008	5,628	-0,007	0,001	-5,215	0,1%
DE	0,895	0,004	205,687	-0,063	0,001	-69,153	7,9%
ES	-0,363	0,007	-50,555	0,001	0,001	0,571	0,0%
FI	-0,003	0,011	-0,257	0,072	0,002	35,289	11,1%
FR	0,359	0,006	57,001	-0,029	0,001	-22,803	1,1%
GR	-1,064	0,013	-84,576	0,022	0,002	9,343	0,5%
IE	-1,110	0,014	-77,535	-0,029	0,003	-11,452	1,2%
IT	0,209	0,006	34,645	-0,022	0,001	-17,100	0,5%
NL	0,586	0,008	70,549	-0,014	0,001	-9,703	0,5%
PT	-1,116	0,017	-67,123	-0,008	0,003	-2,700	0,0%

Slope

	intercept	standard error	t-value a	beta_coefficent	standard error	t-value b	R-sqrd
AT	-0,068	0,012	-5,454	0,001	0,002	0,550	0,0%
BE	0,229	0,010	23,081	0,000	0,002	-0,064	0,0%
DE	0,091	0,006	14,080	-0,012	0,001	-9,144	0,1%
ES	-0,124	0,008	-15,104	0,015	0,002	9,785	0,3%
FI	-0,006	0,018	-0,320	0,007	0,003	2,041	0,0%
FR	-0,037	0,009	-4,173	0,035	0,002	19,576	0,8%
GR	-1,263	0,007	-177,40	-0,003	0,001	-2,533	0,0%
IE	-0,485	0,010	-47,829	-0,013	0,002	-7,185	0,5%
IT	0,515	0,005	101,21	0,011	0,001	10,068	0,2%
NL	-0,494	0,010	-48,614	0,012	0,002	6,602	0,2%
PT	-0,295	0,011	-27,848	0,000	0,002	0,179	0,0%

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