Liquidity in fixed income markets – risk indicators and EU evidence

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Liquidity in EU fixed income markets – Risk indicators and EU evidence[♦]

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Abstract

Over the last few years, market analysts have pointed at an overall reduction of liquidity in fixed income markets. Market liquidity is important to ensure the efficient functioning of financial markets. Poor liquidity is likely to impose significant costs on investors and hence, ultimately on savers and the real economy. This paper provides a broad overview on different dimensions of liquidity in EU government bond markets and in EU corporate bond markets, covering the period from July 2006 to December 2016. Our findings show that, having deteriorated during the financial and sovereign debt crises, sovereign bond market liquidity has increased since then, potentially also due to the effects of supportive monetary policy in recent years. However, we find evidence of several episodes signaling deteriorating secondary market liquidity for corporate bonds, especially between 2014 and 2016. In the sovereign segment, market liquidity seems to be more abundant for bonds that have a benchmark status and issued in larger dimensions. In the corporate segment larger outstanding amounts are related to lower market illiquidity. In both segments, increased stress in financial markets is correlated with deterioration in market liquidity.

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1. Introduction

Episodes of short-term volatility and liquidity stress across several markets over the past few years have increased concerns about the worsening of secondary market liquidity, in particular in the fixed income segment.[1] Market analysts continue to point at an overall reduction of liquidity, at changes in the role of banks as market makers and at their willingness and ability to facilitate liquidity as reflected by the decrease of market makers' inventories in particular in the corporate bond segment. Overall, the decrease in either gross or net inventories could lead to reduced market liquidity due to a lower ability or willingness of a bank to function as a market maker.

Both buy-side and sell side market practitioners have claimed that it has become much more difficult to sell a large position quickly. Since our data do not include quotes we cannot measure the difficulty to trade looking at the time needed for trade execution or the need to get more quotes or to split large transactions. We observe, however, an increase of zero trading days in corporate bond markets, pointing at somewhat diminished market liquidity.

Market participants observe liquidity bifurcation in corporate bond markets with the most liquid segment experiencing no liquidity issues in both primary and secondary markets, and the rest of the market characterised by deteriorated liquidity conditions. Our data focus on the most liquid segment of european corporate bond markets (Markit Iboxx index costituents) and therefore we cannot address this important topic.

Our study covers both corporate and government bonds. Concerning the sovereign bond segment, a number of factors have led in recent years to a significant amount of research, including the sovereign bond crisis and the role played by sovereign securities in the collateral determination.[2] The measurement of sovereign bond market liquidity is important for market participants (for instance when hedging positions, correctly pricing other securities, etc.). For policy makers market liquidity plays a central role in the decision making process when issuing new debt. Furthermore, sovereign bond market liquidity plays a role in the transmission of monetary policy and, more in general, in ensuring the orderly functioning of financial markets and financial stability.

Following the 2008 financial crisis, the EU corporate bond markets have been affected by a number of structural changes, such as regulatory reforms, changes in dealer business models, electronification, or bond holding concentration. Those factors, together with cyclical dynamics, can affect market liquidity conditions. Understanding liquidity dynamics in the EU corporate bond markets is increasingly important as market financing has become a significant source of funding for the economy over last years[3] and in consideration of the relation between liquidity risk and cyclical developments. Cyclical factors may impact underlying liquidity risk: In the last years, benign monetary policy conditions, the low interest rate environment and related strong investor risk appetite have supported bond valuations and contained volatility in many fixed income market segments, sustaining market liquidity. Shifts in policies and in market confidence, however, can significantly affect liquidity conditions and liquidity resilience, especially in an environment subject to frequent market swings and where spillovers across asset classes have increased. Evidence of spillover effects across asset categories shows how

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[1] There have been a number of episodes of short-term volatility and illiquidity in different markets: the US equity and derivatives market on 6 May 2010, US Treasuries on 15 October 2014, the Swiss franc in January 2015, German bunds in April 2015, and equities and ETFs in August 2015.

[2] See Bai et al (2012) for an analysis of the Eurozone sovereign bond crisis.

[3] See ESMA report on Trends Risks and Vulnerabilities No. 2, 2017.

corporate bond markets are exposed to illiquidity shocks in equities as well as sovereign bond market. Thus, there could be challenges to financial stability and consistent and effective market monitoring is crucial.

Previous studies investigating the liquidity of US, UK and French corporate bonds between 2008 and 2015 find that although liquidity measures have improved in the period following the financial crisis, they have not yet recovered to their pre-crisis levels (2005-2007).[4] IOSCO (2016) published a report on market liquidity in secondary corporate bond market, acknowledging the difficulties to aggregate and compare data across jurisdictions, and did not draw firm conclusions on market liquidity in corporate bond markets, While some of the relevant metrics to measure liquidity (turnover ratio, dealer inventories, and block trade size) might indicate potential signs of lower liquidity, most metrics reviewed show mixed evidence of changes in liquidity (bifurcation of trading, average trade size, and average number of counterparties or market makers) or some evidence of improving liquidity (trading volume, bid-ask spreads, and price-impact measures).

The contribution of this paper to the literature is twofold. First, it provides a broad overview of market liquidity across several national European sovereign bond and corporate bond markets, reporting on different dimensions of market liquidity (tightness, breadth, depth and resilience[5]) through several market liquidity proxies and a composite liquidity index. Overall, our findings show that liquidity has been relatively ample in the sovereign segment, potentially also due to the effects of supportive economic policies over more recent years. This is different from our findings in the corporate bond market, where in recent years we observed episodes of decreasing market liquidity when market conditions deteriorated.[6] Second, it investigates the drivers of liquidity in these markets, finding that in the sovereign segment, market liquidity seems to be more abundant for bonds that can be traded in the Euro Benchmark Market (EBM) and issued in larger dimensions. In the corporate segment larger outstanding amounts are related to lower market illiquidity. In both segments, increased stress in financial markets is correlated with deterioration in market liquidity. Results hold when different samples (in terms of geography, maturity and market liquidity volatility) are taken into account in both sovereign bond and corporate bond markets. In particular, liquidity resilience seems to be particularly low in corporate bond markets. Our results are very interesting in light of the current debate around the implications of low volatility in financial markets. Market liquidity may be overestimated in current financial market conditions and may be negatively affected by abrupt increases in volatility levels.

The paper is organized as follows: Section 2 reviews the relevant literature, market liquidity definitions and describes the European fixed income markets. Section 3 introduces the dataset while section 4 presents the market liquidity indicators. Section 5 presents the empirical results and section 6 concludes.

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[4]   Trebbi and Xiao (2016) analyse secondary corporate bond market transactions in the US from April 2005 to December 2014. Aquilina and Suntheim (2016) study the evolution of liquidity in the UK corporate bond market for the period 2008-2014. AMF (2015) focus on liquidity in French bond markets between 2005 and September 2015. See IMF (2015) and BIS (2016) for a review of fixed income market liquidity.

[5]   See Anderson et al (2015) for an analysis of the resilience of financial market liquidity in UK.

[6]   Previous studies for US bonds, UK bonds and French bonds investigating liquidity between 2008 and 2015 find that liquidity measures have improved in the period following the financial crisis, albeit without recovering to their pre-crisis levels (2005-2007).

2. Literature review, definitions and market overview

2.1 Literature review

This paper contributes to two main strands of the literature: first, the literature investigating market liquidity and how to measure it and second, analysesing the of market liquidity drivers in fixed income markets.

Aquilina and Suntheim (2016) contribute to the debate on market liquidity in the corporate bond markets by documenting a decline in the inventories by UK primary dealers, without being reflected by a reduction of liquidity in the market, which remained flat from 2011 to 2014. These results are in line with evidence on the French (AMF, 2015) and US bond markets. Mizrach (2015) explores liquidity provisions in the corporate bond market using TRACE transactions from 2003 to 2015. They find liquidity associated with smaller trade sizes, more transactions and larger dealer networks. Bessembinder et al. (2016) study the market liquidity conditions in the US corporate bond market from 2013 to 2014. The authors measure market liquidity using intraday and overnight dealer commitment, dealer participation as principals, turnover, the frequency of block trades and interdealer trading. Their evidence suggests that market liquidity has worsened in the years under analysis. Galliani et al. (2014) use several price – and volume-based liquidity indicators to analyse fixed income market liquidity in the EU between 2006 and 2011. Concerning sovereign bonds, they find that in 2006 market liquidity was high, with little variation across individual bonds. Later on, in 2008, especially in 3Q08 and 4Q08 (Lehman Brothers' collapse, September 15), market conditions deteriorated. In 2011 liquidity conditions remained tense and got worse in the second half of the year, because of the sovereign debt crisis spreading to some large European countries.

A recent European Commission study (2017) shows that an increasing number of corporate bonds are hardly traded at all, probably held in portfolios of long-term or buy-and-hold investors. They also demonstrate that transaction cost indicators exhibit noticeable upward trends since 2014. Our corporate bond market liquidity indicators and our synthetic illiquidity indicator do not document a systematic and significant drop in market liquidity in the last years. However, when wider market conditions deteriorate, we observe episodes of decreasing market liquidity.

Concerning the second workstream several empirical studies analyse the relationship between corporate bond market liquidity and individual corporate bond characteristics such as rating, maturity, age, size of issuance. Chen et al. (2007), exploiting a sample spanning nine years composed by 4,000 corporate bonds (from investment grade to speculative grade), show that the lower the rating, the higher the liquidity cost. Less robust seems to be the relation between maturity and market liquidity, though generally showing that the longer is the maturity the higher the liquidity cost. We investigate the role of rating in driving market liquidity in corporate bond markets[7] and we do not find any robust evidence supporting this relation, probably due to the fact that corporate bonds included in our sample are all investment grade.

Houweling et al. (2003), using data on European corporate bonds in the period 1999-2001, show that the older the bond the less liquid it is: as a bond gets older an increasing percentage of its outstanding is absorbed by buy and hold investors, making it more and more illiquid. Our analysis does not confirm these results.[8] Market intelligence suggests that corporate bonds are liquid in the first weeks following their issuance and in case of some credit events otherwise the

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[7]   For sovereign bond markets ratings are given at country level and do not vary for specific sovereign bonds in the same country.

[8]   We run all the regressions in Section 4 including maturity variables. Results do not support any strong role of maturity variables in determining market liquidity in EU fixed income markets and therefore we have not included them in the final tables reported in section 4. They are however available on request.

buy and hold behaviour by investors seems to prevail. This result has been confirmed by European Commission (2017).

Dick-Nielsen et al. (2012) analyse liquidity components of corporate bond spreads between 2005 and 2009 in the US market. They use a composite illiquidity indicator to analyse spread contribution from illiquidity and they find that liquidity matters in particular in periods of stressed financial markets. We follow Dick-Nielsen et al (2012) and we build a composite illiquidity indicator taking into considerations different dimensions of market liquidity.[9]

Concerning sovereign bonds, Beber et al. (2009), based on the analysis of order flow for 10 Euro-area active sovereign debt markets find that investors care about credit quality and market liquidity but they do so at different times and for different reasons. Coluzzi et al. (2008) apply a wide set of liquidity measures to the Italian wholesale secondary market and they find that even though the market provides an amount of liquidity that fits the market needs, the quality of the order book is low, and despite the large presence of market makers, the degree of competition among them is not very high. Our database does not allow to analyse the order book and we focus our market liquidity analysis of EU sovereign bond markets on trade-based indicators. Schneider et al. (2016) aim to quantify illiquidity risks in the Italian market, especially such related to liquidity dry-ups, and illiquidity spillover across maturities. They find that long-term bonds are less liquid and the medium-term bonds are generally liquid. Spillover of illiquidity risk is higher when the market is less liquid and it is more frequent between bonds of the same maturity.

The econometric strategy in this paper is built on the model presented in Galliani et al. (2014), where the authors analyse the liquidity determinants in both corporate and government bond markets. Building a robust liquidity indicator based on principal component analysis (PCA) to aggregate several measures of market liquidity, the authors find that EU fixed income market liquidity is driven by bonds' specific characteristics such as duration, rating, amount issued and time to maturity. Similarly, Iachini and Nobili (2014) build a synthetic indicator for market liquidity risk using ten different liquidity stress measures for the Italian financial markets. Market liquidity measures are then aggregated using a multivariate GARCH approach; their results show that the systemic market liquidity risk indicator accurately identifies events characterized by high systemic risk, while not exaggerating the level of stress during calm periods. In this paper we follow a methodology similar to Galliani et al. (2014) on an expanded dataset of sovereign and corporate bonds. We aggregate several measures of market liquidity through a PCA and find evidence of several episodes signalling deteriorating secondary market liquidity especially between 2014 and 2016.

Our empirical results that market liquidity deteriorates in stressed financial market conditions in both sovereign and corporate bond markets are in line with Acharia et al. (2012). Acharia et al. (2012) use a regime switching model to study the exposure of US corporate bond returns to market liquidity shocks of stocks and Treasury bonds over the period 1973-2007. They find that the response of corporate bond prices to liquidity shocks varies over time in a systematic way: In times of economic and financial stress, liquidity risk becomes a significant determinant of bond prices.

Finally, part of the literature focuses on the role of dealers in fixed income markets. Ferrari (2015) analyses the role of primary dealers in the sovereign bond market, and finds that banks' financial constraints are generally passed through to lower liquidity and higher yield spreads of

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[9]   In the econometric analysis, the composite illiquidity indicator is used as dependent variable for market liquidity determinants.

the sovereign bonds for which these banks make the market. Unfortunately, our data do not allow to control for market maker behaviour in the econometric exercise. However, in section 2.3 we present some evidence on inventories of EU market makers and show that no decrease can be detected for sovereign bonds while a decline characterises the corporate bond inventories of market makers.

2.2 Market liquidity: Definition and measures

A market can be considered liquid when trades can be executed at very low costs, in a timely manner and with large trades having only limited impact on market prices (Foucault *et al.*, 2013). It is widely recognised that liquidity is not a concept that is directly observed or uniquely defined and it is generally measured across five dimensions: tightness, immediacy, depth, breadth and resilience.[10] Some of those features require order level data to more precisely measure liquidity, as for the case of immediacy, considered as the speed at which orders can be executed. For the others, however, liquidity proxies can be meaningfully developed also relying on trade level data. Tightness identifies the possibility of executing transactions at a low cost. Depth, which using order level data refers to the existence of enough orders at prices above or below market price, can also be meaningfully proxied looking at volumes of trades. Breadth can be defined as the ability to transact large volumes with a minimum impact on prices. Finally, resilience refers to the availability of liquidity in period of higher volatility and market stress.[11]

Chart 1
Measuring market liquidity with trade level data

Liquidity dimensions	Liquidity metrics
Tightness	Bid-Ask spreads
	Roll
Depth and Breadth	Volumes traded
	Turnover ratio
	Average trade size
	Amihud illiquidity coefficient
Resilience	Volatility spikes
	Dealer count
	Probabilities of liquidity regime

Given data availability, we analyse the dimensions which can be represented using trade level data (Chart 1). Moreover, a synthetic indicator, computed by applying the principal component methodology, is estimated using the input measures above.[12]

Finally, we will investigate the resilience dimension with the econometric exercise, trying to identify the drivers of market liquidity.

2.3 Sovereign and corporate bond markets – overview and policy context

In terms of the liquidity debate, it is important to distinguish between primary and secondary EU bond markets. The primary market is the market related to new debt issuance: It is influenced by the financing needs and policies of the different EU Member States in the sovereign bond

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[10] The definition of market liquidity across different dimensions is widespread in academic literature. A comprehensive overview of liquidity proxies is given in Sarr and Lybek (2002).

[11] On the other hand, market illiquidity is the lack of ability, or difficulty, to trade the asset; it is a cost expected to be discounted in securities prices. The liquidity cost rise with investors' or financial intermediaries' risk appetite, funding costs, price discovery, transition costs, transition time.

[12] Four measures are used to build the synthetic liquidity indicator: Bid-ask spreads; Amihud; Roll and turnover ratio.

markets and of the different issuers in corporate bond markets. The secondary market for sovereign bonds mainly concentrates on wholesale interdealer platforms; for corporate bond markets trading takes place mainly OTC though electronic trading platforms are developing. In this paper, we focus on secondary market liquidity.[13]

Compared to equity markets, fixed income markets are characterised by a significantly larger number of instruments with different characteristics (tenor, payment terms, coupon rates etc.), which makes matching supply and demand for a given instrument more challenging. Fixed income instruments are also by their nature purchased for income rather than capital appreciation, and some investors are less likely to trade these instruments after the initial purchase. In the absence of a continuous two-way market for buyers and sellers in these markets, market makers such as banks and broker-dealers facilitate transactions by stepping in as counterparties to such transactions by buying or selling financial instruments without an immediate matching transaction.[14]

Market participants indicate that the trading environment has become more difficult. They are still generally able to carry-out the trades they require, but the time taken and effort required to trade with dealers and across multiple platforms has increased. They argue that large trades have become more difficult to execute without affecting prices, with market participants breaking up larger trades into smaller tranches. As already mentioned our database is based on trade data and does not include information on the order book. Therefore, it does not allow to measure the time needed to trade, for instance. However, three indicators we regularly employ to analyse liquidity developments in fixed income markets, average trade size, time needed to unwind a position and number of zero trading days (the last two available only for corporate bonds) do not seem to point at an increased difficulty to trade.[15]

Concerning corporate bonds, indicators related to the time necessary to unwind a position show that it has become more difficult to unwind large positions in secondary markets.[16] By averaging across the constituents of the Markit IBoxx aggregate EU corporate bond index, in March 2015 it would take 55 days to close a position of USD 50mln while in March 2016 more than 70 days would be needed to unwind the same amount. [17]

Market participants finally suggest that dealers seem to have reduced their market making activities following changes in their attitude towards risk taking and also in relation to new regulation.[18] Building on a quantitative data collection with the largest market-makers operating in Europe, ESRB (2015) shows that for asset classes other than corporate bonds, gross and net inventories have either increased or remained unchanged. However, for European corporate bond markets, gross and net inventories have declined since 2010, possibly indicating a reduced ability or willingness of market-makers to act as intermediaries in these markets (See Chart 2 and Chart 4).

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[13] MiFID II/MiFIR new rules have introduced greater transparency in fixed income secondary markets at the beginning of 2018. Our analysis is based on data corresponding to the period before MiFID II/ MiFIR entry into force.

[14] See PricewaterhouseCoopers (2015) for an extensive rewiew of structural factors affecting market liquidity.

[15] See ESMA Trends, Risks and Vulnerabilities.

[16] Among the Markit Euroclear Liquidity Fields, indicative time to unwind in USD is available. It is defined as the number of days to exit an *x* USD position in a particular ISIN. We aggregate by computing the daily average across all ISINs included in the Markit IBoxx Index.

[17] ESMA, 2017, ESMA Report on Trends Risks and Vulnerabilities No. 2, 2017.

[18] For instance, the liquidity coverage ratio introduced by the Basel Committee (Basel III: The Liquidity Coverage Ratio and liquidity risk monitoring tools, BIS, January 2013).

Main features of the European sovereign bond market

In terms of primary sovereign bond markets, issuance levels and credit quality have changed since the financial and sovereign debt crises (Chart 3). Both issuance volumes and rating quality significantly decreased starting from the crisis period. In 2012, just after the peak of the EU sovereign crisis, the share of BBB issuance was much higher compared to pre-sovereign bond crisis levels and continued to increase until 2016. Overall, compared to pre-crisis times issuance was significantly lower (-26% in 2016 compared to 2009). Looking at credit quality, the risk profile of issuance deteriorated with securities rated A to AAA decreasing from almost 99% of total EU sovereign bond issuance at the beginning of 2009 to less than 88% at the end of 2016, while BBB-rated securities increased their share in the same period from less than 1% to almost 10%. The EU sovereign bond crisis has driven the decrease of the credit quality. Sovereign bond yields in EU countries more affected by the sovereign bond crisis increased significantly in 2011 and 2012 raising the risk related to their debt sustainability, with an impact on their credit quality. At the end of 2016 sovereign bond yields are lower than they were in 2009, also due to the effects of a prolonged accommodative monetary policy.[19]

Chart 2

Market-maker government bond inventories

Broadly stable
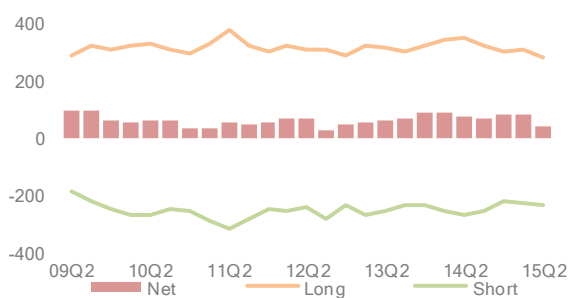
Note: EU government bond inventories collected for 13 EU market makers, EUR bn.
Sources: ESRB, ESMA.

Chart 3

Sovereign bond issuance in the EU

Increase in lower-rated bonds
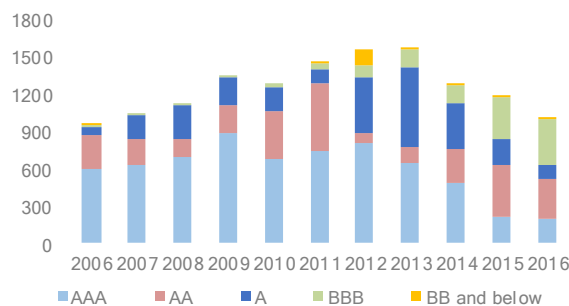
Note: Yearly sovereign bond issuance in the EU by rating, EUR bn.
Sources: Thomson Reuters Eikon, ESMA.

As mentioned in the previous section , the debate around market liquidity has been focusing on issues related to reduced market makers' inventories, unbalanced supply and demand, and the need to review trading strategies, with the tendency now to place a higher number of trades of smaller volume.[20] In the sovereign segment, however, developments are different (Chart 2).[21] Focusing on net inventory positions, which reflect the level of risk that a market maker is willing or able to assume, following a decline during the crisis period, they have remained stable in recent years (data available until 2Q15) at around EUR 4bn (See ESRB, 2016). This compares to an outstanding amount of EUR 12tn and Eurosystem holdings under the public sector purchase programme of about EUR 1.27tn[22].

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[19] See ESMA report on Trends Risks and Vulnerabilites for more empirical evidence on the topic.

[20] This seems to be the case in the corporate bond market. De Renzis et al, EU corporate bond market liquidity – recent evidence, ESMA report on Trends Risks and Vulnerabilities, No. 2 2016.

[21] This chart is based on a quantitative data collection exercise as well as a qualitative survey with the largest market-makers operating in Europe carried out in 2015. See ESRB (2016) for more details.

[22] Updated data available from the ECB, Asset purchase programmes – Expanded asset purchase programme.

Main features of the EU corporate bond market

With reference to primary corporate bond markets, corporate bond issuance in EU has increased between 2014 and 2016 by 21%. Probably supported by historically low interest rates and persistent favourable monetary policy, issuance increased to EUR 899bn in 2016 (from EUR 723bn in 2014), 47% of which High Yield (Chart 5). The decline in credit quality in the corporate bond market segment should also be noted, with the outstanding for BBB and lower-rated securities increasing their share (9pps increase over the last two years) while AAA-rated and AA-rated decreased respectively by 6 and 4pps.[23]

Market intelligence suggests that the rapid growth of the size of the primary market is outpacing the growth of secondary market trading activity. This trend raises some concerns on potential evaporation of liquidity in the secondary market especially in periods of market stress. Indeed limited liquidity could translate into higher illiquidity premiums and higher borrowing costs. If credit conditions were to deteriorate, some companies could quickly find it harder to access debt markets.[24]

The corporate bond segment is inherently less liquid compared to other asset classes, such as equities or sovereign bond market, also given the large number of non-standardised corporate bonds often characterised by small outstanding amounts. Therefore, dealers have traditionally played an essential role as intermediaries between clients wishing to execute trades, though the decreasing longer-term trend in both gross and net market maker inventories of EU corporate bonds in the last years indicates a structural change in the market (Chart 4).

Chart 4

Non-financial corporate bond inventories

Decrease in net inventories
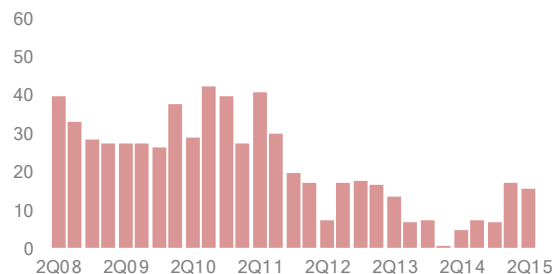
Note: Investment grade non-financial inventories data collected for 13 EU market makers, EUR bn.
Sources: ESRB.

Chart 5

Non-financial corporate bond market issuance

Increase in issuance in 2016
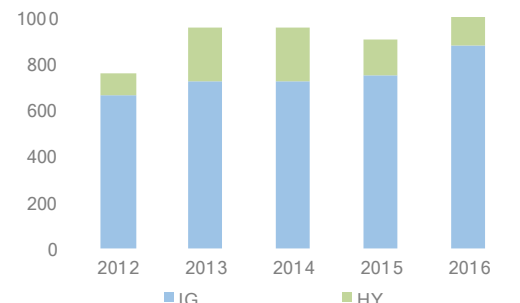
Note: Yearly debt investment grade (IG) and high-yield (HY) issuance in EU, EUR bn.
Sources: Thomson Reuters Eikon, ESMA.

However, EU non-financial corporate bond inventories have slightly recovered since 3Q14, yet remaining at very low level compared to the period before 2012. Even though inventory levels provide only a rough approximation of dealers' capacity to build up large trading or market making positions, the net inventory position reflects the level of risk that a market maker is willing or able to assume. The size of gross short and long inventories reflects the ability of market makers to take short and long positions. Overall, the decrease in either gross or net inventories could lead to reduced market liquidity due to a lower ability or willingness of a bank to function as a market maker. Related to the above developments is the growth in electronic trading in the

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[23]   ESMA report on Trends Risks and Vulnerabilities No. 2 2017.

[24]   See IOSCO (2016) and EU Commission (2015).

corporate bond markets.[25] Electronification has started to affect the traditional corporate bond markets structure in recent years. Trading on the three main electronic platforms in the EU corporate bond markets (Bloomberg, MarketAxess and Tradeweb) is estimated to account for more than 40% of total transactions in the IG corporate bond market.[26] However, the percentage of electronic trading in total value traded is estimated to be significantly lower and the vast majority of bonds continues to be traded over-the-counter (OTC). At the same time, traditional dealers are also using technology to improve the efficiency of their market making activities, and non-bank liquidity providers are searching for ways to trade directly with end-investors using direct electronic connections.[27]

2.4 Dataset description and market liquidity indicators

In this section we describe the dataset used for sovereign bonds and corporate bonds.

Sovereign bond data

The sovereign bond analysis is based on MTS daily data for domestic and EuroMTS platforms. MTS is the largest wholesale interdealer platform for Euro-denominated sovereign debt securities. Having been introduced by the Italian Treasury in 1988 and then privatised in 1997, the MTS system was gradually enlarged to other euro-denominated countries.[28] Several domestic MTS markets were then formed focused on domestic markets, followed by the creation of the EuroMTS platform, which then became the largest interdealer trading system for Euro-zone government bonds, mostly based on electronic transactions.[29] This coincided with the definition of standards in terms of issuance policy, transparency and quotation requirements and the origination of the so-called *Liquidity Pact*.[30] Within this framework, market makers are required to make double-sided quotes above a given minimum size, for a certain number of hours per day, within a maximum bid-offer spread according to bond maturity and liquidity.[31]

The main idea was to foster secondary market liquidity through a common platform where issuers and dealers could trade committing to a few common rules.[32] It should be noted that while there are some common characteristics governing MTS trading platforms, regulatory responsibilities remain at the respective domestic level implying differences across domestic MTS markets.

Our sample is based on daily price statistics of MTS markets for the cash market.[33] Among other information these data include: trading date, ISIN, type of bond, description of each bond,

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[25] Electronification may result in further changes in market structure and market making activities, possibly becoming more similar to EU equity markets. Regarding equity markets ESMA (2014) and ESMA (2016) look at high-frequency trading activity and some of the associated impacts on market structure and market making activities. The starting point for both reports is the change in the trading landscape of equity markets over the last decade. The defining features of this change are increased competition between trading venues, fragmentation of trading of the same financial instruments across EU venues and the increased use of fast and automated trading technologies.

[26] ICMA, 2014, "The current state and future evolution of the European investment grade corporate bond secondary market: perspectives form the market".

[27] See BIS (2016) report on electronic trading in fixed income markets.

[28] MTS Group includes also MTS US that operates on the US electronic fixed income market. See MTS, "Discover MTS Markets", MTS Corporate Brochure 2013.

[29] Art 2.1, EuroMTS Market Rules, active from 4th April 2016.

[30] Coluzzi et al. (2008).

[31] MTS Associated Markets Common Market Rules (2016). See Pelizzon et al (2013) for an extensive review of MTS microstructure.

[32] For example, as documented by Coluzzi *et al.* (2008), the required assets to be held by market makers in order to have access to the respective domestic MTS platform may vary across countries.

[33] The overall MTS Data is sourced directly from the MTS interdealer market and includes benchmark real-time data, reference data, reference prices and historical data.

market type (domestic and EuroMTS), actual transaction price for the last trade of the day, average daily bid-ask spread, total daily volume.

Our dataset covers daily data for sovereign bonds for ten EU members from January 2006 to December 2016.[34] The sample period allows us to capture liquidity developments across both stressed and more benign market conditions. The sample includes 2,680 sovereign bonds traded on the domestic MTS platform, of which 1,892 are also traded on EuroMTS. The number of bonds in the domestic market is usually higher than that of EuroMTS. While every bond can be quoted on the domestic platforms, this is not the case for EuroMTS, as certain minimum size conditions need to be met. In our sample, in most cases, bonds are quoted on both platforms, (Table A.1 in Annex A).

These observations are in line with previous research, whose findings show that most dealers participate in both markets.[35] Our liquidity metrics consider both the domestic and the EuroMTS markets. Significant differences in volumes can be observed across countries. In terms of size, some markets are significantly larger than others: Looking at the EuroMTS, in our sample, volumes traded in IT are around 43% of total volume traded in 2016 with only 15% in FR and an even smaller share for other markets (e.g. 1.6% AT, 8.8% NL, 9.3% ES).[36] Interesting is the case of DE with a very low share of traded volume on MTS (only 7.8% on EuroMTS market and 1% on domestic MTS platform in 2016) especially considering the importance and the role of the German market as the EU benchmark market.[37]

Notable variations are not only observed in terms of size but also maturity profiles. For some countries like BE, ES, IT, trading is concentrated in short maturities. For others, instead, as shown in table A.1 in annex A, we observe higher trading volumes in longer maturities (e.g., AT, FI). This is in line with developments in the EU sovereign bond market since the sovereign bond crisis. Market intelligence documents that more vulnerable countries, like IT and ES, reacted to increased yields by issuing bonds at shorter maturities to reduce refinancing costs with maturity of issuance extending only more recently. On the other hand, less vulnerable economies have taken the opportunity to obtain long-term refinancing at historically low interest rates thus increasing the average maturity of their debt.[38]

Against this background, heterogeneity results as a distinctive feature of the EU sovereign debt market: EU member countries are structurally different in terms of debt profiles, market size and therefore liquidity.

Corporate bond data

The corporate bond market analysis builds on Markit EUR iBoxx Corporate database representing the most liquid segment of the European corporate bond market. Therefore, given the composition of our database, we are aware that our analysis may overestimate the amount of liquidity available in the market. Also, our data cannot be used to address the concerns expressed by market participants related to market liquidity bifurcation, indicating that liquidity is increasingly concentrating in the most liquid instruments and falling in less liquid assets. In terms of time series, data on traded volume are available starting in 2014 – thus any assessment

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[34]   The countries considered are: Austria, Belgium, Germany, Spain, Finland, France, Ireland, Italy, Netherlands, Portugal.

[35]   See Caporale and Girardi, 2011; Pelizzon *et al.*, 2013.

[36]   There are structural differences across markets: in IT the stock of debt is significantly higher than in other EU countries.

[37]   See Cheung et al, 2005, ECB Working Paper Series. The German market is comparably liquid. The reasons behind low volumes on MTS are related to the fact that a significant amount of trading is done via EUREX, and to the existence of successful futures contract on EUREX and LIFFE providing investors a low cost margin based trading mechanism.

[38]   Bonds with maturities exceeding 30 years were excluded from the sample. Therefore, the estimated average maturity in our sample could be slightly lower than the actual one, especially considering that, in the last year, the maturity of new issuance increased considerably. In the first half of 2016, BE, ES and FR issued bonds at fifty-year maturity taking advantage of the very low interest rates.

of structural changes of market liquidity in this market based on our data is based on price-based indicators only.

The database is composed by 4,185 EUR- denominated corporate bonds, more than 70% of which having maturity between 5 and 10 years or longer. The highest share refers to bonds at maturity between 5 and 10 years, while the share of bonds issued at shorter maturity is negligible. This reflects the characteristics of corporate bonds as a class of securities aimed at financing a company business, yet at the same time entailing among others, increasing credit risk at longer horizons.

The sample appears to be balanced between non-financial (NFCs) and financial corporations both in terms of number of bonds (57% for NFCs against 43% for financial corporations) and issued amounts, with the share of issuance by NFCs increasing in the latest years (Chart 6). It includes only EUR-denominated IG corporate bonds, from AAA to BBB. The highest share is composed by A-rated and BBB-rated bonds (42% and 45 % respectively for 2016). To be noted is the deterioration in credit quality, within the sample, in line with the overall deterioration in the EU corporate bond market.[39] In our sample BBB-rated bonds increased by 25% over the last two years against a 4% growth for A-rated ones (Chart 7).

Chart 6	Chart 7
Sample distribution	Sample distribution - Rating classes
Balanced sample	**Deterioration of credit quality**

Note: Issued amount, EUR mln. Share of non-financial bonds in percentage of total number of bonds (rhs).
Sources: Markit, ESMA.

Note: Issued amount in the sample across time, by rating category.
Sources: Markit, ESMA.

Chart 8 reports descriptive statistics for the main variables used in the analysis classified according to their maturity:

- Number of bonds: most of the bonds included in our database have more than 5-year maturity;
- Bid-ask spreads; they are lower for bonds with longer maturity;
- Traded Volumes: they are higher for bonds with longer maturity;
- Age is the time elapsed since issuance: as expected, it is generally higher for bonds with longer maturity;
- Rating is an index values from 1=AAA to 4=BBB: it is broadly homogeneous across maturities.

All values refer to the overall averages across the sample except for number of bonds.

More descriptive statistics are available in Table A.4 (Panel A and Panel B) in Annex A, where corporate bonds are grouped by maturity and by bid-ask volatility bucket. Corporate bonds characterised by more volatile market liquidity (included in the top 10% volatility bucket) tend to

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[39]   De Renzis et al (2017), ESMA Report on Trend Risks and Vulnerabilities No.2, 2017.

have lower traded volumes and higher bid-ask spreads. Traded volumes decrease and bid-ask spreads increase when the maturity of the bonds is longer.

Chart 8

Descriptive statistics – Corporate bonds by maturity

	Number of bonds	Bid Ask Spread	Traded Volume	Age	Rating
Less than 1y	9	0.31	874	0.26	3.42
Between 1y and 3y	291	0.40	760	0.96	3.07
Between 3y and 5y	673	0.40	741	1.87	3.10
Between 5y and 10y	1,476	0.61	699	3.26	3.20
Between 10y and 30y	407	0.98	648	4.51	3.12
Higher than 30y	1,326	0.95	707	3.22	3.41

Note: Number of bonds refer to the number of ISINs; Traded volume, Bid-Ask Spread, Age and Rating are computed as average by maturity type. Traded volume, EUR mln, Age expressed in years, Rating is an index values from 1=AAA to 4=BBB.
Sources: Markit, ESMA.

3. Market liquidity indicators

In this section we measure different dimensions of market liquidity (tightness, breadth and depth)[40] through several market liquidity proxies (Chart 9) and a composite liquidity index for both sovereign bond market and corporate bond market.

Chart 9

Market liquidity indicators

	Bid-ask	Volume	Trade size	Turnover	Amihud	Roll	BPW	Composite	Number	Zero
Corp bond	yes	yes	yes	yes	yes	no	yes	yes	no	no
Sov bond	yes	yes	yes	yes	yes	yes	no	yes	yes	yes

Note: Bid-ask is bid ask spread; volume is traded volume, Trade size is the ratio between traded volume and number of trades, Turnover is the turnover ratio. Amihud, BPW (Bao Pan Wang) and Roll are three price impact market liquidity indicators; Number is the number of trades; Zero is the number of zero trading days. Composite is computed by applying the principal component methodology to liquidity measures (Amihud, Bid-ask, Roll and turnover for sovereign, and Amihud, bid-ask, Bao Pan Wang and zero trading days for corporate bond).

Source: ESMA.

Sovereign bond market liquidity

Decreased market liquidity was observed at the peak of the financial and of the EU sovereign bond crisis, while being buoyant in more recent years as the beneficial effects of monetary policy measures unfolded. This is reflected in reduced trade execution costs in the EU countries considered in the analysis.

Bid-ask spreads have decreased, in both domestic and Euro MTS markets, starting from end-2012 (Chart 10). They have stabilised on average at around 8bp for both EuroMTS and domestic

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[40] Our market liquidity indicators are based on trade data and do not allow to analyse the resilience dimension of market liquidity.

MTS, at a level higher compared to pre-financial crisis times. Bid-ask spreads have increased significantly at the end of the reporting period. It is worth noting that, in magnitude, bid-ask spreads for sovereigns are lower than those for corporate bonds – likely reflecting higher liquidity in the sovereign bond market.[41] Bid-ask spreads response to events is not homogeneous across countries (Chart A2 in Annex). Both average levels and dynamics are different across countries. In particular, during the sovereign debt crisis such heterogeneity reflected concerns related to debt sustainability for peripheral countries against the safe-heavens role assumed by core countries during this period. As expected, the bonds characterised by more volatile market liquidity are the ones more affected by stressed financial market conditions (Chart 11).

Chart 10

Bid ask spreads on EU sovereign bonds
Decrease from end 2012, flat in recent times

Note: Bid-ask spread as average bid ask spread throughout a month across ten EU markets, Domestic and Euro MTS, in %. 1Y MA = one-year moving average. Sources: MTS, ESMA.
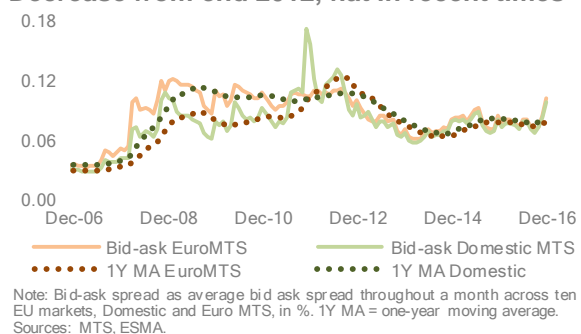
Chart 11

Bid-ask spreads by volatility bucket
High reaction to events for some bonds

Note: Average bid-ask spread by percentiles of bid-ask spread standard deviation. Sources: MTS, ESMA.
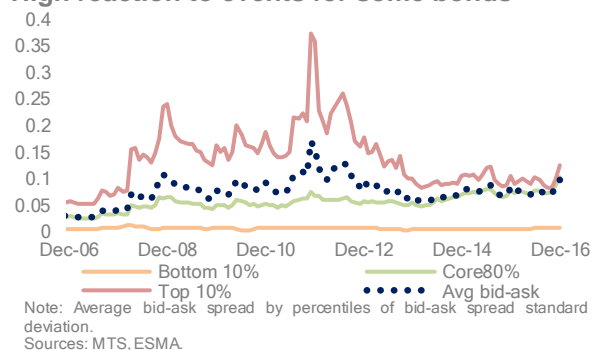
In terms of depth and breadth of the market the overall trend reflects previous findings: During the financial and sovereign crises, market liquidity decreased to then pick up since 2012.

Dynamics in both volumes traded and turnover show a decline in liquidity between 2008 and 2012, yet an amelioration thereafter (Chart 12 and Chart 13). Though significant differences exist among countries in terms of amount traded, volumes are generally higher for domestic MTS reflecting the MTS market structure: Across countries the size of the domestic MTS is bigger than the EuroMTS (see Table A.1 in Annex A.1). Trading volumes decreased in both markets during the financial crisis first and the sovereign bond crisis later and they started to increase in 2012. However, trading activity remained more contained for some large and more vulnerable markets that mainly operate on the domestic MTS platform. A steep decline was observed in the end of 2016, driven by a decrease in trading volumes in one large country.

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[41]   ESMA, EU corporate bond market liquidity – recent evidence, TRV No. 2, 2016; ESMA TRV No. 1 2017, Statistical Annex.

Chart 12

Volumes traded

Lower during crisis periods

Note: Aggregated monthly traded volume across ten EU markets, Domestic and Euro MTS, in EUR bn. 1Y MA = one-year moving average, Euro MTS on the right hand side.
Sources: MTS, ESMA.

Chart 13

Turnover ratio

Decline during crisis periods

Note: Aggregated monthly turnover ratio across ten EU markets, Domestic and Euro MTS, in EUR bn. 1Y MA = one-year moving average, Euro MTS on the right hand side.
Sources: MTS, ESMA.

The turnover ratio again reflects substantial heterogeneity across markets. Moreover, during crisis periods, there is a significant decrease in volumes in vulnerable countries, with especially very low secondary market liquidity in programme countries, and an increase in trading in core economies as heightened risk aversion pushed investor towards safer strategies.[42]

An alternative transaction-cost-based liquidity metric is the Roll measure, which is based on observed market prices or returns and calculated from the negative autocovariance of returns.[43] It assumes that with more negative return autocorrelation market illiquidity is higher. Chart 14 shows how periods of market stress between 2008 and 2012 correspond to higher market illiquidity.[44]

Chart 14

Roll measure

Oscillating at low levels following the crises

Note: Roll liquidity measure on the domestic and Euro MTS markets, normalised between 0 and 1. Higher levels indicate increased illiquidity. 6M MA = six-month moving average.
Sources: MTS, ESMA.

Chart 15

Amihud illiquidity coefficient

Abundant liquidity following the crises

Note: Amihud illiquidity coefficient on the domestic and Euro MTS markets, normalised between 0 and 1. Higher levels indicate increased illiquidity. 1Y MA = one-year moving average.
Sources: MTS, ESMA.

The indicators reported so far point at increased overall liquidity in the market, following the stress characterising the financial and sovereign crises. Similar conclusions can also be inferred by looking at price impact measures like the Amihud coefficient. Very high illiquidity was observed around September 2008, as well as in 2011 and 2012, the latter periods characterised by heightened stress in peripheral countries including IT (Chart 15). Since the end of 2012,

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[42] Programme countries were Greece, Ireland, Portugal and Cyprus. In April 2010, Greece became the first euro area country to request financial support from the European Commission ECB and IMF, followed by Ireland (December 2010), Portugal (May 2011), and Cyprus (May 2013). In addition, the IMF provided technical assistance to Spain in support of European financial assistance for the recapitalization of Spanish financial institutions.

[43] Shestag et al., 2016.

[44] The large spike in the EuroMTS relative to the domestic MTS platform might be linked to the structure of the domestic and EuroMTS platforms. The volumes of trade in the domestic markets are higher than that of EuroMTS, as specific conditions need to be met to quote on the latest, being inherently more liquid.

however, markets seem calmer and liquidity ampler. The Amihud illiquidity coefficient points at a relative increase in stress at the end of 2016 in the domestic MTS platform and, as for volumes, this may be driven by Italy.

The above dynamics are also confirmed by the average trade size developments: Declines corresponding to both the financial and sovereign bond crises are observed. This may reflect the reduction in volumes and increase in number of trades signalling reduced availability of market liquidity and the need for market agents to rely on smaller trades (Chart 17).

Finally, and as expected, our composite indicator, constructed by applying the principal component methodology, corroborates previous findings. Chart 16 shows lower liquidity in the EuroMTS relative to the domestic MTS platform except for the period corresponding to the peak of the sovereign bond crisis. This could be related to the fact that volumes on the domestic market are higher than those of EuroMTS, as specific conditions need to be met to quote on the latter. The sharp increase in liquidity stress on the domestic MTS platform in 2011 is believed to be related to the dynamics of the Italian market whose trades are concentrated on the domestic MTS platform. On the other hand, the dynamics within another large market, Germany, that is largely accepted as the benchmark for euro denominated government bonds, is not reflected in the developments affecting the domestic MTS platform as the volume traded on it is relatively low.[45]

Chart 16

Composite illiquidity indicator
Low illiquidity compared to crisis periods
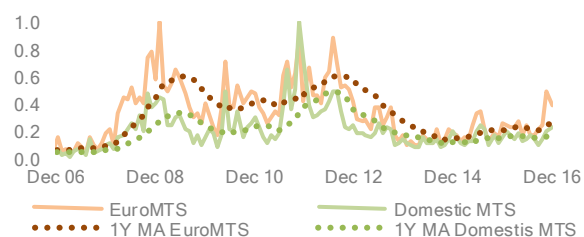
Note: Composite indicator of market liquidity in the sovereign bond market for the domestic and Euro MTS platforms, computed by applying the principal component methodology to four input liquidity measures (Amihud illiquidity coefficient, Bid-ask spread, Roll illiquidity measure and Turnover). 1Y MA = one-year moving average. The indicator range is between 0 (higher liquidity) and 1 (lower liquidity).
Sources: MTS, ESMA.

Chart 17

Average trade size
Lower in stress periods, yet recent increase
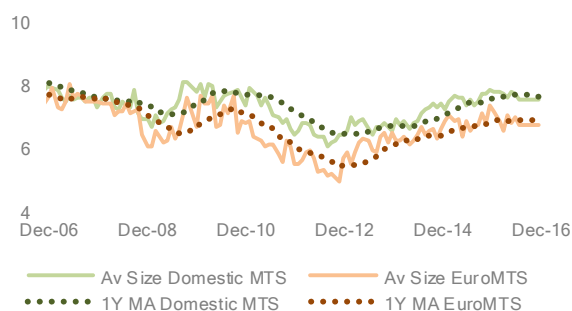
Note: Aggregated average trading size ratio across ten EU markets, Domestic and Euro MTS, EUR mln. 1Y MA = one-year moving average.
Sources: MTS, ESMA.

Corporate bond market

As mentioned above, for the corporate bond market segment, data on traded volumes are available only starting in 2014. Therefore, we calculate all the liquidity metrics based on traded volumes starting in 2014.

The average size of transactions has declined in the period under analysis from almost EUR 1.5mln in 2014 to less than EUR 1.1mln in 4Q15 before increasing again to almost EUR 1.5mln in 1Q16. The average daily trading volume declined from almost EUR 7bn in 2014 to EUR 5bn at the end of 2015. In 1Q16 the trading volume has almost tripled in the first month to EUR 14bn before declining to EUR 11bn at the end of February (Chart 18).

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[45]   Cheung *et al.*, 2005, document how the EUREX Bond trading platform is comparable to the MTS system.

Chart 18

Volume traded and average transaction size
Aggregate trading volume increased in 1Q16
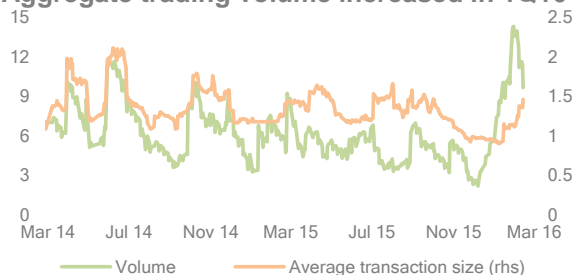
Note: Daily volumes of transactions on the constituents of the Markit IBoxx EU corporate bond aggregate index, in the current composition, EUR bn; Average transaction size for the corporate bond segment as the ratio of nominal amount of settlement instructions to number of settled instructions, in EUR mln.
Sources: Markit, ESMA.

Chart 19

Average monthly settlements by bond rating
Higher settlement activity for lower ratings
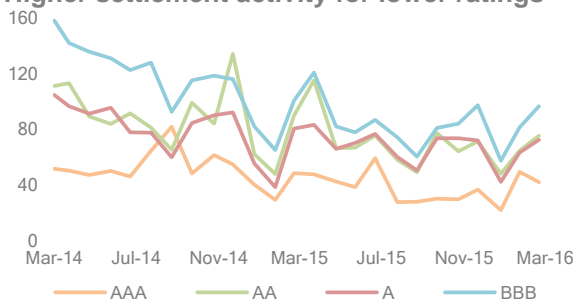
Note: Monthly average number of settlements, by rating classes.
Sources: Markit, ESMA.

Overall the average monthly number of settlements per bonds has declined in the analysed period across different rating categories.[46] Between March 2014 and March 2016 the decrease has been particularly relevant for lower rated bonds (-39%) while it has been less important for AAA bonds (-19%; Chart 19).[47]

Transaction costs are measured by bid-ask spreads showing how much a trader pays by buying and immediately selling a given security. This indicator points to lower liquidity with bid-ask spreads increasing in the last year by 12 basis points (Chart 19). The charts also show the difference in levels between crisis periods (EU financial and sovereign bond crisis).

Chart 20

Corporate bond bid-ask spread
Higher spreads than before the crisis

Note: EUR Markit iBoxx corporate bond index bid-ask spread, in %, computed as a one-month moving average of the iBoxx components in the current composition. Highest value indicates less liquidity.
Sources: IHS Markit, ESMA.

Chart 21

Zero trading days and turnover ratio
Decreasing turnover ratio
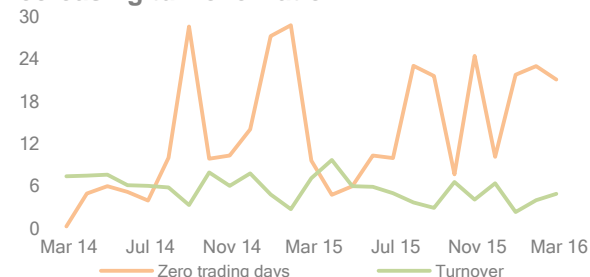
Note: Zero trading days is is calculated by focusing on the number of days within a month for which there was a missing record for volumes in our dataset. Turnover is the ratio of trading volume over outstanding amount, in %.
Sources: Markit, ESMA.

Transaction cost measures are complemented with volume-based measures in order to have a more complete picture of the market. As mentioned before due to data constraints, differently from sovereigns, volumes are only available starting from 2014. The average turnover ratio of the constituents of the Markit iBoxx index is therefore computed. The average turnover ratio declined from 7% in 2014 to 4% in 1Q16, signalling a deterioration in liquidity for the period under consideration (Chart 21), in a context of high volatility in EU financial markets.[48] Moreover,

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[46] From Markit Euroclear the following data are only available starting from 2014 and used as a proxy for trade number: the number of settled instructions generated from standard settlement instructions over a 30 days period.

[47] The decrease of number of settlements and transaction size coupled with the increase of trading volume may appear contradictory. However, these figures are not directly comparable. Trading volume is aggregated across bonds while the number of settlement and the average transaction size refer to an average bond in the sample.

[48] https://www.esma.europa.eu/sites/default/files/library/2016-1234_-_trv_no._2_2016.pdf.

we calculate the number of zero trading days.[49] The number of zero trading days increased by 3.5 percentage points between 2014 and 2015, and then remained broadly constant between 1Q15 and 1Q16 (Chart 21).

Overall, these findings point at somewhat diminished market liquidity. As already pointed out in other sections, it is once more worth noticing that the analysis focuses on a partial segment of the EU corporate bond market. The sample is based on the constituents of the Markit IBoxx aggregate EU corporate bond index for the last two years. This index includes only the most liquid segment of the IG market. Future research, integrated by extending the time-series, will be undertaken to ensure higher robustness of the current results and deepen the analysis.

To capture aspects related to the depth and resilience of the market we use the Amihud illiquidity coefficient which measures the average price impact on a given day and the Bao Pan Wang illiquidity measure which estimates the magnitude of price reversals (Chart 22). These estimates, based on our limited sample, support the previous findings: Several episodes of increasing illiquidity can be detected in the analysed period corresponding to phases of high volatility in EU financial markets.

Using aggregate measures of illiquidity we can capture the systematic component of bond illiquidity which can only be singled out when many bonds become illiquid around the same time. In 4Q15 and 1Q16 we observe that both the Amihud coefficient and the Bao Pan Wang measures point to an increase in market illiquidity which is in line with the increased volatility observed in the market (Chart 23).[50]

Chart 22
Amihud index and Bao Pan Wang measure
Periods of increasing liquidity
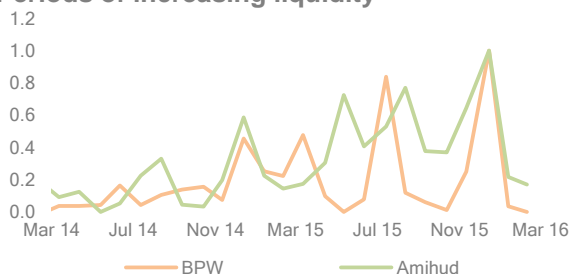
Note: Bao Pan Wang and Amihud illiquidity indicators for the constituents of the Markit IBoxx corporate bond index, normalised between 0 and 1. Higher levels indicate increased illiquidity.
Sources: Markit, ESMA.

Chart 23
The composite liquidity measure
Episodes of decreasing liquidity
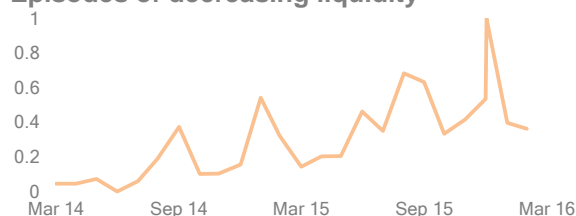
Note: Composite indicator of market liquidity in the corporate bond market for the constituents of the Markit IBoxx corporate index, computed by applying the principal component methodology to four input liquidity measures (Amihud illiquidity coefficient, bid-ask spreads, Bao Pan Wang illiquidity indicator, zero trading days). The indicator range is between 0 (higher liquidity) and 1 (lower liquidity).
Sources: Markit, ESMA.

As expected, the figures reported in Chart 24 show a high positive correlation between Amihud and Bao Pan Wang measures while the turnover ratio is negatively correlated with the Amihud index. Overall turnover is not significantly correlated with other measures except the Amihud index (by construction).[51]

[49] Zero trading days are calculated by focusing on the number of days within a month for which there was a missing record for volumes in our dataset.

[50] Further analysis is required to better investigate the comovement of this aggregate illiquidity measure with the aggregate market conditions.

[51] Both the Amihud and the turnover ratio are a function of volumes traded.

Chart 24
Correlation of market liquidity measures

	Bid-Ask	BPW	Amihud	ZTD	Turnover
Bid-Ask	1				
BPW	0.17	1			
Amihud	0.49**	0.50**	1		
ZTD	0.29	0.33	0.44**	1	
Turnover	-0.33	-0.33	-0.75**	-0.57	1

Note: BPW= Bao Pan Wang measure, ZTD= zero trading days. ** indicates a level of significance of 5%.
Sources: ESMA.

As already done for the sovereign bond market segment, we use principal component analysis to build a composite measure of market liquidity in EU corporate bond market (Chart 23). The composite measure is based on the Amihud index, Bao Pan Wang measure, bid-ask spreads and zero trading days.[52] The composite indicator shows that market liquidity has generally deteriorated in the last two years with a spike of illiquidity at the end of 4Q15 and beginning of 1Q16 in line with overall increase in volatility in financial markets.

4. The drivers of market liquidity: econometric results

In this section, we run an econometric exercise aimed at identifying the drivers of secondary market liquidity in both sovereign bond and corporate bond markets. Some of the indicators developed in section 3, i.e., the composite indicator for sovereign bond and the bid-ask spread for corporate bond market,[53] are the dependent variables that we try to explain through our model. The explanatory variables we include in our exercise are related to both bond characteristics and financial market developments.

Sovereign bond markets

Concerning the sovereign bond market we focus our analysis on domestic MTS markets that, as described in section 2, include all sovereign bonds in the sample. In line with previous literature on the topic (for instance, Galliani et al., 2014), we assume that market liquidity is related to both bond-specific characteristics and broad financial market conditions. Moreover, as already mentioned, the period we analyse includes the unconventional monetary policy of the ECB and, in particular, the ECB quantitative easing (QE) from the beginning (ECB Public sector Purchase Programme started on 9 March 2015). We use our econometric exercise to get first insights on the impact of the ECB QE on sovereign bond market liquidity.

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[52] Turnover is not included in the composite measure given the absence of correlation with other liquidity measures and the fact that the aspects related to volume are included, by construction, in the Amihud coefficient.

[53] The dependent variable for coporate bond markets is bid-ask spread due to data availability: the time series we have for the composite indicator is too short.

We employ panel data analysis to analyse the drivers of market liquidity in EU sovereign bond markets using the following simple model:[54]

$$MktLiq_{it} = \alpha + \beta outstanding_{it} + \delta EUERObenchmark_{it} + \vartheta ECB\_PPP_t + \gamma mkt_t + \varepsilon_{it}$$

Where:

$MktLiq_{it}$: Composite illiquidity indicator (Chart 15)[55].

$Outstanding_{it}$: Logarithm of the outstanding amount for each bond (Thomson Reuters Eikon).

$EUERObenchmark_{it}$: Dummy variable that takes the value of 1 when the bond has a benchmark status (MTS database).

ECB_PPP_t : Dummy variable that takes the value of 1 after the start of the ECB Public sector purchase programme (9 March 2015).

Mkt_t : Vector of the following market controls:

- *Vstoxx 3M*: The VSTOXX Indices are based on EURO STOXX 50 real time options prices and are designed to reflect the market expectations of near-term up to long-term volatility by measuring the square root of the implied variance across all options of a given time to expiration (Thomson Reuters Datastream).
- *EUESI*: The Economic Sentiment Indicator (ESI) is a composite indicator made up of five sectoral confidence indicators with different weights: Industrial confidence indicator, services confidence indicator, consumer confidence indicator, construction confidence indicator, retail trade confidence indicator. Confidence indicators are arithmetic means of seasonally adjusted balances of answers to a selection of questions closely related to the reference variable they are supposed to track (e.g. industrial production for the industrial confidence indicator). The ESI is calculated as an index with mean value of 100 and standard deviation of 10 over a fixed standardised sample period (European Commission).
- *Stress-Euribor*: interaction between the Euribor rate and the dummy Stress. The dummy Stress takes the value of one when the selected interbank stress indicator exceeds its median. The interbank stress indicator is defined as the spread between the three-month Euribor and the three-month OIS rate, which measure the degree of tension in terms of liquidity and perceived credit risk. [56]

We expect lower market liquidity for bonds having smaller outstanding amounts and without benchmark status. Additionally, we expect market liquidity to decrease when market uncertainty (measured by Vstoxx, i.e. 3M volatility expectations) is higher and when market confidence (measured by EUESI) is lower. Finally, we expect that market liquidity deteriorates in period of stress in the financial markets, measured by the variable Stress-Euribor.

We apply our regression model to the whole sample of sovereign bonds to estimate the drivers of market liquidity using two different econometric specifications: in the first one the dependent variable is the composite illiquidity indicator, in the second one it is the bid-ask spread. For clarity of presentation, results reported are based on the composite illiquidity indicator, as the

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[54]   The econometric exercise is based MTS daily data for domestic platforms. We ran the same regression on the EuroMTS platform and we found equivalent results.

[55]   We run the same econometric exercise using as dependent variable the bid ask spread. We report the results only for the first set of regressions (Table B.1). Results are available for all the other model specifications.

[56]   Galliani et al (2014) follow a similar approach to include stressed financial markets conditions in the econometric analysis.

outcomes are similar, In both econometric specifications, we observe that market liquidity is higher for benchmark bonds having larger outstanding amounts (though the latter result is not statistically significant when the ECB quantitative easing is taken into account in the specification where the dependent variable is the composite illiquidity indicator). Market uncertainty and stress in financial markets affect liquidity in sovereign bond markets, as expected, as shown by the positive coefficients of the variables Vstoxx 3M and Stress-Euribor. Better confidence in the markets seems to be positively correlated with market liquidity as reflected by the negative sign of the variable EUESI (though the latter result is not statistically significant when the ECB quantitative easing is taken into account in the specification where the dependent variable is the composite illiquidity indicator). Finally, the ECB Asset Purchase Programme that started in March 2015 had a positive effect on market liquidity as shown by the negative sign of the variable ECB QE start (Table B1 in Annex B).

As described in previous sections, sovereign bond markets are different across countries in the EU. Therefore we run the same econometric exercise in each country in our sample using composite illiquidity indicator as dependent variable[57]: Austria, Belgium, Germany, Spain, Finland, France, Ireland, Italy, Netherlands, Portugal (Table B2 in Annex B). Results confirm that larger outstanding amounts are related to more abundant market liquidity across countries with the exception of Ireland and Italy. However, when the crisis period is not included in the regressions the expected relation between outstanding and liquidity is confirmed for Ireland. For Italy, the result can be driven by the high incidence of larger amounts outstanding of bonds characterised by long maturity. Across countries, market illiquidity tends to be more severe in stressed financial market conditions as clearly shown by the positive and mostly significant coefficients of both implied market volatility (Vstoxx 3M)[58] and the stress-Euribor variables. The EU confidence variable seems to be less relevant as national confidence indicators matter more.[59] Benchmark bonds are more liquid, as indicated by the negative and statistically significant coefficients, only for Finland and Italy. The latest result can be related to the fact that these sovereign bond market have a relatively higher volume of trading in benchmark bonds. ECB QE seems to improve market liquidity in sovereign bond markets, across countries.

Then, we analyse if the identified relations hold when we consider different maturity buckets separately. In particular, we split the sample according to the following bond maturity buckets: lower than 1.5 years, between 1.5 years and 5.5 years, between 5.5 years and 12 years and higher than 12 years. The estimates broadly confirm aggregated sample results, with a few differences (table B.3 in Annex B). Bonds with larger outstanding amounts are confirmed to be more liquid in a statistically significant way, except for bonds with longest maturity. Bonds with long maturities may to a large part be part of buy-and-hold investor portfolios.[60] Stressed financial markets seem to reduce market liquidity in sovereign bond markets across maturities, with more robust results for the variables volatility and stress-Euribor. Market liquidity seems to be lower when market volatility is high in particular for bonds with medium and long term maturity. While for bonds with a maturity lower than 1.5 years, the main liquidity driver is the amount of outstanding, market variables seem to have a marginal impact on liquidity in this

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[57]   We run all the regressions using as dependent variable the bid ask spread and we get equivalent results. Results are available from the authors on request.

[58]   The only exception to the positive relation between volatility and market illiquidity is represented by Spanish sovereign bond markets. However, the stress related to the interbank market confirms also for Spain that market liquidity tends to disappear in stressed financial markets conditions.

[59]   We run the same regressions including national confidence indicators and, as expected, we observed the expected negative relationship.

[60]   For bonds with medium-long term maturity the coefficient is no more statistically significant.

case. ECB QE is confirmed to be related to more abundant market liquidity in sovereign bond markets and the result is robust when different maturities are taken into account.

Finally, we run the same regression to different samples of bonds whose market liquidity is characterised by different levels of volatility (Table B.4 in Annex B). More precisely we apply the same econometric exercise to the bonds having more stable market liquidity (below 10th percentile), to the core 80%, and to the ones characterised by more volatile market liquidity (above 90th percentile). Results are consistent with previous regressions and more robust for bonds having market liquidity whose volatility is between the 10th lowest percentile and the highest 10th percentile. Bonds characterised by more volatile market liquidity, proxied by the composite illiquidity indicator, tend to be greatly affected by stressed financial markets. Overall results are not confirmed for the smaller sample of bonds whose market liquidity has very low volatility (lowest 10th percentile).

Corporate bond markets

With reference to the corporate bond market, in line with the econometric exercise we investigate the relation between market liquidity and and both bond specific and broad financial market conditions. In the tables included in the article, we use as market liquidity proxy for corporate bonds the bid ask spreads. We run all the regressions using the composite indicator we developed for corporate bond markets (Chart.23). However, due to data availability our composite indicator is built on a very short time series reducing its statistical robustness. Therefore, for corporate bond markets our baseline model is based on bid ask spreads. We investigate also the impact of the ECB QE, Corporate Sector Purchase Programme (CSPP), started on 8 June 2016.

Taking into account different market characteristics and data availability, we apply a slightly different model to analyse the drivers of market liquidity in the corporate bond segment[61]:

$$MktLiq_{it} = \alpha + \beta bond_{it} + \gamma mkt_t + \vartheta ECB\_CSPP_t + \varepsilon_{it}$$

Where:

$MktLiq_{it}$ is proxied by the bid-ask spread.[62]

$Bond_{it}$ includes bond characteristics:

- The outstanding amount of the bond defined as the natural logarithm of volume in EUR;
- Credit class, proxied by the variable rating, that is an index variable from 1 to 4, respectively AAA, AA, A, BBB.[63]

mkt_t is the vector of the market controls already described above in the sovereign bond empirical chapter (VStoxx 3M, the EU economic sentiment indicator, Stress-Euribor indicator).

ECB_CSPP_t : Dummy variable that takes the value of 1 after the start of the ECB CSPP on 8 June 2016.

In line with the sovereign bond market, we expect lower market liquidity for bonds having smaller outstanding amounts Additionally, we expect market liquidity to decrease when market uncertainty (measured by Vstoxx, i.e. 3M volatility expectations) is higher and when market confidence (measured by EUESI) is lower. Finally, we expect that market liquidity deteriorates

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[61]   The sample includes all corporate bonds with maturity lower than 12 years. We dropped the very few bonds having longer maturity (less than 0.5% of the observations).

[62]   Results obtained as dependent variable our synthetic liquidity indicator are available on request.

[63]   We have not included rating information in the sovereign bond regression, the reason being that ratings for bonds correspond to issuers' rating, i.e. country governments. The regressions by country address geographical differences for sovereign bond markets.

in period of stress in the financial markets, measured by the variable Stress-Euribor. We do not have a clear expectation for the impact of ECB QE on corporate bond market liquidity. It may be positive as the demand for corporate bonds increases but it may also be negative if a buy-and-hold-attitude by investors prevails and if corporate bonds become scarce in secondary markets.

For the corporate bond market segment, results for the whole sample and for the NFC subsample show that, as in the case of sovereign bonds, larger outstanding amounts are generally related to more abundant market liquidity; for the financial sector, the sign remains negative but the coefficient loses statistical significance. Moreover, as expected, consistently with the sovereign bond markets regressions, and in line with Galliani et al. (2014), better economic conditions and lower market risk, represented respectively by the economic sentiment indicator, VSTOXX and Euribor spreads, are related to better market liquidity. This result is in line with the worsening of market liquidity in stressed financial market conditions observed in section 3 looking at corporate bond market liquidity indicators. Both results seem to point to a broadly reduced resilience of corporate bond market liquidity. Credit quality does not seem to be related in a statistically significant way to market liquidity. Probably the lack of significance of rating categories is related to the sample used, including only investment grade bonds.[64] Overall, aside from outstanding amounts, these results are confirmed also when distinguishing between market sectors, namely financials and non-financials (Table C.1).[65] Finally, we analyse the impact of the ECB Corporate Sector Purchase Programme (CSSP) started in June 2016. Differently for findings for the sovereign segment, the ECB CSSP seems to be negatively related to market liquidity. As mentioned earlier, a priori we do not have an unique expectation about the impact of the ECB CSPP in corporate bond markets in the first 6 months of the programme. As of 31 December 2016, the Eurosystem had purchased almost EUR 52bn of these bonds, of which 14% on the primary market and 86% on the secondary market. This compares with an outstanding volume of around EUR 1.2tn in euro-denominated non-bank corporate IG bonds from EA issuers, i.e. asset purchases make up less than 5% of outstanding volumes.[66] Notwithstanding the relatively low weight in volume terms of the holdings at the end of 2016 it seems that a buy and hold attitude of the investors as well as an increased scarcity effect of the bonds prevail, at least in the first six months of the CSPP .[67]

We apply the same econometric model to different samples characterised by diverse levels of volatility of market liquidity. More precisely, consistently with the sovereign bond analysis, we run the same regression on the bonds having more stable market liquidity (below 10th percentile), on those in the core 80%, and on the ones characterised by more volatile market liquidity (above 90th percentile). As before we run the same regression for the overall sample and we distinguish between financial and non-financial corporate bonds. Previous findings are overall confirmed. Table C.2 (Panel A, Panel B and Panel C) report results for the different volatility buckets. Looking at the overall sample (Panel A). Bonds characterised by larger outstanding seem to be related to more abundant market liquidity conditions, measured by bid-ask spreads. This result does not hold for corporate bonds characterised by very volatile market liquidity (10% of the total sample). For this group of bonds stressed financial market conditions

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[64]   Markit database includes only investment grade bonds; Data on high yields bonds are not available.

[65]   A similar analysis considering additional variables trying to proxy for age or maturity has been carried out. Yet results come out not to be significant and therefore not reported. Further research is planned in order to gather more comprehensive evidences conditional on the availability of additional databases in the future.

[66] See https://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html#cspp and ESMA Trends Risks and Vulnerabilities Report No. 1 2017 for more details on ECB CSPP.

[67]   We check the Corporate Sector Purchase Programme impact on market liquidity in all the regression specifications described in this section and we obtain consistent results. Results are not displayed in the tables but they are available on request.

are the main driver of market liquidity pointing at lower market resilience. As in the first estimates, rating categories do not seem to be related in a statistically significant way with market liquidity. Moreover, it seems that lower-rated bonds, though in the investment grade category, are more liquid than better-rated ones. This result may be explained by the need of investors to hold higher-rated bonds to improve the quality of the portfolios.

Also, we run the same regression separately for samples characterised by different maturity buckets (measured in number of years: less than two years, between two and five years, between five and ten years, between ten and thirty years). Again, we distinguish between the whole sample, NFCs and financials (Table C.3). Results are overall confirmed in the whole sample and more robust for bonds having longer maturity (more than five years)[68]: larger bond outstanding and good market and financial conditions seem to be related to more abundant market liquidity. Rating categories do not seem to drive market liquidity for corporate bonds: the results are confirmed when different maturities are taken into consideration. When we look at financial corporate bonds and non-financial corporate bonds, all results are broadly confirmed, in particular the ones related to the potential disappearance of market liquidity in stressed financial markets.

5. Conclusions

Episodes of short-term volatility and liquidity stress across several markets over the past few years have increased concerns about the worsening of secondary market liquidity, in particular in the fixed income segment. The contribution of this paper to the ongoing debate around market liquidity is twofold.

First, we provide a broad overview of market liquidity across several EU sovereign bond and corporate bond markets, reporting on different dimensions of market liquidity (tightness, breadth, depth and resilience) through several market liquidity proxies and a composite liquidity index. We construct a liquidity index based on PCA to aggregate several market liquidity measures and proxies for liquidity and estimate a multivariate regression model to identify the main factors driving fixed income market liquidity in ordinary times as well as in times of market stress.

Overall, our findings show that market liquidity has been relatively ample in the sovereign segment, potentially also due to the effects of supportive economic policies over more recent years. This is different from our findings in the corporate bond market, where in recent years we did not find systematic and significant drop in market liquidity but we observed episodes of decreasing market liquidity when market conditions deteriorated.

The second contribution of this paper builds on an econometric analysis we use to investigate the drivers of market liquidity in these markets. We find that in the sovereign bond segment, bonds that have a benchmark status and are characterised by larger outstanding amounts tend to be more liquid while market volatility is negatively related to market liquidity. Outstanding amounts are the main bond-level drivers in the corporate bond segment.

Moreover, in both segments, overall stressed financial markets conditions seem to be related to lower market liquidity in fixed income markets. Results hold when different samples (in terms

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[68]   Our sample is underrepresented for short-term maturities corporate bonds: This emerges clearly looking at the negligible number of bonds with less than 2-year maturity and the related negligible number of observations.

of geography, maturity and market liquidity volatility) are taken into account in sovereign bond and corporate bond markets.

With reference to corporate bond markets, the sensitivity of bond liquidity to bond-specific and market factors is larger when financial markets are under stress. In particular, bonds characterised by more volatile market liquidity are found to be more vulnerable in periods of market stress. This empirical result is consistent with the market liquidity indicators developed for corporate bonds pointing at episodes of decreasing market liquidity when wider market conditions deteriorate.

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Annex A: Descriptive statistics

A.1

Sovereign bonds by country, number and volume*

Differences across countries and market type

	Number of bonds		Traded volume	
	EuroMTS	Domestic	EuroMTS	Domestic
AT				
M < 1				
1<M<5	3			
5<M<10	10	10	8.6	48.1
10<M<30	22	22	11.0	80.4
BE				
M < 1		124		908.0
1<M<5	2	23	17.4	542.0
5<M<10	11	13	25.4	351.0
10<M<30	24	32	24.3	303.0
DE				
M < 1	203	217	2.0	72.2
1<M<5	57	58	19.3	73.3
5<M<10	41	48	14.5	84.8
10<M<30	35	53	17.0	104.0
ES				
M < 1	21	25	18.4	165.0
1<M<5	118	177	28.0	204.0
5<M<10	16	79	34.6	59.5
10<M<30	32	135	27.9	53.8
FI				
M < 1				
1<M<5	1	1	22.5	43.5
5<M<10	10	10	30.9	177.0
10<M<30	16	17	31.4	225.0
FR				
M < 1	482	510	19.3	193.0
1<M<5	81	91	23.6	146.0
5<M<10	29	31	39.1	200.0
10<M<30	48	68	23.1	171.0
IE				
M < 1	16	47	1.7	20.8
1<M<5	6	7	8.5	54.3
5<M<10	4	4	23.3	62.3
10<M<30	12	12	14.3	61.8
IT				
M < 1	173	225	57.2	1150.0
1<M<5	172	195	64.0	1210.0
5<M<10	57	68	72.0	945.0
10<M<30	49	58	60.2	788.0
NL				
M < 1	51	153	35.0	498.0
1<M<5	11	12	40.6	333.0
5<M<10	8	8	59.3	312.0
10<M<30	18	28	47.9	273.0
PT				
M < 1	20	69	26.5	291.0
1<M<5	11	24	46.6	300.0
5<M<10	5	5	36.3	254.0
10<M<30	17	21	41.7	301.0

Note: *M = Maturity in years. Volumes, monthly average, in EUR mln.

A.2   Bid-ask spread time series, by country
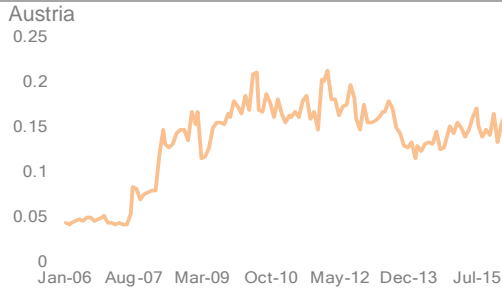
Austria

Note:Average bid-ask spead.
Sources:MTS, ESMA.

Belgium

Note:Average bid-ask spread.
Sources:MTS, ESMA.

Germany

Note:Average bid-ask spead.
Sources:MTS, ESMA.

Spain

Note:Average bid-ask spread.
Sources:MTS, ESMA.

Finland

Note:Average bid-ask spead.
Sources:MTS, ESMA.

France

Note:Average bid-ask spead.
Sources:MTS, ESMA.

Ireland

Note:Average bid-ask spead. Ireland has been part of the EU-IMF program of
financial support.
Sources:MTS, ESMA.

Italy
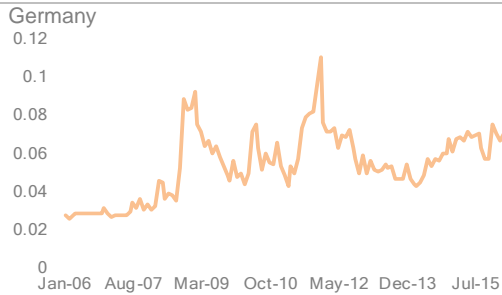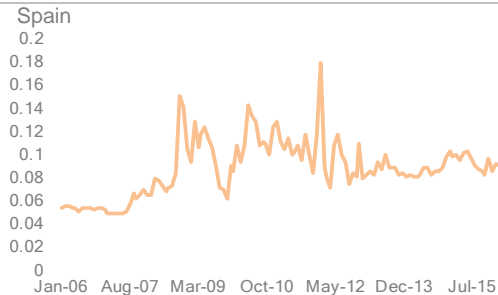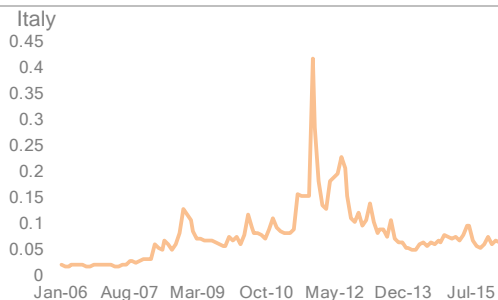
Note:Average bid-ask spead.
Sources:MTS, ESMA.

Netherlands

Note:Average bid-ask spead.
Sources:MTS, ESMA.

Portugal

Note:Average bid-ask spead. Ireland has been part of the EU-IMF program of
financial support.
Sources:MTS, ESMA.

Note: Sources: MTS, ESMA.

A.3

Sovereign bonds by country, bid-ask spreads

Descriptive statistics by bottom 10% and top 10% of the distribution of the bid-ask spread standard deviation

	Top 10% - bid-ask spread standard deviation				Bottom 10% - bid-ask spread standard deviation			
	Number of ISINs	Maturity	Avg. spread	Avg. monthly volume	Number of ISINs	Maturity	Avg. spread	Avg. monthly volume
AT								
M < 1								
1<M<5								
5<M<10	9	9.4	0.1	64.9				
10<M<30	5	15.3	0.2	57.7				
BE								
M < 1					23	1.0	0.004	1290.3
1<M<5								
5<M<10	13	9.5	0.1	346.5				
10<M<30	8	17.3	0.2	189.9				
DE								
M < 1					11	0.6	0.006	312.4
1<M<5					1	2.0	0.019	88.8
5<M<10	3	9.6	0.1	300.3				
10<M<30								
ES								
M < 1					5	1.0	0.007	1710.9
1<M<5								
5<M<10	10	10.3	0.1	149.6				
10<M<30	9	15.2	0.2	142.0				
FI								
M < 1								
1<M<5	1	5.5	0.1	158.5				
5<M<10	8	9.8	0.1	206.0				
10<M<30	2	16.0	0.2	234.5				
FR								
M < 1					14	0.6	0.007	155.9
1<M<5					1	5.0	0.024	163.6
5<M<10	15	10.4	0.1	167.5				
10<M<30	9	16.2	0.2	161.4				
IE								
M < 1								
1<M<5								
5<M<10	3	10.9	0.1	38.5				
10<M<30	2	16.6	0.1	63.2				
IT								
M < 1					81	0.7	0.004	1534.1
1<M<5	3	5.4	0.2	927.9	8	2.7	0.004	2342.4
5<M<10	31	8.5	0.1	862.1	5	9.4	0.003	1485.0
10<M<30	12	15.9	0.1	591.4				
NL								
M < 1					10	0.5	0.004	550.7
1<M<5								
5<M<10	6	10.3	0.1	330.2				
10<M<30	2	18.1	0.2	151.9				
PT								
M < 1								
1<M<5	1	5.4	0.1	147.8				
5<M<10	6	10.4	0.1	294.3				
10<M<30	1	16.2	0.1	205.0				

Note: M = Maturity in years. Volumes, monthly average, in EUR mln.

Source: MTS, ESMA.

A.4
Corporate bonds – Panel A - All sample

	Number of bonds	Bid-Ask Spread	Traded Volume	Age	Rating
	Volatility Top 10%				
Less than 1					
Between 1 and 3	14	1.48	519	0.82	3.37
Between 3 and 5	17	1.30	684	1.73	3.02
Between 5 and 10	134	1.26	600	3.65	3.18
Between 10 and 30	80	1.44	575	4.99	3.16
Higher than 30	143	2.27	573	4.57	3.36
	Volatility Core 80%				
Less than 1	6	0.32	939	0.26	3.43
Between 1 and 3	227	0.38	768	0.97	3.02
Between 3 and 5	527	0.40	744	1.85	3.11
Between 5 and 10	1,211	0.53	712	3.18	3.21
Between 10 and 30	317	0.81	671	4.32	3.12
Higher than 30	817	0.56	743	3.00	3.45
	Volatility Bottom 10%				
Less than 1	1	0.12	761	0.30	4.00
Between 1 and 3	41	0.15	782	0.95	3.27
Between 3 and 5	92	0.17	713	2.16	2.97
Between 5 and 10	109	0.21	733	3.86	3.17
Between 10 and 30	7	0.22	962	5.76	2.63
Higher than 30	138	0.31	806	1.35	3.17

Note: Number of bonds=number of ISINs; Traded volume, Bid-Ask Spread, Age and Rating are computed as average by maturity type. Traded volume, EUR mln, Age expressed in years, Rating is an index values from 1 =AAA to 4 =BBB. Top 10%, Core 80%, Bottom 10% computed from the bid-ask spread standard deviation.
Sources: Markit, ESMA.

Corporate bonds – Panel B By sector: Financials and NFCs
Descriptive statistics – Corporate bonds by maturity bucket

	Financials					Non Financial Corporations				
	Number of bonds	Bid-Ask Spread	Traded Volume	Age	Rating	Number of bonds	Bid-Ask Spread	Traded Volume	Age	Rating
Volatility Top 10%										
Less than 1										
Between 1 and 3	13	1.52	516	0.80	3.30	1	1.13	541	1.00	4.00
Between 3 and 5	12	1.32	777	1.65	2.70	5	1.25	486	1.92	3.66
Between 5 and 10	91	1.33	654	3.68	2.89	43	1.12	482	3.59	3.76
Between 10 and 30	66	1.45	580	4.87	2.99	14	1.42	557	5.48	3.85
Higher than 30	133	2.37	572	4.46	3.30	11	1.11	587	5.97	3.97
Volatility Core 80%										
Less than 1	3	0.36	1165	0.26	3.17	3	0.29	726	0.26	3.68
Between 1 and 3	137	0.41	835	0.97	2.80	90	0.33	666	0.97	3.38
Between 3 and 5	242	0.41	832	1.89	2.77	286	0.39	657	1.81	3.45
Between 5 and 10	408	0.55	844	3.36	2.80	804	0.51	651	3.10	3.40
Between 10 and 30	107	0.77	756	4.45	2.93	210	0.83	639	4.27	3.19
Higher than 30	290	0.53	836	2.78	3.30	527	0.58	698	3.11	3.53
Volatility Bottom 10%										
Less than 1	1	0.12	761	0.30	4.00					
Between 1 and 3	26	0.15	781	0.86	3.30	15	0.15	782	1.04	3.24
Between 3 and 5	53	0.17	765	1.95	2.75	39	0.16	644	2.43	3.28
Between 5 and 10	40	0.22	813	3.04	2.96	69	0.20	682	4.37	3.31
Between 10 and 30	5	0.25	841	3.84	2.83	2	0.15	1257	10.87	2.00
Higher than 30	64	0.28	882	1.47	3.06	74	0.36	703	1.18	3.32

Note: Number of bonds=number of ISINs; Traded volume, Bid-Ask Spread, Age and Rating are computed as average by maturity type. Traded volume, EUR mln, Age expressed in years, Rating is an index values from 1 =AAA to 4 =BBB. Top 10%, Core 80%, Bottom 10% computed from the bid-ask spread standard deviation.
Sources: Markit, ESMA.

Annex B: Sovereign bond markets - panel estimates

Table B1: Sovereign bond market whole sample

B.1

VARIABLES	(1) Y=composite illiquidity indicator	(2)	(3) Y=average bid-ask spreads	(4)
Outstanding	-0.314***	-0.0745	-0.0198***	-0.00929***
	(0.0455)	(0.0492)	(0.00252)	(0.00305)
Volatility	0.0124***	0.0295***	0.000508***	0.00124***
	(0.00280)	(0.00307)	(0.000106)	(0.000107)
EU confidence	-0.0122***	-0.00139	-0.00115***	-0.000673***
	(0.00182)	(0.00164)	(9.31e-05)	(7.03e-05)
Stress_Euribor	0.987***	0.847***	0.0291***	0.0219***
	(0.0608)	(0.0529)	(0.00280)	(0.00230)
Eurobenchmark flag	-1.205***	-1.140***	-0.0821***	-0.0793***
	(0.288)	(0.275)	(0.0230)	(0.0224)
ECB QE start		-0.727***		-0.0368***
		(0.0492)		(0.00310)
Constant	4.538***	1.030**	0.406***	0.254***
	(0.460)	(0.467)	(0.0291)	(0.0272)
Observations	17,967	17,967	44,261	44,261
R-squared	0.169	0.201	0.158	0.181
Number of isin	1,989	1,989	2,426	2,426

Note: Sample period between January 2006 and December 2016. Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1.Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table B2: Sovereign bond markets by country (Y= Composite illiquidity indicator)

B.2										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	AT	BE	DE	ES	FI	FR	IE	IT	NL	PT
Outstanding	-0.422	-0.155***	-0.347***	-0.0972	-0.107	-0.258***	0.406	0.513***	-0.142**	-0.366***
	(0.319)	(0.0459)	(0.119)	(0.128)	(0.371)	(0.0738)	(0.674)	(0.187)	(0.0554)	(0.0938)
Volatility	0.0736***	0.0219***	0.0419***	-0.0328**	0.0666***	0.0264***	0.0290	0.0274***	0.0310***	-0.00533
	(0.0207)	(0.00580)	(0.00613)	(0.0136)	(0.00898)	(0.00545)	(0.0249)	(0.00630)	(0.00734)	(0.00724)
EU confidence	0.00657	0.00597	0.00530*	-0.0307***	0.0124**	0.000711	-0.0220	-0.00294	-0.00169	-0.0226***
	(0.00975)	(0.00423)	(0.00297)	(0.00749)	(0.00578)	(0.00276)	(0.0201)	(0.00376)	(0.00357)	(0.00440)
stress_EURIBOR	0.901***	0.780***	0.734***	0.712***	1.244***	1.096***	1.576**	0.845***	0.543***	0.598***
	(0.161)	(0.134)	(0.0875)	(0.204)	(0.240)	(0.0914)	(0.685)	(0.128)	(0.135)	(0.136)
Eurobenchmark flag	0.0540		0.00916	-0.0406	-0.812***	-0.0649		-2.366***	0.0448	0.00722
	(0.285)		(0.0529)	(0.0895)	(0.191)	(0.119)		(0.455)	(0.0847)	(0.0303)
ECB QE start	-0.514***	-0.783***	-0.821***	-0.468***	-0.733***	-0.432***	-0.0940	-1.065***	-0.682***	-0.258**
	(0.184)	(0.0943)	(0.112)	(0.147)	(0.181)	(0.0904)	(0.184)	(0.120)	(0.151)	(0.0995)
Constant	2.312	-0.116	1.925	5.260***	-0.751	1.754**	-0.661	-3.454*	0.293	4.981***
	(3.715)	(0.580)	(1.208)	(1.319)	(3.243)	(0.811)	(7.463)	(1.864)	(0.703)	(0.961)
Observations	553	1,928	2,643	1,488	655	3,422	207	4,753	1,649	669
R-squared	0.234	0.265	0.245	0.121	0.472	0.264	0.107	0.224	0.305	0.365
Number of isin	29	185	236	168	27	555	17	499	187	86

Note: Sample period between January 2006 and December 2016. Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1.Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table B3: Sovereign bond markets by maturity (Y= composite illiquidity indicator)

B.3				
	(1)	(2)	(3)	(4)
VARIABLES	mat<=1.5	1.5<mat<=5.5	5.5<mat<=11.9	mat>11.9
Outstanding	-0.0770***	-0.278***	-0.0438	0.327**
	(0.00442)	(0.0982)	(0.115)	(0.144)
Volatility	-0.000104	0.00821*	0.0325***	0.0434***
	(0.000400)	(0.00478)	(0.00395)	(0.0123)
EU confidence	-0.000531	-0.00368	0.00472**	-0.00551
	(0.000674)	(0.00273)	(0.00212)	(0.00584)
Stress_Euribor	0.0204*	0.560***	1.141***	1.383***
	(0.0107)	(0.0770)	(0.0816)	(0.148)
Eurobenchmarkflag	0.000185	-1.396**	-2.988***	-0.367
	(0.00875)	(0.618)	(0.616)	(0.225)
ECB QE start	-0.0469***	-0.536***	-0.805***	-0.681***
	(0.00873)	(0.0823)	(0.0656)	(0.148)
Constant	-0.371***	3.625***	2.085*	-1.312
	(0.0790)	(0.985)	(1.146)	(1.468)
Observations	4,569	3,481	7,907	2,010
R-squared	0.202	0.229	0.286	0.171
Number of isin	1,257	301	357	74

Note: Sample period between January 2006 and December 2016. Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1.Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table B4: Sovereign bond markets by market volatility (Y= composite illiquidity indicator)

B.4			
	(1)	(2)	(3)
VARIABLES	top 10%	bottom 10%	core 80%
Outstanding	0.237	0.0228	-0.150***
	(0.163)	(0.0523)	(0.0292)
Volatility	0.0466***	-0.00269	0.0141***
	(0.00597)	(0.00269)	(0.00329)
EU confidence	0.00137	-0.0175	-0.000974
	(0.00312)	(0.0153)	(0.00163)
Stress_Euribor	1.531***	-0.0889	0.571***
	(0.139)	(0.0849)	(0.0396)
eurobenchmarkflag	-2.699***	-0.0202	-0.201***
	(0.548)	(0.0291)	(0.0595)
EU QE start	-0.935***	-0.0210	-0.426***
	(0.0856)	(0.0238)	(0.0568)
Constant	-0.221	0.689	1.085***
	(1.612)	(1.297)	(0.333)
Observations	4,979	837	11,305
R-squared	0.326	0.026	0.123
Number of isin	157	158	1,211

Note: Sample period between January 2006 and December 2016. Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1.Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Annex C: Corporate bonds

Table C1: Corporate bond market whole sample (Y = Bid-ask spreads)

C.1	All sample	NFC	Financials
Outstanding	-0.0745*	-0.115***	-0.0176
	(0.0435)	(0.0322)	(0.0889)
Volatility	0.0242***	0.0118***	0.0368***
	(0.00112)	(0.000468)	(0.00210)
EU confidence	-0.0316***	-0.0136***	-0.0532***
	(0.00132)	(0.0004)	(0.00257)
Stress_Euribor	0.375***	0.462***	0.260***
	(0.0191)	(0.0134)	(0.0372)
Rating	0.0129	-0.0236	-0.00514
	(0.0280)	(0.0150)	(0.0421)
ECB CSPP	0.0531***	0.0238***	0.0837***
	(0.0041)	(0.0042)	(0.0078)
Constant	3.601***	2.358***	5.300***
	(0.279)	(0.212)	(0.553)
N. Obs	160,459	92,570	67,889
R-squared	0.266	0.470	0.302
Number of ISINs	4,098	2,333	1,768

Note: Sample period between January 2006 and December 2016. Bid-ask spreads = bid-ask spread as computed by Markit; Outstanding = natural log of outstanding volume in EUR; Volatility = the three month VSTOXX index; EUESI = European Commission Economic Sentiment Indicator; Stress_Euribor = interaction between the Euribor rate and the dummy Stress; Rating = index from 1 to 4 according to rating being AAA, AA, A, BBB. ECB CSPP: dummy taking the value of 1 after the start of ECB Corporate Sector Purchase Programme (8 June 2016). Robust standard errors in parentheses; ***$p<0.01$, **$p<0.05$, *$p<0.1$.

Table C2: Corporate bond market liquidity by volatility (Y = bid-ask spreads)

C.2

Panel A – All sample

	Top 10	Core 80	Bottom 10
Outstanding	0.311	-0.170***	-0.0301***
	(0.223)	(0.0215)	(0.0105)
Volatility	0.0583***	0.0101***	0.00158***
	(0.00338)	(0.000277)	(0.000201)
EU confidence	-0.0894***	-0.0118***	-0.00185***
	(0.00392)	(0.000293)	(0.000352)
Stress_Euribor	0.189***	0.391***	0.0395***
	(0.0711)	(0.00845)	(0.00604)
Rating	-0.0133	-0.0461***	-0.00578
	(0.0817)	(0.00943)	(0.00538)
Constant	6.844***	2.639***	0.613***
	(1.360)	(0.142)	(0.0737)
N. Obs	23,510	130,171	6,185
R-squared	0.434	0.549	0.123
Number of ISINs	384	3,088	386

Note: Sample period between January 2006 and December 2016. Bid-ask spreads = bid-ask spread as computed by Markit; Outstanding = natural log of outstanding volume in EUR; Volatility = the three month VSTOXX index; EUESI = European Commission Economic Sentiment Indicator; Stress_Euribor = interaction between the Euribor rate and the dummy Stress; Rating = index from 1 to 4 according to rating being AAA, AA, A, BBB. Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1.

Panel B - NFCs

	Top 10	Core 80	Bottom 10
Outstanding	-0.359	-0.135***	-0.0423**
	(0.248)	(0.0294)	(0.0175)
Volatility	0.0297***	0.00999***	0.00186***
	(0.00398)	(0.000332)	(0.000318)
EU confidence	-0.0357***	-0.0113***	-0.00162***
	(0.00218)	(0.000333)	(0.000417)
Stress_Euribor	0.798***	0.416***	0.0391***
	(0.0733)	(0.00975)	(0.00620)
Rating	-0.295***	-0.0147	-0.00806
	(0.107)	(0.0132)	(0.0102)
Constant	6.942***	2.256***	0.675***
	(1.416)	(0.197)	(0.118)
N. Obs	4,976	84,363	2,908
R-squared	0.541	0.566	0.174
Number of ISINs	73	1,915	198

Note: Note: Sample period between January 2006 and December 2016. Bid-ask spreads = bid-ask spread as computed by Markit; Outstanding = natural log of outstanding volume in EUR; Volatility = the three month VSTOXX index; EUESI = European Commission Economic Sentiment Indicator; Stress_Euribor = interaction between the Euribor rate and the dummy Stress; Rating = index from 1 to 4 according to rating being AAA, AA, A, BBB. Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1.

Panel C - Financials			
	Top 10%	Core 80%	Bottom 10%
Outstanding	0.625**	-0.224***	-0.0192
	(0.272)	(0.0273)	(0.0148)
Volatility	0.0645***	0.0102***	0.00134***
	(0.00394)	(0.000486)	(0.000280)
EU confidence	-0.103***	-0.0130***	-0.00231***
	(0.00458)	(0.000581)	(0.000637)
Stress_Euribor	0.0125	0.343***	0.0371***
	(0.0836)	(0.0149)	(0.0125)
Rating	-0.0339	-0.0815***	-0.00467
	(0.0878)	(0.0132)	(0.00604)
Constant	6.315***	3.222***	0.586***
	(1.652)	(0.178)	(0.106)
N. Obs	18,534	45,808	3,277
R-squared	0.451	0.524	0.075
Number of ISINs	312	1,175	188

Note: Sample period between January 2006 and December 2016. Bid-ask spreads = bid-ask spread as computed by Markit; Outstanding = natural log of outstanding volume in EUR; Volatility = the three month VSTOXX index; EUESI = European Commission Economic Sentiment Indicator; Stress_Euribor = interaction between the Euribor rate and the dummy Stress; Rating = index from 1 to 4 according to rating being AAA, AA, A, BBB. Volatility percentiles refer to bid-ask volatility. Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1.

Table C3: Corporate bond markets by maturity

C.3				
Panel A – All sample				
	Mat < 2	Mat 2-5	Mat 5-10	Mat 10-30
Outstanding	0.128	0.0478	-0.114***	-0.372***
	(0.171)	(0.0435)	(0.0364)	(0.0850)
Volatility	0.0282**	0.00826***	0.0141***	0.0206***
	(0.0101)	(0.000743)	(0.000783)	(0.00138)
EU confidence	0.000798	-0.00924***	-0.0192***	-0.0335***
	(0.00852)	(0.000815)	(0.000954)	(0.00183)
Stress_Euribor	0.342	0.289***	0.498***	0.435***
	(0.201)	(0.0215)	(0.0193)	(0.0417)
Rating	0.315**	0.0229	-0.0331	-0.0645**
	(0.0984)	(0.0362)	(0.0248)	(0.0325)
Constant	-2.524***	0.638**	2.882***	6.257***
	(0.514)	(0.275)	(0.255)	(0.594)
N. Obs	52	28,644	74,373	23,987
R-squared	0.591	0.217	0.366	0.496
Number of ISINs	9	962	1,915	499

Note: Note: Sample period between January 2006 and December 2016. Bid-ask spreads = bid-ask spread as computed by Markit; Outstanding = natural log of outstanding volume in EUR; Volatility = the three month VSTOXX index; EUESI = European Commission Economic Sentiment Indicator; Stress_Euribor = interaction between the Euribor rate and the dummy Stress; Rating = index from 1 to 4 according to rating being AAA, AA, A, BBB. Maturity buckets: Less than 2 years, between 2 and 5 years, between 5 and 10 years, between 10 and 30 years. Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1.

Panel B – NFCs

	Mat<2	Mat 2-5	Mat 5-10	Mat 10-30
Outstanding	-0.266	0.0702	-0.0577	-0.189*
	(0.211)	(0.0427)	(0.0433)	(0.0979)
Volatility	-0.0397	0.00789***	0.0106***	0.0128***
	(0.0277)	(0.000655)	(0.000606)	(0.00109)
EU confidence	0.00329	-0.00979***	-0.0127***	-0.0190***
	(0.00608)	(0.000644)	(0.000531)	(0.00110)
Stress_Euribor	0.394	0.226***	0.491***	0.688***
	(0.140)	(0.0173)	(0.0181)	(0.0329)
Rating		0.0290	-0.0247	-0.0110
		(0.0395)	(0.0226)	(0.0295)
Constant	2.840	0.518	1.872***	3.538***
	(1.676)	(0.334)	(0.270)	(0.656)
N. Obs	19	13,843	47,770	14,009
R-squared	0.767	0.485	0.445	0.617
Number of ISINs	3	457	1,169	287

Note: Note: Sample period between January 2006 and December 2016. Bid-ask spreads = bid-ask spread as computed by Markit; Outstanding = natural log of outstanding volume in EUR; Volatility = the three month VSTOXX index; EUESI = European Commission Economic Sentiment Indicator; Stress_Euribor = interaction between the Euribor rate and the dummy Stress; Rating = index from 1 to 4 according to rating being AAA, AA, A, BBB. Maturity buckets: Less than 2 years, between 2 and 5 years, between 5 and 10 years, between 10 and 30 years. Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1.

Panel C – Financials

	Less 2 Bid Ask	2-5 Bid Ask	5-10 Bid Ask	10-30 Bid Ask
Outstanding	-0.0152	0.0156	-0.179**	-0.596***
	(0.862)	(0.0800)	(0.0708)	(0.160)
Volatility	0.0225**	0.00861***	0.0198***	0.0248***
	(0.00614)	(0.00141)	(0.00172)	(0.00253)
EU confidence	-0.0574***	-0.00888***	-0.0306***	-0.0508***
	(0.0141)	(0.00153)	(0.00231)	(0.00310)
Stress_Euribor	0.420**	0.353***	0.500***	0.143**
	(0.106)	(0.0398)	(0.0440)	(0.0674)
Rating	0.0734	0.0335	-0.0495	-0.172***
	(0.0527)	(0.0491)	(0.0406)	(0.0505)
Constant	5.238	0.796*	4.483***	9.791***
	(5.986)	(0.471)	(0.501)	(1.082)
N. Obs	33	14,801	26,603	9,978
R-squared	0.775	0.153	0.369	0.503
Number of ISINs	6	506	747	212

Note: Sample period between January 2006 and December 2016. Bid-ask spreads = bid-ask spread as computed by Markit; Outstanding = natural log of outstanding volume in EUR; Volatility = the three month VSTOXX index; EUESI = European Commission Economic Sentiment Indicator; Stress_Euribor = interaction between the Euribor rate and the dummy Stress; Rating = index from 1 to 4 according to rating being AAA, AA, A, BBB. Maturity buckets: Less than 2 years, between 2 and 5 years, between 5 and 10 years, between 10 and 30 years. Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1.