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Abstract

Using high-frequency data we document that episodes of market turmoil in the European sovereign bond market are on average associated with large decreases in trading volume. The response of trading volume to market stress is conditional on transaction costs. Low transaction cost turmoil episodes are associated with volume increases (investors rebalance), while high transaction cost turmoil periods are associated with abnormally low volume (market freezes). We find suggestive evidence of market freezes in response to shocks to the risk bearing capacity of market makers while investor rebalancing is triggered by wealth shocks. Overall, our results show that the recent sovereign debt crisis was not associated with large-scale investor rebalancing.

Keywords: Sovereign Debt Crisis, Trading volume, Liquidity, Flights, Rebalancing

JEL: G12, G14, G21, E44.

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1 Introduction

During the European sovereign debt crisis bond markets experienced unprecedented yield changes.[1] Asset pricing models with heterogeneous agents and incomplete markets predict that wealth effects (yield changes) result in rebalancing (examples include; Cochrane et al., 2008; Chabakauri; 2013 and Judd et al., 2013). Moreover, there is an extensive literature that documents the existence of flight-to-safety and flight-to-liquidity in times of market stress (e.g., Beber et al., 2009; Longstaff, 2004; Garcia and Gimeno, 2014 and Beck et al., 2016). The existence of flights is suggestive of investor rebalancing.[2] Additionally, the

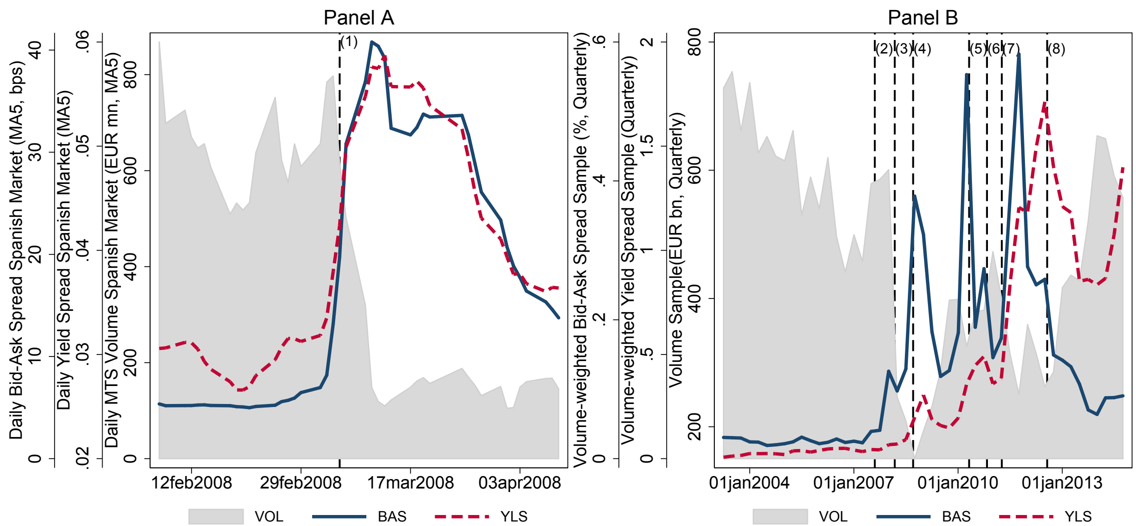

Figure 1: Volume, Bid-ask Spreads and Yield spreads

Panel A of Figure 1 displays the time series of the daily sum of Euro volume, the volume weighted bid-ask spreads of all Spanish bonds in our sample and the yield spread between 10 year Spanish and German government bonds (scaled by the yield of the German bond) over the first quarter of 2008. Panel B of Figure 1 displays average quarterly Euro volume, volume weighted bid-ask spread of our sample (all countries) and the mean (across countries) yield spread over 10 year Bunds. The dashed lines: (1) March 6, 2008 (MBS downgrades), (2) August 2007 (start of interbank crisis), (3) March 2008 (MBS downgrades and Bear Stearns), (4) September 2008 (Lehman), (5) April 2010 (S&P downgrades Greece to junk), (6) November 2010 (Austerity referendum in Greece), (7) April 2011 (Portugal requests EU bailout), (8) July 2012 (Draghi "whatever it takes"). For a more detailed description of the variables see section 3 and Figure 5.

empirical literature documents a link between volatility and trading volume (e.g., Chordia, et al., 2007; Huang and Wang, 2011).[3] Thus, these three strands of literature predict

[1]The sovereign bond yields in the GIIPS (Greece, Italy, Ireland, Portugal and Spain) countries reached the highest levels since the introduction of the Euro. The 10 year yield for Spanish and Italian bonds peaked at 7.4% and 7.5%, respectively. The yields in Ireland, Portugal and Greece reached even higher levels of 12.0%, 18.1% and 49.3%, respectively.

[2]For example, on July 14, 2011, the Financial Times commented on the widening of the yield gap between France and Germany in the following way "Economists put the widening gap down to a flood of investors into German debt." http:www.ft.com/cms/s/0/fb9cc4d4-ae24-11e0-a2ab-00144feabdc0.html#axzz4Ii8Yc4Vv

[3]Foster and Viswanathan (1993) report that the 1987 stock market crash was associated with abnormally high trading activity.

massive investor rebalancing during the sovereign debt crisis and hence abnormal trading volume.[4]

[Insert Figure 2 and Figure 3 here]

This paper examines the trading behavior - primarily volume - of sovereign bond markets in times of stress. Panel A of Figure 1 illustrates the trading volume of Spanish government bonds during the first quarter of 2008. The graph displays a striking pattern, in the five trading days before March 6, the total daily volume was on average EUR 797.6 million, but in the five trading days afterwards (the week prior to the collapse of Bear Stearns) the total volume was on average EUR 109.8 million, a drop of 86.2%. The low trading volume persisted for several months. At that time there were growing concerns about prime structured credit products.[5,6] These concerns spilled over to financial institutions and CDS spreads of market makers in the sovereign bond market increased by 19.7% from March 5 to March 7. These fears were incorporated into bid-ask spreads. The mean bid-ask spread for Spanish sovereign debt was on average 13.8 bps over the five trading days prior to March 6. On March 6 they roughly tripled to 39 bps and remained elevated until the end of April. Thus, this is suggestive of concerns about structured products resulting in financial intermediaries having a reduced capacity or willingness to bear risk. This led to a substantial increase in trading costs (consistent with the evidence in Pelizzon et al., 2016) which in turn resulted in a market freeze.[7] To illustrate that this episode generalizes, Panel B of Figure 1 displays quarterly volume, the volume weighted bid-ask spreads and yield

[4]There are multiple other reasons to expect abnormal trading volume during crisis times. For example, changes in frictions (such as private information, Kyle, 1985), margin calls leading to a liquidity spiral (Brunnermeier and Pedersen, 2009) and interbank market frictions that result in liquidity pull-back (Nyborg and Östberg, 2014) can justify increased trading volume during times of crises.

[5]Between March 5 and March 7, Moody's downgraded structured credit products of multiple issuers worth USD 14.5 billion. Among the downgraded products were senior tranches and some of them were downgraded up to eight notches (Aaa to Baa2). At the same time the four major rating agencies downgraded 166 financial institutions (including subsidiaries).

[6]To make sure that the pattern in Figure 1 does not represent a shift from one trading venue to another or data errors we consider other data sources. Panel A of Figure 2 plots trading volume from data obtained from an alternative Spanish trading platform (Sistema Electrónico de Negociación de Activos Financieros, SENAF). Also, Spanish primary dealers are obliged to report trades to the Bank of Spain. Panel B plots the reported volume (from the Mercado de Deuda Pública Anotada, MDPA dataset) which unlike MTS volume also includes customer to dealer trades, interdealer trading on all trading platforms as well as OTC trades. The decrease in volume is observed in the alternative datasets. In addition, Engle, Fleming, Ghysels and Nguyen (2012) observe a drop in trading volume in the U.S. Treasury market following the Lehman bankruptcy.

[7]Market maker risk bearing capacity is likely affected by funding costs (Brunnermeier and Pedersen, 2009) and the functioning of interbank markets (Nyborg and Östberg, 2014) whereas market maker willingness is likely affected by changes in uncertainty.

spreads for our sample. Overall, volume is significantly reduced during the sovereign debt crisis, while bid-ask spreads and yield spreads are significantly elevated.

This illustrates that the view that stress results in large scale rebalancing (i.e., trading) potentially needs to be qualified. In this paper we argue that one has to consider market micro structure effects of market stress to completely understand the dynamics of trading activity. Several central market microstructure models imply that bid-ask spreads (transaction cost channel) are likely to increase in times of stress due to increases in asymmetric information (Glosten and Milgrom, 1985), increases in credit risk / inventory risk (Stoll, 1978, Pelizzon et al., 2016) and decreases in risk bearing capacity (Ho and Stoll, 1981). Additionally, Epps (1976) and Lo et al. (2004) find that increases in bid-ask spreads result in reductions in volume. Thus, these models imply that stress results in reduced volume.

In this paper we examine the relation between market stress and volume in the European sovereign bond market. First, we document that stress in the European sovereign bond market is associated with significantly reduced trading volume. To define stress we adapt the flight measure by Baele et al. (2013), which is developed to study flights from equity markets to bond markets, to capture flights within the European sovereign debt market from the periphery to the core (Germany). We examine volume around these stress events using event study methodology in the spirit of Kandel and Pearson (1995). We find that trading volume is approximately reduced by 32.6% during the stress events.

Second, we find evidence for the existence of both the bid-ask spread and the rebalancing channel. In the event study analysis we document that volume is particularly low if the stress is severe or associated with high bid-ask spreads. For market stress events in low bid-ask spreads periods we find evidence of volume increasing (suggestive of rebalancing). We run cross-sectional regressions using our events and further document the existence of these two opposing effects. High yield spreads are positively related to volume (consistent with wealth effects resulting in rebalancing), while high bid-ask spreads are associated with lower volume.

Third, we verify that a reduction in risk bearing capacity of market makers leads to increased bid-ask spreads and therefore reduced trading volume. Intuitively the reduction of risk bearing capacity depends on the exposure of the market makers' balance sheet to the stress event. On MTS a bond may be traded on a domestic and a pan-European platform implying that the set of market makers differs.[8] Market making in domestic markets is mainly facilitated by domestic banks. Potential reasons for this concentration include home bias (French and Poterba, 1991) and moral suasion (Ongena et al., 2016).[9] Consequently the balance sheet exposure of market makers in the domestic market to (domestic) stress events is significantly higher. Using within bond variation and difference-in-difference regressions we show that bid-ask spreads rise more and volume falls more on the domestic platform.

Next, in an aggregate time-series setting we trace the effects of aggregate shocks on volume through the rebalancing and transaction cost channel. This is done by first estimating the sensitivity of yield spreads (rebalancing channel) and bid-ask spreads (transaction cost channel) to the aggregate shocks and subsequently relating trading volume to our two channels. Shocks that impair the risk-bearing capacity of market makers, such as, market maker CDS spreads and interbank market frictions are transmitted to volume predominantly through their effect on bid-ask spreads. On the other hand shocks in the equity market that are mainly associated with wealth effects seem to be transmitted to volume mainly via the rebalancing channel.

While the difference-in-difference analysis exploits that the market makers on different platforms differ in their exposure to the stress event the time series regressions use the fact that different types of shocks have differential impact on the risk bearing capacity. Overall, we find that in this market during the sovereign debt crisis the transaction cost channel dominates rebalancing motives. Further, our findings suggest that the close relation between the stress events and market maker balance sheets impacts risk bearing capacity to such an extent that the resulting increase in bid-ask spreads curtails trading.

Previous research in U.S. Treasury markets has shown that volume is generally positively related to volatility (Huang and Wang, 2011), macroeconomic announcements (Fleming and Remolona, 1997 and Beber and Brandt, 2009) and jumps (Jiang, Lo and Verdelhan, 2011).[10] Consistent with this trading activity in the U.S. treasury market increased substantially during the LTCM crisis (Furfine and Remolona, 2005) and during flight-to-safety episodes

[8]The average number of market makers on the domestic platform is 12.6 compared to 9.2 on the pan-European platform.

[9]For example in Italy 24.8% of the market makers are Italian banks while on average in the other markets Italian banks constitute only 4.68% of the market makers.

[10]Foster and Viswanathan (1993) and Gallant, Rossi and Tauchen (1993) and Chordia, Huh and Subrahmanyam (2007) report similar findings for equity markets. On p. 712 Chordia et al. (2007) note "The results show that higher positive and more negative returns substantially increase trading activity. In other words, the more extreme the returns (positive or negative), the higher is the trading activity. Overall, these results are consistent with portfolio rebalancing [...]."

(Engle, Fleming, Ghysels and Nguyen, 2012). There are several potential reasons for our results difffering. First, they study flights from the equity market to the treasury market while we study flights within the European sovereign bond market. In their context the transaction cost channel is less important since a flight episode is characterized by a drop in equity returns and an increase in bond prices. Put differently, we study the volume of the shocked market (where the price drop occurs) whereas they study volume of the safe market (which experiences a price increase). Second, arguably the U.S. treasury market was less affected by the European sovereign debt crisis. Third, sovereign market stress is likely to affect European market makers more since European banks (which are often market makers) hold more domestic sovereign debt than their U.S. counterparts.[11]

Interestingly, Fleming and Remolona (1999) who study the U.S. treasury market surrounding macro announcements find evidence in favour of volume both increasing and decreasing. In the minute after the news release uncertainty is high and market makers protect themselves by increasing bid-ask spreads ultimately resulting in a lull in trading volume. In the next minute and over the following one and half hours trading volume, price volatility, and bid-ask spreads are elevated. In contrast our results suggest that market makers in the European sovereign bond market have reduced risk bearing capacity for extended periods resulting in persistent freezes (at least an entire trading week).

Previous work has documented an ambiguous relation between liquidity and volume.[12] Our perspective that stress events affect both the rebalancing and transaction cost channel can rationalize these findings. Intuitively, in the European sovereign debt market the transaction cost channel is likely to dominate since there are few liquidity providers that have significant exposure to the stress events.

A recent paper by Bessembinder et al. (2017) documents a significant reduction in dealer capital commitment in the US corporate bond market during the financial crisis and the post-crisis period and a decrease in volume. We complement their work by running a horce race between the rebalancing and transaction cost channels to determine when and why freezes occur. They primarily study capital commitment (which they have excellent data

[11]The Bruegel database of sovereign bond holdings (the database covers Greece, Ireland, Italy, Spain, France, Germany, Netherlands, Portugal, UK and US) developed by Merler and Pisani-Ferry (2012) shows that European domestic banks hold on average 22.4% of the outstanding sovereign bonds while the corresponding number for U.S. banks is 2.8%.

[12]Fleming (2003) reports that in the US Treasury market "both high and low levels of trading activity are associated with periods of poor liquidity." Ranaldo et al. (2013) also conclude that "the relation between liquidity and trading activity is ambiguous."

on) as the outcome while we study the consequences of decreases in capital comittment by focusing on volume and we are able to link the reduction in trading volume to an increase in transaction costs since we have access to quote data.

There is a growing literature that studies flight-to-liquidity and flight-to-quality in sovereign bond markets. Longstaff (2004) and Favero et. al (2010) study the flight-to-liquidity / flight-to-quality premium in yields. Beber et al. (2009) and García and Gimeno (2014) study these premia along with order imbalances. Given that our goal is to gauge the relative importance of the rebalancing and the transaction cost channel we need to study volume since order imbalances will mechanically be associated with selling pressure in falling markets that do not necessarily represent large-scale rebalancing.[13]

The rest of the paper is organized as follows. Section 2 presents the data and section 3 our variables. Section 4 contains our results and Section 5 concludes.

2 Data

Our main data source is high frequency trade and quote data from the electronic interdealer platform MTS, covering the period from April 2003 to December 2014. Data from MTS provides a comprehensive picture of the European sovereign bond market since the majority of trading occurs on electronic trading platforms of which MTS has the largest market share.[14] MTS volume is representative of overall market volume since it is highly correlated with volumes figures reported by primary dealers (the reported data is at a more aggregate level and often at lower frequencies).[15]

The MTS dataset is organized into three types of files available on a monthly basis: the

[13]As an extreme example imagine a market with only one trade that is classified as being driven by a sale, the order imbalance would indicate extreme selling pressure, but the market is rather characterized by extreme illiquidity. Thus, we can have the same order imbalances at high or low trading volume since it is scaled by dollar volume or the number of trades.

[14]According to industry research (Deutsche Bank, 2005) more than 95% of the bond trading takes place off-exchange. It finds that about 75% of orders and around 50% of volume is traded on electronic trading platforms in Europe. Dunne et al. (2010) estimate that MTS has a market share of 60.8% of the electronic trading. Own calculations using a report from primary dealers in Portugal (published by the Portuguese Treasury and Government Debt Agency) verify that MTS has indeed a high overall market share of volume (73.9% of the Portuguese electronic trading).

[15]Data from the French and Portugeese national treasury agencies as well as the Bank of Spain also include customer-dealer and non-MTS interdealer trading by primary dealers. The correlation between MTS volume and the total market volume (as reported by the Agence France Trésor) is 0.72 in France (based on monthly data), 0.90 in Portugal (based on monthly data) and 0.57 in Spain (based on daily data). Figure 4 shows the close co-movement between the transaction volume in the electronic, interdealer and the customer-dealer markets for the French sovereign bond market.

reference files which contain bond characteristics as well as the fills and best proposal files that contain all the trades and quote updates with millisecond timestamps. We use this data to calculate yields, volume and the cost of trading (bid-ask spreads).

[Insert Figure 4 here]

In screening the reference files we only consider bonds that are issued by a central government. That is, we exclude ISINs where the issuer is classified as quasi-government, local government or corporate. Also, we exclude bonds for which we have no information on the issuer even though they are categorized as they were issued by a central government. We keep bonds issued by countries that have data coverage over the entire sample period (i.e., we exclude Denmark, Poland, Slovenia and the United Kingdom). This leaves us with the following 11 European countries: Austria (AT), Belgium (BE), Germany (DE), Spain (ES), Finland (FI), France (FR), Greece (GR), Ireland (IE), Italy (IT), the Netherlands (NL) and Portugal (PT). Additionally we only keep fixed and zero-coupon bonds. That is, we exclude bonds with floating or indexed coupons and bonds with derivative features. To facilitate the yield curve estimations (see below) we exclude the 16 bonds that at any point in time during our sample have more than 40 years to maturity. All trades that are made by national treasury agencies are recorded under a separate ISIN code. Since these trades do not reflect investor rebalancing we eliminate them from the sample.

When we merge the monthly reference files we occasionally observe information that should be time-invariant (e.g., issuer category) changing. In such cases we look up the information in other data sources (DataStream, Bloomberg and Findex) for that particular ISIN.[16] If the information cannot be verified then the particular bond is dropped. Applying these screens implies that we have a total of 3,181 bonds.

Next we merge the resulting reference file information with the best proposal files. In total we have 1.12 billion quote updates and 1.28 million bond-days at this point. We drop

[16] For the variable issuer country nine bonds were misclassified resulting in five changes and four drops. In case of the variable issuer type 34 bonds (33 dropped and one changed) were sorted into the wrong category. A total of 17 bonds were classified as coupon bonds even though they are index-linked bonds and were thus dropped. For the variable issue date 36 bonds had multiple entries (33 were changed and three deleted because verification was not possible). The variable coupon rate was sometimes missing and thus replaced by the coupon rate that was present in the reference files of the other months. In six cases we made changes to bonds with multiple coupon rates. Lastly we changed 37 first coupon dates. Details are available upon request. We found that the reference file for May 2003 had a significant amount of errors so we filled in data for May 2003 with data from June 2003 when it was identical to the record for April 2003. If this was not the case we used external sources to try to reconcile the records.

quotes were the mid price is missing, either the bid or ask price is 999 (error code) and quotes which imply negative bid-ask spreads (together these screens lead to a loss of 0.03% of the quotes). In April 2003 we occasionally observe inconsistencies in the order book (we observe three layers) in terms of sorting of the best bid and ask prices (e.g., the best bid price is smaller than the second best bid price). In these instances we drop these quotes (0.05% of the quotes). Additionally, we only consider quotes during regular trading hours (8:15 am to 5:30 pm which is referred to as the open market phase by MTS; this leads to a loss of 0.57% of the quotes).[17] We also drop quotes that imply a relative bid-ask spread in excess of 0.6 (this implies a loss of 414,531 quotes or 0.04% of the quotes).

We also exclude bond-days that occur during grey market trading (0.2% of the bond-days). Moreover we exclude bonds that have less than 30 days to maturity (2.4% of the bond-days). To remove quotes that are unlikely to reflect market wide liquidity changes we drop bond-days where the price changes (from close to close, in %) are five times larger than those of the entire country and the absolute price changes additionally exceed 4% on the day in question and reverses at least 4% the next day (a loss of 0.1% of bond-days).[18]

Moreover we exclude dates that are in the dataset but are not regular trading days. These dates are 28^{th} of May 2007 (Whitsunday), the 24^{th} of December as well as the 31^{st} of December in the years 2003, 2004 and 2007 (on these days overall trading volume in the European sovereign bond market was roughly one hundredth of the normal level). Similarly we drop two Saturdays that are present in the dataset (January 17, 2009 and November 22, 2008). After these screens we are left with a sample of 1.1 billion quote updates, 3.5 million trades, 1.2 million bond-days and 2,937 unique bonds.

This dataset is the basis from which we calculate our main variables: trading volume, bid-ask spreads and yields. All of these quantities are calculated per day and country.

[Insert Table 1 here]

Row (1) and (2) of Panel A, Table 1 provide descriptive statistics of the total number of trading days and bonds across our sample countries. We have a time-series of 2,957 trading days from April 2003 to December 2014 (covering both crisis and pre-crisis periods).[19]

[17]We ignore quotes from the pre market phase and the offer phase. For further information see London Stock Exchange Group: General MTS Domestic Market Rules, Effective as of 4th April 2016.

[18]We remove these extreme idiosyncratic price movements that subsequently reverse since they are likely to adversely affect convergence in our yield curve estimations.

[19]The only exception is Greece where we have 2,602 days because a lack of valid bid-ask spreads during

Larger countries with significant amount of debt outstanding such as France, Germany, Italy and Spain have more bonds in our sample (between 334 and 874) while smaller countries have fewer bonds (e.g., 33 in Austria, 27 in Finland, and 61 in Ireland).

Rows (3) to (7) of Panel A, Table 1 present the daily average number of bonds, trades and quotes as well as average trade size and Euro volume. On average we observe between 8.72 (IE) and 85.66 (FR) bonds per day. This cross-section of bonds allows to almost always estimate a daily country specific yield curve (see below). There is ample variation in the amount of trades across our sample countries (from an average of 5.59 to 734.16 trades per day in Ireland and Italy, respectively). The daily cross-country average number of trades is 108.72 (the last column). Even though the absolute number of trades is small in some countries, given that the trade sizes in this market are substantial (mean cross-country trade size is EUR 7.77 million), the mean daily Euro trading volume is large (EUR 38.99 in Ireland to EUR 4,029.84 million in Italy). The large number of quote updates per day (between 7,390 in Ireland and 82,610 in Italy) provides us with ample number of observations to calculate daily average bid-ask spreads.

On the MTS platform designated market makers are obliged to continuously quote firm bid- and ask prices for at least five hours a day. From Panel B of Table 1 we see that for the average bond in our sample there are 12.85 market makers (the mean number of market makers ranges from 8.35 in Spain to 15.45 in Portugal). In addition to the market makers, there are on average between 33.29 and 78.09 market takers that can post market orders. Moreover MTS defines a minimum quantity (cross-country average of EUR 7.45 million) that market makers have to quote to ensure depth. Pagano and von Thadden (2004) argue that the minimum quantity and the obligatory continuous quotes of bid-ask spreads result in the Euro MTS being the most important trading venue for European sovereign bonds.[20]

In Panel C of Table 1 we display the S&P ratings of our countries at the beginning and the end of the sample period. The sample is characterized by variation in credit quality across sovereigns and over time (many sovereigns experienced downgrades).

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the height of the sovereign debt crisis.

[20]Additionally, it is the premier choice of academics: Bai, Juliard and Yuan (2012), Beber, Brandt and Kavajecz (2009); Caporale and Girardi (2013); Caporale, Girardi and Paesani (2012); Cheung, de Jong, and Rindi (2005); Darbha and Dufour (2013); Dufour and Nguyen (2008); Dufour and Skinner (2004); Dunne, Hau and Moore (2010); Dunne, Moore and Portes (2006); Favero, Pagano and von Thadden (2010); Garcia and Gimeno (2014); Gerlach, Schulz and Wolff (2010); Girardi (2008); Girardi and Impenna (2013); Pagano and von Thadden (2004); Paiardini (2010); Pelizzon, Subrahmanyan, Tomio and Uno (2016) and Schneider, Lillo, and Pelizzon (2016) all use the MTS data set for their empirical analysis.

3 Variable Definition and Descriptive Statistics

3.1 Volume

For each trade on the MTS platform we observe the price, the timestamp and the notional amount traded. We use this to calculate Euro volume per trade and sum up the volume over all trades within a country and day (similarly we calculate the number of bonds traded). To facilitate comparison of volume across countries (given the large heterogeneity) we scale volume with the average volume over the previous five days and can therefore interpret it as abnormal volume. Our relative volume measure ($RVOL$) is defined as:

$$RVOL_t = log(VOL_t) - \frac{1}{5}\sum_{l=1}^{5} log(VOL_{t-l}), \tag{1}$$

where VOL_t is either the euro volume of a particular country or the total volume of all countries excluding Germany (sample volume) during day t. Germany is excluded because it is our reference country when classifying flights. In calculating the measure we use the log transformation of volume (as in Dong, 2012) since it implies a symmetric measure.[21] This measure can be interpreted as a percentage change if the difference in the two logs is sufficiently small.

[Insert Table 2 here]

[Insert Figure 5 here]

Table 2, Panel A contains the descriptive statistics of the time series of the volume ratio ($RVOL$). For the individual countries the means range from -0.0061 (GR) to -0.0006 (IE) and the sample average is -0.0009. In fact all the means for all of our sample countries are very close to zero, but slightly negative. This reflects that volume is marginally decreasing over our sample period. Positive medians combined with the fact that negative extremes (minimum) are larger, in absolute terms, than positive extremes (maximum) suggest that our time series are characterized by large infrequent drops in volume. This pattern is also visible in Figure 5. Additionally, the extreme values show that there are days with very high or very low volume (compared to the previous five days) suggesting the potential existence of both extensive rebalancing activity and freezes.

[21] Without the log transformation $RVOL$ would be restricted to the range of [-100%,$+\infty$] implying a potential positive bias. Applying the log transformation leads to the symmetric range of [$-\infty$,$+\infty$]. In the rare occasion that the daily total volume is zero we set the trading volume to be one since the log of zero is not defined.

3.2 Bid-Ask Spreads

In the MTS dataset we observe the first three layers of the order book. We use the best bid and the best ask prices to calculate transaction costs. For each quote we calculate the relative bid-ask spread (BAS) as the difference between the best ask-price P^A and the best bid-price P^B divided by the mid price P^M (the mid price is the average of the bid and the ask price). We aggregate this to a daily bid-ask spread for each bond by calculating the equally weighted average over all $K_{i,t}$ updates for bond i during day t as:

$$BAS_{i,t} = \frac{1}{K_{i,t}} \sum_{k=1}^{K_{i,t}} \left(\frac{P^A_{i,t,k} - P^B_{i,t,k}}{P^M_{i,t,k}} \right). \tag{2}$$

We aggregate the bond-level bid-ask spread to the country and sample level to get market-wide transaction cost estimates. In aggregating to the country or sample level we use volume weighting to reflect transaction costs of traded volume as opposed to transaction costs of tradeable bonds (giving higher weight to quotes of bonds that are frequently traded). The weight w of bond i is given by:

$$w_{i,t} = \frac{\sum_{m=6}^{25} VOL_{i,t-m}}{\sum_{i=1} \sum_{m=6}^{25} VOL_{i,t-m}}, \tag{3}$$

where the volume weighting of bond i depends on trading volume over days from $t = -25$ to $t = -6$. We calculate bid-ask spreads as the weighted sum of the individual bid-ask spreads for a country or our entire sample on a daily level.

Table 2 Panel B displays descriptive statistics for the volume weighted bid-ask spreads time series on country and sample level. The first three rows show the averages for the whole sample period as well as two sub periods which correspond to the crisis and non-crisis period (The crisis period starts, as in Nyborg and Östberg (2014), August 9, 2007 and lasts until the end of the sample period). The figures show that the European sovereign bond market is extremely liquid in the pre-crisis period. The average volume weighted bid-ask spread in the sample is 0.025%. In the pre-crisis period Italy is the most liquid country with an average bid-ask spread of 0.020%. This is consistent with the description of European sovereign bond markets as very liquid in the pre-crisis period (e.g. Cheung, De Jong and Rindi, 2005 and Pagano and von Thadden, 2004).

However during the crisis the bid-ask spreads increase dramatically. The average volume weighted bid-ask spreads in the crisis period is 7.7 times larger (increase from 0.025% to

0.194%) than in the pre-crisis period. Bid-ask spreads increase less in the CORE countries (E.g. in Germany the bid-ask spreads increase from 0.34% to 0.140%) than in the GIIPS countries (e.g. in Greece the bid-ask spreads increase 0.054% to 4.708%). Additionally, one should note that the average level in GIIPS countries also reaches very high values in absolute terms (the cross-country average bid-ask spread is 1.585%). The other figures in the Panel B show descriptive statistics for the whole sample period. The median values show the same patterns as described for the means. The standard deviations are high indicating a lot of time variation in bid-ask spreads. Maximum bid-ask spreads in Ireland, Greece and Portugal even cross the 10% level, reflecting the severity of the crisis. Overall the statistics in Panel B indicate that trading costs increased significantly during the crisis.

3.3 Yields

The extant literature identifies flight episodes through yield spreads.[22] In particular we use a threshold model similar to Baele, Bekaert, Inghelbrecht and Wei (2013) to identify flights. Since the composition of our sample (in terms of maturity and duration) varies over time and countries we base our flight measure on the yield of a synthetic 10 year constant maturity bond. This yield is backed out from a Nelson and Siegel (1987) yield curve that we estimate for each country and day of our sample. We selected this model since it represents a good trade-off between model complexity and tractability (Beber et al., 2009 use it for a MTS sample of sovereign bonds). The estimation procedure is explained in more detail in Appendix A.

Our goal is to measure changes in relative safety of sovereigns. Both academics and the financial press view German bunds as a safe haven and as a result it is natural to consider the spread of a sovereign over the German yield (Geyer, Kossmeier, and Pichler (2004) and Favero, Pagano and von Thadden (2010) consider the spread over the German yields as well). For all of our countries (except Germany) the daily (t) yield spread YLS_t is calculated as:

$$YLS_t = \frac{Y_t - Y_t^{DE}}{Y_t^{DE}}, \tag{4}$$

[22] Beber, Brandt and Kavajecz (2009) show that the yields spread between the sovereign par yield and the euro swap yield reflects flight-to-liquidity (using cross-country liquidity differences) and flight-to-quality (using cross-country differences in CDS premia). Similarly, Longstaff (2004) uses the yield spread between US Treasuries and Refcorp bonds to identify flights-to-liquidity. Garcia and Gimeno (2014) calculate a flight-to-safety and flight-to-liquidity factor based on agency spreads (e.g. the KfW-Bund spread).

where Y_t and Y_t^{DE} are the 10-year constant maturity yields of the sovereign and Germany (DE), respectively. In addition to the country-specific yield spreads a sample aggregate is required for our analysis. Thus we calculate volume weights on a country basis in a similar way as in Section 3.2 (effectively replacing the bond index in Eq. (3) with a country equivalent). We use these weights to calculate a daily sample yield spread. This yield spread can approximately be interpreted as the the difference in sovereign risk (vis-a-vis Germany) of the average traded Euro in the sample.

Panel C of Table 2 contains descriptive statistics for the time series of these yield spreads (relative to the German yield). The statistics for median and average confirm that all the countries in the sample have to pay higher yields to borrow for 10 years than Germany. As expected the yield spreads in the GIIPS countries are far above the German yield (they average between 63.87% (Spain) and 194.51% (Greece)). Also in line with expectations the yields of highly rated CORE countries such as Finland (6.72%) or the Netherlands (6.88%) are only slightly above the German yield. This substantiates our choice of Germany as the benchmark country.[23]

From Figure 5 it is evident that yield spreads are highly time varying. The sample yield spread is very low (close to zero) in the beginning of the sample period. However yields start to diverge when the financial crisis starts and then soar during the European sovereign debt crisis often connected to events such as bailouts and bank collapses. Yield spreads start to converge again for a short period after Mario Draghis "whatever it takes"-speech (See also Figure 1). The sovereign debt crisis is characterized by severe changes in yields spreads and thus relative safety of the individual countries.

4 Results

4.1 Event Study

As outlined in the introduction the academic literature suggests that the flight-to-safety phenomenon leads to large-scale rebalancing in times of market stress. Consequently trading in the sovereign bond markets should be characterized by high trading activity when markets are stressed. In order to investigate this claim we undertake an event study in the spirit of

[23] In the beginning of the sample period the yields of all countries are very similar. In this period the German yield is occasionally above those of the other countries, which leads to the negative yield spreads displayed in the minimum statistics.

Kandel and Pearson (1995) to identify abnormal volume surrounding market stress events. We identify market stress days using a threshold model in the spirit of Baele et al. (2013) that identifies days with an increase in the yield of one of our sample countries and a decrease in the German yield. The model is:

$$FTS_t = I\{\Delta Y_{j,t} > z_{j,t}\} \times I\{\Delta Y_t^{DE} < z_t^{DE}\}, \tag{5}$$

where I is an indicator function and $\Delta Y_{j,t}$ and ΔY_t^{DE} are the changes in the 10-year constant maturity yield of the country j and Germany, respectively. For each day t and risky country j (i.e., all except Germany) a day is classified as a flight event if the increase in the yield is greater than the threshold $z_{j,t}$ and the decrease in the German yield (the safe country) is lower than the threshold z_t^{DE}. The thresholds $z_{j,t}$ and z_t^{DE} are:

$$z_{j,t} = \kappa \times \sigma_{j,t} \quad and \quad z_t^{DE} = \kappa^{DE} \times \sigma_t^{DE}. \tag{6}$$

The $\sigma_{j,t}$ is the country-specific, time-varying volatility of the yield changes (calculated based on the previous 100 days) and κ is the threshold parameter. For the risky countries we apply three different values of κ which are 1.0, 1.5 and 2.0 while the κ^{DE} is fixed at -0.75.[24]

[Insert Table 3 here]

The number of events per country and event type are tabulated in Table 3, Panel A. 245 days were classified as event days using the threshold model with $\kappa = 1.0$. If κ is increased to 1.5 or 2.0 the number of observed events decreases to 138 and 84, respectively. Not surprisingly most of the events occur in GIIPS countries since the yields of these countries and the German yield are more likely to diverge given the development of country-specific credit risks (See e.g. the evolution of the ratings in Table 1, Panel C).

We examine the volume ratio $RVOL$ as defined in Eq. (1) around these events. As discussed in section 3.1 this measure can be directly interpreted as abnormal volume since it compares the volume on the current day to the volume in the previous five days. We

[24]We choose the values for κ in the risky countries in line with the previous literature. Baele et al. (2013) choose a κ of 1.5 and Engle et al. (2012), select κ's of 1.0, 1.5 and 2.0. Since these papers study flights from equity to bond markets and we study flights within the sovereign bond market we do not use a symmetric κ. There are several reasons for this: (1) An equal amount of rebalancing from the risky to the safe country is likely to have a larger impact on the yield of risky countries because on average these markets are considerably smaller (debt outstanding). (2) Yield changes in the risky country most likely reflect both rebalancing effects and information revelation whereas the yield changes in Germany are likely to include mostly rebalancing effects.

consider a window of 8 days around an event (in event time τ from $\tau = -2$ to $\tau = +5$). To ensure that we benchmark the volume at a particular day with volume that is not influenced by the event itself we compare the volume in this period with the volume in the five days from $\tau = -6$ to $\tau = -10$.[25]

Table 3, Panel B shows descriptive statistics for the event windows around our flight events. In all three cases for the threshold model both the mean and the median of the volume ratio are negative indicating that volume is depressed surrounding the flight events. The more severe the market stress (higher the threshold κ), the higher is the reduction in volume. Similarly one can see that the bid-ask spreads (mean) are increasing in the degree of market stress. By construction we observe a similar pattern for yield spreads.

We assess the significance of the volume ratio $RVOL$ at a particular day τ in the event-window using standard errors that are calculated using the ordinary cross-sectional method (See Boehmer et al., 1991).[26] It is defined as the standard deviation of the volume ratio of all events on event-day τ. Applying the described cross-sectional approach means that we use only observations from the event window and only one observation per event which results in standard errors that are not biased by autocorrelation (there is no time dimension) and event-induced variance (only data from events used).[27]

In Panel A of Table 4 we present the average values of the volume ratio $RVOL$ from day $\tau = -2$ to $\tau = 5$ (columns) and the different types of events (rows). The first row contains results using the threshold model with a κ of 2.0. From day $\tau = 1$ to $\tau = 5$ point estimates are negative and economically large. At $\tau = 1$ the volume ratio is -33.6 and statistically significant at the 5%-level. This implies that one day after the event volume is 33.6% lower than it was on average over days $\tau = -10$ to $\tau = -6$. As we progress in event time the volume ratio seems to decrease. At ($\tau = 5$) the volume ratio is -36.9% and significant at the

[25] If this period contains data that is associated with another event we consider the closest previous period that does not contain any other event.

[26] Formally, the standard error σ_τ^{cross} is defined for each event-day τ as:

$$\sigma_\tau^{cross} = \sqrt{\frac{1}{N(N-1)} \sum_{e=1}^{N} \left(RVOL_{n,\tau} - \sum_{n=1}^{N} \frac{RVOL_{n,\tau}}{N} \right)^2}, \tag{7}$$

where n is a single event, N is the number of all events and $RVOL_{n,\tau}$ is the volume ratio at event n at event-day τ.

[27] We have also calculated standard errors with the traditional portfolio approach (based on the time series variation of our variables in an estimation window) which has resulted in slightly lower standard errors suggesting that we have event induced variance and / or autocorrelation. The advantage of the portfolio approach is that it deals with cross-event correlation, but there is little clustering of events in our sample.

1%-level. Prior to the event (event days $\tau = -1$ and $\tau = -2$) volume is not significantly different from zero suggesting our threshold measure identifies large shocks fairly well.

It is striking that when the shocks that we consider become smaller (i.e., the κ is reduced and we consider more events) the reduction in volume becomes less pronounced or even turns into an increase. When κ is reduced to 1.5 the freeze occurs later and is less severe. We only observe a significant drop in volume from day $\tau = 2$ on. For $\kappa = 1.0$ we even have a positive volume ratio of 4.3% at the event day ($\tau = 0$). However after that volume turns negative again but the extent of the decrease is less pronounced. The volume ratio on day $\tau = 4$ is 16.6% lower for a κ of one than for a κ of two. The average difference across days from $\tau = 1$ to $\tau = 5$ is 12.9%. The evidence in this panel shows that our events are associated with market freezes and more severe events are associated with significantly lower volume.

To evaluate whether the volume response to the shock is conditional on transaction costs we classify all of our events (within a country) into two groups depending on whether they are associated with above or below median bid-ask spreads. In order to have a significant amount of events we use the events classified with a κ of 1.0.

[Insert Table 4 here]

The high bid-ask spread events are associated with significant market freezes. At the event day the volume ratio is -14.7% and insignificant. Given that the shock to yield spreads can occur at any point during the day it is quite likely that the volume reaction will only be fully incorporated a day later. Consistent with this we find that on day $\tau = 1$ the volume ratio is -42.2% with an associated t-statistic of -3.54. The volume ratio is statistically significant below zero in the following days ($\tau = 1$ to $\tau = 5$). The magnitude of the freeze is remarkable since the decrease in volume is between -37.4% and -55.3%.

For low bid-ask spread events we observe the opposite, volume increases suggesting that investors rebalance. At the event day ($\tau = 0$) the volume ratio is 22.9% and statistically significant at the 1% level. This suggests that in the absence of large increases in transaction costs investors choose to rebalance. This is consistent with evidence of flights in sovereign bond markets during the pre-crisis period (Beber, Brandt and Kavajecz, 2009) and in equity markets (Ben-Raphael, 2014). Following the event day we observe neither the market freezing nor rebalancing. This suggests that rebalancing occurs fairly immediately and is not persistent (unlike the freezes).

The third row of Panel B shows the differences in volume ratios between the two groups of events and the associated t-statistics (based on a two-sample t-test). In the six days from the event date $\tau = 0$ to $\tau = 5$ the differences are negative as well as economically and statistically significant. They range between 26.8% and 59.3%. The differences are not as large before the event day. This suggests that the differences are not only driven by the differences in the two groups but also by a differential impact of the event itself across groups.

Now we examine whether the decrease in the volume ratio is driven by (abnormal) increases of the bid-ask spreads. Abnormal values of the bid-ask spread are calculated as the bid-ask spread on a particular day in the event window less the average bid-ask spread from $\tau = -10$ to $\tau = -6$. The bid-ask spreads increase substantially around our events, both when the bid-ask spreads are at a high level and when they are at a low level. For both high and low bid-ask spreads the increase in bid-ask spreads precedes the decrease in volume. The absolute increases in bid-ask spreads are greater for the high bid-ask spread group suggesting that the larger decrease in volume is due to the more pronounced responses in the bid-ask spreads.[28]

[Insert Figure 6 here]

In Figure 6, we present the evolution (over our event window) of our main quantities of interest: relative volume, bid-ask spreads and yield spreads. Essentially the figure graphically presents the results of Table 4 while providing a benchmark based on placebo events. The red line represents the point estimates and the grey shaded area is the 95% confidence interval around them. In the leftmost graphs we plot relative volume. In the overall sample, displayed in the top panel there is an insignificant increase in volume on the event day. The middle and bottom panels display the results for high and low bid-ask spread events separately. From this it is evident that the insignificant increase in the top graph is due to low bid-ask spread events which experience an immediate increase in volume. Examining the bottom volume ratio graph (low bid-ask spreads) it is apparent that rebalancing only

[28]In order to ensure that our results are not driven by Greece (for which we have occasionally sparse data) we estimated Table 4 without Greece. Additionally, to make sure that our results are not driven by trends in volume we use alternative benchmark models. Instead of using $RVOL$ we calculate the abnormal volume as the difference between $RVOL$ at a particular day in the event window minus the average RVOL from $\tau = -10$ to $\tau = -6$ (from $\tau = -205$ to $\tau = -6$) to control for short term (long term) trends. None of these deviations changes our qualitative results (available upon request).

occurs on the event day and after this day volume is not higher than it was during our benchmark period. In contrast for high bid-ask spread events volume falls on the event day and remains low throughout our event period (i.e. the freeze is persistent).

The middle graphs display the changes in bid-ask spreads during our events. In the top graph we examine bid-ask spreads around the pooled sample of events. The bid-ask spreads are elevated throughout the event period. The elevated levels prior to the event day are suggestive of bid-ask spreads eliciting the observed volume responses. Bid-ask spreads seem to exhibit a sharp increase from day $\tau = -1$ to $\tau = 1$ followed by an incomplete reversal that leaves bid-ask spreads at a persistent higher level than during our benchmark period. The difference in bid-ask spreads between the middle (high spread events) and bottom (low spread events) graphs are striking. On the event day, the mean abnormal bid-ask spread is 1% for the high bid-ask spread events whereas the corresponding number for low bid-ask spread events is 0.1%. This large difference explains the asymmetric volume response across groups.

In order to exclude that our results are generated by an incomplete benchmark model or mechanical relations in the data we perform a placebo test. We draw 15 random events per country and resample them 200 times. We calculate the mean abnormal values of our quantities of interest in the same way as our actual abnormal quantities. In each graph the blue lines represent the mean of the placebo quantities and it is reassuring that they are always very close to zero.

[Insert Table 5 here]

In Table 5 the events are split according to whether they occur in a CORE or in a GIIPS country. The table shows that the GIIPS countries are more likely to experience decreases in volume (statistically and economically significant for days $\tau = 1$ to $\tau = 5$) while for CORE countries the effect of stress seems to lead to rebalancing. At the event day we observe a positive volume ratio of more than 27.7%. The difference in the volume ratios between the CORE and the GIIPS countries is always negative confirming that volume decreases are more severe and common in the GIIPS countries. The evidence in Table 5 corroborates our previous finding that increasing transactions costs lead to market freezes. First, the bid-ask spreads increase significantly more for GIIPS which are the countries that also experience a market freeze. Second, increases in the bid-ask spread occur prior to decreases in volume.

4.2 Cross-Sectional Regressions

The results in the previous section have shown that freezes are prevalent in the sovereign bond market, but occasionally when events are not associated with elevated transaction costs there is rebalancing. In this section we want to establish that there are two opposing effects of market stress on trading volume. First, given that agents are heterogeneous and markets are incomplete price changes (changes in the yield spread) should lead to agents trading to reach their new optimal portfolio. Second, market stress is also associated with increased transaction costs and therefore less trading. Thus, the net effect on volume is ambiguous. In this section we use as sample days from $\tau = -2$ to day $\tau = 5$ around our flight events. Using the entire window has the advantage that it provides us with both cross-sectional variation (across events) and time-series variation (days within the event window). The time-series variation is necessary since by definition our flight events do not exhibit much cross-sectional variation in yield spreads. We pool all events and all days in the event window and estimate the following regression:

$$RVOL = \alpha_j + \beta BAS + \gamma YLS + \sum_{k=1}^{K} \delta_k Control + u, \tag{8}$$

where $RVOL$, BAS and YLS are the relative volume, bid-ask spread and yield spread in the country where the event takes place on that particular day in the event window, respectively. Control is a set of control variables. Standard errors are clustered by event to account for cross-correlation of errors within an event.

[Insert Table 6 here]

In column (1) of Table 6 we consider the events given by the threshold model with a κ of one. As expected, we find that the point estimate on the bid-ask spread is negative while the estimate on the yield spread is positive. Both of the estimates are significant at the 1% level. In terms of economic magnitude, a one standard deviation increase in the yield spread is associated with an increase in relative trading volume of 0.24 which corresponds to a 69.0% increase relative to the unconditional mean (the unconditional mean of the relative volume is -0.141). A one standard deviation increase in the bid-ask spread leads to a decrease in the relative volume of 0.27 (or 92.5% relative to the unconditional mean). Columns (2) and (3) are identical to column (1) except that they use a κ of 1.5 and 2, respectively. Statistical significance and economic magnitudes are very similar.

In columns (4)-(6) we introduce control variables. We include day of the week and month of the year dummies, indicator variables for macroeconomic news as well as monetary policy announcements and country fixed effects (α_j). The inclusion of control variables does not change the point estimates significantly.

In Panel B we consider first differences of all of our variables to ensure that our results are not driven by serial correlation. We find negative and significant point estimates for the bid-ask spread in five out of six specifications. Surprisingly, we find insignificant results for the yield spread in five out of six specifications. However, it is reassuring that the point estimates are positive in all specifications.

Overall the statistical significance of the results as well as the estimated economic magnitudes show, consistent with the event study results that the transaction costs channel is more important suggesting that freezes are a likely outcome in sovereign bond markets in times of market stress.

4.3 Bond level Evidence and Difference-in-Difference

To confirm that it is reduced risk-bearing capacity that results in the drop in aggregate volume we exploit variation in the effect of the shock on risk-bearing capacity of market makers. MTS has two platforms, one domestic (with predominantly local market makers) and one international (European Bond Market) where large international financial institutions act as market makers. Table 7 provides an overview of the nationality of market makers in each market.[29] The share of domestic market makers is high e.g. in the Italian market 24.8% of the market makers are Italian banks while in the other markets under study only 4.7% of the market makers are Italian. Given that domestic banks hold a significant amount of domestic sovereign bonds we expect the domestic market to be more affected by our flight events.[30] Thus, volume and bid-ask spreads should be more affected in the domestic market where the market making ability is more exposed to the flight event.

[Insert Table 7 here]

[29] Unfortunately MTS does not provide a participant list for the EBM. However anecdotal evidence suggests that market making is facilitated by a more international group of market makers on the EBM.

[30] Merler and Pisani-Ferry (2012) document that European domestic banks hold on average 22.4% of the outstanding sovereign debt. Potential reasons for these large exposures of banks to domestic sovereign bonds could be home bias (French and Poterba, 1991) and moral suasion (Ongena et al., 2016).

In this section we consider volume and bid-ask spreads on the bond level. Apart from providing more power this has two additional advantages. First, since we compare volume and bid-ask spreads for a particular bond across platforms we can exclude that bond characteristics are driving our results. Second, it is quite likely that the bonds that are traded on the two platforms differ (selection), by considering the same bond across the domestic and international platform we can alleviate selection concerns.

We use a difference-in-difference regression framework to quantify the different response of volume and bid-ask spreads to stress on the two platforms. We compare the domestic and the EBM market before and after our stress events and predict that the domestic market experiences larger increases in bid-ask spreads and larger decreases in trading activity. We consider 21 days around our events (from τ = -10 to +10), where the sample events (denoted by e) are defined by our threshold model with varying κ's. We only consider events for which we observe quotes on both the international and the domestic MTS platform (we lose some events due to this restriction).[31] Additionally we require active trading for at least three dates per platform to include the platform volume for a particular event. We estimate the following regressions:

$$VOL_{b,p,t} = \alpha_{b,e} + \alpha_\tau + \beta\ DOM_p + \gamma DOM_p \times post_\tau + \sum_{k=1}^{K} \delta_k Control_{b,p,t} + u_{b,p,t}, \quad (9)$$

$$BAS_{b,p,t} = \alpha_{b,e} + \alpha_\tau + \beta\ DOM_p + \gamma DOM_p \times post_\tau + \sum_{k=1}^{K} \delta_k Control_{b,p,t} + u_{b,p,t}, \quad (10)$$

where $VOL_{b,p,t}$ is the sum of the Euro trading volume for bond b on platform p on day t (the day t corresponds to an event e and an event day τ). $BAS_{b,p,t}$ is the average daily relative bid-ask spread aggregated accross all quotes for a bond b on platform p at day t.

DOM_p is a dummy variable that takes the value of 1 for volume (bid-ask spreads) traded (quoted) on the domestic platform and 0 otherwise. The dummy variable $post_\tau$ takes the value of 0 before the event and 1 on the event day and afterwards. A statistically significant γ on the interaction term, $DOM_p \times post_\tau$, indicates that our events have an asymmetric impact across our platforms. We expect γ to be negative when we consider volume, indicating that volume falls more in the domestic market than in the international market and vice versa for bid-ask-spreads.

[31] The number of events drops from 245 (κ = 1.0), 138 (κ = 1.5), 84 (κ = 2.0) to 240, 135 and 83, respectively.

The intercept $\alpha_{b,e}$ is a bond×event fixed effect. This implies that we are effectively using within-bond-event variation. This ensures that our results cannot be driven by bond characteristics that are invariant within the event (e.g., 21 days). Also, this excludes our results being driven by any market and macro conditions which are constant throughout the event. Additionally, we introduce 21 event-day dummies α_τ (one for each event-day τ from -10 to 10) to ensure that our results are not driven by mechanical trading patterns around events. In addition we add the same set of control variables as in the cross-sectional regressions (see the caption to Table 6) plus the minimum-price tick to control for other differences in market structure across the platforms. Standard errors are clustered at the event level.

[Insert Table 8 here]

The results with volume as the dependent variable is presented in Panel A of Table 8. The coefficient γ of the interaction term $DOM \times post$ is always negative and statistically significant at the 1% level. This shows that trading volume decreases disproportionately in the domestic market. This is consistent with a larger decrease of risk bearing capacity of domestic market makers. Based on specification (6) this corresponds to an additional decrease of Euro 4.39 million (or 20.2% relative to the unconditional mean) on the domestic platform. The coefficient on *post* is negative and statistically signifcant at the 1% level. This is consistent with volume falling on both platforms in response to stress. The coefficient on DOM is always postive and statistically significant showing that the trading volume is on average higher in the domestic market.

The results for the bid-ask spread are in Panel B of Table 8. Here the coefficient γ of the interaction term $DOM \times post$ is always positive and statistically significant at the 1% or 5% level. This shows that spreads increase more on the domestic platform than on the EBM. Based on specification (5) this corresponds to an additional increase in bid-ask spreads of 0.0008 (or 6.2% relative to the unconditional mean) on the domestic platform. Even though the economic magnitudes are small in absolute terms, given that this is a competitive market it is significant that the change in average spread of the same bond differs across platforms. The coefficient on the variable post indicates that bid-ask spreads rise signifcantly in response to stress events and that the increase is monontonically increasing with the degree of market stress (increasing κ).

[Insert Figure 7 here]

Panel A of Figure 7 graphs the average trading volume on the domestic and the EBM platform from 10 days prior to the event to 10 days after the event. After the event volume decreases on both platforms, but significantly more on the domestic platform. Similar to the difference-in-difference analysis we find that prior to the event trading volume is greater on the domestic platform. Prior to the event day volume is more or less constant on both platforms suggesting that we do not have diverging trends prior to the event. We also display the trading volume of our placebo events (randomly generated). It is reassuring that the placebo events do not seem to be associated with abnormal volume.

This section has shown that the reduction in trading volume primarily occurs in the domestic market and that domestic spreads increase disproportionately. For domestic market makers our events represent a larger decrease in their risk bearing capacity due to the overweighting of domestic sovereign bonds in their balance sheet. Thus, this section is consistent the existence of a link between market maker wealth and liquidity provision (Ho and Stoll, 1981). Essentially, this section documents that when the exposure to the shock is large and market makers are homogenous the freeze is more palpable.

4.4 Time Series Regressions

In this section we use the fact that certain shocks have a larger impact on investor rebalancing while others are more likely to affect the liquidity provision of market makers and thus have different implications for volume. For example, an increase in Bank CDS spreads is likely to affect the funding costs of the market maker and therefore liquidity provision and ultimately results in a decrease in volume. On the other hand, we hypothesize that equity market shocks primarily affect volume through investor wealth effects (generating investor rebalancing).

In Eqs. (11)-(13) we estimate a simultaneous equation system, based on aggregate time series data, where volume is determined by the yield spread and the bid-ask spread. These two variables in turn are a function of shocks (described below). This implies that we can trace the impact of those shocks on volume through their impact on yield and bid-ask spreads. The equation system we estimate is:

$$VOL_t = \alpha_1 + \rho_1 VOL_{t-1} + \beta YLS_t + \gamma BAS_t + \sum_{k=1}^{K} \delta_{1k} Control_{k,t} + u_{1t}, \tag{11}$$

$$BAS_t = \alpha_2 + \rho_2 BAS_{t-1} + \sum_{n=1}^{N} \phi_n Shock_{k,t} + \sum_{k=1}^{K} \delta_{2k} Control_{k,t} + u_{2t}, \quad (12)$$

$$YLS_t = \alpha_3 + \rho_3 YLS_{t-1} + \sum_{n=1}^{N} \pi_n Shock_{k,t} + \sum_{k=1}^{K} \delta_{3k} Control_{k,t} + u_{3t}, \quad (13)$$

where VOL_t, BAS_t and YLS_t are the sample volume, the volume weighted bid-ask spread and the volume weighted yield spread. The shocks that we hypothesize will affect volume trough investor rebalancing (as a consequence of wealth effects) are: VSTOXX (implied volatility of EuroStoxx50), equity returns (returns of EuroStoxx50) and foreign exchange movements (Euro-to-US Dollar exchange rate).[32] We hypothesize that the following shocks primarily affects volume through the transaction cost channel: Bank CDS spreads (CMA Bank Sector Credit Default Swap Index) and the Libor-OIS spread (funding frictions imply that market makers are unable to fund inventory, Nyborg and Östberg, 2014).

Additionally, we control for macroeconomic announcements, changes of the main refinancing rate, day of the week, month of the year and a time trend. The system is estimated using the General Method of Moments (GMM) in order to take the pre-estimation of the yield and bid-ask spreads as well as cross-equation correlations into account. Standard errors are calculated using the method of Newey and West (1984) with seven lags.[33]

[Insert Table 9 here]

Table 9 displays the descriptive statistics of the shock variables and the sample volume. In this section since we consider the entire sample we do not need to benchmark volume to facilitate cross-country comparison. On the average day sovereign bonds worth EUR 7.38 billion are traded on MTS. The traded amount is substantially lower in the crisis period (see Figure 1). Additionally, the table shows descriptive statistics for the Libor-OIS spread, the Euro-to-US Dollar exchange rate, Bank CDS spreads, the EuroStoxx 50 returns and the VSTOXX.

[32] In Calvet, Campbell and Sodini (2009) price changes (volatility) lead to passive changes in investor portfolios that are offset with active rebalancing. In addition to that Kyle and Xiong (2001) argue that a shock in one market (here equity or foreign exchange market) can lead to a trade in another market because investors liquidate positions in both markets when they face losses. Additionally, foreign currency appreciations are hypothesized to trigger a reallocation of funds of foreign investors if FX risk-trading is imperfect (Hau and Rey, 2004).

[33] In unreported analysis we estimated the system in Eqs. (11)-(13) using equation-by-equation OLS and the results were qualitatively the same. The results are available upon request. The number of lags used to calculate Newey-West standard errors is determined by the fourth root of the number of observations, as suggested by Greene (2012, p. 960).

Table 10 presents the results of esimating the system described by Eqs. (11)-(13). The shock variables, VSTOXX, Libor-OIS and the bank CDS spreads are all correlated and therefore we start by estimating the system with only one of the variables included at a time (equation systems (1)-(3) in Table 10). Additionally, in system (4) we include all variables simultaneously. Reassuringly, the results are qualitatively similar and therefore we base the following discussion on system (4).

[Insert Table 10 here]

We find that the bid-ask spread is negatively related to volume (throughout all estimated equation systems). The point estimates are statistically significant at the 1% level. In terms of economic magnitude, a one standard increase in the bid-ask spread reduces volume by EUR 898.67 million which represents a drop of 12.2% relative to the unconditional mean (EUR 7,383.1 million). Moreover we find that the yield spread is positively related to volume (statistically significant at the 1% level in all the estimated equation systems). An increase of the yield spread by one standard deviation leads to an increase in volume of EUR 161.16 million (2.18% relative to the unconditional mean). Even though economically significant the economic impact of the yield spreads on volume is much lower than the impact of the bid-ask spreads (consistent with our previous results). This suggests that the liquidity and the rebalancing channel both exist, but that the transaction costs channel is the dominant one.

We explore the determinants of the bid-ask spread by estimating Eq. (12). Bank CDS spreads and the Libor-OIS spread have a positive impact on bid-ask spreads and are statistically significant at the 1% level. This is consistent with the idea that reduced risk-taking capacity of market makers or higher costs to finance inventories result in higher bid-ask spreads (Ho and Stoll, 1981). As expected the VSTOXX has a positive effect while equity returns are negatively related to bid-ask spreads, however, both are not statistically significant.

In Eq. (13) we examine the determinants of the yield spread. We find that yield spreads are negatively related (statistically significant at the 1% level) to equity returns suggesting that losses in the equity market (associated with wealth effects) lead to a desire of holding safe assets (German bonds as opposed to more risky sovereign bonds of for example Italy or Spain). The Euro-to-US Dollar exchange rate is positively and significantly related to yields spreads as well. A weak euro is often associated with concerns about the soundness of the fiscal situation of euro-area economies and has wealth effects (Hau and Rey, 2008).

Having estimated system Eqs. (11)-(13) we can trace shocks through the system. A shock in bank CDS spreads will effect volume trough both the bid-ask spread and the yield spread. A one standard deviation increase in bank CDS spreads increases bid-ask spreads by 19.44% and yield spreads by 1.0% (relative to the unconditional mean). The net effect on volume of these two effects is estimated to be a EUR 135.19 million decrease in volume (-1.8% relative to the unconditional mean). A shock to the Libor-OIS spread only has a significant effect on volume trough the bid-ask spread. A one standard deviation increase leads to an increase in the bid-ask spread by 11.37% relative to the unconditional mean. This increase in the bid-ask spread feeds into a decrease of volume by EUR 77.7 million (-1.1% relative to the unconditional mean).

A decrease in equity returns leaves bid-ask spreads unchanged (no significant relation) but leads to a statistically significant increase of the yield spread of 2.8% (compared to the unconditional mean). Through the yield spread volume increases by EUR 3.77 million which corresponds to 0.1% increase compared to the unconditional mean. This suggests that the yield spread channel is rather weak but can be dominant if the origin of market stress is mainly associated with wealth effects.

[Insert Table 11 here]

In Table 11 we estimate Eq. (11) using first differences of the bid-ask spread and the yield spread as well as the relative volume ratio $RVOL$. In specification (1) we do not add any control variables. Going from specification (1) to (5) we add control variables (the same as in the level regressions) one by one until we have included the full set. In all the specifications the results show that $RVOL$ is decreasing in bid-ask spreads and increasing in yield spreads (associated coefficients are always statistically significant). These results thus support the conclusions from the level regressions.

5 Conclusion

The European sovereign bond market is central to the operation of the European financial system. Not only is the functioning of this secondary market essential for countries that need to borrow, but also affects monetary transmission in the Euro area since sovereign debt is often used as collateral in refinancing operations (both the main refinancing operations and the longer-term refinancing operation of the European Central Bank) and other repo transactions. Given that liquidity providers (large banks) have significant exposure to our stress events the recent European sovereign debt crisis provides an ideal setting to study the impact of reductions in risk bearing capacity and the follow on effects on liquidity (bid-ask spreads) and ultimately trading.

In this paper we use trade-by-trade data from the MTS platform from April 2003 to December 2014. The comprehensiveness of the data allows us to characterize trading activity of participants in this market. In particular, we find that in, times of stress, trading is occasionally almost halted. The response of the market to stress is highly conditional on the willingness / capacity of market makers to provide liquidity. Additionally, we show that more exposed market makers quote higher spreads which depresses trading activity. Moreover our results suggest that a shock that results in an increase in market maker CDS spreads will reduce their risk bearing capacity and as a result market makers protect themselves by widening bid-ask spreads. Consistent with this, we find that shocks that are not associated with an increase in bid-ask spreads are associated with rebalancing (elevated volume). However, if the shock is also associated with an increase in bid-ask spreads, then it is often the case that the increase in trading costs outweigh the rebalancing motive and the market appears to freeze.

Given the central nature of this market, freezes may contribute to system wide instability. Our research suggests that the functioning of the European sovereign bond markets depends on a small number of dealer banks whose balance sheets are not able to facilitate intermediation services in times of stress. In other markets alternative market makers such as high frequency traders step in (Carrion, 2013, notes that HF traders provide liquidity in the equity market when other providers are unable). Potentially, regulators should thus aim at making this market more resilient by facilitating more market makers and disentangling the market maker balance sheets from sovereign risk. Extrapolating, the reduction in liquidity provision is potentially a negative side effect of moral suasion (Ongena et al., 2016). Overall, this paper challenges the view that the recent sovereign debt crisis was associated with large scale rebalancing.

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Appendix: Constant Maturity Yields

The Nelson and Siegel (1987) model expresses the yield Y as a function of the maturity m and four parameters as follows:

$$Y_t(m) = \beta_{0,t} + \beta_{1,t}\frac{1 - exp(-\frac{m}{\tau_t})}{\frac{m}{\tau_t}} + \beta_{2,t}\left[\frac{1 - exp(-\frac{m}{\tau_t})}{\frac{m}{\tau_t}} + exp\Big(-\frac{m}{\tau_t}\Big)\right], \qquad (14)$$

where β_0 can be interpreted as the long-term interest rate and $\beta_0 + \beta_1$ as the short term interest rate (as m tends to zero the yield tends to $\beta_0 + \beta_1$). The β_2 parameter defines the magnitude and the shape of the hump or the U-shape of the estimated curve. The τ-parameter determines exponential decay.

First, we determine theoretical prices based on the yield curve. This involves defining discount rates for each cash flow for all our bonds. Each discount rate depends on the maturity of the cash flow and is calculated from Eq. (14). The theoretical price of the bond is the sum of all the discounted cash flows. Second, we choose the parameters β_0, β_1, β_2 and τ such that the weighted squared difference between observed and theoretical prices is minimized. We calculate weights based on the duration of the bonds as proposed by Bliss (1997).[34] The problem is solved using the Newton-Raphson algorithm. To reduce the dependence of the solution on the starting values we apply a grid search for globally optimal starting parameters using a methodology developed by Werner and Ferenzi (2006).[35]

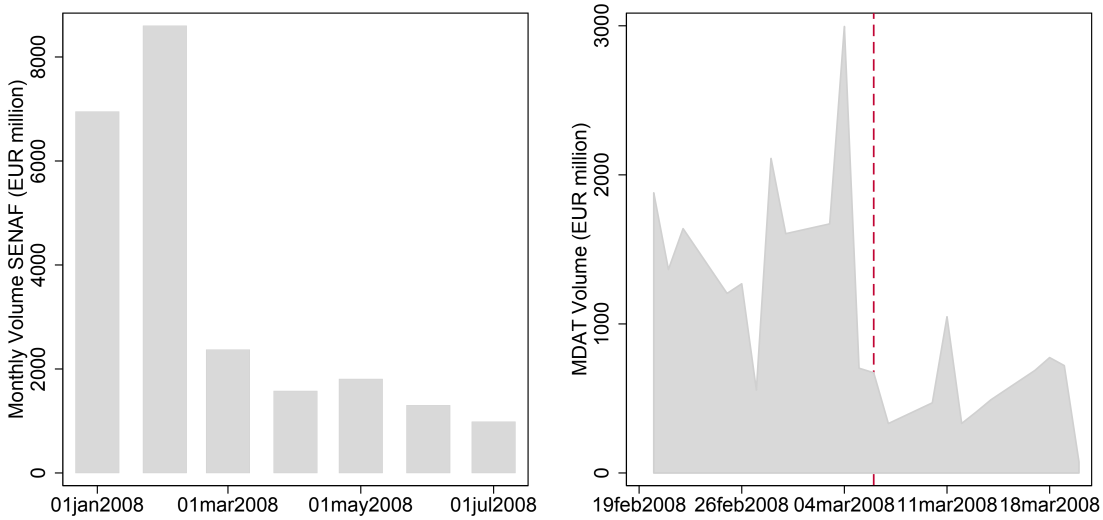
Practically, we use information from the reference files to construct the series of cash-flows for each bond. The cash-flow dates are determined by the first coupon date, the maturity date and the coupon frequency. The size of the cash flow is defined by the coupon rate and the principal payment at maturity. The convention on MTS is that prices are quoted without accrued interest (referred to as clean price), implying that the price actually paid is the sum of the clean price and the accrued interest (dirty price). To match the dirty theoretical price we add the accrued interest to the quoted clean price.

For Belgium, Germany, France, Italy, the Netherlands and Spain our yield curve optimization converges for all of our sample days. In other countries we fail to achieve convergence in rare occasions (with the exception of Greece, Portugal (99.86%) and Ireland

[34] The weighting is introduced since longer duration bonds are more price sensitive and therefore lead to heteroskedasticity.

[35] Ferstel and Hayden (2010) provides a good description of the implementation of Nelson and Siegel yield curve estimation using the weights proposed by Bliss (1997) and the grid search algorithm of Werner and Ferenzi (2006) in R. We implemented the corresponding optimization in mata. Further details of the yield curve estimations are summarized in Appendix A.

(99.15%) have the lowest rate of convergence). In these cases of non-convergence we interpolate the 10 year yield using the value from day $t = -1$ and day $t = +1$. In total this results in 31 replacements which corresponds to 0.01% of the country bond-days. In Greece we observe a widening of quotes during the height of the sovereign debt crisis making the mid price unreliable for a large cross-section of bonds and ultimately resulting in non-convergence. Thus, after April 14, 2011 we use the yields of the bond that is closest to have 10 years to maturity.



Panel A *Panel B*

Figure 2: Total volume SENAF and MDPA

Panel A displays the monthly trading volume (in Euro millions) as reported by SENAF (Sistema Electrónico de Negociación de Activos Financieros) a domestic electronic trading platform for Spanish sovereign debt between January, 2008 and July, 2008. Panel B plots daily trading volume (in Euro millions) from the Mercado de Deuda Pública Anotada (as reported by primary dealers to the Bank of Spain) over the period February, 12, 2008 to March, 20, 2008. The vertical dotted line is on March 6, 2008.

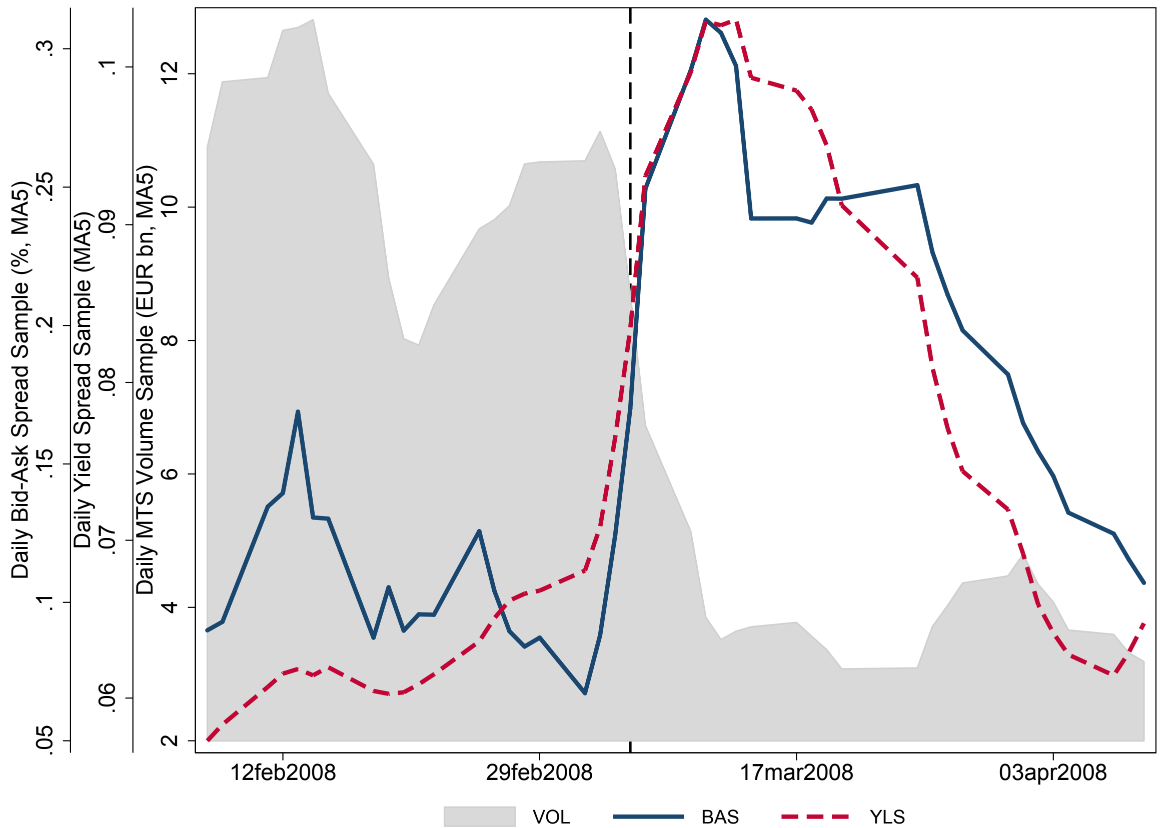


Figure 3: Sample volume, bid-ask spreads and yield spreads around March 6, 2008

This figure displays the time series of five-day moving averages (MA5) of the Euro volume, the volume weighted bid-ask spreads and the yield spread over the first quarter of 2008. The euro volume is calculated from notional amounts and trade prices for all trades that occur on MTS. The volume of all trades at a particular day is then summed across all bonds in the sample (excluding Germany) to arrive at the sample volume. The daily bid-ask spread is calculated as an equally weighted average across all the quotes (for a particular bond). Next the daily sample bid-ask spread is calculated as volume weighted average (based on the last 20 trading days) across all bonds. The yield spread is calculated as the difference between 10-year constant maturity yields of Germany and the respective country divided by the German yield and then aggregated to the sample level using volume weighting (based on the last 20 trading days). The 10-year constant maturity yields are estimated from the cross-section of bonds in a country using the Nelson and Siegel (1987) method.

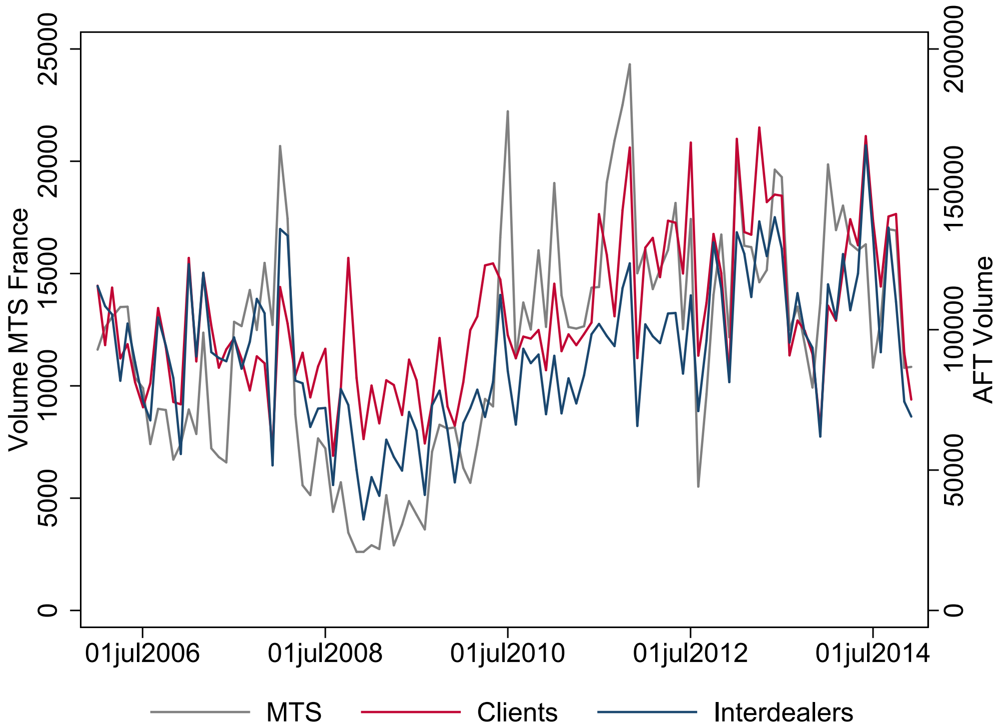


Figure 4: Volume by Market Segments in the French Market

This figure displays time series of monthly trading volume in the French sovereign bond market. The blue line labeled Interdealer is the total trading volume (in EUR) when both parties of a trade are dealers. The red line labeled Clients is the total trading volume (denominated in EUR) when one party is a client and the other is a dealer. The Interdealer and the Clients data is supplied by the French treasury agency (Agence France Trésor). The grey line labeled MTS is the overall volume traded in the French segment of the MTS platform.

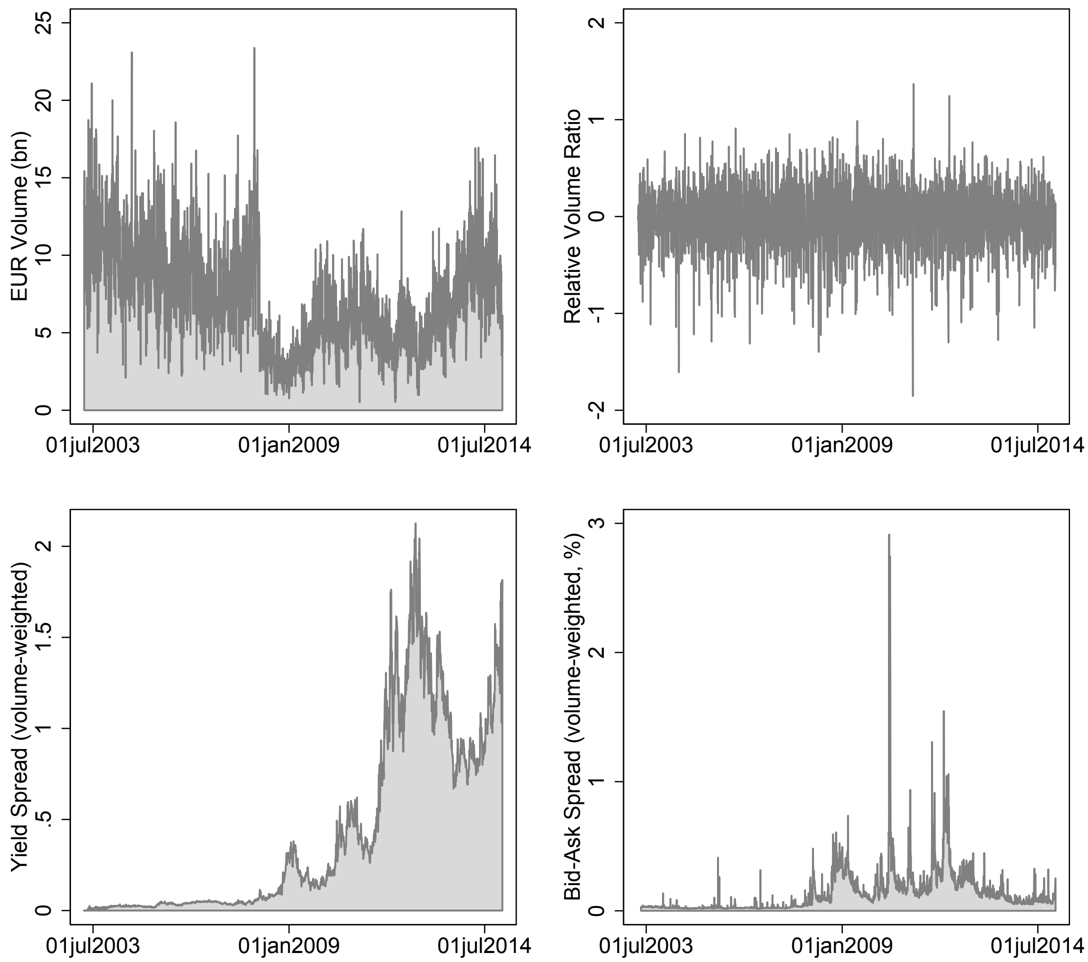


Figure 5: Time series of daily volume, relative volume, bid-ask spreads and yield spreads

This figure shows the evolution of euro volume (VOL), the relative volume ratio ($RVOL$), the bid-ask spreads (BAS) and the yield spreads (YLS) at daily frequency for the whole sample (excluding Germany) between April 2003 to December 2014. The first graph shows daily volume. The euro volume is calculated from notional amounts and trade prices for all trades that occur on MTS. The volume of all trades at a particular day is then summed across all bonds in the sample (excluding Germany) to arrive at the sample volume. The second graph shows the relative volume ratio, which is calculated as the difference between the logarithm of current volume and the average of the logarithm of volume in the previous five days, as follows:

$$RVOL_t = log(VOL_t) - \frac{1}{5}\sum_{l=1}^{5} log(VOL_{t-l}).$$

The third graph shows yield spreads. The yield spread is calculated as the difference between 10-year constant maturity yields of Germany and the respective country divided by the German yield and then aggregated to the sample level using volume weighting (based on the last 20 trading days). The 10-year constant maturity yields are estimated from the cross-section of bonds in a country using the Nelson and Siegel (1987) method. The fourth graph shows relative bid-ask spreads. For each quote (we observe each quote update of best bid- and ask prices) the bid-ask spread is calculated as the difference between the best ask price and the best bid price divided by the mid price (average of bid and ask price). The daily bid-ask spread is calculated as an equally weighted average across all the quotes (for a particular bond). Next the daily sample bid-ask spread is calculated as volume weighted average (based on the last 20 trading days) across all bonds.

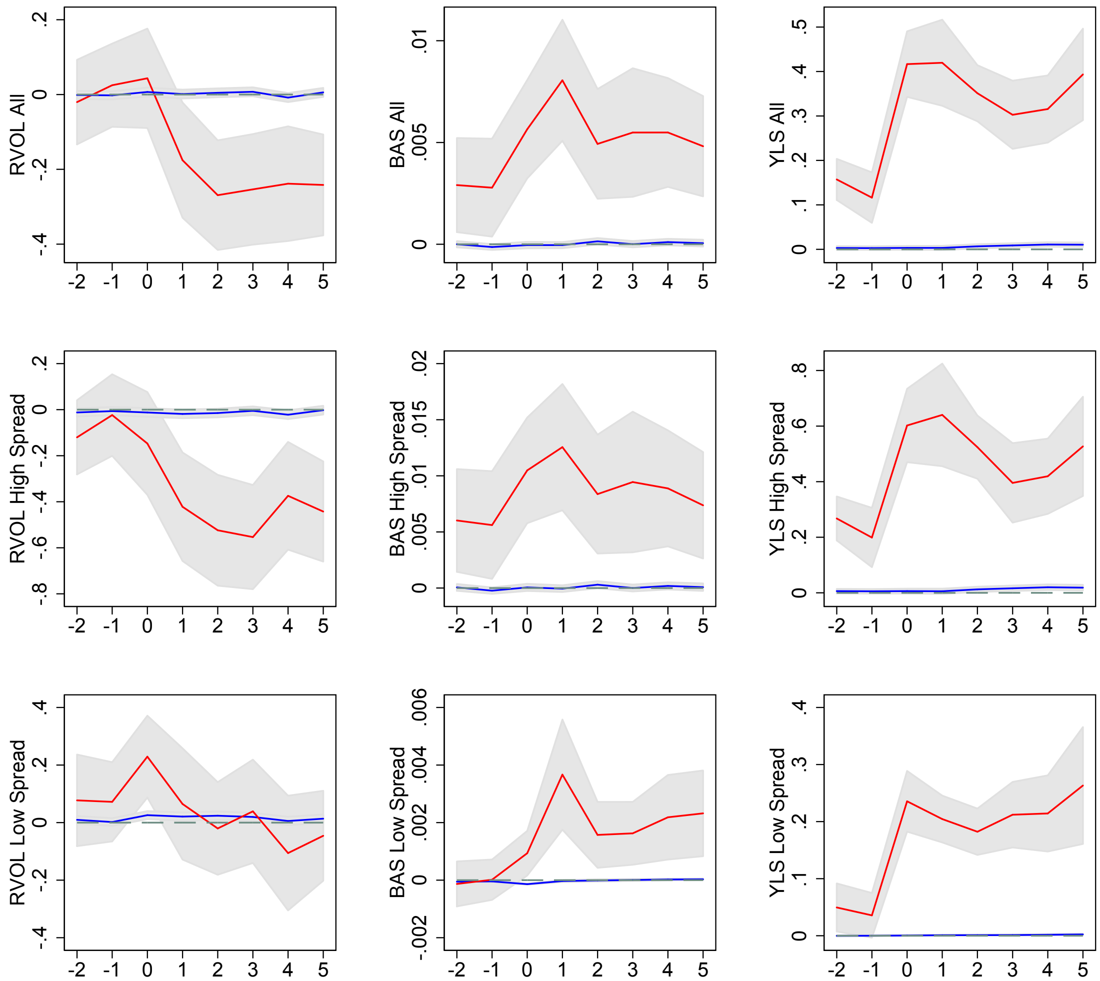


Figure 6: Relative volume, bid-ask spread and yield spread in event time

This figure shows the evolution of the average relative volume ratio, the abnormal bid-ask spread and the abnormal yield spread (calculated as the difference between the value of the variable at a particular day in the event window and the five day average from $\tau = -10$ to $\tau = 6$) for events as defined by the threshold model with $\kappa = 1.0$ and $\kappa^{DE} = -0.75$ over the event window from $\tau = -2$ to $\tau = 5$. The relative volume ratio, yield spreads and bid-ask spreads are calculated as described in Figure 5 (Note here the aggregation takes place on the country level). The red solid line represents the mean of the variable of interest calculated from the actual events and the blue line represents the means calculated from 15 random (placebo) events (resampled 200 times). The grey shaded areas are 95% confidence intervals (calculated using standard errors obtained with the cross-sectional approach). From left to right the figure shows the graphs for different variables: volume ratio $RVOL$ (left), bid-ask spread BAS (middle) and yield spread YLS (right). From top to the bottom we plot different sets of events. The graphs at the top show the average for all events. In the middle and at the bottom we show graphs for high and low bid-ask spread events. We split events according to the bid-ask spread at the event day. If the bid-ask spread is below (above) the median bid-ask-spread across all events in a country it is classified as low (high) bid-ask spread event.

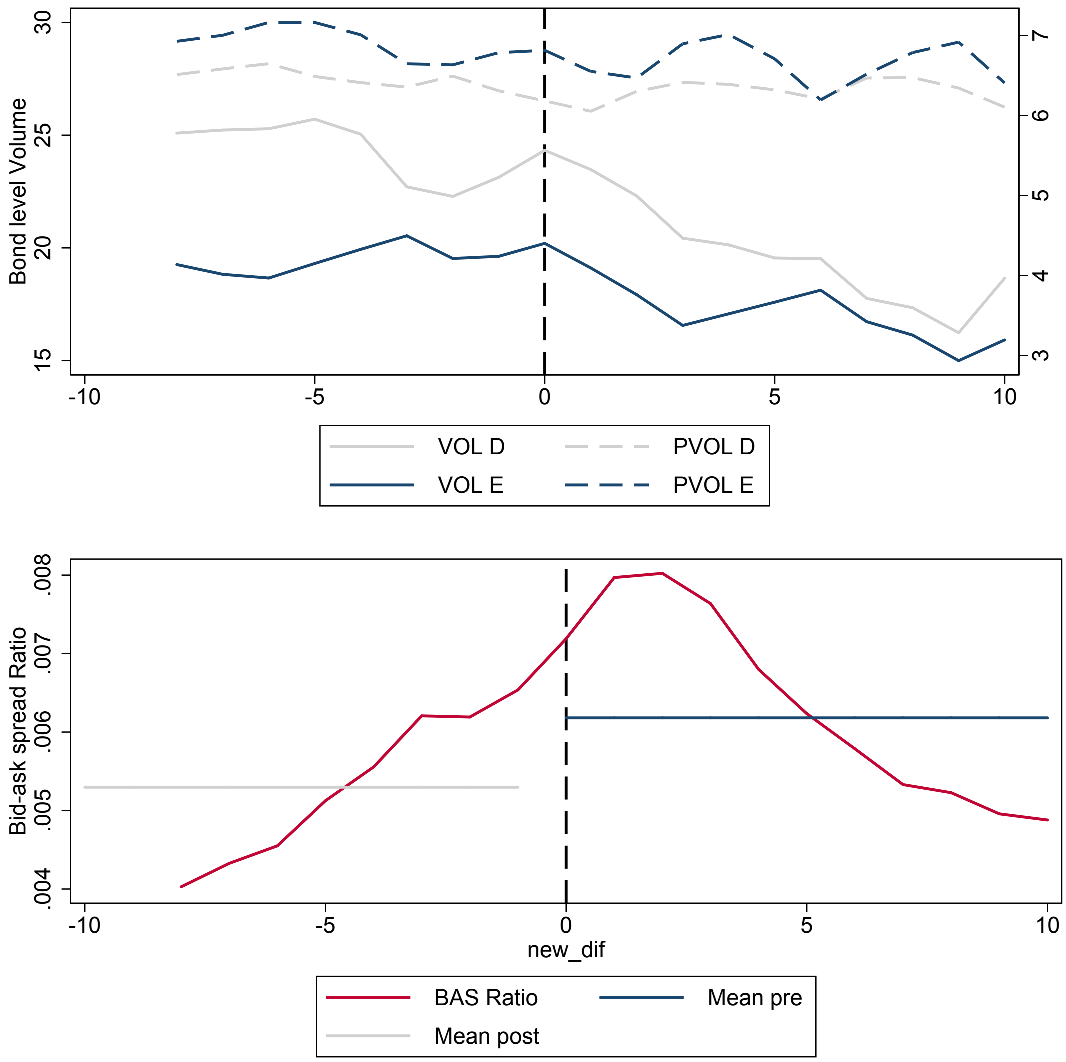


Figure 7: Platform Comparison

The graphs show volume and the bid-ask spread for the European Bond Market E (blue) and the domestic bond market D (grey) around our events for the threshold model with a κ of 2. The first graph shows the mean daily aggregated trading volume at the bond level in both markets. The time series is smoothed using an MA(3). The dashed lines are placebo lines (P) based on 200 randomly sampled events (20 for each country). The Second graph plots the difference of the bid-ask spreads in the domestic and EBM market. The difference between the bid-ask spreads is smoothed using an MA(3). The straight lines represent the pre (post) event mean of the difference (grey/dark blue).

Table 1: Descriptive statistics - Sample size, trading environment and ratings

This table contains descriptive statistics of the sample size (Panel A), the trading environment (Panel B) and credit ratings (Panel C) at country and sample level. Panel A shows the *Number of trading days* (number of days where we can calculate the full set of variables), the *Number of bonds* (overall number of bonds in the dataset), the number of bonds, trades and quotes observed in the cross-section at an average day (*Bonds/trading day, Trades/trading day* and *Quotes/trading day*), the average daily *EUR volume* in millions (first summed over all bonds every day and then averaged across days) and the average *Trade size* (quotient of EUR volume in millions and number of trades). Panel B shows averages (across both time and the cross-section of bonds) for the *Minimum quantity* which is the minimum EUR amount in millions that has to be quoted on the MTS platform (varies across securities), the *Number of participants* (number of banks that trade on the MTS platform), the *Number of market makers* which shows the number of participants that have quoting obligations and the *Compliance time* which is the minimum time in hours that market makers have to quote prices. Panel C shows the Standard & Poors (S&P) credit ratings for the issuer in 2003 (beginning of the sample) and 2014 (end of the sample).

	AT	**BE**	**DE**	**ES**	**FI**	**FR**	**GR**	**IE**	**IT**	**NL**	**PT**	**Sample**
	Panel A: Sample Size Statistics											
Number of trading days	2957	2957	2957	2957	2957	2957	2602	2957	2957	2957	2957	2928.29
Number of bonds	33	258	383	334	27	874	103	61	565	216	116	271.84
Bonds/trading day	15.65	43.84	62.21	58.55	9.56	85.66	19.75	8.72	71.01	26.69	19.31	38.47
Trades/trading day	12.54	86.97	56.83	64.59	18.33	74.51	38.53	5.59	734.16	52.15	43.09	108.7
Quotes/trading day (k)	19.43	33.49	53.7	43.24	12.68	55.3	18.33	7.39	82.61	24.54	16.43	33.54
Trade size (mn)	7.85	9.21	7.08	8.03	9.15	8.32	5.86	6.74	5.49	9.6	7.59	7.77
EUR volume (mn)	103.46	812.92	405.64	496.32	174.17	623.95	284.25	38.99	4029.84	492.74	361.12	715.93
	Panel B: Trading Environment (averages)											
Minimum quantity (mn)	7.57	8.59	7.30	9.20	9.75	7.03	8.60	7.21	4.08	9.23	8.17	7.45
Number of participants	50.85	33.29	56.05	45.44	43.29	33.51	40.88	34.38	78.09	43.00	41.56	48.84
Number of market makers	13.10	13.65	12.62	8.35	15.81	14.42	12.39	12.88	12.70	14.76	15.45	12.85
Compliance time	5.22	5.14	5.28	6.90	5.26	5.22	5.00	5.22	5.31	5.23	5.24	5.48
	Panel C: Overview Rating											
S&P Rating in 2014	AA+	AA	AAA	BBB-	AA+	AA	CCC-	BBB+	BBB-	AA+	BB	-
S&P Rating in 2003	AAA	AA	AAA	AAA	AAA	AAA	A	AA+	AA-	AAA	AA	-

Table 2: Descriptive statistics main variables

This table shows mean, standard deviation (*sd*), median as well as the minimum (*min*) and the maximum (*max*) for the main variables in our analysis. The last column shows the statistics for the whole sample (excluding Germany) while the other columns show the corresponding statistics for the single countries. The statistics on this table are calculated for the entire sample period from April 2003 to December 2014. In panel A this table shows descriptive statistics of the relative volume ratio ($RVOL$) which is calculated as follows:

$$RVOL_t = log(VOL_t) - \frac{1}{5}\sum_{l=1}^{5} log(VOL_{t-l}),$$

where VOL is the euro volume of the country/sample (EUR value of the traded quantity at a particular day over all bonds in a country/the sample excluding Germany). Panel B shows statistics for the relative bid-ask spreads. For each quote (we observe each quote update of best bid- and ask prices) the bid-ask spread is calculated as the difference between the best ask price and the best bid price divided by the mid price (average of bid and ask price). The daily bid-ask spread is calculated as an equally weighted average across all the quotes (for a particular bond). Next the daily country/sample bid-ask spread is calculated as volume weighted average (based on the last 20 trading days) across all bonds. Lastly, Panel C shows statistics for the yield spread. The yield spread for each country is the difference between 10-year constant maturity yields of Germany and the other sample countries divided by the German yield and then aggregated to the sample level using volume weighting (based on the last 20 trading days). The 10-year constant maturity yields are estimated from the cross-section of bonds in each country using the Nelson and Siegel (1987) method.

	AT	**BE**	**DE**	**ES**	**FI**	**FR**	**GR**	**IE**	**IT**	**NL**	**PT**	**Sample**
Panel A: Descriptive Statistics Volume Ratio												
mean	-0.004	-0.001	-0.002	-0.001	-0.003	-0.001	-0.006	-0.001	-0.001	-0.003	-0.002	-0.001
median	0.094	0.028	0.035	0.047	0.102	0.027	0.039	0.060	0.011	0.036	0.065	0.019
sd	1.271	0.657	0.621	0.729	1.304	0.565	0.743	1.478	0.372	0.669	1.073	0.309
min	-5.207	-6.838	-4.653	-5.406	-6.229	-4.669	-5.118	-4.750	-1.736	-5.338	-5.719	-1.853
max	4.008	2.613	2.730	3.277	4.236	2.158	2.756	4.505	1.303	2.384	4.342	1.367
count	2957	2957	2957	2957	2957	2957	2602	2957	2957	2957	2957	2957
Panel B: Descriptive Statistics Relative Bid-Ask Spreads (%)												
mean (all)	0.300	0.091	0.101	0.249	0.143	0.099	2.777	0.967	0.123	0.062	0.749	0.132
mean (pre crisis)	0.038	0.027	0.034	0.031	0.025	0.032	0.054	0.040	0.020	0.024	0.033	0.025
mean (crisis)	0.451	0.127	0.140	0.375	0.211	0.137	4.708	1.501	0.182	0.085	1.160	0.194
median	0.165	0.042	0.068	0.112	0.086	0.067	0.216	0.265	0.064	0.042	0.197	0.081
sd	0.396	0.127	0.097	0.351	0.173	0.105	6.075	1.690	0.178	0.070	1.296	0.169
min	0.023	0.014	0.020	0.022	0.016	0.016	0.023	0.024	0.012	0.013	0.017	0.016
max	5.026	1.418	1.394	4.253	1.482	1.247	56.245	23.429	2.666	1.330	11.773	2.914
count	2957	2957	2957	2957	2957	2957	2602	2957	2957	2957	2957	2957

(This table continous on the next page)

Continuation of Table 2

Panel C: Descriptive Statistics Yield Spreads											
mean	0.124	0.226	-	0.142	0.639	0.067	1.945	0.779	0.644	0.069	1.210	0.434
median	0.082	0.086	-	0.042	0.119	0.044	0.117	0.366	0.186	0.039	0.132	0.155
sd	0.162	0.297	-	0.200	0.897	0.085	3.480	0.984	0.824	0.078	1.760	0.515
min	-0.072	-0.011	-	-0.016	-0.017	-0.049	-0.506	-0.075	0.007	-0.070	-0.003	-0.001
max	1.032	1.565	-	1.034	4.592	0.418	23.193	4.546	3.879	0.408	11.322	2.126
count	2957	2957	-	2957	2957	2957	2602	2957	2957	2957	2957	2957

Table 3: Descriptive statistics events

Panel A shows the frequency of each type of event for the different countries. We define events by using a threshold model which defines events as days where both the decrease in the German yield is below a certain threshold and the increase in the yield of the corresponding country is above a certain threshold (at the same time). The thresholds are calculated as the product of past volatility of yield changes and the parameter κ (i.e., $z_{m,t} = \kappa \times \sigma_t$). For Germany we use a fixed κ^{DE} of -0.75, while for the other countries we use different values (κ is either 1.0, 1.5 or 2.0). Panel B shows descriptive statistics for the volume ratio ($RVOL$), the bid-ask spreads (BAS) and the yield spreads (YLS), defined as in Table 2. The statistics in Panel B are only calculated for the event period between $\tau = -2$ and $\tau = 5$ (event time) around the events.

Panel A: Number of events per country

	$\kappa = 2.0$	$\kappa = 1.5$	$\kappa = 1.0$
Austria	1	3	6
Beligium	4	11	20
Spain	15	27	51
Finland	2	2	3
France	0	1	5
Greece	21	27	38
Ireland	11	21	38
Italy	17	24	50
Netherlands	2	2	2
Portugal	11	20	32
Total	84	138	245

Panel B: Descriptive statistics event periods

	mean	median	sd	semean	min	max	count
RVOL TM $\kappa = 1.0$	-0.1412	-0.0311	1.0986	0.0248	-5.4991	4.5819	1960
RVOL TM $\kappa = 1.5$	-0.1880	-0.0879	1.1406	0.0343	-5.4991	4.5819	1104
RVOL TM $\kappa = 2.0$	-0.2676	-0.1198	1.1602	0.0448	-4.5347	4.4798	672
BAS TM $\kappa = 1.0$	1.7016	0.7178	2.9548	0.0667	0.0175	44.385	1960
BAS TM $\kappa = 1.5$	2.0100	0.8651	3.0864	0.0929	0.0181	44.385	1104
BAS TM $\kappa = 2.0$	2.3818	0.9731	3.6473	0.1407	0.0181	44.385	672
YLS TM $\kappa = 1.0$	1.7921	1.4572	1.7548	0.0396	-0.5063	18.708	1960
YLS TM $\kappa = 1.5$	1.8021	1.5815	1.6388	0.0493	-0.5063	17.619	1104
YLS TM $\kappa = 2.0$	1.8320	1.5538	1.7790	0.0686	-0.5063	17.619	672

Table 4: Market Stress, Trading Volume and Liquidity

Panel A contains the results of the event study for different measures of market stress. The event window starts at $\tau = -2$ and lasts until $\tau = 5$. Events are defined as explained in table 3 according to the threshold model. As a measure for abnormal volume the relative volume ratio $RVOL$ as defined in Table 2 is used. Panel B is based on the threshold model with a $\kappa = 1$ and contains the results for abnormal volume and bid-ask spreads for two subgroups (a high and a low bid ask spread group). We split events according to the bid-ask spread at the event day. If the bid-ask spread is below (above) the median bid-ask-spread across all events in a country it is classified as low (high) bid-ask spread event. The top of Panel B contains the result for the $RVOL$. The first (second) row contains the result for the high (low) bid-ask spread group. The third row shows the difference between the abnormal volume in the two groups. The bottom of Panel B contains the abnormal value of the bid-ask spreads BAS during the event window for both groups and the difference between the two groups. The abnormal bid-ask spread is calculated as the difference between the bid-ask spread in a given day in the event window and the average bid-ask spread in the [-10,-6] period. Each entry in this table contains two values: point estimates and t-statistics calculated based on standard errors from the cross-sectional approach (in brackets). ***,**,* denote statistical significance at the 1%, 5% and 10% level.

	-2	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
Panel A: RVOL for different flight measures								
TM $\kappa = 2.0$	-0.080	-0.057	-0.180	-0.336**	-0.381***	-0.335***	-0.404***	-0.369***
	(-0.75)	(-0.52)	(-1.32)	(-2.45)	(-2.75)	(-2.83)	(-3.08)	(-2.83)
TM $\kappa = 1.5$	-0.067	0.038	-0.052	-0.167	-0.253**	-0.298***	-0.379***	-0.326***
	(-0.77)	(0.49)	(-0.55)	(-1.55)	(-2.52)	(-2.97)	(-3.52)	(-3.41)
TM $\kappa = 1.0$	-0.020	0.025	0.043	-0.176**	-0.269***	-0.253***	-0.238***	-0.242***
	(-0.35)	(0.44)	(0.64)	(-2.24)	(-3.62)	(-3.38)	(-3.06)	(-3.53)
Panel B: RVOL and abnormal BAS for high and low bid-ask spread Events (TM $\kappa = 1.0$)								
HS $RVOL$	-0.120	-0.024	-0.147	-0.422***	-0.524***	-0.553***	-0.374***	-0.443***
	(-1.48)	(-0.26)	(-1.30)	(-3.54)	(-4.31)	(-4.84)	(-3.17)	(-4.03)
LS $RVOL$	0.077	0.072	0.229***	0.065	-0.020	0.039	-0.106	-0.046
	(0.96)	(1.04)	(3.19)	(0.66)	(-0.25)	(0.43)	(-1.05)	(-0.58)
Difference	-0.197*	-0.096	-0.376***	-0.487***	-0.504***	-0.593***	-0.268*	-0.397***
	(-1.73)	(-0.85)	(-2.83)	(-3.17)	(-3.46)	(-4.07)	(-1.73)	(-2.95)
HS BAS	0.215***	0.132***	0.911***	0.967***	0.816***	0.789***	0.813***	0.751***
	(5.58)	(3.04)	(11.58)	(10.59)	(9.24)	(8.55)	(9.30)	(10.02)
LS BAS	0.025	0.098***	0.275***	0.454***	0.285***	0.308***	0.347***	0.340***
	(0.75)	(3.22)	(5.80)	(7.54)	(4.28)	(5.12)	(5.06)	(5.42)
Difference	0.190***	0.034	0.636***	0.512***	0.531***	0.481***	0.465***	0.411***
	(3.72)	(0.64)	(6.96)	(4.71)	(4.82)	(4.39)	(4.20)	(4.22)

Table 5: Market Stress, Trading Volume and Liquidity - Countrygroup results

In this table we display the results of the event study (executed as described in Table 4) for two country groups. The first group contains all events that occur in a GIIPS country (Greece, Italy, Ireland, Portugal or Spain) and the second group contains all events that occur in a CORE country (Austria, Belgium, Finland, France and the Netherlands). The top of the table contains the results for abnormal volume (based on the relative volume ratio $RVOL$ as defined in Table 2) for the two subgroups. The bottom of the table contains the results for abnormal bid-ask spreads (calculated as described in Table 4 from bid-ask spreads calculated as described in Table 2) for the two subgroups. Each entry in this table contains two values: point estimates and t-statistics calculated based on standard errors from the cross-sectional approach (in brackets). ***,**,* denote statistical significance at the 1%, 5% and 10% level.

	-2	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
GIIPS RVOL	-0.051	0.016	0.003	-0.199**	-0.305***	-0.269***	-0.246***	-0.274***
	(-0.82)	(0.28)	(0.04)	(-2.43)	(-3.85)	(-3.36)	(-2.95)	(-3.76)
CORE RVOL	0.157	0.079	0.277	-0.040	-0.059	-0.165	-0.194	-0.054
	(1.05)	(0.40)	(1.40)	(-0.17)	(-0.28)	(-0.76)	(-0.89)	(-0.28)
DIF	-0.208	-0.063	-0.274	-0.159	-0.246	-0.104	-0.052	-0.220
	(-1.28)	(-0.39)	(-1.44)	(-0.72)	(-1.17)	(-0.49)	(-0.24)	(-1.14)
GIIPS BAS	0.003**	0.003**	0.006***	0.009***	0.005***	0.006***	0.006***	0.005***
	(2.46)	(2.21)	(4.42)	(5.19)	(3.44)	(3.27)	(3.81)	(3.67)
CORE BAS	0.000	0.001	0.002***	0.002***	0.002**	0.002***	0.002***	0.002**
	(0.66)	(1.35)	(2.88)	(3.24)	(2.56)	(2.90)	(3.21)	(2.37)
DIF	0.003	0.003	0.004	0.007*	0.004	0.004	0.004	0.004
	(0.95)	(0.75)	(1.30)	(1.69)	(0.99)	(0.97)	(0.95)	(1.04)

Table 6: Results cross-sectional regressions

This table contains results from estimating the following regression equation using ordinary least squares (OLS):

$$RVOL = \alpha_c + \beta BAS_{+}\gamma YLS + \sum_{k=1}^{K} \delta_k Control + u,$$

where $RVOL$ is the relative volume ratio, BAS is volume weighted relative bid-ask spread and YLS is the volume weighted yield spread (calculated as described in Table 2) in the country in which the event takes place on a particular day in the event window. Panel A shows the results for the levels and Panel B for the first differences. Specification (1)-(3) are estimated without control variables while specification (4)-(6) contain the full set of control variables. The control variables include dummies for the country, the weekday and the month as well as indicator variables for EU wide macroeconomic announcements (CPI, Employment GDP) and for ECB monetary policy decisions (change of main refinancing rate). For brevity we only display the coefficients of the bid-ask spread and the yield spread. N is the number of observations. Standard errors are clustered at the event level. ***,**,* denote statistical significance at the 1%, 5% and 10% level, respectively.

	(1) $\kappa = 1.0$	**(2)** $\kappa = 1.5$	**(3)** $\kappa = 2.0$	**(4)** $\kappa = 1.0$	**(5)** $\kappa = 1.5$	**(6)** $\kappa = 2.0$
Panel A: Cross-sectional Regressions Results Levels						
BAS	-0.095***	-0.095***	-0.122***	-0.092***	-0.098***	-0.107***
	(-3.88)	(-3.49)	(-3.53)	(-3.95)	(-3.38)	(-2.95)
YLS	0.114***	0.145***	0.174***	0.136***	0.163***	0.170***
	(4.11)	(3.91)	(3.80)	(4.83)	(4.08)	(3.50)
N	1960	1104	672	1960	1104	672
adjusted R^2	0.046	0.059	0.113	0.172	0.213	0.282
Panel B: Cross-sectional Regressions Results First Differences						
ΔBAS	-0.023**	-0.026**	-0.019	-0.034***	-0.037***	-0.029***
	(-2.08)	(-2.32)	(-1.61)	(-3.18)	(-3.36)	(-2.69)
ΔYLS	0.023	0.037	0.009	0.045	0.053*	0.011
	(0.64)	(1.20)	(0.27)	(1.12)	(1.69)	(0.32)
N	1960	1104	672	1960	1104	672.000
adjusted R^2	0.001	0.002	0.001	0.137	0.166	0.222
Country FE	No	No	No	Yes	Yes	Yes
Weekday	No	No	No	Yes	Yes	Yes
Month	No	No	No	Yes	Yes	Yes
Macro	No	No	No	Yes	Yes	Yes
Monetary	No	No	No	Yes	Yes	Yes

Table 7: Share of Domestic Market Makers

The table shows the share of market makers by their nationality for each of the 10 domestic MTS markets. The calculations are based on the participant lists published on the MTS website on November 21, 2016. The rows of the Table contain the market while the columns contain the market maker nationality. For example column one shows the number of Austrian market makers in the MTS domestic market indicated in each row. The first row splits market makers in Austria by their nationality. The mean is calculated across all column-wise. The difference is calculated as the difference between the share of domestic market makers and the mean. The t-value assesses the statistical significance. The standard deviation is calculated column-wise.

	AT	**BE**	**ES**	**FI**	**FR**	**GR**	**IE**	**IT**	**NL**	**PT**
AT	**8.33%**	0.00%	8.33%	0.00%	16.7%	0.00%	0.00%	4.17%	4.17%	0.00%
BE	0.00%	**4.55%**	4.55%	0.00%	18.2%	0.00%	0.00%	0.00%	13.6%	0.00%
ES	0.00%	0.00%	**29.2%**	0.00%	20.8%	0.00%	0.00%	0.00%	0.00%	0.00%
FI	0.00%	0.00%	0.00%	**10.00%**	15.0%	0.00%	0.00%	5.00%	5.0%	0.00%
FR	0.00%	0.00%	8.70%	0.00%	**17.4%**	0.00%	0.00%	8.70%	4.35%	0.00%
GR	0.00%	0.00%	0.00%	0.00%	14.3%	**14.3%**	0.00%	4.76%	4.76%	0.00%
IE	0.00%	0.00%	0.00%	0.00%	15.0%	0.00%	**5.00%**	0.00%	5.00%	0.00%
IT	0.00%	0.00%	6.90%	0.00%	13.79%	0.00%	0.00%	**24.1%**	3.45%	0.00%
NL	0.00%	0.00%	9.09%	4.55%	18.2%	0.00%	0.00%	0.00%	**13.6%**	0.00%
PT	0.00%	0.00%	8.00%	0.00%	16.0%	0.00%	0.00%	0.00%	4.00%	**20.0%**
mean	0.83%	0.45%	7.47%	1.45%	16.53%	1.43%	0.50%	4.68%	5.80%	2.00%
Diff	7.50%	4.09%	21.69%	8.55%	0.86%	12.9%	4.50%	19.5%	7.84%	18.0%
t-value	3.00	3.00	2.69	2.71	0.42	3.00	3.00	2.74	1.89	3.00

Table 8: Difference-in-Difference - Bond Level

This table contains the point estimates of the coefficients as well as the t-statistics (in parenthesis) from estimating the following regression,

$$Y_{b,p,t} = \alpha_{b,e} + \alpha_\tau + \beta\ DOM_p + \gamma DOM_p \times post_\tau + \sum_{k=1}^{K} \delta_k Control_{b,p,t} + u_{b,p,t},$$

using OLS. We consider 21 days around our events (from τ = -10 to +10), where the sample events (denoted by e) are defined by our threshold model with varying κ's. We only consider events for which we observe quotes on both the international and the domestic MTS platform. Additionally we require active trading for at least three dates per platform to include the platform volume for a particular event. The dependent variable is the euro volume ($VOL_{b,p,t}$) or the bid-ask spread ($BAS_{b,p,t}$) of bond b, on platform p at day t (which corresponds to an event e at event time τ). The volume is expressed in millions EUR divided by 10 and bid-ask spreads are expressed in % times 10. The variable post is an indicator variable that takes the value of 1 after the event and 0 before the event. The variable treatment takes the value of 1 for the domestic market and 0 for the EBM market. Specification (1) to (3) are without control variables while specification (4) to (6) contain the full set of control variables. The control variables are as defined in Table 6 and include additionally the minimum price tick. The specification also contains Bond×Event fixed effects and event time fixed effects. Standard errors are clustered around events. ***,**,* denote statistical significance at the 1%, 5% and 10% level, respectively.

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	$\kappa = 1.0$	$\kappa = 1.5$	$\kappa = 2.0$	$\kappa = 1.0$	$\kappa = 1.5$	$\kappa = 2.0$
Panel A: Results for EUR Volume						
Post	-0.032**	-0.085***	-0.081***			
	(-2.49)	(-3.18)	(-2.89)			
DOM	1.862***	1.788***	2.018***	3.408***	3.491***	3.820***
	(13.94)	(9.42)	(7.38)	(17.76)	(10.92)	(8.89)
DOM × *Post*	-0.254***	-0.441***	-0.429***	-0.249***	-0.453***	-0.439***
	(-3.71)	(-4.85)	(-3.77)	(-3.33)	(-4.27)	(-3.29)
N	163,149	81,900	53,739	163,149	81,900	53,739
R^2	0.042	0.034	0.039	0.314	0.310	0.334
Panel B: Results for Bid-Ask Spreads						
Post	2.616***	4.002***	4.640***			
	(7.48)	(6.46)	(5.00)			
DOM	3.823***	5.028***	5.467***	-0.458***	-0.534***	-0.677***
	(8.54)	(6.12)	(5.33)	(-4.56)	(-2.95)	(-3.06)
DOM × *Post*	0.832***	0.770**	0.882*	0.716***	0.808**	1.128***
	(4.24)	(2.19)	(1.87)	(3.71)	(2.34)	(2.68)
N	163,149	81,900	53,739	163,149	81,900	53,739
R^2	0.019	0.021	0.023	0.615	0.592	0.588
Minpricetick	NO	NO	NO	YES	YES	YES
Macro Dummy	NO	NO	NO	YES	YES	YES
Monetary Dummy	NO	NO	NO	YES	YES	YES
Month Dummies	NO	NO	NO	YES	YES	YES
Dow Dummies	NO	NO	NO	YES	YES	YES
Bond×Event FE	NO	NO	NO	YES	YES	YES
Event Time FE	NO	NO	NO	YES	YES	YES

Table 9: Descriptive statistics time series regressions

This table contains descriptive statistics for the time series of the aggregate volume (sample), the VSTOXX, bank CDS spreads, the Libor-OIS, the Euro-to-US Dollar exchange rate and the returns of the EuroStoxx50 between April 2003 and December 2014. The euro volume is calculated from notional amounts and trade prices for all trades that occur on MTS. The volume of all trades at a particular day is then summed across all bonds in the sample (excluding Germany) to arrive at the sample volume. The Libor-OIS spread is calculated as the difference between the EUR 3-Month London Interbank Offering Rate and the middle rate of the EUR 3-Month Overnight Index Swap (EONIA Swap). The European Bank Sector Credit Default Swap Index represents the 5-year CDS-premium of major European banks and is based on data from Credit Market Analysis (CMA). The VSTOXX is a volatility index that is calculated from the implied volatility of EuroStoxx50 index options. EuroStoxx50 returns are calculated from Index close prices assuming continuous compounding. The Euro-to-US Dollar exchange rate is the Reuters closing spot middle rate. All of this data is retrieved from DataStream.

		mean	**median**	**sd**	**semean**	**min**	**max**	**count**
VOL	EUR bn	7.383	7.123	3.343	0.062	0.513	23.387	2957
BAS	%	0.132	0.081	0.169	0.003	0.016	2.914	2957
YLS	-	0.434	0.155	0.515	0.010	-0.001	2.126	2957
LOIS	%	0.260	0.095	0.319	0.006	-0.015	1.953	2957
BCDS	%	1.576	1.275	1.430	0.027	0.074	6.064	2799
VSTOXX	/100	0.233	0.212	0.092	0.002	0.116	0.875	2957
EQRET	%	0.010	0.052	1.207	0.022	-9.001	10.219	2957
FXUSD	-	0.761	0.761	0.054	0.001	0.626	0.924	2957

Table 10: Time series regressions - Levels

This table contains the point estimates of the coefficients as well as the t-statistics (in parenthesis) from estimating the equation system (11)-(13) using GMM. The sample consists of the entire time series between April 2003 and December 2014. The dependent variables in the system are volume (VOL), the volume weighted yield spread (YLS) and the volume weighted bid-ask spread (BAS) which are calculated as described before in Table 2. The independent variables are different shocks: Bank CDS spreads ($BCDS$), Volatility Index ($VSTOXX$), Libor-OIS-Spread ($LOIS$), equity returns ($EQRET$) and the Euro-to-US Dollar exchange rate ($FXUSD$). Our shock variables are defined in Table 9. Standard errors are calculated using the method of Newey and West (1987) with 7 lags. ***,**,* denote statistical significance at the 1%, 5% and 10% level, respectively.

	VSTOXX (1)			**Bank CDS spread (2)**				**Libor-OIS (3)**			**ALL (4)**		
	VOL	*BAS*	*YLS*	*VOL*	*BAS*	*YLS*		*VOL*	*BAS*	*YLS*	*VOL*	*BAS*	*YLS*
Y_{t-1}	0.661***	0.941***	0.983***	0.644***	0.920***	0.981***		0.665***	0.953***	0.983***	0.638***	0.725***	0.978***
	(30.49)	(25.01)	(180.48)	(29.31)	(24.61)	(165.50)		(30.30)	(27.95)	(181.68)	(28.46)	(11.09)	(149.86)
BAS	-4.296***			-4.642***				-4.331***			-5.305***		
	(-6.86)			(-7.64)				(-6.71)			(-8.79)		
YLS	0.393***			0.314***				0.347**			0.313***		
	(2.96)			(2.59)				(2.49)			(2.59)		
VSTOXX		0.046	0.005									0.021	0.001
		(1.06)	(0.64)									(0.54)	(0.05)
BCDS					0.008**	0.003**						0.018***	0.003**
					(2.16)	(2.10)						(4.48)	(2.09)
LOIS									0.013	0.001		0.046***	-0.004
									(1.27)	(0.35)		(3.62)	(-0.90)
EQRET		-0.005***	-0.009***		-0.004**	-0.009***			-0.005***	-0.010***		-0.001	-0.010***
		(-2.86)	(-7.90)		(-2.44)	(-7.55)			(-2.83)	(-8.14)		(-0.64)	(-7.99)
FXUSD		0.002	0.078***		-0.032*	0.085***			0.019	0.082***		0.051*	0.084***
		(0.11)	(4.34)		(-1.69)	(4.50)			(0.64)	(4.38)		(1.96)	(3.74)
Controls		YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table 11: Time series regressions - First differences

This table contains the point estimates of the coefficients as well as the t-statistics (in parenthesis) from estimating the following regression,

$$RVOL_t = \alpha + \beta \Delta YLS_t + \gamma \Delta BAS_t + \sum_{k=1}^{K} \delta_k Control_{k,t} + u_t,$$

using OLS. The sample consists of the entire time series between April 2003 and December 2014. The dependent variable is the relative volume ratio ($RVOL$) which is explained by the volume weighted yield spread (YLS) and the volume weighted bid-ask spread (BAS) which are calculated as described before in Table 2. From specification (1) to (5) we continuously add additional control variables. N is the number of observations. Standard errors are calculated using the method of Newey and West (1987) with 7 lags. ***,**,* denote statistical significance at the 1%, 5% and 10% level, respectively.

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
ΔBAS	-22.323***	-29.296***	-29.185***	-28.529***	-28.527***	-28.202***
	(-2.71)	(-3.25)	(-3.24)	(-3.22)	(-3.22)	(-3.26)
ΔYLS	0.288*	0.380**	0.376**	0.370**	0.370**	0.401**
	(1.88)	(2.19)	(2.17)	(2.14)	(2.14)	(2.31)
N	2956	2956	2956	2956	2956	2956
Day of the week	NO	YES	YES	YES	YES	YES
Macro announcements	NO	NO	YES	YES	YES	YES
Monetary policy	NO	NO	NO	YES	YES	YES
Month of the year	NO	NO	NO	NO	YES	YES
Time trend	NO	NO	NO	NO	NO	YES

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