Impeded Flights in European Sovereign Debt Markets

March, 2026

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*We are grateful for financial support from the Swiss National Science Foundation (SNF) through the grant "Trading and Financing during Market Stress #100018_172679" and the Stiftung für Wissenschaftliche Forschung an der Universität Zürich. Additionally, we thank Mario Bellia (discussant), Hank Bessembinder, Bruno Biais, Jacob Bjorheim, Nina Boyarchenko, Sandro Braun, Pierre Collin-Dufresne, Stijn Claessens, Thierry Foucault, Michel Habib, Harald Hau, Jon Karpoff, David Lando, Simone Manganelli, Albert Menkveld, Kjell Nyborg, Giorgio Ottonello (discussant), Ivan Petzev, Angelo Ranaldo, Antoinette Schoar, Adriano Tosi, Serafeim Tsoukas (discussant), Christian Wagner, Jiri Woschitz, seminar participants at the University of Zurich, University of Sheffield, Audencia Business School, University of Stockholm, University of Essex, the ECB internal seminar and conference participants at the EFiC Conference in Banking and Finance, 24th Annual Meeting of the German Finance Association (DGF), the SFI Research Days and the 16th Annual Financial Markets and Liquidity Conference for valuable comments. This paper previously circulated under the title "The Sovereign Debt Crisis: Flights or Freezes?" This paper should not be reported as representing the views of the European Central Bank (ECB). The views expressed are those of the authors and do not necessarily reflect those of the ECB.

Abstract

Theory predicts that yield shocks trigger flights from risky to safe assets. We show that in the European sovereign bond market these flights are impeded. In the week after a flight event, trading volume falls by a fifth to a third, bid-ask spreads nearly double and market depth falls by about a fifth. The cause is a contraction in liquidity supply. On MTS the same bond trades on a domestic platform, where local banks with large holdings of their own sovereign make markets, and on a pan-European one; after a flight event, spreads widen more and volume falls more on the domestic platform. The bonds investors could not shed stayed where they were: Italian banks absorbed more of the new issues around flight events and did not reduce their existing holdings, so home bias rose. Concentrated dealer exposure to sovereign risk can thus freeze a central secondary market and, through the freeze, deepen the exposure that caused it.

Keywords: Sovereign Debt Crisis, Trading volume, Liquidity, Flights, Rebalancing
JEL: G12, G14, G21, E44.

1 Introduction

A large theoretical literature predicts that shocks to asset values trigger investor rebalancing — flights from risky to safe assets.[1] During the European sovereign debt crisis, yield changes were unprecedented, suggesting that large-scale rebalancing should have occurred.[2] This paper shows that it did not. Instead, flights were impeded: following flight events in the European sovereign bond market, trading volume fell rather than rose, and the market intermittently froze. We show that these freezes originate on the supply side of liquidity: the same bond freezes more on the trading platform whose market makers are more exposed to the shocked sovereign. We then ask where the exposures investors could not shed ended up. Around flight events, Italian banks absorbed a larger share of new issues, and neither they nor foreign banks sold more in the secondary market, so impeded flights left sovereign risk concentrated on domestic bank balance sheets.

We begin with the aggregate picture. Figure 1 plots trading volume, bid-ask spreads and yield spreads for European sovereign bonds on the MTS platform from 2003 to 2014. As yield spreads soar during the crisis, trading volume collapses and bid-ask spreads spike. A single week shows the phenomenon at its starkest. In the five trading days before 6 March 2008, when the rating agencies downgraded structured credit products worth USD 14.5 billion, a shock to the balance sheets of the banks that make markets in sovereign bonds, Spanish government bonds traded EUR 798 million a day on MTS; in the five trading days after, they traded EUR 110 million, a fall of 86%, and volume stayed depressed for months. Bid-ask spreads on Spanish bonds tripled on 6 March, from 14 to 39 basis points.[3] To move beyond single episodes and the time series, we identify flight events using a threshold model in the spirit of Baele et al. (2020). A flight event is a day on which the yield of a euro-area country other than Germany rises while the Bund yield falls, each by more than a multiple of its recent volatility. We then examine

[1] Heterogeneous agent models with incomplete markets predict that wealth effects result in rebalancing (e.g., Cochrane et al., 2008; Chabakauri, 2013; Judd et al., 2003). When agents have heterogeneous beliefs, new information results in trade (Varian, 1985, Harris and Raviv, 1993). Additionally, theories predict flight-to-liquidity, flight-to-safety, and liquidity spirals in times of stress (e.g., Vayanos, 2004; Brunnermeier and Pedersen, 2009).

[2] 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.

[3] Neither the aggregate decline nor the Spanish episode reflects a migration of trading away from MTS. For France, where the Treasury reports total interdealer and dealer-to-client volume, MTS volume tracks the market-wide series with a correlation of 0.72 (Figure 10). For Spain, the Bank of Spain's register of all dealer trades and the SENAF platform show the same collapse in March 2008 (Figure 12).

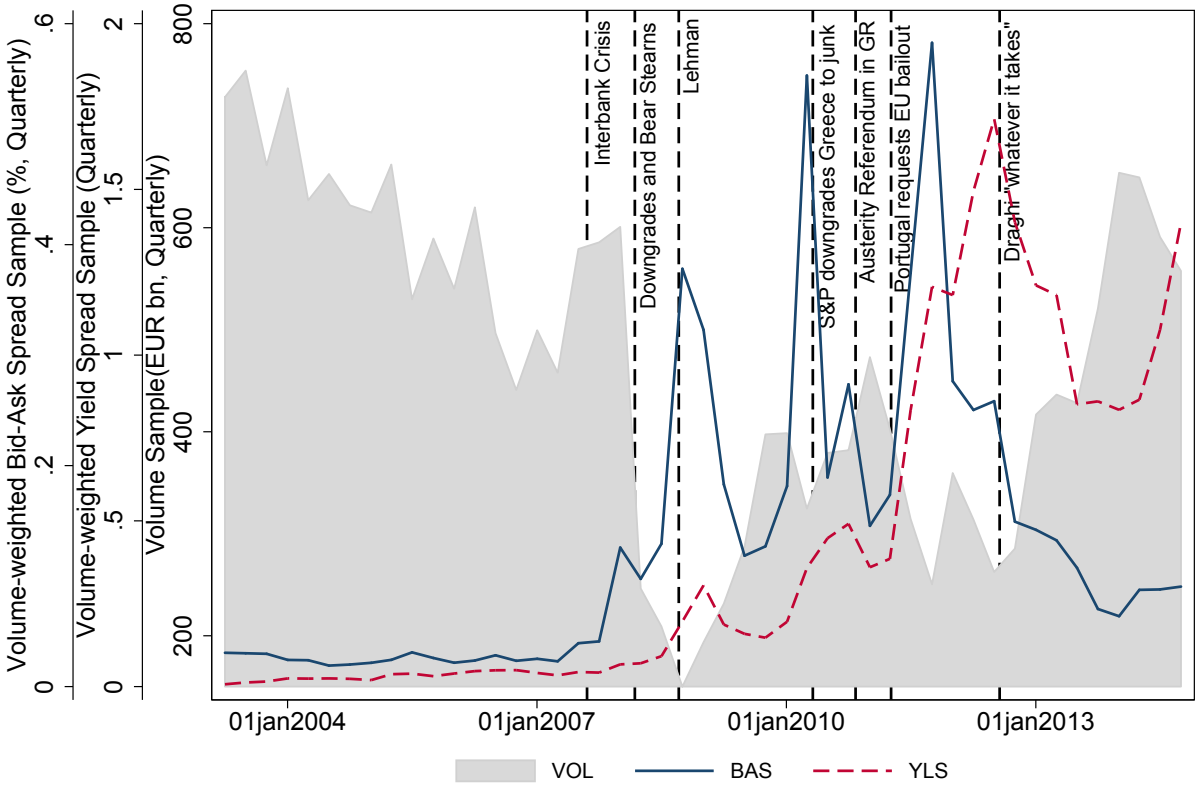


Figure 1: Volume, Bid-ask Spreads and Yield Spreads

This Figure 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 Bonds. The dashed lines represent (1) August 2007 (start of interbank crisis), (2) March 2008 (MBS downgrades and Bear Stearns), (3) September 2008 (Lehman), (4) April 2010 (S&P downgrades Greece to junk), (5) November 2010 (Austerity referendum in Greece), (6) April 2011 (Portugal requests EU bailout), (7) July 2012 (Draghi "whatever it takes"). For a more detailed description of the variables see Section 3.2.

trading around these events with the event-study approach of Kandel and Pearson (1995). In the week after a flight event, trading volume is 21% to 31% below its pre-event level, depending on the severity of the event. Bid-ask spreads widen by 0.8 to 1.4 percentage points, nearly doubling relative to the sample average, and market depth falls by about a fifth. Spreads widen on the event day and volume falls from the following day, a sequence consistent with a deterioration in liquidity provision impeding rebalancing.

This finding runs against a well-documented regularity: large price moves come with high trading volume, in equity markets (Gallant et al., 1992), in the interdealer Treasury market (Huang et al., 2002), and in flight-to-safety episodes, during which Baele et al. (2020) document substantial rebalancing from equities into bonds. It sits instead with the smaller literature in which dealers supply less liquidity when their capital is impaired (Bessembinder et al., 2018). Why does the European sovereign bond market freeze rather than trade? Unlike equity mar-

kets, liquidity provision in this market is restricted to a small number of large banks that hold substantial exposures to sovereign bonds — disproportionately to their own sovereign (Ongena et al., 2019, Merler and Pisani-Ferry, 2012). When sovereign yields spike, these banks suffer balance sheet losses, reducing their capacity to make markets (Ho and Stoll, 1981, Comerton-Forde et al., 2010, He and Krishnamurthy, 2013).

To identify this mechanism, we exploit a distinctive feature of MTS: the same benchmark bond trades simultaneously on a domestic platform, where liquidity is predominantly supplied by local banks, and on a pan-European platform (EBM), where large international institutions make markets. Because domestic banks hold disproportionately more of their own sovereign's bonds, a shock to that sovereign should reduce the risk-bearing capacity of domestic market makers more, and liquidity should deteriorate more on the domestic platform.

We test this prediction with a stacked difference in differences: for each flight event we compare the same bond across the two platforms, with bond-by-event and event-time fixed effects. In the week after an event, trading volume on the domestic platform falls by a further €2.5 to €5.1 million per bond and day relative to EBM, depending on event severity. On the day after the event, the domestic relative bid-ask spread rises by 9% to 21% more than on EBM, and for the most severe events domestic depth falls by a further 1% to 2%. These are differences for the same bond on the same day.

The concern with this comparison is that liquidity demand, not supply, could have shifted across platforms. Three pieces of evidence point to supply. First, under the sign restriction of Goldberg (2020), also used by Goldberg and Nozawa (2021) and Huang et al. (2025), a fall in quantity together with a rise in the price of liquidity identifies a supply contraction, and we observe this with spreads, with depth, and with the mid-price gap between the two platforms for the same bond, a price-of-liquidity measure that is free of credit risk by construction. Second, the domestic decline is concentrated among participants who trade on both platforms, while participants confined to one platform show no differential. Those able to substitute did so, which is what a deterioration in domestic liquidity supply, rather than a fall in their demand to trade, would produce. Third, the bid side of the domestic market reacts more strongly than the ask side, consistent with domestic market makers holding lopsided inventories of their own sovereign's bonds and being reluctant to accumulate more.

What does a frozen secondary market imply for who ends up holding sovereign risk? Domestic banks absorb a large share of new sovereign issues, a pattern that Ongena et al. (2019)

attribute to moral suasion. We propose a complementary mechanism: a bank that takes bonds at auction and cannot pass them on at acceptable cost in a frozen secondary market keeps them. Using the ECB's Securities Holdings Statistics, we focus on Italy, the largest sovereign bond market in the euro area and the one our trading data cover most completely,[4] and compare Italian banks with banks in other euro-area countries in the quarters of Italian flight events. Italian banks' home bias rises by 0.04 more than that of other banks, about 7% of its mean. The increase does not come through the secondary market, where the domestic share of outstanding Italian bonds does not move. It comes through the primary market, where the domestic share of newly issued Italian benchmark bonds is 0.27 higher than for control issues. Moral suasion alone cannot account for this: foreign banks, which are not subject to it, barely changed the weight of Italian bonds in their portfolios either. We read this as freezes leaving sovereign risk with the banks that absorbed the issue, and home bias rising in the very episodes when risk sharing across the euro area mattered most.

This paper makes three contributions. First, we show that flights are impeded when the suppliers of liquidity are exposed to the shocked asset. Our design holds the asset, the day and the shock fixed and varies only the dealers, which connects the flight-to-safety literature, built on prices and order flow, to the intermediary literature, built on dealers' capacity to bear risk. Second, we document a form of market dysfunction that differs in kind from the one now most studied. In the U.S. Treasury market in March 2020, investors sold in record volumes and dealers constrained by regulatory balance-sheet capacity absorbed the flow only at a steep price (Duffie, 2020, He et al., 2022): the flight happened and overwhelmed the intermediaries. In the European sovereign market the intermediaries were themselves exposed to the asset being sold, trading collapsed rather than surged, and the episodes recurred over several years rather than two weeks. Third, we provide evidence that freezes feed back into the exposure that causes them, a channel for the sovereign-bank nexus that runs through market liquidity rather than through bailouts or moral suasion. It implies that the resilience of this market depends not only on how much balance sheet its dealers have, but on what is on it.

[4]Italian regulation requires all interdealer trades in Italian government bonds to take place on MTS, which gives the platform a legal monopoly in that segment (Dunne et al., 2010). Italy accordingly accounts for 52% of euro volume and 62% of trades in our sample, and has 78 participants against a sample average of 49 (Table 1). Italy is also, with Spain and Greece, among the countries with the most flight events (Table 4), and the market in which domestic banks' share of market making is largest (Table 6).

2 Related Literature

There is a large literature that studies the determinants of volume (Epps, 1976, Hirshleifer et al., 1994, Chordia et al., 2001, 2007). One of the main findings is that there is a positive volatility-volume relation (i.e., investor rebalancing - see Karpoff 1987, for findings and a review of the early literature). Among others, Foster and Viswanathan (1993) and Gallant et al. (1992) confirm the volatility-volume relation. This relation extends to bond markets (Huang et al., 2002). In contrast, we document that the European sovereign bond market freezes in response to large price changes in the countries under stress, where the liquidity providers are most exposed to the shocked sovereign; for core-country events, spreads widen but volume does not fall significantly (Table 15).[5]

A large literature documents deterioration of liquidity during periods of market stress (e.g., Pelizzon et al., 2016), however, the impact on trading activity is ambiguous (rebalancing versus freezes). On one side, the volatility–volume regularity predicts more trading when prices move; on the other, Bessembinder et al. (2018) document that trading volume falls when dealers commit less capital. The most closely studied recent episode is the U.S. Treasury market in March 2020, where investors sold in record volumes and regulatory balance-sheet constraints limited dealers' capacity to absorb the flow (Duffie, 2020, He et al., 2022); there trading activity surged while liquidity deteriorated, the opposite of the pattern we document. We emphasize that trading volume is distinct from liquidity. For example, Fleming (2003, p.84) points out that "both high and low levels of trading activity are associated with periods of poor liquidity." Similarly, Mancini et al. (2013, p. 1180–1181) state "the relation between liquidity and trading activity is ambiguous."

Our mechanism belongs to the literature on intermediaries and liquidity provision. In intermediary asset pricing, the net worth of financial intermediaries determines their capacity to bear risk and therefore prices and liquidity (He and Krishnamurthy, 2013, Adrian et al., 2014); Brunnermeier and Pedersen (2009) obtain the same link through funding constraints. In market microstructure, Comerton-Forde et al. (2010) show that market makers' inventories and trading losses predict bid-ask spreads, and in bond markets Bessembinder et al. (2018) and Adrian et al. (2017) document that dealers supply less liquidity when their capital commitment or balance-

[5] In the December 2012 version of their study, Engle et al. (2012) find that on flight-to-safety days the number of trades in 5- and 10-year U.S. Treasury notes rises markedly and net selling weakens; that is trading in the market receiving the flight, whereas we study the market it leaves.

sheet capacity falls. These papers identify the channel from intermediary capital to liquidity with time-series variation or with cross-sectional exposure to a common factor. We identify it within a security: the same bond, on the same day, under the same shock, is intermediated by two sets of dealers that differ in their exposure to the asset, and the dealers whose capital is hit by that asset are the ones who withdraw.

Our third contribution speaks to the literature on the sovereign-bank nexus. Sovereign risk and bank risk reinforce each other through banks' holdings of domestic government debt (Acharya et al., 2014, Brunnermeier et al., 2016, Farhi and Tirole, 2018), and sovereign stress is transmitted to lending through those exposures (Altavilla et al., 2017). The rise in domestic holdings during the crisis has been attributed to moral suasion by governments (Ongena et al., 2019), to carry trades financed with central bank liquidity (Acharya and Steffen, 2015, Crosignani et al., 2020), and to the incentives of undercapitalised banks (Crosignani, 2021). We add a mechanism that operates through the secondary market itself: when the market freezes, banks that absorb new issues in the primary market cannot pass them on, and exposure accumulates without government pressure or a deliberate choice to hold. Section 6.2 provides evidence consistent with this channel.

A second literature identifies flight-to-safety episodes and studies their pricing. Baele et al. (2020) define flight-to-safety days from joint movements in equity and bond returns and document, for twenty-three countries, the return patterns and the fund flows out of equities and into government bonds that accompany them; Longstaff (2004), Beber et al. (2009) and Garcia and Gimeno (2014) study the yield premia and order imbalances that flights generate within sovereign bond markets. Our event definition adapts the threshold approach of Baele et al. (2020) to flights within the euro-area sovereign market, from the bonds of a country under stress into Bunds. Two things differ. Their flights run between asset classes, so the market they study is the one that receives the flight and whose prices rise; we study the market the flight leaves, where prices fall and where the dealers hold the asset that is losing value. And these papers characterise prices and flows; we ask whether trades occur at all. Order imbalances cannot answer that question: in a falling market they register selling pressure even when volume is negligible, so a large imbalance can coexist with a frozen market.

By virtue of studying bond markets in times of stress this paper is related to research that investigates the liquidity of bonds in crisis times. Bao et al. (2011), Dick-Nielsen et al. (2012) and Friewald et al. (2012) document a relation between liquidity and corporate bond yield spreads.

These papers document a liquidity-spread relation and find that the relation is stronger in crisis times. Liquidity has also been used as the dependent variable. For example, Pelizzon et al. (2016) document that changes in credit risk (CDS spreads) have a large impact on the liquidity of the European sovereign debt market.

A large microstructure literature uses MTS data to study the euro-area sovereign market: its trading protocols, market-maker obligations and the coexistence of domestic and pan-European platforms (Cheung et al., 2005, Dufour and Skinner, 2004, Pagano and von Thadden, 2004), price discovery and quote dynamics across the platforms (Caporale and Girardi, 2013, Darbha and Dufour, 2013, Dunne et al., 2015), and the pricing of liquidity and credit risk before and during the crisis (Beber et al., 2009, Favero et al., 2010, Pelizzon et al., 2016). We build on the institutional facts this literature establishes, the same bond quoted on two platforms by two sets of market makers, and use them as an identification device; whether trading survives a flight is a question it leaves open.

Crises are often associated with freezes in security issuance. For example, during the global financial crisis issuance of mortgage-backed securities halted (see Benmelech and Bergman, 2018, for a description of issuance freezes). A number of papers study funding markets in crisis times. For example, Copeland et al. (2014) and Krishnamurthy et al. (2014) find that US repo volume decreases by over 30% from 2008 to 2010. In contrast, Mancini et al. (2016) finds that CCP-based euro repo volume increased during the crisis, suggesting that market design is key to market resilience. Afonso et al. (2011) find that the federal funds is stressed but not frozen and Pérignon et al. (2018) document dry-ups (individual bank "freezes" of certificate deposits), but find no evidence of aggregate market freezes. In sum, although there is evidence of issuance and repo freezes, we contribute by documenting extensive and recurring freezes in the periphery segment of a central secondary market.

Our results have a parallel in the findings of Fleming and Remolona (1999), who study trading in the U.S. treasury market surrounding macro announcements. In the minute after the news release uncertainty is high and market makers protect themselves by increasing bid-ask spreads ultimately resulting in a decrease in trading volume. In the next minute and over the following one and a half hours trading volume, price volatility, and bid-ask spreads are elevated. In contrast the decrease in trading activity in the European sovereign bond market lasts for at least a trading week, which allows us to investigate the reasons for the freezes.

3 Data and Main Variables

3.1 Sample Construction

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 provide 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.[6] MTS volume is representative of overall market volume since it is highly correlated with volume figures reported by primary dealers (the reported data is at a more aggregate level and often at lower frequencies).[7]

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

We screen the data as follows. From the reference files, we only consider fixed and zero-coupon bonds issued by central governments, excluding quasi-government, local government and corporate issuers, as well as bonds with floating or indexed coupons and derivative features.[8] We keep countries with data coverage over the entire sample period, leaving us with 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). We merge the resulting reference file information with the best proposal files (1.12 billion quote updates and

[6] 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).

[7] Data from the French and Portuguese 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 10 shows the close co-movement between the transaction volume in the electronic, interdealer and the customer-dealer markets for the French sovereign bond market.

[8] We exclude ISINs where the issuer is classified as quasi-government, local government or corporate, as well as bonds for which we have no information on the issuer. To facilitate the yield curve estimations 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 and are eliminated since they do not reflect investor rebalancing. 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. If the information cannot be verified then the particular bond is dropped. Details are available upon request.

1.28 million bond-days), applying standard quality filters.[9] 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.

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 (see Appendix A) 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.[10]

[9] We drop quotes where 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). We drop inconsistent order book entries in April 2003 (0.05% of the quotes). We only consider quotes during regular trading hours (8:15 am to 5:30 pm; a loss of 0.57% of the quotes) and drop quotes that imply a relative bid-ask spread in excess of 0.6 (0.04% of the quotes). We also exclude bond-days during grey market trading (0.2%), bonds with less than 30 days to maturity (2.4%), and bond-days with extreme idiosyncratic price movements that subsequently reverse (0.1%). We remove non-regular trading days (Whitsunday 2007, December 24 and 31 in 2003, 2004 and 2007, and two Saturdays in the dataset).

[10] Additionally, MTS data have been extensively used in the academic literature.: Bai et al. 2012, Beber et al. 2009; Caporale and Girardi 2013; Caporale et al. 2012; Cheung et al. 2005; Darbha and Dufour 2013; Dufour and Nguyen 2008; Dufour and Skinner 2004; Dunne et al. 2015; Dunne et al. 2006; Favero et al. 2010; Garcia and Gimeno 2014; Gerlach et al. 2010; Girardi 2008; Girardi and Impenna 2013; Pagano and von Thadden 2004; Paiardini 2010; Pelizzon et al. 2016 and Schneider et al. 2016 all use the MTS data set for their empirical analysis.

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 on the average day (Bonds/trading day, Trades/trading day and Quotes/trading day), the average Trade size (ratio of EUR volume in millions and number of trades) and the average daily EUR volume in millions (first summed over all bonds every day and then averaged across days). Panel B shows averages (across both time and the cross-section of bonds) for 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	2,982	2,982	2,982	2,982	2,982	2,982	2,627	2,982	2,982	2,982	2,982	2,949.73
Number of bonds	33	259	385	334	27	885	103	61	570	217	116	273.67
Bonds/trading day	15.61	43.72	62.23	58.41	9.52	85.55	19.69	8.68	71.06	26.65	19.24	38.42
Trades/trading day	12.70	87.17	57.30	65.11	18.50	75.22	38.74	5.59	736.57	52.29	43.41	109.18
Quotes/trading day (k)	19.56	34.05	54.37	44.17	12.92	56.41	18.47	7.51	84.12	24.85	16.85	34.10
Trade size (mn)	7.86	9.21	7.08	8.04	9.16	8.32	5.88	6.76	5.49	9.60	7.59	7.77
EUR volume (mn)	104.78	814.62	409.32	501.69	175.82	629.12	285.66	38.80	4,042.54	494.17	363.08	719.20
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	56.04	45.42	43.28	33.50	40.88	34.37	78.14	42.99	41.55	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: Sovereign credit rating												
S&P rating at sample end (2014)	AA+	AA	AAA	BBB	AA+	AA	B	A	BBB-	AA+	BB	-
S&P rating at sample start (2003)	AAA	AA+	AAA	AA+	AAA	AAA	A	AAA	AA	AAA	AA	-

Table 1 provides descriptive statistics. We have a time-series of 2,982 trading days from April 2003 to December 2014.[11] Larger countries such as France, Germany, Italy and Spain have more bonds (between 334 and 874) while smaller countries have fewer (e.g., 33 in Austria, 27 in Finland, and 61 in Ireland). Even though the absolute number of trades is small in some countries, given that trade sizes are substantial (mean cross-country trade size is 7.77 € million), the mean daily Euro trading volume is large (38.99 € million in Ireland to 4,029.84 € million in Italy). In Panel C the S&P ratings at the beginning and end of the sample show significant variation in credit quality across sovereigns and over time.

3.2 Main Variables

Volume. For each trade on the MTS platform, we observe the price, the timestamp and the notional amount traded. We sum up the volume over all trades within a country and day. To facilitate comparison across countries we scale volume with the average volume over the previous five days. 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. We use the log transformation of volume (as in Dong, 2012) since it implies a symmetric measure. Because $RVOL$ is a log difference, the percentage changes quoted in the text are computed as $\exp(RVOL) - 1$; the same applies to relative market depth below.[12]

Bid-Ask Spreads. In the MTS dataset we observe the first three layers of the order book. For each layer, we calculate the relative bid-ask spread (BAS) as the difference between the ask-price P^A and the bid-price P^B divided by the mid price P^M. We aggregate to a daily

[11] The only exception is Greece where we have 2,602 days because a lack of valid bid-ask spreads during the height of the sovereign debt crisis.

[12] Without the log transformation $RVOL$ would be restricted to the range of [-100%,+∞] implying a potential positive bias. Applying the log transformation leads to the symmetric range of [$-\infty$,+∞]. 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. As shown by Chen and Roth (2024), economic magnitude can not be evaluated when the dependent variable uses a log transformation with zeros. To make sure this is not driving our results, we also implement the event study with only the extensive margin (i.e, excluding all zeros), and the results remain similar both qualitatively and quantitatively. The result is available upon request.

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,

$$BAS_{i,t} = \frac{1}{K_{i,t}} \sum_{k=1}^{K_{i,t}} \Big[\frac{1}{3} \sum_{layer=1}^{3} \Big(\frac{P^A_{i,t,k} - P^B_{i,t,k}}{P^M_{i,t,k}} \Big) \Big]. \tag{2}$$

We aggregate the bond-level bid-ask spread to the country and sample level using equal weighting for each bond.[13]

Market Depth. We calculate the market depth ($DEPTH$) as the average of the total bid quantity and the total ask quantity for each layer, where the total quantity of each side is the sum of the quantity in all three best quotes. We aggregate to a daily market depth for each bond as,

$$DEPTH_{i,t} = \sum_{k=1}^{K_{i,t}} \frac{1}{2} \Big(\sum_{bid=1}^{3} Quantity_{i,t,k,bid} + \sum_{ask=1}^{3} Quantity_{i,t,k,ask} \Big). \tag{4}$$

We aggregate to the country level by taking the average depth for each bond within a country on a daily level.[14] To facilitate comparison, we also scale market depth with the average over the previous five days. Our relative depth measure ($RDEP$) is defined as,

$$RDEP_t = log(DEP_t) - \frac{1}{5} \sum_{l=1}^{5} log(DEP_{t-l}), \tag{5}$$

where DEP_t is the total market depth of a particular country during day t.

Yields. The extant literature identifies flight-to-safety episodes through yield spreads.[15] We use a threshold model similar to Baele et al. (2020) to identify flights. Since the composition of

[13] We also implement volume weighting to reflect transaction costs of traded volume. 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 $t = -6$. The result does not qualitatively change. See Appendix B.

[14] In order to aggregate to the country level, we also implement a weighted average of the market depth for each bond in a country, where the weight of each bond is its volume weight over the last 20 days. The result does not qualitatively change. See Appendix B.

[15] Beber et al. (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).

our sample varies over time and countries we base our flight measure on the yield of a synthetic 10-year constant maturity bond, calculated from estimating a Nelson and Siegel (1987) model for each country and day. Both academics and the financial press view German bunds as a safe haven, and we consider the spread of a sovereign over the German yield (Geyer et al. 2004 and Favero et al. 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,

$$YLS_t = \frac{Y_t - Y_t^{DE}}{Y_t^{DE}}, \tag{6}$$

where Y_t and Y_t^{DE} are the 10-year constant maturity yields of the sovereign and Germany (DE), respectively.

Table 2: Descriptive statistics of event study 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 event study 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. Panel A reports the trading volume (VOL, EUR millions). Panel B reports the net order flow (NOF, EUR millions). Panel C reports the aggregate equal-weighted relative bid-ask spread (%). Panel D reports the average market depth (EUR millions). Panel E reports the yield level spread (YLS).

	AT	**BE**	**ES**	**FI**	**FR**	**GR**	**IE**	**IT**	**NL**	**PT**	**Sample**
Panel A: Trading Volume (VOL, EUR millions)											
mean	104.848	814.622	501.696	175.890	629.123	285.771	39.008	4042.543	494.166	363.129	750.613
median	67.338	709.564	397.393	121.124	562.430	185.021	20.145	3868.298	407.116	264.518	302.009
sd	116.429	561.365	413.911	180.251	401.715	324.679	55.654	2122.379	352.521	376.921	1354.826
min	1.000	1.000	0.878	1.000	5.338	0.112	0.640	232.957	1.000	1.000	0.112
max	1518.130	4249.364	2827.902	1289.680	2958.466	2878.517	825.179	15220.855	2579.798	3606.510	15220.855
count	2982	2982	2982	2982	2982	2627	2982	2982	2982	2982	29465
Panel B: Net Order Flow (NOF, EUR millions)											
mean	-0.233	-1.606	-0.614	-1.292	3.811	-0.185	-0.345	-4.113	13.463	0.341	0.998
median	-0.058	0.892	0.189	-0.786	3.225	0.001	-0.055	1.861	2.291	0.253	0.077
sd	7.635	85.362	25.356	10.989	28.162	11.248	4.583	103.749	57.123	19.857	50.037
min	-103.669	-3861.167	-144.145	-76.372	-174.448	-109.487	-31.220	-639.690	-200.067	-102.458	-3861.167
max	70.547	206.278	151.425	74.481	161.750	82.415	29.173	368.371	457.978	159.607	457.978
count	2801	2980	2973	2768	2982	2416	2380	2982	2979	2852	28113

(This table continues on the next page)

Table 3: Descriptive statistics main variables (continued)

Panel C: Aggregate Relative Bid-Ask Spread (%)											
mean	0.482	0.331	0.706	0.201	0.495	3.193	1.510	0.250	0.204	1.844	0.894
median	0.303	0.206	0.450	0.117	0.400	0.479	0.309	0.145	0.098	0.299	0.221
sd	0.544	0.384	0.730	0.530	0.439	6.378	2.903	0.356	0.504	3.346	2.570
min	0.036	0.030	0.069	0.028	0.053	0.042	0.041	0.029	0.038	0.029	0.028
max	7.142	5.841	6.089	11.197	5.166	55.960	30.084	5.640	9.854	25.655	55.960
count	2982	2982	2982	2982	2982	2627	2982	2982	2982	2982	29465
Panel D: Market Depth (EUR millions)											
mean	55.343	53.975	52.619	84.821	44.080	44.441	38.430	57.799	55.374	52.098	54.012
median	49.689	57.382	48.450	89.847	45.465	38.046	31.212	56.974	55.953	46.346	52.266
sd	21.015	10.852	18.663	31.032	10.414	37.772	20.724	18.735	12.652	25.038	25.043
min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
max	97.604	75.522	91.576	145.692	70.071	108.678	81.079	100.945	88.836	103.919	145.692
count	2982	2982	2982	2982	2982	2627	2982	2982	2982	2982	29465
Panel E: Yield Level Spread (YLS)											
mean	0.123	0.224	0.633	0.066	0.140	1.927	0.773	0.639	0.068	1.200	0.563
median	0.080	0.083	0.112	0.043	0.040	0.114	0.358	0.183	0.038	0.129	0.069
sd	0.161	0.296	0.895	0.085	0.199	3.469	0.982	0.822	0.078	1.756	1.400
min	-0.072	-0.011	-0.017	-0.049	-0.016	-0.506	-0.075	0.007	-0.070	-0.002	-0.506
max	1.032	1.565	4.591	0.418	1.034	23.193	4.546	3.879	0.408	11.322	23.193
count	2982	2982	2982	2982	2982	2627	2982	2982	2982	2982	29465

Tables 2 present descriptive statistics for the main variables. All country-level $RVOL$ means are close to zero but slightly negative, reflecting marginally decreasing volume over the sample period. Positive medians combined with larger negative extremes suggest that the time series are characterized by large infrequent drops in volume. The European sovereign bond market is extremely liquid in the pre-crisis period — the average aggregate bid-ask spread in the sample is 0.86%, with Italy being the most liquid country at 0.13%. During the crisis, bid-ask spreads increase dramatically: the average is 5.4 times larger in the crisis period, and the increase is far more pronounced for GIIPS countries (10 times higher) than for CORE countries (40% higher). Market depth decreases by 23% on average during the crisis, with GIIPS countries experiencing a 33% decline compared to 13% for CORE countries. Yield spreads in GIIPS countries are far above the German yield (averaging between 6.6% for Spain and 192.7% for Greece), substantiating our choice of Germany as the benchmark country.

4 Flight Events and Market Responses

4.1 Identifying Flight Events

We identify flight events using a threshold model in the spirit of Baele et al. (2020) 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,

$$FTS_t = I\{\Delta Y_{j,t} > z_{j,t}\} \times I\{\Delta Y_t^{DE} < z_t^{DE}\}, \tag{7}$$

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 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 is lower than the threshold z_t^{DE}. We call these days flight events because prices move as in a flight to safety, the country's yield rising while the German yield falls; whether investors actually rebalance on these days is what the remainder of the paper tests. The thresholds $z_{j,t}$ and z_t^{DE} are:

$$z_{j,t} = \kappa \times \sigma_{j,t} \quad and \quad z_t^{DE} = \kappa^{DE} \times \sigma_t^{DE}. \tag{8}$$

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. 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.[16]

Table 4: Flight events by country

Panel A shows the frequency of events 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).

	$\kappa = 2.0$	$\kappa = 1.5$	$\kappa = 1.0$
Austria	1	3	6
Belgium	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

The number of events per country and event type are shown in Table 4. 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).

4.2 Event Study Results

We examine the volume ratio $RVOL$ as defined in Eq. (1) around these events. We consider a window of 11 days around an event (in event time τ from $\tau = -5$ 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 $\tau = -6$

[16] We choose the values for κ in the risky countries in line with the previous literature. Baele et al. (2020) 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.

to $\tau = -10$.[17] 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)).[18] Applying this 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 or event-induced variance.[19]

In Panel A of Table 5 we present the average values of the volume ratio $RVOL$ from day $\tau = -5$ to $\tau = 5$ for different event severities. From day $\tau = 1$ to $\tau = 5$ point estimates are negative and economically large. At $\kappa = 2.0$ the volume ratio at $\tau = 1$ is -0.329 and statistically significant at the 5%-level, implying that volume is 32.9% lower than during the benchmark period. The volume ratio stays negative throughout the post-event window. Not only does trading volume drop significantly after events, the severity of the freeze increases with κ: when κ is raised to 2.0, the freeze occurs on day 1 already and is more severe.[20]

Now we examine whether the decrease in the volume ratio is driven by the deterioration of liquidity provision. As shown in Figure 2 and Panel B of Table 5, bid-ask spreads increase substantially after events. Even for $\kappa = 1.0$ events, bid-ask spreads on average increase by 0.8 percentage point during the event window from $\tau = 0$ to $\tau = 5$, corresponding to a nearly 100% increase of the sample average. Bid-ask spreads widen on the event day and volume falls from the following day, a sequence consistent with a deterioration in liquidity provision impeding rebalancing. Market depth (Panel C) also decreases, by a fifth to a quarter depending on κ, and stays depressed for the whole trading week.[21]

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

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

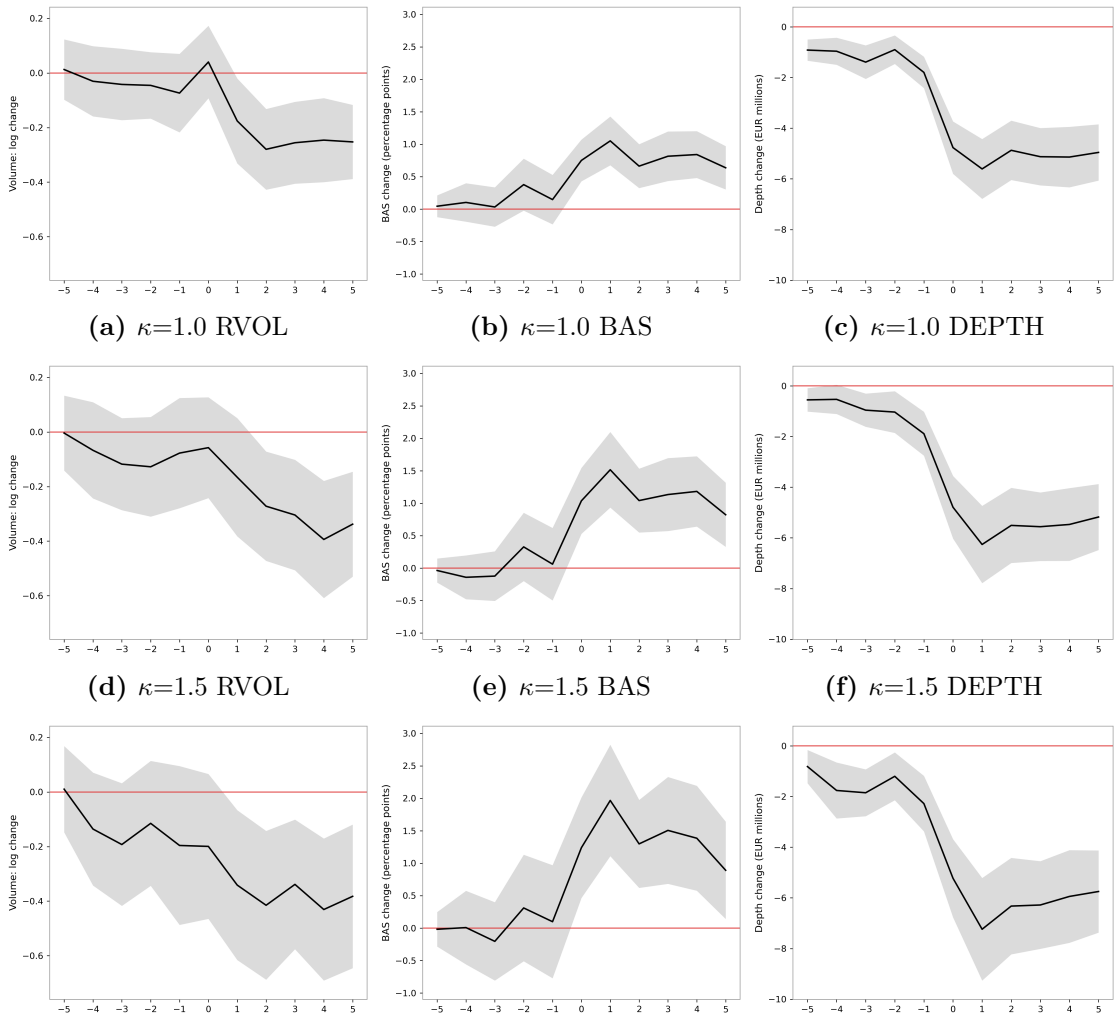
$$\sigma_\tau^{cross} = \sqrt{\frac{1}{N(N-1)} \sum_{e=1}^{N} \left(RVOL_{n,\tau} - \sum_{n=1}^{N} \frac{RVOL_{n,\tau}}{N} \right)^2}, \tag{9}$$

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.

[19] 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.

[20] 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.

[21] A follow-up question could be if the trading activity recovers if the event window is extended. To shed light on this aspect, we implement the same exercise with an extended event window of [-30, 30], and we see that the trading activity stabilizes within this window; however, the volume or bid-ask spread and market depth do not recover to the pre-event level. See Appendix F.



(a) κ=1.0 RVOL **(b)** κ=1.0 BAS **(c)** κ=1.0 DEPTH

(d) κ=1.5 RVOL **(e)** κ=1.5 BAS **(f)** κ=1.5 DEPTH

(g) κ=2.0 RVOL **(h)** κ=2.0 BAS **(i)** κ=2.0 DEPTH

Figure 2: Relative volume, bid-ask spread and depth of event countries

This figure shows the evolution of the relative trading volume, the bid-ask spread and the market depth of event countries in the event window of $[-5, 5]$. The relative trading volume, the bid-ask spread and the market depth are calculated as described in equation (1), equation (2) and equation (5) respectively. The red solid line represents 0 and the black line represents the mean of the variable of interest calculated from events. The grey shaded areas are 95% confidence intervals (calculated using standard errors obtained with the cross-sectional approach). From left to right: relative volume $RVOL$ (left), bid-ask spread (middle) and market depth (right). From top to bottom: different severities of events.

Table 5: Market Stress, Trading Volume and Liquidity

This table contains the event study results for different degrees of stress (κ). The event window is from $\tau = -5$ to $\tau = 5$. Events are defined as in Table 4. In Panel A, the outcome variable is the relative volume ratio $RVOL$ as defined in equation (1). In Panel B, the outcome variable is the abnormal bid-ask spread calculated as the difference between the bid-ask spreads in a given day in the event window and the average bid-ask spreads in the previous trading week (i.e., the $[-10, -6]$ period). In Panel C, the outcome variable is the relative market depth, which is based on the market depth from equation (4), and then take logarithm in the same way as RVOL. The t-statistics (in parentheses) are based on standard errors from the cross-sectional approach. ***,**,* denote statistical significance at the 1%, 5% and 10% level.

	-5	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
Panel A: RVOL for different flight measures											
κ=2.0	0.023	−0.124	−0.180	−0.103	−0.184	−0.187	−0.329**	−0.403***	−0.326***	−0.419***	−0.370***
	(0.27)	(−1.13)	(−1.53)	(−0.87)	(−1.21)	(−1.37)	(−2.33)	(−2.85)	(−2.64)	(−3.13)	(−2.75)
κ=1.5	0.007	−0.056	−0.107	−0.117	−0.067	−0.047	−0.155	−0.261**	−0.293***	−0.383***	−0.327***
	(0.10)	(−0.61)	(−1.23)	(−1.25)	(−0.64)	(−0.49)	(−1.41)	(−2.55)	(−2.83)	(−3.48)	(−3.33)
κ=1.0	0.017	−0.026	−0.037	−0.041	−0.069	0.045	−0.171**	−0.275***	−0.251***	−0.241***	−0.248***
	(0.31)	(−0.39)	(−0.56)	(−0.65)	(−0.93)	(0.66)	(−2.16)	(−3.65)	(−3.28)	(−3.07)	(−3.57)
Panel B: abnormal BAS for different flight measures											
κ=2.0	0.000	−0.001	−0.003	0.003	0.000	0.012***	0.020***	0.013***	0.015***	0.014***	0.009**
	(−0.26)	(−0.20)	(−0.81)	(0.68)	(0.08)	(3.08)	(4.36)	(3.73)	(3.48)	(3.21)	(2.20)
κ=1.5	−0.001	−0.002	−0.002	0.003*	0.000	0.010***	0.016***	0.011***	0.012***	0.012***	0.008***
	(−0.48)	(−0.92)	(−0.78)	(1.13)	(0.03)	(3.91)	(4.96)	(4.05)	(3.82)	(4.09)	(3.08)
κ=1.0	0.000	0.001	0.000	0.004*	0.001	0.007***	0.011***	0.007***	0.007***	0.008***	0.006***
	(0.06)	(0.43)	(−0.05)	(1.75)	(0.47)	(4.32)	(5.19)	(3.61)	(3.91)	(4.16)	(3.37)
Panel C: relative market depth for different flight measures											
κ=2.0	−0.039	−0.087***	−0.089***	−0.040	−0.130***	−0.157***	−0.258***	−0.212***	−0.221***	−0.231***	−0.177***
	(−1.28)	(−3.64)	(−4.58)	(−1.02)	(−5.00)	(−4.96)	(−8.86)	(−5.42)	(−8.86)	(−8.04)	(−5.82)
κ=1.5	−0.009	−0.024	−0.039	−0.037	−0.125**	−0.161***	−0.281***	−0.235***	−0.236***	−0.239***	−0.174***
	(−0.27)	(−0.72)	(−1.22)	(−1.06)	(−2.96)	(−5.11)	(−8.11)	(−7.32)	(−8.72)	(−6.68)	(−5.27)
κ=1.0	−0.013	−0.022	−0.031	−0.022	−0.080**	−0.137***	−0.215***	−0.189***	−0.198***	−0.201***	−0.172***
	(−0.61)	(−1.00)	(−1.39)	(−0.95)	(−3.00)	(−5.71)	(−8.66)	(−7.99)	(−8.71)	(−7.57)	(−7.32)

4.3 Net Order Flow

To verify that the yield changes indeed induce investors to attempt to rebalance, we examine the Net Order Flow (NOF), defined as the trading volume initiated by the buyer minus the volume initiated by the seller. For each bond i, we calculate the NOF on date t and then aggregate to the country level,

$$NOF_{c,t} = \sum_{i=1}^{n} \sum_{k=1}^{K_{i,t}} \Big(\text{buying volume}_{i,t,c,k} - \text{selling volume}_{i,t,c,k} \Big) \tag{10}$$

, where c denotes the country and $K_{i,t}$ is the number of transactions for bond i on day t.

As shown in Figure 3, on the event day there is tremendous selling pressure for bonds of the impacted countries, suggesting that investors are trying to sell the affected risky bonds. However, contrary to expectation from theory, we do not observe large trading volume, and thus no large-scale rebalancing. The total trading volume drops substantially. When we investigate

the net order flow of German bonds, we do not see a flight-to-safety effect either: German bonds do not exhibit significant buying pressure during our event windows. As the severity of events increases, the point estimates of German bonds' buying pressure becomes even less salient. This is consistent with investors unable to rebalance due to the elevated transaction cost and the decreases in market depth. Appendix E provides complementary time-series evidence: shocks to equity volatility, which raise bond trading volume in normal times, fail to do so in the crisis, when shocks to bid-ask spreads reduce volume instead.

5 Identifying the Mechanism

The results of the previous section show that large-scale rebalancing does not occur after flight events. Instead, we observe liquidity deterioration and market freezes. We argue that the European sovereign bond market relies heavily on designated market makers whose risk-bearing capacity is reduced during events, leading to impeded flights. To identify this channel, we use a difference-in-differences framework that exploits the dual-platform structure of MTS, comparing bond-level reactions of trading volume, bid-ask spreads and market depth across the domestic and international markets.

5.1 MTS Market Structure

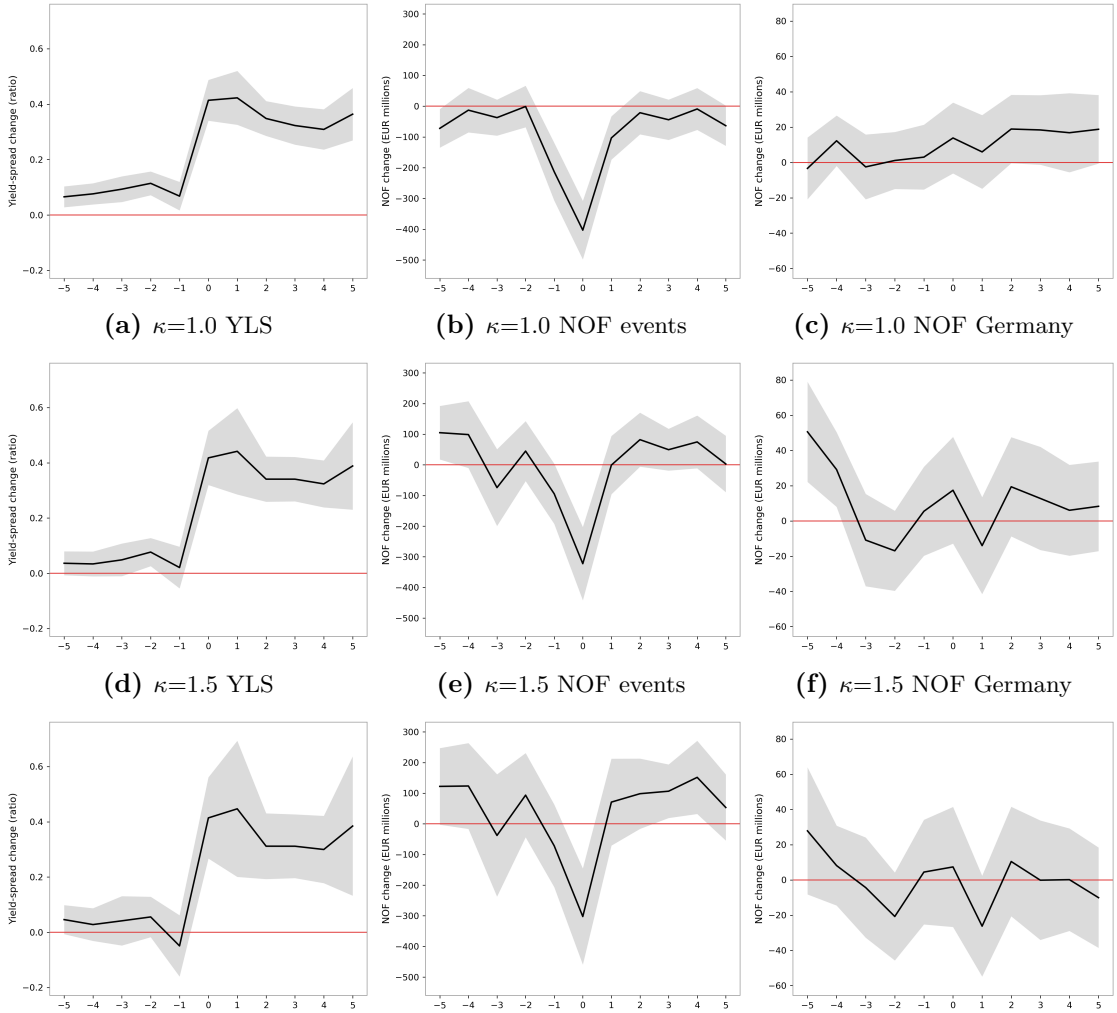
MTS is the dominant trading venue for European sovereign bonds with a central limit order book structure.[22] A special feature of MTS is that it has two trading platforms: a domestic market with predominantly local market makers (e.g. local banks), and an international market (European Bond Market, EBM) where large international financial institutions act as market makers.[23,24] In normal periods, the two platforms are highly synchronized and the correlations of our variables of interest are higher than 0.9.

There are two key differences between the local banks and the international institutions. First, local banks are generally smaller than international institutions. As shown in Figure 4a,

[22] MTS is a dealer-to-dealer platform whose participants are professional dealers.

[23] For example, although the entry capital requirement for both markets is 10 million euros, Cheung et al. (2005) notes that market makers for Belgian securities must have assets of at least EUR 250 million. For the EuroMTS, market makers must have assets of minimum net worth of EUR 375 million.

[24] The share of domestic market makers in the domestic market is high e.g. in the Italian market 24.1% of the market makers are Italian banks while in the other markets under study only 4.7% of the market makers are Italian (see Table 6), while anecdotal evidence suggests that market making is facilitated by a more international group of market makers on the EBM.



(a) κ=1.0 YLS **(b)** κ=1.0 NOF events **(c)** κ=1.0 NOF Germany

(d) κ=1.5 YLS **(e)** κ=1.5 NOF events **(f)** κ=1.5 NOF Germany

(g) κ=2.0 YLS **(h)** κ=2.0 NOF events **(i)** κ=2.0 NOF Germany

Figure 3: Yield spreads and net order flow of event countries and Germany

This figure shows the evolution of the yield spread (YLS), the net order flow of event countries (NOF events) and the net order flow of Germany (NOF Germany) in the event window of $[-5, 5]$. The YLS and the net order flow are calculated as described in equation (6) and equation (10) (Note here the aggregation takes place on the country level). The unit of yield spread is percentage and the unit of net order flow is euro million. The red solid line represents 0 and the black line represents the mean of the variable of interest calculated from events. 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: yield spread YLS (left), net order flow of event countries NOF events (middle) and net order flow of Germany (right). From top to the bottom we plot different severity of events.

the average size of market maker banks is approximately 10 billion less in the local markets than in the international market. Second and more importantly, a large portion of local banks' assets are local sovereign bonds, while international institutions have less concentrated portfolios.[25] As shown in Figure 4b, for dealer banks in local markets, around 50% to 80% of their government bond holdings consist of domestic sovereign bonds, while in the international market, less than 60% of dealer banks' government bond portfolios consists of domestic sovereign bonds. This implies that a shock to the domestic sovereign should disproportionately impact the risk-bearing capacity of market makers on the domestic platform. Thus, volume and market depth should be particularly depressed in the domestic platform, while bid-ask spreads should widen disproportionately.

Table 6: Share of Domestic Market Makers

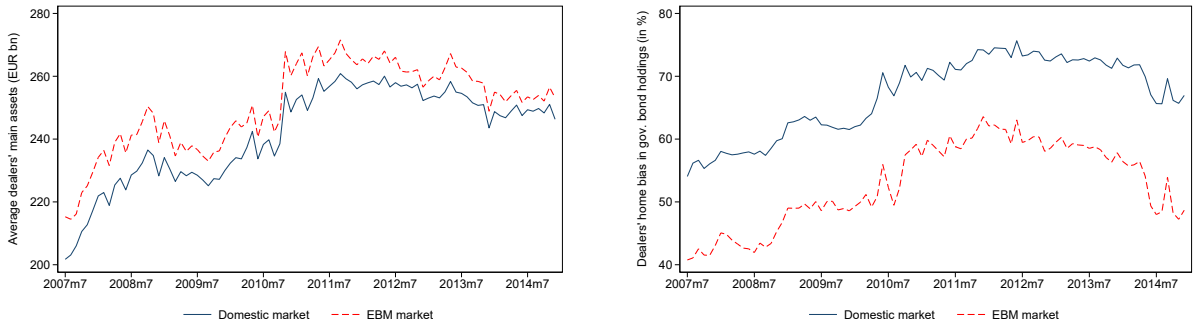
The table shows the share of market makers by their nationality for each of the 10 domestic MTS markets. The calculations are based on the participant lists published on the MTS website on November 21, 2016. The rows of the table contain the market while the columns contain the market maker nationality. 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 rows. 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

5.2 Difference-in-Differences Design

The fact that the risk-bearing capacity of market makers differs across the domestic and international platform provides the basis for our difference-in-differences analysis. We compare the

[25] 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., 2019).



(a) Dealer size **(b)** Home bias

Figure 4: Market maker characteristics: domestic vs. international platforms

Panel (a) shows the evolution of the average asset size of market maker banks at a quarterly frequency. Panel (b) shows the portion of own sovereign bonds in banks' portfolio of government bonds. In both panels, the blue solid line represents 35 dealer banks in domestic markets, while the red line represents 24 dealer banks in the EBM market. Data have been sourced from the ECB Monetary Financial Institution (MFI) individual balance sheet statistics (iBSI).

domestic and the EBM market before and after our flight events and predict that the domestic market experiences larger increases in bid-ask spreads and larger decreases in trading activity and market depth. We consider 11 days around our events (from τ = -5 to +5), where the sample events (denoted by e) are defined by our threshold model with varying κ's. In the regression, instead of directly studying the raw level of trading volume and liquidity variables, we benchmark our dependent variable against the previous trading week, calculating the percentage change of our variables of interest for each bond in each market. For trading volume, instead of percentage change, we subtract the average trading volume in the previous trading week (as we have many zeros in the denominator). The reasons are twofold. Firstly, the raw level of trading volume are very different in the two platforms. [26] Therefore, naively comparing the change in the raw level of trading volume is almost guaranteed to find a larger decrease in the local platforms. Secondly, since the two platforms differ in quoting obligations of market makers, the change of the raw level of bid-ask spread and market depth are potentially distorted by regulation.[27] As we can see in Table 13, after benchmarking, in the pre-event periods, the two platforms are not significantly different in trading volume and liquidity provisions. Besides benchmarking the dependent variables, we also focus on bonds for which regulation did not change when events

[26] For example, in Table 12, we can see that trading volume is on average more than 10 times larger on the local platforms.

[27] A peculiarity on MTS is so-called 'market making commitments'. These commitments regulate variables such as minimum quoting quantity and maximum bid-ask spread. Market makers are evaluated monthly based on their compliance ratio, and violations can lead to exclusion from market maker list or penalty. For example, for Italian short-term bonds, the domestic market has a maximum bid-ask spread of 10 basis point, while the international market allows a bid-ask spread of 15 basis point. Therefore, directly comparing the bid-ask spread across these two markets will include the impact of regulation. See Appendix A for details.

happen.[28] We estimate the following regressions,

$$\Delta VOL_{b,p,t,e} = \alpha_{b,e} + \alpha_t + \beta\ DOM_p + \gamma_\tau DOM_p \times eventday_{t=\tau} + \sum_{k=1}^{K} \delta_k Control_{b,p,t,e} + u_{b,p,t,e}, \quad (11)$$

$$\Delta^{\text{rel}} BAS_{b,p,t,e} = \alpha_{b,e} + \alpha_\tau + \beta\ DOM_p + \gamma_\tau DOM_p \times eventday_{t=\tau} + \sum_{k=1}^{K} \delta_k Control_{b,p,t,e} + u_{b,p,t,e}, \quad (12)$$

$$\Delta^{\text{rel}} DEPTH_{b,p,t,e} = \alpha_{b,e} + \alpha_\tau + \beta\ DOM_p + \gamma_\tau DOM_p \times eventday_{t=\tau} + \sum_{k=1}^{K} \delta_k Control_{b,p,t,e} + u_{b,p,t,e}, \quad (13)$$

where $VOL_{b,p,t,e}$ is the sum of the Euro trading volume for bond b on platform p on day t during event e. $BAS_{b,p,t,e}$ is the average daily relative bid-ask spread aggregated across all quotes for a bond, and $DEPTH_{b,p,t,e}$ is the average daily market depth aggregated across all quotes for a bond respectively. DOM_p is a dummy variable that takes the value of 1 for volume (or bid-ask spreads or market depth) traded (quoted) on the domestic platform and 0 otherwise. The set of dummy variables $eventday_{t=\tau}$ takes the value of 1 if day t is τ day relative to the event day ($\tau = \{-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5\}$, i.e., we focus on 5 days before and after the event day). A statistically significant γ on the interaction term $DOM_p \times eventday_{t=\tau}$ indicates that our events have an asymmetric impact across platforms. We expect γ's to be negative for days after events when we consider volume or market depth, indicating that volume and market depth falls more in the domestic market than in the international market and vice versa for bid-ask-spreads. 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., 11 days). Also, this excludes our results being driven by market conditions which are constant throughout the event. Additionally, we introduce 11 event-day dummies α_t (one for each event-day τ from -5 to 5) to ensure that our results are not driven by mechanical trading patterns around events.

5.3 Results

The result with trading volume as the dependent variable is presented in Figure 5 and Table 7. The coefficient γ of the interaction term $DOM \times eventday_\tau$ is always negative for days after events and mostly statistically significant at the 5% level. This shows that compared to

[28] For example, the maximum bid-ask spread for French bonds are calculated based on the average of best spreads, which update daily and change with events, thus we drop French bonds from our dataset. There are other types of bonds with changing market regulation as well. See Appendix A for details.

Table 7: Difference-in-Difference - Bond Level

This table contains point estimates and t-statistics (in parentheses) from estimating the following regression,

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

where Y can be abnormal trading volume, relative change of bid-ask spread or relative change of market depth of bond b on platform p under event e at eventday t, compared to those of the previous trading week (i.e, the $[-10,-6]$ period). We consider 11 days around our events (from τ = -5 to +5) with the -1 day as base, 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 quotes for all the benchmark dates (i.e., the previous trading week) and the whole event window to include the bond for a particular event. The volume is expressed in millions EUR, and bid-ask spreads and market depth are expressed in %. The variable $eventday_{t=\tau}$ is an indicator variable that takes the value of 1 when day t is τ days relative to the event day. The variable DOM_p takes the value of 1 for the domestic market and 0 for the EBM market. The specification also contains Bond×Event fixed effects and event time fixed effects. Standard errors are clustered around event×bond. ***,**,* denote statistical significance at the 1%, 5% and 10% level, respectively.

	-5	-4	-3	-2	0	1	2	3	4	5
Panel A: Abnormal trading volume (EUR millions)										
$k = 2.0$	2.130	-2.480^{*}	-1.514	-0.681	-2.811^{**}	-3.910^{***}	-4.175^{***}	-6.557^{***}	-4.928^{***}	-5.697^{***}
	(1.55)	(-1.65)	(-1.19)	(-0.52)	(-2.02)	(-2.65)	(-2.97)	(-4.85)	(-3.63)	(-4.08)
$k = 1.5$	0.953	-1.938^{*}	-0.940	-0.396	-1.594	-2.545^{**}	-2.563^{***}	-3.528^{***}	-4.486^{***}	-4.268^{***}
	(1.02)	(-1.89)	(-1.05)	(-0.42)	(-1.62)	(-2.49)	(-2.63)	(-3.60)	(-4.87)	(-4.38)
$k = 1.0$	-0.717	-1.820^{**}	-0.773	0.017	-1.155	-2.433^{***}	-1.996^{***}	-2.230^{***}	-3.363^{***}	-2.652^{***}
	(-0.98)	(-2.45)	(-1.06)	(0.02)	(-1.58)	(-3.29)	(-2.73)	(-3.01)	(-4.50)	(-3.34)
Panel B: Relative change in bid–ask spread										
$k = 2.0$	0.001	0.047^{*}	0.022	0.019	0.052^{*}	0.207^{***}	0.028	0.023	0.134^{**}	0.003
	(0.02)	(1.68)	(0.98)	(0.90)	(1.91)	(3.34)	(1.13)	(0.76)	(2.40)	(0.13)
$k = 1.5$	-0.006	-0.002	0.018	0.008	0.062^{***}	0.135^{***}	0.031	0.012	0.113^{**}	-0.068^{*}
	(-0.47)	(-0.14)	(1.37)	(0.64)	(3.39)	(3.60)	(1.59)	(0.53)	(2.05)	(-1.84)
$k = 1.0$	-0.00001	0.012	0.010	0.014	0.046^{***}	0.094^{***}	0.027^{*}	0.040^{**}	0.085^{**}	-0.012
	(-0.0011)	(0.90)	(0.74)	(1.05)	(3.18)	(3.61)	(1.85)	(2.28)	(2.48)	(-0.51)
Panel C: Relative change in market depth										
$k = 2.0$	0.001	-0.005^{*}	-0.007^{**}	-0.002	-0.0002	-0.017^{***}	-0.023^{***}	-0.019^{***}	-0.013^{***}	-0.012^{***}
	(0.40)	(-1.87)	(-2.52)	(-0.91)	(-0.09)	(-5.44)	(-8.20)	(-6.36)	(-4.53)	(-4.23)
$k = 1.5$	-0.008^{***}	-0.003	-0.003	-0.002	0.002	-0.006^{***}	-0.009^{***}	-0.007^{***}	-0.005^{**}	-0.005^{**}
	(-3.57)	(-1.24)	(-1.25)	(-1.26)	(0.96)	(-2.88)	(-4.30)	(-3.33)	(-2.31)	(-2.10)
$k = 1.0$	0.0001	-0.0002	0.001	-0.001	-0.001	-0.006^{***}	-0.003^{*}	-0.001	0.003	-0.001
	(0.08)	(-0.14)	(0.75)	(-0.52)	(-0.73)	(-3.66)	(-1.81)	(-0.62)	(1.64)	(-0.31)

the previous week, trading volume decreases disproportionately more in the domestic market, consistent with a larger decrease of risk bearing capacity of domestic market makers. Based on the result in Table 7, for $\kappa = 1.0$ events, the domestic market experiences an additional decrease of 2.3 € million (or 13.1% relative to the unconditional mean of volume in domestic markets in previous trading week) in trading volume.

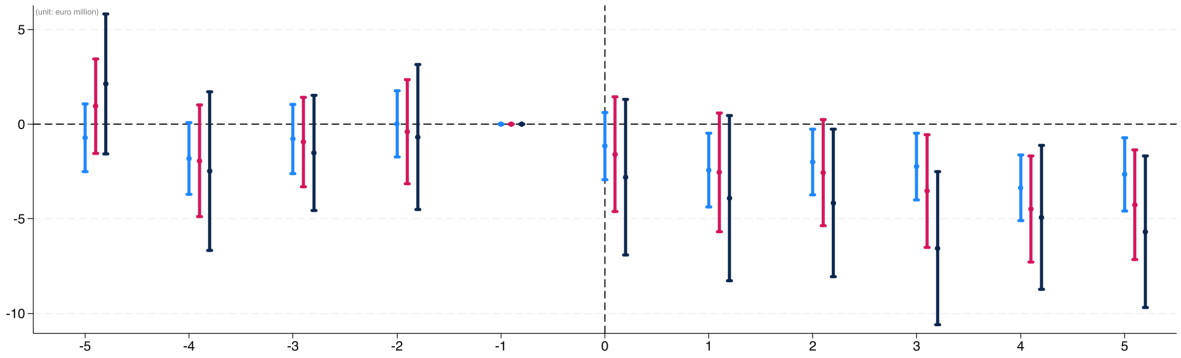
Besides trading volume, other market liquidity indicators also exhibit asymmetric reactions across the two platforms. Compared to the previous trading week, the increase in bid-ask spread is more than 6% higher in domestic markets on the days following events. Note that we are comparing the spread of exactly the same bond across markets, so any difference in the market reactions indicates that arbitrage exists. Remarkably, the differences in spreads across the two markets exist for more than one day, and the magnitude is large (5% of the benchmark bid-ask spreads in domestic markets is 4.1 basis point). Compared to the previous trading week, the market depth on the domestic platforms decreased by 2% more in domestic markets in our most severe events. For all the dependent variables, the asymmetry in market reactions is larger as events become more severe.

This section has shown that the reduction in trading volume primarily occurs in the domestic market while domestic spreads increase disproportionately and domestic market depth decreases more. The reason is that, 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 with the existence of a link between market maker wealth and liquidity provision (Ho and Stoll, 1981).

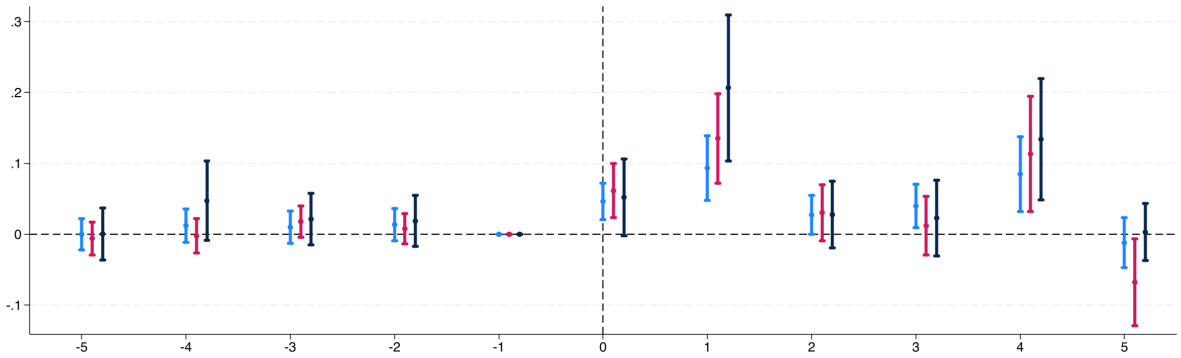
5.4 Ruling Out Demand-Side Explanations

So far, we have shown that market makers' risk-bearing capacity is the primary cause of liquidity deterioration and the decline in trading volume. However, one might be concerned that our comparison across the two platforms could be capturing the difference in changes of liquidity demand as well. We provide several pieces of evidence that the volume decline is driven by a contraction in liquidity supply.

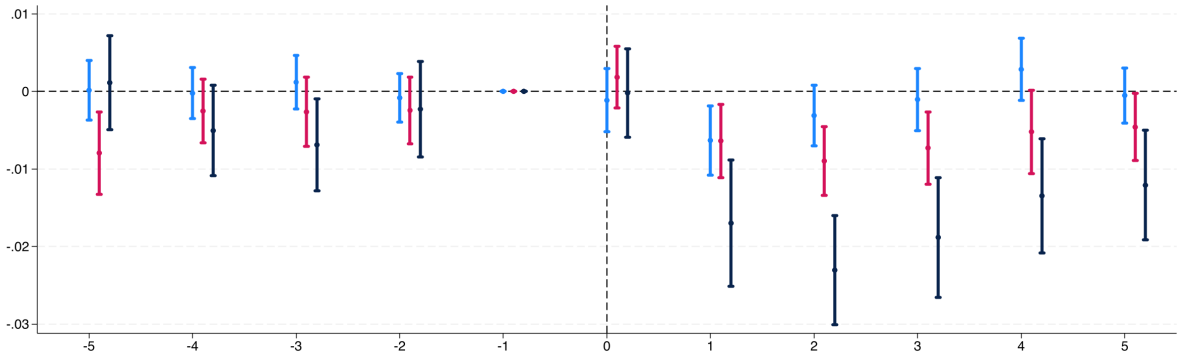
First, notice that trading volume (the quantity of liquidity) decreases while bid-ask spreads increase and market depth decreases (the price of liquidity increases). As proposed by Goldberg (2020), this pattern of contemporaneous opposite-sign changes in price and quantity can identify



(a) Trading volume drops more in domestic markets



(b) Relative bid-ask spread increases more in domestic markets



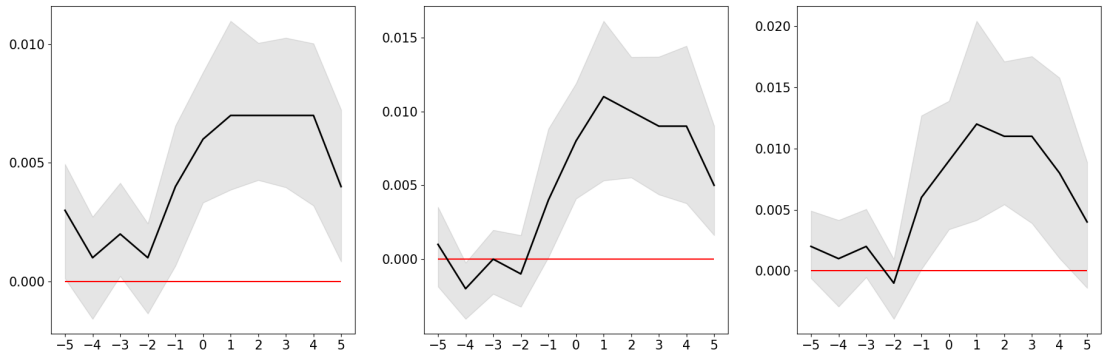
(c) Market depth decreases more in domestic markets

$\kappa = 1.0$ $\kappa = 1.5$ $\kappa = 2.0$

Figure 5: Market reactions in domestic market vs. international market

The figure illustrates the difference-in-differences result in Table 7. We consider 11 days around our events (from τ = -5 to +5) with the -1 day as base, 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 quotes for all the benchmark dates (i.e., the previous trading week) and the whole event window to include the bond for a particular event. The volume is expressed in euro millions, and bid-ask spreads and market depth are expressed in %. We control for Bond×Event fixed effects and event time fixed effects, and the standard errors are clustered at event × bond level. The confidence intervals for trading volume and market depth are at 95%, while it is at 90% for bid-ask spread.

liquidity supply shocks.[29] When a supply shock tightens dealer constraints, the supply curve shifts inward and produces less volume but higher liquidity prices, while a demand shock would lead to same-sign changes in price and volume. One caveat is that although bid-ask spread is commonly used as a proxy for the price of liquidity, what it truly measures is trade cost, which can be affected by factors other than liquidity supply. To better measure liquidity price due to dealers' intermediation capacity, we use an alternative proxy, "noise", which captures systemic deviation from no-arbitrage. Conceptually, noise quantifies the divergence of midprices of the same bond across the two types of markets, where these prices should be close to each other because of law of one price.[30,31]



(a) κ=1.0 **(b)** κ=1.5 **(c)** κ=2.0

Figure 6: Noise as measurement of liquidity cost of event countries

This figure shows the evolution of noise in the event window of $[-5, 5]$. Noise is calculated as the discrepancy of mid-prices of the same bond across local and international platforms, benchmarked against itself in the previous trading week. The red solid line represents 0 and the black line represents the mean of the variable of interest calculated from events. The grey shaded areas are 95% confidence intervals (calculated using standard errors obtained with the cross-sectional approach). From left to right, we plot different severities of events.

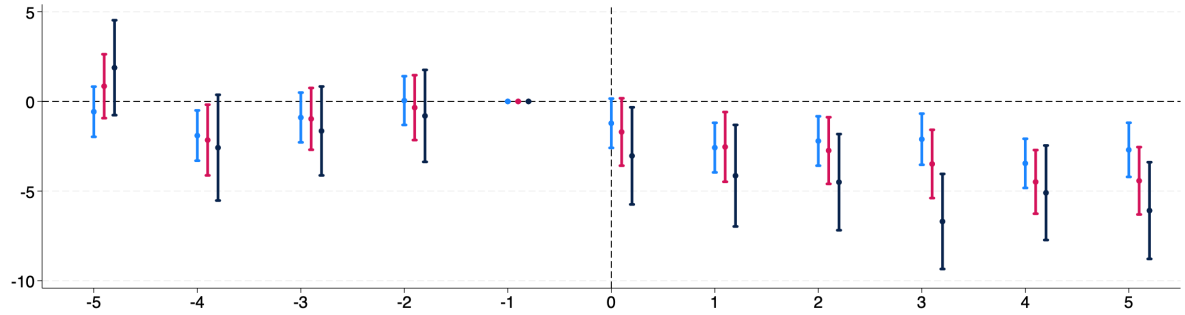
Second, we explicitly control for potential differences in liquidity demand by further categorizing the asymmetric decrease of trading volume in the domestic market into the volume from participants that have access to both the domestic and international markets for that bond, and the volume from participants who are only in the domestic market for that bond. As shown in Figure 7, the asymmetric decrease of trading volume is mainly because the participants who have access to both markets for one bond trade much less in the domestic markets. This is consistent

[29] Goldberg and Nozawa (2021) and Huang et al. (2025) also use this sign restriction to identify liquidity supply shocks.

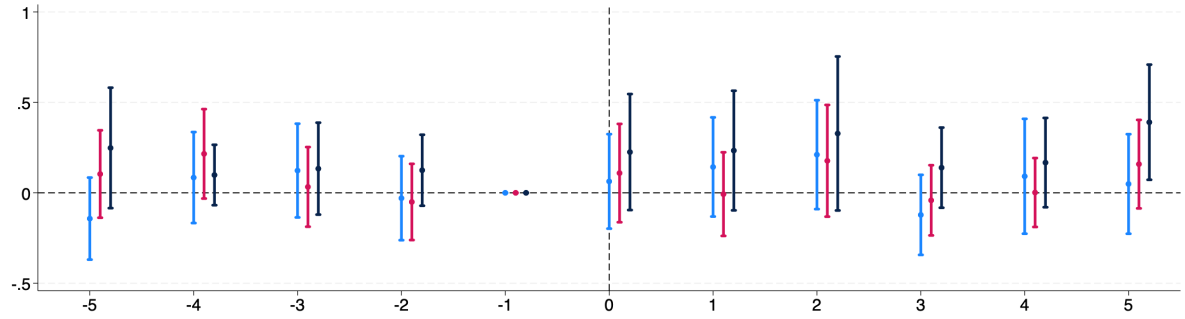
[30] The concept of noise is similar to the measurement of liquidity cost in Goldberg and Nozawa (2021) and Huang et al. (2025) as well.

[31] The law of one price may not hold if local markets and the EBM market are segmented. However, previous research shows that they are quite integrated. In addition, we benchmark the difference of mid-prices to itself in the trading week before so that we focus on the change of noise around our events.

with the argument that the supply of liquidity decreases more in domestic markets. Since these participants can access both markets for the same bond, they are able to place orders or quotes in parallel on both platforms. However, their orders/quotes are fulfilled less in the domestic markets due to the more severe deterioration of the supply of liquidity. On the other hand, for those who can only access one market, they are forced to trade in their market and do not have a choice between the local and international platforms. Therefore, the difference-in-differences terms for these participants do not show significant differences across the two markets.



(a) Volume from multiple-market participants decreases more in domestic markets



(b) Volume from only-one-market participants does not show asymmetry

$\kappa = 1.0$ $\kappa = 1.5$ $\kappa = 2.0$

Figure 7: Trading Volume divided by different categories

The figure shows the difference-in-differences result for different types of trading volume. The volume from multiple-market participants is defined as the trading volume from participants who are members of more than one MTS market. We consider 11 days around our events (from τ = -5 to +5) with the -1 day as base, 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 quotes for all the benchmark dates (i.e., the previous trading week) and the whole event window to include the bond for a particular event. The volume is expressed in euro millions, and bid-ask spreads and market depth are expressed in %. We control for Bond×Event fixed effects and event time fixed effects, and the standard errors are clustered at event × bond level. The confidence intervals for trading volume and relative bid-ask spread are at 95%, while it is at 90% for market depth.

Third, we separate the bid-side reaction from the ask-side reaction of the domestic market.

We find that the bid-side reacts more strongly in prices and quantities. This is consistent with domestic market makers holding excessive inventories of their own sovereign bonds and they are reluctant to accumulate more. From Table 8, we can see that, when decomposing the bid-ask spread and market depth into the bid-side and the ask-side, it is the bid-side that reacted more strongly after the event, while the ask side did not experience significant changes.

Table 8: Difference-in-Difference - Bid vs Ask side

This table contains point estimates and t-statistics (in parentheses) from estimating the following regression,

$$Y_{b,p,t,e} = \alpha_{b,e} + \alpha_t + \beta DOM_p + \gamma \left(DOM_p \times Post_{t,e}\right) + u_{b,p,t,e},$$

where Y can be relative change of bid-ask spread or relative change of market depth of bond b on platform p under event e at eventday t, compared to those of the previous trading week (i.e, the $[-10, -6]$ period). We consider 11 days around our events (from τ = -5 to +5) and aggregate them to pre-period and post-period, 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 quotes for all the benchmark dates (i.e., the previous trading week) and the whole event window to include the bond for a particular event. The volume is expressed in millions EUR, and bid-ask spreads and market depth are expressed in %. The variable $Post_{t,e}$ is an indicator variable that takes the value of 1 when day t is in post-event days relative to the event e. The variable DOM_p takes the value of 1 for the domestic market and 0 for the EBM market. The specification also contains Bond×Event fixed effects and event time fixed effects. Standard errors are clustered around event×bond. ***,**,* denote statistical significance at the 1%, 5% and 10% level, respectively.

	Ask side			Bid side		
	$k = 1.0$	$k = 1.5$	$k = 2.0$	$k = 1.0$	$k = 1.5$	$k = 2.0$
Panel A: Percentage change in price						
Local × Post	0.003	0.006^{*}	0.010^{**}	-0.009^{***}	-0.011^{***}	-0.029^{***}
	(0.870)	(1.910)	(2.185)	(−3.240)	(−2.767)	(−4.640)
Panel B: Percentage change in quoted quantity						
Local × Post	−0.070	−0.128	-1.059^{***}	-0.243^{**}	-0.269^{*}	-1.245^{***}
	(−0.588)	(−0.854)	(−5.156)	(−2.047)	(−1.815)	(−6.100)
Bond × event FE	Yes	Yes	Yes	Yes	Yes	Yes
Event-day FE	Yes	Yes	Yes	Yes	Yes	Yes

6 Consequences of Market Freezes

The previous sections showed that the secondary market for sovereign bonds freezes when there are large opposing movements in yield spreads across the euro area. Additionally, during these events, there is substantial demand for re-balancing. This section asks what this implies for who ends up holding sovereign debt. During the sovereign debt crisis, domestic banks absorbed a large part of newly issued bonds in the primary market. We argue that as the secondary market froze offloading these purchases became prohibitively expensive, and the bonds eventually remained on the books of the banks that bought them. Consequently, home bias increased, implying a

lower risk-sharing and higher segmentation in the euro area over this period.

We develop this argument for Italy, which is among the countries with the most flight events in our sample and whose sovereign bonds are the largest single position in euro-area banks' portfolios.

6.1 Data and variable definition

To measure the allocation of sovereign debt across investors we use the Securities Holdings Statistics by Sector (SHSS) of the European Central Bank. For each quarter, the data report the nominal amount of each security held by each institutional sector in each euro-area country. We denote by $H_{b,t,s,h}$ the nominal holdings of bond b in quarter t by sector s in holder country h. Because holdings are recorded at nominal value, our measures are not mechanically affected by the decline in the market value of periphery debt during the crisis.

The holdings data used in this section cover the period from 2009Q1 to 2014Q4.[32] We restrict the sample to bonds issued by euro-area central governments for which the holder country is also in the euro area and the holder is classified as a credit institution (CI), since the mechanism we study operates through the balance sheets of dealer banks.[33] For each flight event, the secondary market sample includes bonds that are outstanding in the pre-event, event and post-event quarters. This restriction implies that bonds issued on an event or post-event quarter are excluded from the secondary market analysis. Thus, the primary and secondary market results in Section 6.2 are estimated on nearly disjoint samples.

We aggregate the daily flight events from Section 4.1 to the quarterly frequency of the holdings data. For each issuer country, we define an event quarter as a calendar quarter containing at least one flight event identified by the threshold model with $\kappa = 2.0$. If a quarter containing

[32] SHSS data prior to 2013Q4 are classified as experimental and were provided by the National Central Banks to the ECB on a best-effort basis. For country-quarter observations with missing holding information, no imputation or interpolation was performed. These observations have been treated as missing. We assessed the quality of the dataset by evaluating the plausibility of both the levels and trends of our constructed measures before and after 2013Q4, confirming the absence of structural breaks in the series. However, data coverage was incomplete for a few issuer countries prior to 2013Q4, specifically Cyprus, Greece, Malta, and Spain. Consequently, data for these countries were excluded from the charts and from the regression specifications in the primary market analysis, where country- or bond-level fixed effects could not be applied to address potential data limitations. It is important to emphasise that neither 2013Q3 nor 2013Q4 represent an event quarter for Italy, ensuring that our identification strategy in the difference-in-difference regressions remains unaffected by the transition from experimental data to the official data collection.

[33] Central government bonds have been identified by their European System of Accounts sector code (S1311). Principal and interest strips have been excluded. The SHSS additionally covers government bond holdings of households, insurance corporations and pension funds, investment funds, money market funds, non-financial corporations, and other financial institutions. Regression results for these sectors are available upon request.

an event is immediately preceded by another event quarter for the same issuer, we exclude it from the event-quarter indicator so that the preceding quarter used as the benchmark is not contaminated by the earlier shock. Applying this rule to Italy yields six event quarters: 2010Q2, 2011Q3, 2012Q2, 2013Q1, 2014Q2 and 2014Q4.

Holding shares. Let $\mathcal{B}$ denote the set of euro-area sovereign bonds in the sample and let $\mathcal{C}$ denote the set of euro-area countries. Each bond is assigned to its issuer country by the mapping $\phi : \mathcal{B} \to \mathcal{C}$, where $\phi(b)$ is the issuer country of bond b. For each $c \in \mathcal{C}$, we define the set of bonds issued by country c as $\mathcal{B}_c = \{b \in \mathcal{B} : \phi(b) = c\}$. Our first set of variables measures the share of a sovereign's debt that is held domestically. At the bond level, the domestic holding share is

$$ds^F_{b,t} = \frac{H_{b,t,s,h=\phi(b)}}{\sum_{h\in\mathcal{C}} H_{b,t,s,h}}, \tag{14}$$

that is, the fraction of the holdings of bond b by sector s that is in the hands of investors resident in the issuing country. Aggregating across all bonds of a given issuer gives the country-level counterpart,

$$ds^F_{c,t} = \frac{\sum_{b\in\mathcal{B}_c} H_{b,t,s,h=c}}{\sum_{b\in\mathcal{B}_c}\sum_{h\in\mathcal{C}} H_{b,t,s,h}}. \tag{15}$$

Portfolio weights and home bias. The holding shares in (14) and (15) describe the investor base of an issuer. To describe instead the portfolio of an investor, we define the weight of issuer country c in the sovereign bond portfolio of sector s in holder country h,

$$s_{h,c,t} = \frac{\sum_{b\in\mathcal{B}_c} H_{b,t,s,h}}{\sum_{b\in\mathcal{B}} H_{b,t,s,h}}, \tag{16}$$

and the corresponding weight of country c in the aggregate portfolio of sector s across all holder countries,

$$w_{c,t} = \frac{\sum_{b\in\mathcal{B}_c}\sum_{h\in\mathcal{C}} H_{b,t,s,h}}{\sum_{b\in\mathcal{B}}\sum_{h\in\mathcal{C}} H_{b,t,s,h}}. \tag{17}$$

The weight $w_{c,t}$ is the natural benchmark against which to judge $s_{h,c,t}$: it represents the portfolio weight that a sector-s investor in holder country h would allocate if she mirrored the weight of the aggregate sector-s market portfolio of euro-area sovereign debt. Following the standard measure in the international finance literature proposed by Ahearne et al. (2004), we define home

bias as the extent to which an investor underweights foreign assets relative to this benchmark,

$$hb_{h,c,t} = 1 - \frac{1 - s_{h,c,t}}{1 - w_{c,t}}, \tag{18}$$

which equals zero for an investor holding the market portfolio and one for an investor holding only the bonds of country c. The measure is positive whenever the sector-s investor in holder country h holds a higher share in country c bonds relative to the market portfolio (i.e. $s_{h,c,t} > w_{c,t}$) and is negative if the opposite applies (i.e. $s_{h,c,t} < w_{c,t}$). In what follows, we evaluate (16) and (18) at $h = c$ for domestic investors, and at $h \neq c$ when we turn to foreign investors.

Primary market absorption. To measure how much of a new issue is absorbed domestically, we restrict attention to bonds in their first quarter of life and compute (14) on that subsample, which we denote $ds_{b,t}^{F,PM}$. We complement this with the domestic holdings of a bond scaled by its amount outstanding,

$$q_{b,t} = \frac{H_{b,t,s,h=\phi(b)}}{AMT_{b,t}}, \tag{19}$$

where $AMT_{b,t}$ is the nominal amount outstanding of bond b.[34] The two measures differ in their denominator: $ds_{b,t}^{F,PM}$ describes the composition of the recorded holder base, while $q_{b,t}$ describes the fraction of the issue that domestic banks take onto their books.

Table 9 reports summary statistics. Two features are worth noting. First, the domestic share of euro-area sovereign debt held by banks is large: the mean of $ds_{b,t}^{F}$ is 0.575 and the median is 0.680, so for a typical bond the majority of bank holdings sit with their local banks. Second, home bias varies substantially across countries. The cross-country mean of $hb_{h,c,t}$ is 0.565 with a standard deviation of 0.329, ranging from 0.182 for German banks to 0.955 for Italian banks.

[34] Bonds' nominal amount outstanding is sourced from the Centralised Securities Database (CSDB).

Table 9: Summary statistics – sovereign bond holdings

This table reports summary statistics for the holdings variables defined in Section 6.1, computed for the credit institutions sector over the event quarters and the surrounding quarters. Panels A and B refer to the sample used to compare Italian banks with banks in other euro-area countries. Panels C and D refer to the sample of non-Italian investors used in Section 6.2. $ds^F_{b,t}$ and $ds^F_{c,t}$ are the domestic holding shares defined in equations (14) and (15), $s_{h,c,t}$ and $w_{c,t}$ are the portfolio weights defined in (16) and (17), $hb_{h,c,t}$ is the home bias measure defined in (18), $\Delta ds^F_{b,t}$ is the flow-based change in the domestic holding share, and $q_{b,t}$ is domestic holdings over amount outstanding as defined in (19).

	N	Mean	SD	p25	p50	p75
Panel A: Bond level, Italian vs. other euro-area banks						
$ds^F_{b,t}$	20,418	0.575	0.392	0.145	0.680	0.984
$\Delta ds^F_{b,t}$	20,904	−0.004	0.251	−0.010	0.000	0.022
$q_{b,t}$	17,122	0.175	0.268	0.000	0.049	0.227
Panel B: Country level, Italian vs. other euro-area banks						
$ds^F_{c,t}$	281	0.484	0.291	0.292	0.544	0.710
$s_{h,c,t}$	254	0.583	0.323	0.288	0.643	0.873
$w_{c,t}$	282	0.057	0.101	0.001	0.010	0.055
$hb_{h,c,t}$	254	0.565	0.329	0.262	0.623	0.867
Panel C: Bond level, non-Italian investors						
$ds^F_{b,t}$	124,988	0.161	0.305	0.000	0.002	0.125
$\Delta ds^F_{b,t}$	131,900	−0.002	0.162	−0.000	0.000	0.000
$q_{b,t}$	114,070	0.035	0.134	0.000	0.000	0.007
Panel D: Country level, non-Italian investors						
$ds^F_{c,t}$	3,946	0.067	0.157	0.000	0.005	0.042
$s_{h,c,t}$	3,716	0.071	0.169	0.001	0.008	0.050
$w_{c,t}$	3,948	0.070	0.109	0.003	0.017	0.073
$hb_{h,c,t}$	3,716	−0.014	0.226	−0.038	−0.003	0.003

Specification. We estimate difference-in-differences regressions of the form

$$Y_{i,t} = \alpha_i + \alpha_t + \gamma_0 \, Treated_i \times Event_t + \gamma_1 \, Treated_i \times Post_t + u_{i,t}, \tag{20}$$

where $Y_{i,t}$ is one of the variables defined above, $Treated_i$ takes the value of one for Italy and zero for the other euro-area countries, $Event_t$ is an indicator for the event quarter, and $Post_t$ is an indicator for the quarter following the event. The unit i is a bond when the dependent variable is measured at the bond level and an issuer country when it is measured at the country level. The intercept α_i is a bond fixed effect in the secondary market specifications, so that we use within-bond variation, and α_t is a quarter fixed effect that absorbs euro-area wide movements in the investor base. The primary market specifications do not include bond fixed effects, since a newly issued bond enters the sample only in its first quarter. A positive γ_0 indicates that the domestic share, portfolio weight, or home bias of Italian banks increased by more than the corresponding quantity for banks in control countries around flight events. In the specifications

presented in this section, standard errors are clustered around the issuer country of the bond.

6.2 Empirical results

Home bias increased across the euro area during the sovereign debt crisis. Figure 8 plots the change in the average home bias $hb_{h,c,t}$ of the euro-area banking sector and of the Italian banking sector over our sample period. Home bias in the euro area has risen sharply between 2010 Q2 and 2013 Q2, as the sovereign debt crisis intensified, before marginally retracing in the following quarters. This increase in home bias could be observed in broadly all countries, but with large heterogeneity in terms of the timing and size of the increase, as well as the home bias levels attained, the latter being also due to the initial country differences in home bias in the pre-sovereign debt crisis period. For example, in 2009 Q1 in Germany $hb_{h,c,t}$ was equal to 0.072, against 0.916 in Italy. Hence, at their respective peaks throughout the sample, home bias in Italy reached levels still far higher than that in Germany (0.979 vs 0.269).

Based on this bond holding perspective, we shall conclude that a re-balancing has actually occurred in the portfolio of the euro area banking sector during the sovereign debt crisis. The natural follow up question is whether this fact can be reconciled with the secondary market freezes documented in Section 5.3, in which investors are unable to re-balance.

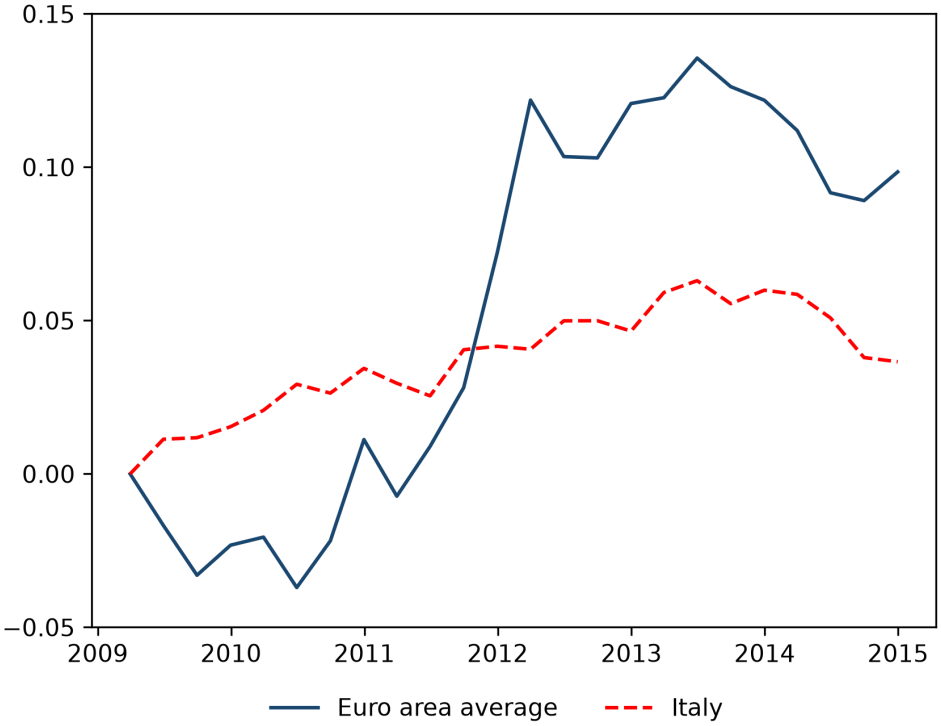


Figure 8: Home bias of euro-area banks

The figure shows the evolution of the home bias measure $hb_{h,c,t}$ defined in equation (18) for the credit institutions sector in Italy (dashed red line) and in the euro area as a whole (blue line, simple average of home bias across euro-area countries). The series display the changes in home bias since 2009 Q1 at a quarterly frequency and have been constructed based on the Securities Holdings Statistics of the ECB. 15 out of 19 euro-area countries have been considered in the average. Data for Cyprus, Greece, Malta and Spain have been excluded due to limited data availability for these countries before 2013 Q4.

Market freezes and increase in home bias reconciled. Figure 9 provides a hint that re-balancing has occurred through a different channel. It shows the share of Italian government bonds held by Italian banks over outstanding (i.e. the aggregate version of $q_{b,t}$) for all bonds and only for bonds that have been issued before the start of our sample in 2009 Q1. Based on this chart, the increased absorption of Italian bonds by the Italian banking sector, hence higher home bias, shall be mainly attributed to its larger and growing share of holdings in newly issued bonds, and only to a limited extent to purchases of existing bonds in the secondary market. This is an important evidence that suggests likely two mechanisms at play: (1) as secondary market freezes impeded aggressive sell-offs of Italian bonds from non-domestic dealers, a reduction of foreign banks' exposure to Italian government bonds might have occurred through the posting of lower bids on newly issued bonds; (2) market freezes might have contributed directly to the higher home bias as domestic dealers' were unable to offload their purchases from the primary

market at convenient prices, and the bonds eventually remained on the books of the banks that bought them.

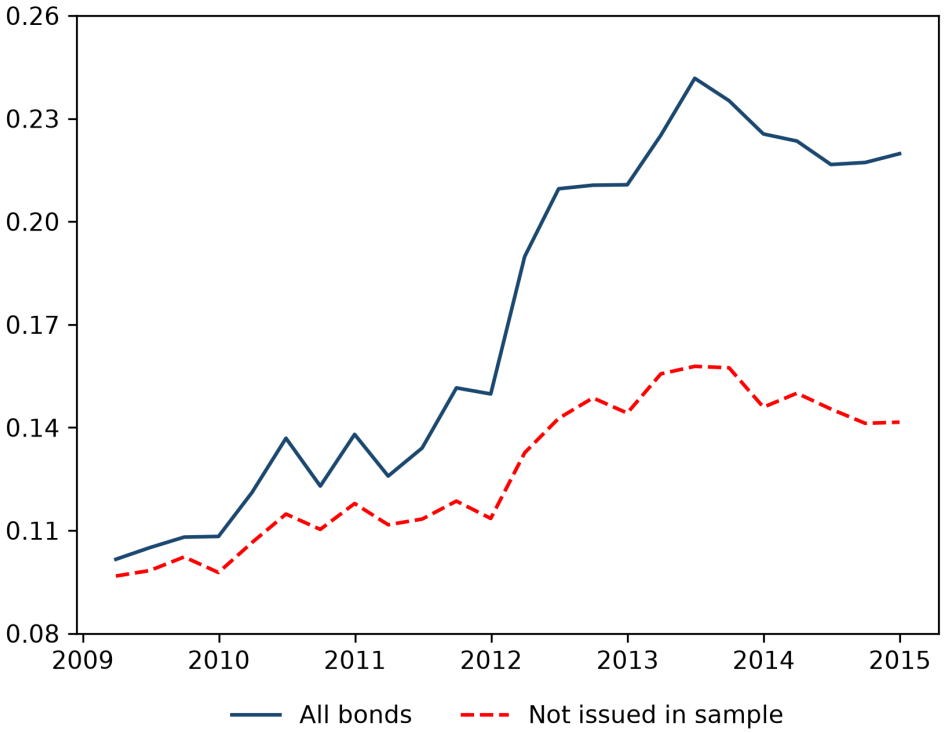


Figure 9: Share of holdings of Italian government bonds by Italian banks

The figure shows the total holdings of Italian government bonds by the Italian credit institutions sector over the total outstanding amounts, considering all bonds (solid blue line) or only bonds issued before the start of the sample period and outstanding throughout (dashed red line). The measure is an aggregate version of equation 19, where bonds $b \in \mathcal{B}_c$ with c representing Italy: $q_t = \left(\sum_{b\in\mathcal{B}_c} H_{b,t,s,h=\phi(b)}\right) / \left(\sum_{b\in\mathcal{B}_c} AMT_{b,t}\right)$. Holding and outstanding amounts underlying the ratio are expressed in nominal value. The series have been constructed based on Securities Holdings Statistics of the ECB.

In the following paragraphs, we consolidate the descriptive evidence derived from Figures 8 and 9 into more rigorous statistical findings, using difference-in-differences regressions around the flight events identified in Section 4.

Home bias increases more for Italian banks. In Table 10 we examine how home bias responds to flight events in Italy. Column (4) of Panel A shows that in the quarter of a flight event the home bias of Italian banks increases by 0.041 more than that of banks in control countries, which corresponds to 7% of the sample mean of 0.565, and the point estimate remains at 0.034 in the following quarter. Column (3) shows that the unadjusted portfolio weight of domestic bonds moves by the same amount, 0.038 in the event quarter, or 7% of its mean

of 0.583, and 0.035 in the quarter thereafter so the result does not arise from the benchmark adjustment in equation (18). That is, home bias in Italy increased more than home bias in other countries following Italian events, suggesting that the flight event precedes and exacerbates home bias.

Italian banks do not reduce their share of exposure to Italian bonds in the secondary market. If Italian banks had responded to these events by shedding the bonds that had become risky, their share of Italian bond holdings would have fallen relative to the share that banks in control countries hold in their own sovereigns. Both columns (1) and (2) of Panel A show that it did not. The estimated differential changes in domestic holding shares at bond level are negative but they are small and are not statistically distinguishable from zero. In absolute terms, the estimates at the bond-level represent less than 3% of the sample mean of 0.575. The country-level measure returns instead positive estimated differential changes, though also not statistically distinguishable from zero.[35]

The data on holdings records positions at the end of each quarter, so that an unchanged share is consistent, in principle, either with the absence of trading or with offsetting purchases and sales. Our transaction-level results bear directly on this. The events used here are those identified by the same threshold model with $\kappa = 2.0$ that underlies Table 7, where trading volume on the domestic platform falls by EUR 2.8 million on the event day relative to the international platform and remains between EUR 3.9 and EUR 6.6 million lower over the following week, with bid-ask spreads widening and market depth deteriorating over the same window. The market in which Italian banks would have reduced their exposure had ceased to function. The two sets of results therefore describe the same episodes from different angles: the transaction data show that the domestic secondary market froze, and the holdings data show that the exposure of Italian banks to their own sovereign did not fall as a result.

[35]The flow-based measure $\Delta ds^F_{b,t}$ gives a coefficient of -0.04 in the quarter after the event. Since the dependent variable is itself a first difference, the corresponding difference-in-differences coefficient measures a differential change in the rate of net purchases rather than in the position itself, and we therefore rely on the holding shares in columns (1) and (2).

Table 10: Flight events and home bias – secondary market

This table contains point estimates and standard errors (in parentheses) from estimating

$$Y_{i,t} = \alpha_i + \alpha_t + \gamma_0 \; Treated_i \times Event_t + \gamma_1 \; Treated_i \times Post_t + u_{i,t}$$

on the sample of bonds outstanding throughout the sample period, for the credit institutions sector. In Panel A, $Treated_i$ takes the value of one for Italy and zero for the other euro-area countries, and the dependent variables are measured for domestic holders. In Panel B the sample is restricted to non-Italian investors, $Treated_i$ takes the value of one for Italian bonds and zero for the bonds of other euro-area sovereigns, and the dependent variables are measured for these foreign holders. The dependent variables are the bond-level domestic holding share $ds^F_{b,t}$ in column (1), the country-level domestic holding share $ds^F_{c,t}$ in column (2), the portfolio weight $s_{h,c,t}$ in column (3), and the home bias measure $hb_{h,c,t}$ in column (4). $Event_t$ is an indicator for the event quarter and $Post_t$ an indicator for the following quarter. Events are defined by the threshold model with $\kappa = 2.0$ and aggregated to the quarterly frequency. All specifications include bond (or issuer country) and quarter fixed effects. ***,**,* denote statistical significance at the 1%, 5% and 10% level, respectively.

	(1) $ds^F_{b,t}$	**(2)** $ds^F_{c,t}$	**(3)** $s_{h,c,t}$	**(4)** $hb_{h,c,t}$
Panel A: Italian banks vs. banks in other euro-area countries				
$Treated \times Event$	-0.005	0.027	0.038^{**}	0.041^{**}
	(0.009)	(0.020)	(0.015)	(0.016)
$Treated \times Post$	-0.017	0.029	0.035^{*}	0.034
	(0.013)	(0.022)	(0.020)	(0.020)
Bond / Country FE	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES
N	19,239	265	239	239
Panel B: Non-Italian investors, Italian vs. other sovereign bonds				
$Treated \times Event$	0.000	-0.001	-0.004^{**}	-0.031^{***}
	(0.000)	(0.001)	(0.002)	(0.002)
$Treated \times Post$	0.004^{***}	-0.001^{**}	0.000	-0.047^{***}
	(0.000)	(0.000)	(0.002)	(0.003)
Bond / Country FE	YES	YES	YES	YES
Quarter FE	YES	YES	YES	YES
N	121,108	4,293	4,021	4,021

Italian banks absorb more in the primary market. Since the additional home bias documented above does not accumulate through the secondary market, in Table 11 we focus on bonds in their first quarter of life. In Panel B, which includes bonds issued in the current or the previous quarter, the domestic share of a newly issued Italian bond is 0.150 higher around flight events than for control bonds, or 23% of the mean domestic holding share of 0.665.[36] Restricting the sample to benchmark issues with an amount outstanding above one billion, the effect rises to 0.250 in the event quarter and 0.227 in the quarter thereafter. Measured as the fraction of the issue taken onto domestic books, column (4) gives 0.177 and 0.173 against a mean of 0.251,

[36]Note that the mean of $ds^{F,PM}_{b,t}$ which refers to the restricted sample of either newly issued bonds or bonds issued in the previous quarter is higher than the mean of the corresponding measure $ds^F_{b,t}$ referring to the full sample (0.665 vs 0.575).

implying that around flight events the domestic share of a large new issue increases by 70% more on average than in the stressed jurisdiction. That the effect is concentrated on large issues is consistent with the mechanism, since both the primary dealer activity and the secondary market freezes documented in Section 5.3 concentrate in benchmark bonds. Taken together with the previous result, the pattern is one in which Italian banks took on new domestic issues at the same time as they were unable to reduce their existing exposure.

Table 11: Flight events and home bias – primary market

This table contains point estimates and standard errors (in parentheses) from estimating equation (20) on bonds in their first quarter of life. In Panel A the sample contains bonds issued in the quarter of the event, in Panel B bonds issued in the quarter of the event or the preceding quarter. Columns (1) and (2) use all bonds, columns (3) and (4) restrict the sample to bonds with an amount outstanding above one billion. The dependent variable is the domestic holding share of the new issue $ds^{F,PM}_{b,t}$ in columns (1) and (3), and domestic holdings over amount outstanding $q_{b,t}$ in columns (2) and (4). $Treated_i$ takes the value of one for Italy and zero for the other euro-area countries. Bond fixed effects are not included since a newly issued bond enters the sample only once. Data for Cyprus, Greece, Malta and Spain have been excluded due to limited data availability for these countries before 2013 Q4. ***,**,* denote statistical significance at the 1%, 5% and 10% level, respectively.

	All bonds		**Amount outstanding > 1bn**	
	(1) $ds^{F,PM}_{b,t}$	**(2)** $q_{b,t}$	**(3)** $ds^{F,PM}_{b,t}$	**(4)** $q_{b,t}$
Panel A: Bonds issued in the event quarter				
$Treated \times Event$	0.144**	0.059	0.217*	0.182***
	(0.067)	(0.072)	(0.101)	(0.030)
$Treated \times Post$	0.113	0.095	0.174	0.182***
	(0.082)	(0.090)	(0.101)	(0.022)
Quarter FE	YES	YES	YES	YES
N	950	974	726	728
Panel B: Bonds issued in the event quarter or the preceding quarter				
$Treated \times Event$	0.150**	0.063	0.250**	0.177***
	(0.066)	(0.063)	(0.093)	(0.031)
$Treated \times Post$	0.152*	0.055	0.227**	0.173***
	(0.080)	(0.079)	(0.100)	(0.025)
Quarter FE	YES	YES	YES	YES
N	1,833	1,799	1,326	1,329

Foreign banks do not reduce their weight in Italian bonds either. One concern with the preceding results is that Italian banks might have retained these bonds under pressure from their government rather than because they were unable to dispose of them (Ongena et al., 2019). Such pressure does not extend to banks outside Italy. Panel B of Table 10 therefore repeats the analysis for non-Italian investors, comparing their positions in Italian bonds with their positions in the bonds of other sovereigns around Italian flight events. Column (3) shows that the weight

of Italian bonds in the portfolios of foreign banks falls differentially around flight events but only marginally: the estimate is small in absolute value (-0.004) in the event quarter and is zero in the quarter thereafter, against a mean weight in Italian bonds of 0.071. It implies a change that is below 6% of the mean. Therefore, banks that supposedly did not face direct pressure from the issuer, and that had every reason to re-balance their exposure to Italy towards other sovereign issuers, did not do so either. This is difficult to reconcile with an explanation resting on government pressure alone, and consistent with an impediment operating through the secondary market itself.

Taken together, in this section we have studied the evolution of home-bias in Italy surrounding market freezes. The results show that home-bias increases following market freezes. Freezes are associated with higher uptake in by local institutions in newly issued bonds and this is not associated with foreign institutions selling more in the secondary market. These findings are consistent with the argument that market freezes contributed to increase home bias and higher market segmentation in the euro area during the sovereign debt crisis.

7 Conclusion

The European sovereign bond market is central to the operation of the European financial system: it is where governments borrow, it supplies the collateral for monetary policy operations and repo, and it is intermediated by a small number of banks that hold large positions in the bonds they trade. The sovereign debt crisis therefore provides a setting in which a shock to an asset is also a shock to the balance sheets of its market makers. We use trade-by-trade data from MTS from April 2003 to December 2014 and holdings data from the ECB to ask three questions: whether the flights that theory predicts occurred, why not, and who ended up holding the risk.

They did not occur. In particular, we find that in times of stress trading is occasionally almost halted: in the week after 6 March 2008, Spanish government bond volume on MTS fell by 86%. Across all flight events, volume falls by a fifth to a third for the following week, bid-ask spreads nearly double, market depth falls by about a fifth, and none of the three returns to its pre-event level within a month. The cause is a contraction in liquidity supply. The same bond, on the same day, freezes more on the platform whose market makers hold more of the shocked sovereign: spreads widen more and volume falls more on the domestic platform than on the international one, and the combination of falling quantity with a rising price of liquidity,

together with the concentration of the decline among participants able to trade elsewhere, points to dealers withdrawing rather than to investors losing interest. The risk that could not be traded stayed where it was. Around Italian flight events, Italian banks absorbed a larger share of new issues and did not reduce their holdings of outstanding bonds, and their home bias rose in the quarters in which the secondary market froze. Freezes thus feed the exposure that causes them, a channel for the sovereign-bank nexus that operates through market liquidity rather than through bailouts or moral suasion (Ongena et al., 2019).

These findings have two implications. The first concerns the resilience of the market. It depends on a small number of dealer banks whose balance sheets cannot intermediate a flight from the asset they hold. In other markets alternative liquidity providers step in (Carrion, 2013), and in the U.S. Treasury market in March 2020 the central bank did. The ECB's Securities Markets Programme and Outright Monetary Transactions fall within our sample and acted on prices and, through purchases, as a buyer of last resort; our results suggest that resilience also requires diversifying who provides liquidity in this market and loosening the tie between market makers' balance sheets and their own sovereign. The second concerns how the crisis is read. The European sovereign debt crisis was not a period of large-scale rebalancing. It was a period in which rebalancing was impeded, and the risk that could not move stayed with the banks least able to bear it.

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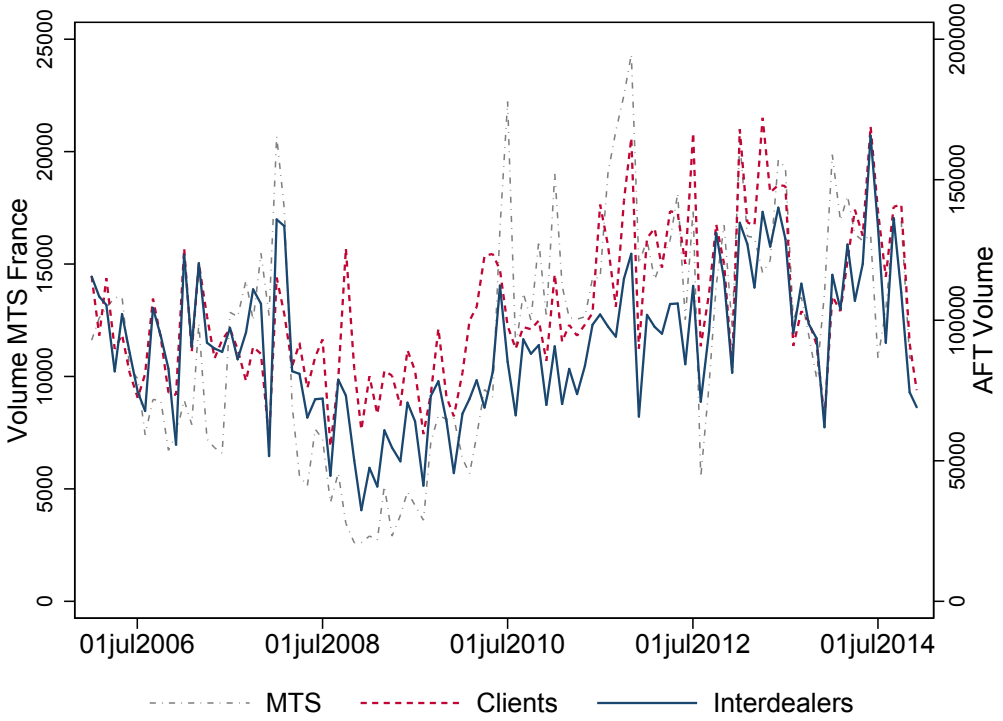


Figure 10: Volume by Market Segments in the French Market

This figure displays time series of monthly trading volume in the French sovereign bond market. The blue solid line labeled Interdealer is the total trading volume (in EUR) when both parties of a trade are dealers. The red dashed 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 dotted-dashed line labeled MTS is the overall volume traded in the French segment of the MTS platform.

Table 12: Pre-event Summary statistics of Trading Volume, Market Depth, and Bid-Ask Spreads

The table shows the summary statistics of trading volume, bid-ask spreads, and market depth before $\kappa = 1.0$ events. The calculations are based on the same dataset that is used for difference-in-differences analysis. We only consider events for which we observe quotes on both the international and the domestic MTS platform. Additionally, we require active quotes for all the benchmark dates (i.e., the previous trading week) and the whole event window to include the bond for a particular event. The trading volume is defined as the sum of all the trades for bonds within the instrument type. The relative bid-ask spread and the market depth are defined in equation (2) and equation (4), respectively. The summary statistics are based on the pre-event period (i.e., the $[-5, -1]$ period). The mean and standard deviation are calculated using daily data and on the instrument type level.

			Trading volume (EUR million)				Relative bid–ask spread (%)				Market depth (EUR million)			
Country	Class	# Bonds	Local	Std.dev	EBM	Std.dev	Local	Std.dev	EBM	Std.dev	Local	Std.dev	EBM	Std.dev
Austria	ATS	19	4.70	21.49	0.37	1.86	1.17%	0.75%	1.18%	0.76%	30.64	8.98	30.55	8.66
Spain	BON	20	12.68	28.38	1.10	4.32	0.50%	0.50%	0.52%	0.51%	53.91	16.59	48.33	12.67
Italy	BOT	64	78.76	84.87	4.37	13.87	0.04%	0.09%	0.04%	0.09%	62.66	16.97	49.36	12.81
Italy	CTZ	9	68.16	79.94	5.99	14.77	0.08%	0.09%	0.08%	0.10%	62.70	15.69	60.84	16.33
Netherlands	DSL	26	36.86	45.25	4.50	8.77	0.21%	0.37%	0.25%	0.49%	72.89	21.31	50.76	12.96
Netherlands	DTC	6	28.89	56.28	0.33	1.83	0.01%	0.00%	0.01%	0.00%	64.95	6.78	51.82	6.46
Greece	GGB	26	7.85	24.28	0.73	3.65	2.78%	3.37%	2.81%	3.42%	15.47	10.40	15.29	10.29
Ireland	IRL	16	2.57	10.04	0.35	2.23	2.85%	2.84%	3.15%	3.21%	19.64	9.78	19.59	8.82
Ireland	ITB	2	0.00	0.00	0.00	0.00	0.03%	0.01%	0.03%	0.01%	20.01	1.84	20.01	1.84
Spain	LET	33	19.69	34.43	0.21	1.84	0.07%	0.11%	0.07%	0.08%	88.16	27.31	61.17	13.95
Spain	OBE	31	8.83	21.81	0.74	3.53	0.93%	0.87%	0.95%	0.88%	42.02	15.43	38.72	13.14
Portugal	PTC	14	9.79	18.85	0.16	1.17	0.09%	0.20%	0.08%	0.17%	30.44	4.58	23.74	3.41
Portugal	PTE	18	13.10	25.52	2.97	9.99	1.89%	3.02%	1.92%	3.11%	35.36	13.29	34.03	12.45
Mean	-	21.85	22.45	34.70	1.68	5.22	0.82%	0.94%	0.85%	0.99%	46.06	13.00	38.78	10.29

Table 13: T test for differences across the control and treated groups

The table shows the results of t test of the differences of key variables across the control and treated groups, in the pre-event period (i.e., the $[-5,-1]$ period). The calculations are based on the same dataset that is used for difference-in-differences analysis. We only consider events for which we observe quotes on both the international and the domestic MTS platform. Additionally, we require active quotes for all the benchmark dates (i.e., the previous trading week) and the whole event window to include the bond for a particular event. For each bond, the abnormal trading volume is defined as the daily trading volume minus the average daily trading volume in the previous trading week (i.e., the $[-10,-6]$ period); the relative change of relative bid-ask spread is defined as the percentage change of daily relative bid-ask spread compared to the average daily relative bid-ask spread in the previous trading week; the relative change of market depth is defined as the percentage change of daily market depth compared to the average daily market depth in the previous trading week. The relative bid-ask spread and the market depth are defined in equation (2) and equation (4), respectively.

(a) Abnormal trading volume

	Control Group		Treated Group		T test	
	Mean	Std. dev	Mean	Std. dev	Difference	t-values
κ=2.0	0.322	0.099	0.777	0.542	-0.455	-0.826
κ=1.5	0.087	0.068	-0.160	0.368	0.247	0.660
κ=1.0	-0.136	0.053	0.596	0.271	-0.732^{***}	-2.653

(b) Relative change of relative bid-ask spread

	Control Group		Treated Group		T test	
	Mean	Std. dev	Mean	Std. dev	Difference	t-values
κ=2.0	0.464	0.028	0.466	0.028	-0.002	-0.054
κ=1.5	0.384	0.023	0.382	0.024	0.002	0.048
κ=1.0	0.385	0.018	0.377	0.018	0.007	0.294

(c) Relative change of market depth

	Control Group		Treated Group		T test	
	Mean	Std. dev	Mean	Std. dev	Difference	t-values
κ=2.0	-0.041	0.002	-0.038	0.003	-0.002	-0.625
κ=1.5	-0.011	0.002	-0.016	0.002	0.005^{*}	1.896
κ=1.0	-0.007	0.001	-0.017	0.001	0.010^{***}	5.041

A Market regulations of Domestic markets vs. International market

In MTS trading platforms, market makers are required to follow market making commitments. These commitments regulate quotes in terms of bid-ask spreads and bid/ask sizes. For example, in EBM market rules, it is written:

> Each Market Maker shall comply with the Market Making Commitments for each Financial Instrument on which it performs a Market Making Strategy, as described here below and as further specified in the Regulatory Specifications: a) For quotes to be of comparable size, there must be no more than 50% difference between bid and ask sizes; b) For quotes to be competitive in terms of price, they must be within the maximum bid-offer spread defined by MTS in the Regulatory Specifications; and c) The two-way Quotes must be available for trading on the Market for at least 50% of daily trading hours.

Market makers on every domestic trading platform also need to comply with market making commitments. The detailed regulations are summarized in Table 14. Instruments with a $*$ are excluded from the difference-in-difference analysis, since their regulations change over time and can vary together with events. In case of breaching the obligations, market makers are subject to various forms of penalty. For example, in EBM market rules, it is written:

> A Participant failing to comply with the obligations deriving directly or indirectly from the application of these Rules or otherwise failing to comply with the operational procedures, shall be subject to the disciplinary measures set out below, taking into account the nature and the severity of the violation and any previous breaches by such Participant: a) a written censure; b) a fine of between Euro 10,000 and Euro 500,000; c) suspension from trading; d) exclusion from the relevant list of Participants.

Table 14: Market making commitments vary across the two platforms

The table summarizes the market regulation of the domestic and international trading platforms, based on the regulation document from MTS official website. Instruments with a star are excluded from our difference-in-differences analysis, since their regulation also changes with events. For the instrument type that is not included in the regulation document, the fields are written NA.

Country	Instrument	Maximum bid–ask Spread		Minimum Quote Size (in million)	
		Local	EBM	Local	EBM
Austria	ATS	Table b) Column 2	Table b) Column 1	2	2
Spain	BON	Table b) Column 2	Table b) Column 1	2.5	1
Italy	BOT	10 basis points	15 basis points	2	2
France	BTA*	NA	NA	NA	NA
Italy	BTP*	Depends on whether a bond is classified as Liquid/Illiquid	Table b) Column 1	2	2
Italy	CTZ	6 basis points	Table b) Column 1	2	2
Netherlands	DSL	Table b) Column 2	Table b) Column 1	2.5	2
Netherlands	DTC	10 basis points	15 basis points	2.5	2
France	FTB*	Twice the average of the 7 best bid–offer spreads recorded among the participants	15 basis points	10	5
Greece	GGB	Table b) Column 3	Table b) Column 1	2.5	1
Ireland	IRL	Table b) Column 2	Table b) Column 1	2.5	1
Ireland	ITB	15 basis points	15 basis points	2.5	1
Spain	LET	15 basis points	15 basis points	2.5	1
France	OAT*	Twice the average of the 7 best bid–offer spreads recorded among the participants	Table b) Column 1	5	5 or 2.5
Spain	OBE	Table b) Column 2	Table b) Column 1	2.5	1
Belgium	OLO*	Time-weighted average spread by all market makers over their best 5 hours plus fixed factor 25% or bottom spread (set at 1.5 bp.)	Table b) Column 1	2.5 or 5 or 10	1 or 2.5
Portugal	PTC	10 basis points	15 basis points	2.5	2.5
Portugal	PTE	Table b) Column 2	Table b) Column 1	2.5	2.5
Finland	RFG*	Time-weighted average spread by all market makers over their best 5 hours excluding the 2 highest spreads plus standard deviation	Table b) Column 1	5 or 2.5	5 or 2.5

(a) Market regulations by instrument types

Maturity Bucket	Column 1 EBM max bid–ask spread	Column 2 LOCAL max bid–ask spread	Column 3 LOCAL max bid–ask spread
A (< 3.5 years)	30	30	40
B ($3.5 <$ years < 6.5)	40	40	50
C ($6.5 <$ years < 13.5)	60	55	75
D (> 13.5 years)	120	75	100

(b) Maximum bid-ask spreads according to maturity buckets

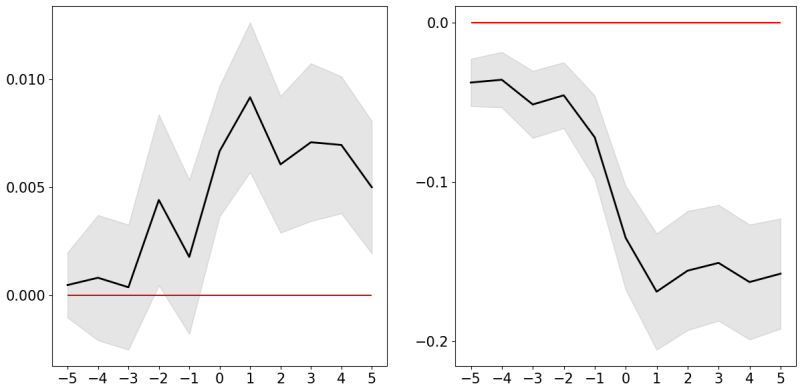
B Other weightings of variables

In our event study analysis, when aggregating bid-ask spreads to the country level, we use the equally weighted mean of all bonds within the country. In this appendix, we present the same event study results using the volume-weighted average of bid-ask spreads. The reason for using volume weighting is to reflect the transaction costs of traded volume. The weight w of bond i is given by:

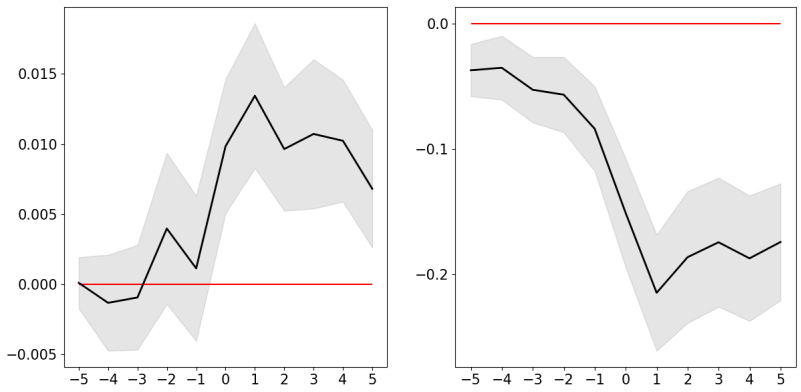
$$w_{i,t} = \frac{\sum_{m=6}^{25} VOL_{i,t-m}}{\sum_{i=1} \sum_{m=6}^{25} VOL_{i,t-m}}, \tag{21}$$

where the volume weighting of bond i depends on trading volume over days from $t = -25$ to $t = -6$. The event study results are shown in column 1 Figure 11. We can see that the spreads still increase dramatically after events happen, and the magnitude of the increase is larger for more severe events.

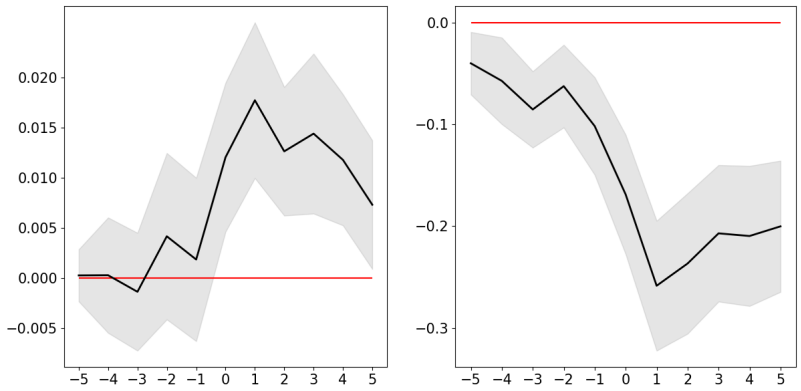
For the aggregation of market depth, instead of summing up the depth of all bonds within a country, we also use the mean of depth across all bonds of that country. The results do not qualitatively change either (as shown in column 2 Figure 11).



(a) κ=1.0 BAS **(b)** κ=1.0 DEPTH



(c) κ=1.5 BAS **(d)** κ=1.5 DEPTH



(e) κ=2.0 BAS **(f)** κ=2.0 DEPTH

Figure 11: Event study result of volume-weighted bid-ask spreads and average depth

This figure shows the evolution of the bid-ask spread and the market depth of event countries in the event window of $[-5, 5]$. The definitions of variables are the same as described in Figure 2. The red solid line represents 0 and the black line represents the mean of the variable of interest calculated from events. 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 bid-ask spread (left) and market depth of event countries (right). From top to bottom we plot different severities of events.

C Event study by country group

Table 15 reports the event study of Section 4.2 separately for the core countries (Austria, Belgium, Finland, France and the Netherlands) and the periphery (Greece, Ireland, Italy, Portugal and Spain). Trading volume falls significantly after periphery events and not after core events, while bid-ask spreads widen in both groups, by more in the periphery.

Table 15: Market Stress, Trading Volume and Liquidity - CORE and GIIPS results

This table presents separate event study results (executed as described in Table 5) for CORE (Austria, Belgium, Finland, France and the Netherlands) and GIIPS (Greece, Italy, Ireland, Portugal or Spain). The abnormal volume is based on the relative volume ratio $RVOL$ as defined in equation (1). The abnormal bid-ask spreads and the relative market depth are calculated as described in Table 5. The t-statistics (in parentheses) are based on standard errors from the cross-sectional approach. ***,**,* 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)
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)

D Trading on alternative Spanish venues around 6 March 2008

Figure 12 shows that the collapse in Spanish trading volume on MTS in the week of 6 March 2008, described in the introduction, is visible in two independent sources that cover trading away from MTS.

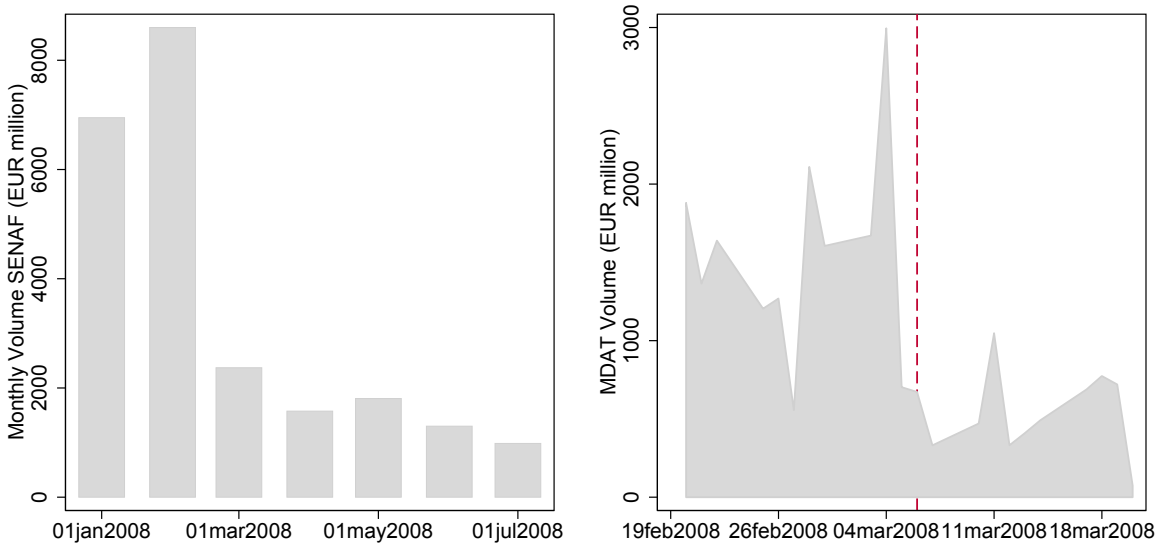


Figure 12: Trading volume on SENAF and in the Bank of Spain register around 6 March 2008

Panel A displays monthly trading volume (in EUR million) 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 EUR million) 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; unlike MTS volume it includes dealer-to-customer and over-the-counter trades. The vertical dotted line marks March 6, 2008.

E Rebalancing shocks in normal and crisis times

The event study and the platform comparison hold the shock fixed and ask how trading responds. This appendix asks the complementary question: when rebalancing demand arrives from outside the bond market, does it produce trading, and does the answer depend on whether liquidity supply is intact? We use daily aggregates for the sample excluding Germany of trading volume, the bid-ask spread, the LIBOR–OIS spread, the VSTOXX, the euro–dollar exchange rate and equity returns, all in first differences, and estimate a vector autoregression separately for the pre-crisis period, April 2003 to 8 August 2007, and the crisis period, 9 August 2007 to December 2014, with the crisis dated as in Nyborg and Östberg (2014).[37] Figure 13 shows cumulative orthogonalised impulse responses of volume to a one-standard-deviation shock to the VSTOXX (Panels A and B) and to the bid-ask spread (Panels C and D) in the two periods. Before the crisis, an equity-volatility shock raises bond trading volume, which is the rebalancing response, and a spread shock leaves it unchanged. During the crisis, the equity-volatility shock produces no volume and the spread shock reduces it. The ordering is VOL, BAS, $LOIS$, $VSTOXX$, $FXUSD$, $EQRET$, $EQRET^2$ and $FXUSD^2$; placing the bid-ask spread first leaves the volume responses qualitatively unchanged.

One objection is that the two periods are set by dates rather than by the data. Table 16 therefore reports the volume equation of a threshold vector autoregression, in the spirit of Pelizzon et al. (2016), in which the state is determined by the sample yield spread and estimated jointly with the coefficients by maximum likelihood. In the high-spread state, which covers 47% of the sample, the lagged change in the bid-ask spread is negatively related to volume; in the low-spread state it is not; and the lagged change in the VSTOXX raises volume in both. These reduced-form relations complement the identified results of Sections 4.2 and 5.3: rebalancing demand from outside the bond market was present throughout the sample, and it translated into trading only when liquidity supply was intact.

[37] Augmented Dickey–Fuller tests reject a unit root in every first-differenced series. The Bayesian information criterion selects one lag before the crisis and two during it. In the volume equation, a one-standard-deviation increase in the lagged change of the bid-ask spread is associated with a change in daily sample volume of EUR −4.5 million before the crisis (not significant) and EUR −86.5 million during it (first lag significant at the 10% level, second lag at the 1% level), and the lagged change in the VSTOXX enters positively and significantly in both periods.

Table 16: Threshold VAR Volume Equation

This table contains point estimates and t-statistics (in parentheses) of the volume equation from estimating a threshold vector auto-regression with the first differences of volume, bid-ask-spread, the LIBOR-OIS spread, the VSTOXX, the EUR-USD exchange rate and equity returns (including squared terms of the latter):

$$\Delta y_t = \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-1} I[z_{t-1} > z^*] + \epsilon_t.$$

Γ are the state contingent vectors of coefficients and $X_t = (1, y_{t-1})'$. The state is determined based on the sample yield spread using an endogenously determined threshold z^*. The variables are defined in the text. ***,**,* denote statistical significance at the 1%, 5% and 10% level, respectively.

	(1)	**(2)**
Intercept	0.0307	0.0226
	(0.4895)	(0.3118)
ΔVOL_{t-1}	-0.354***	-0.369***
	(-12.13)	(-17.19)
ΔBAS_{t-1}	-0.908*	-1.278
	(-1.668)	(-0.638)
$\Delta LOIS_{t-1}$	4.7672*	0.2494
	(1.7245)	(0.0737)
$\Delta VSTOXX_{t-1}$	12.874***	17.324***
	(2.5961)	(2.7470)
$\Delta FXUSD_{t-1}$	-10.35	-20.68
	(-0.842)	(-1.450)
$EQRET_{t-1}$	0.2304***	0.2025**
	(3.2359)	(2.2606)
$EQRET^2_{t-1}$	-0.012	-0.021*
	(-1.040)	(-1.722)
$\Delta FXUSD^2_{t-1}$	-176.8	-632.3
	(-0.175)	(-0.321)
Threshold Variable	YLS	
% Regime	46.50%	53.50%

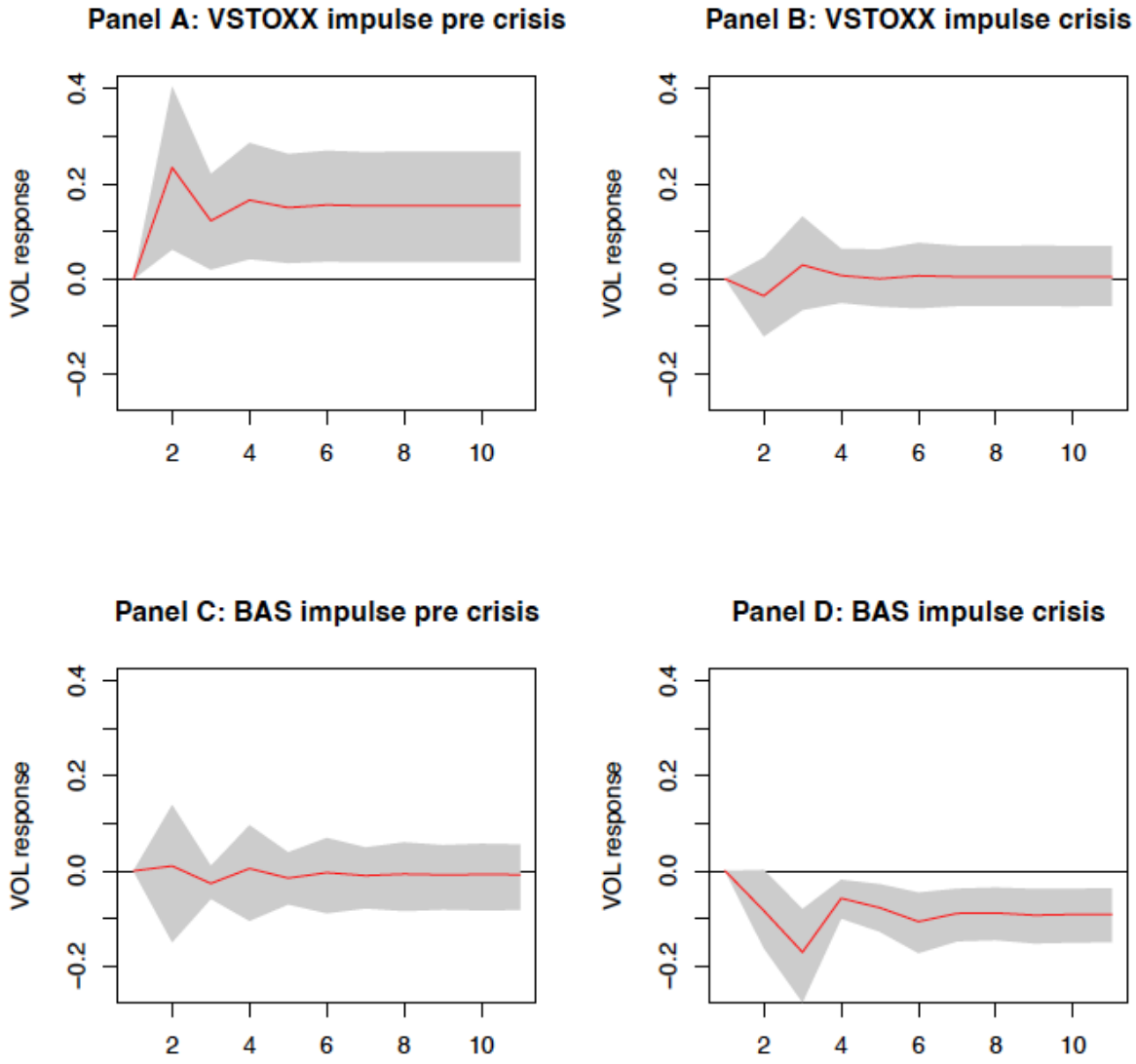


Figure 13: Cumulative Ordered Impulse Response Functions

This figure shows cumulative orthogonalised impulse response functions of daily sample trading volume (in EUR billion) from the vector autoregressions described in the text, estimated separately for the pre-crisis period (April 2003 to 8 August 2007) and the crisis period (9 August 2007 to December 2014). Panels A and B show the response of volume to a one-standard-deviation shock to the VSTOXX before and during the crisis; Panels C and D show the response to a shock to the bid-ask spread before and during the crisis. The horizontal axis is in trading days. The red line is the estimated response and the grey area a 95% confidence interval. The ordering is VOL, BAS, $LOIS$, $VSTOXX$, $FXUSD$, $EQRET$, $EQRET^2$, and $FXUSD^2$.

F Trading activity in extended event window

Our main event study analysis in Section 4 documents significant effects on trading volume, bid-ask spreads, and market depth within the $[\tau = -5, \tau = +5]$ event window. A natural follow-up question is whether these effects are transitory or persistent: when we look at a longer window, does trading activity cease to decline, and does it return to its pre-event benchmark? In this appendix, we extend the event window to $[\tau = -30, \tau = +30]$ trading days and conduct formal recovery and stabilization tests for each outcome variable.

Methodology. For each event i, the abnormal volume/depth at day τ is computed as:

$$AV_i(\tau) = \log(\text{Outcome}_{i,\tau}) - \frac{1}{5}\sum_{l=-10}^{-6} \log(\text{Outcome}_{i,l}), \tag{22}$$

where the benchmark is the average log-outcome over the five trading days $[\tau = -10, \tau = -6]$, consistent with the main analysis.[38] Within the original $[-5, +5]$ window, the abnormal values are taken directly from the main event study. For days outside this window, we take the outcome data from the extended horizons. The benchmark period is always the benchmark in the main event analysis, i.e., the average outcome of $[-10, -6]$.

We then aggregate the individual abnormal values into two tests. The *recovery test* examines whether the average abnormal outcome has returned to zero (i.e., to its pre-event benchmark level). At each event-time τ, we estimate the cross-sectional mean of $AV_i(\tau)$ by regressing the abnormal values on a constant and testing whether the intercept is significantly different from zero, following the cross-sectional approach of Boehmer et al. (1991). To reduce noise and improve readability at extended horizons, we aggregate daily observations into non-overlapping five-day (weekly) blocks and report block-level means with 95% confidence intervals.

The *stabilization test* examines whether the abnormal outcome has stopped actively changing, even if it has not returned to its benchmark level. We compute the first difference of the weekly block means and test whether each week-over-week change is significantly different from zero. The null hypothesis is $H_0 : \Delta AV = 0$; rejection indicates that the outcome is still actively moving in a given week.

[38] For bid-ask spreads we use the level difference in percentage points rather than the log difference, consistent with the abnormal spread measure of Section 4.2, and because relative spreads can be close to zero, which makes log changes unstable.

As shown in Figure 14 and 15, the trading volume and liquidity provision do not return to the pre-event value even after one month. However, they do stabilize quickly within 1 to 2 weeks after the events.

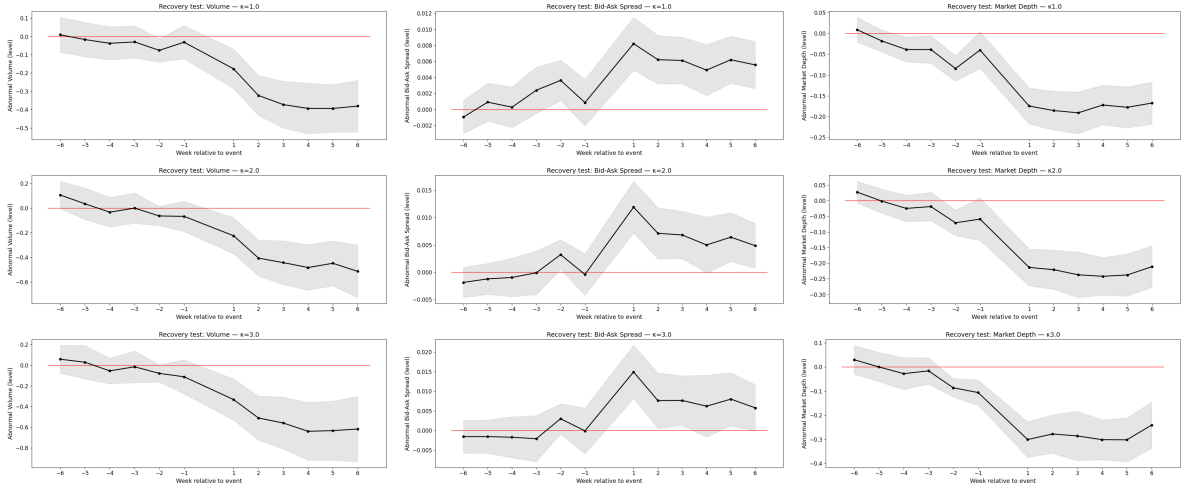


Figure 14: Recovery test for events. This figure shows the average abnormal outcome at weekly horizons in the extended event window $[\tau = -30, \tau = +30]$. Daily observations are aggregated into non-overlapping five-day blocks. The black line plots the cross-sectional mean and the grey shaded area represents the 95% confidence interval. The red horizontal line marks zero (the benchmark level). Abnormal values are winsorized at the 5th and 95th percentiles.

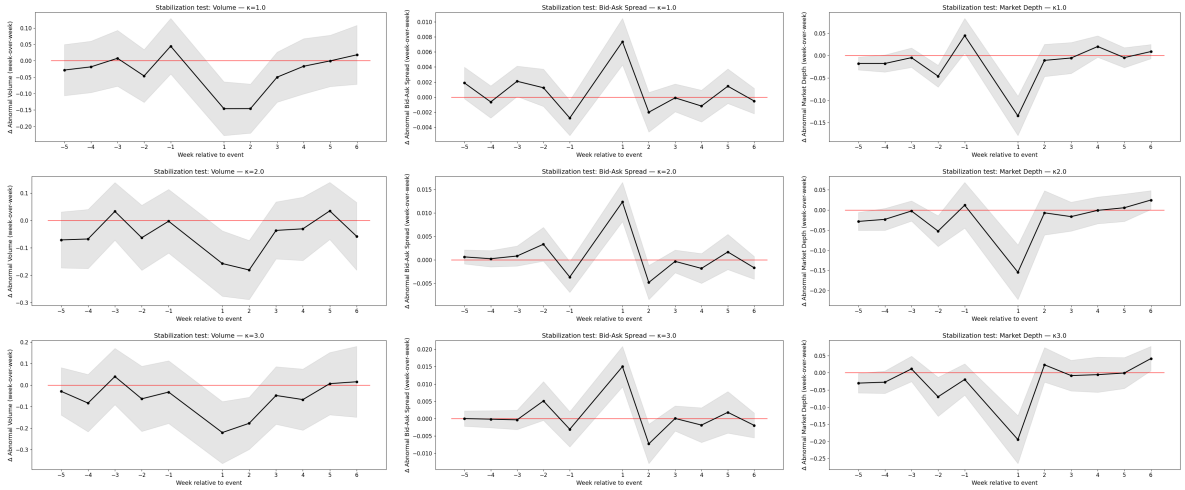


Figure 15: Stabilization test for events. This figure shows the week-over-week change in the average abnormal outcome around flight events. The null hypothesis at each week is that the change is zero, i.e., the variable has stopped actively moving. The grey shaded area represents the 95% confidence interval.