Capital Regulation, Market-Making, and Liquidity

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Abstract

We employ a proprietary transaction-level dataset in Germany to examine how capital requirements affect the liquidity and pricing of corporate bonds. Using the 2011 European Banking Authority capital exercise that mandated certain banks to increase regulatory capital, we find that affected banks reduce their inventory holdings, pre-arrange more trades, have smaller average trade size, and overall aggregate liquidity declines. Our results are stronger for banks with a higher capital shortfall, for non-investment grade bonds, and for bonds where the affected banks were the dominant market-makers. We find that the rise in illiquidity has a small impact of less than 7bps on corporate bond yields.

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1 Introduction

The defaults of Silicon Valley Bank and two other regional banks in March 2023 raised new questions about the resilience of banks. On 27th July 2023, Jerome Powell, chair of the Federal Reserve, put forth a proposal for raising capital requirements for U.S. banks[1] and by the Federal Reserve's own projections the proposal would raise capital requirements by two percentage points for banks with assets of $100 billion or more[2]. Powell acknowledges that "while there could be benefits of still higher capital, as always we must also consider the potential costs. This is a difficult balance to strike, and striking it will require public input and thoughtful deliberation." An important concern is the impact on the liquidity of corporate bond markets, a key source of financing for firms. The Business Roundtable, an association of more than 200 CEOs of America's leading companies, point to the Federal Reserve's own assessment that "overall effect of higher capital requirements on market making activity and market liquidity remains a research question needing further study" and that the Federal Reserve "should study this issue and develop a new proposal after fully understanding its implications, rather than treating the Proposal as a real-life empirical experiment."[3]

In this paper we provide clear and casual evidence on the effect of increasing capital requirements of banks on corporate bond market making, market liquidity, and corporate bond prices. We exploit that the European banking sector went through a similar capital raising exercise in 2011 and have access to transaction-level bond data as well as detailed portfolio holdings of German banks. We find that banks that are forced to improve their capital ratio decrease their corporate bond inventory, trade less, pre-arrange more trades, increase their bid-ask spreads, and have smaller average trade size. These effects are stronger for speculative grade bonds and in times of stress. We find that the liquidity of the overall corporate bond market drops after the event. However, we also find that the impact of the drop in liquidity on corporate credit spreads is small, less than seven basis points. Overall, our results clearly show that liquidity decreases after the capital raising exercise but that the funding cost of firms are only weakly affected.

[1] https://www.federalreserve.gov/newsevents/pressreleases/powell-statement-20230727.htm

[2] https://www.federalreserve.gov/newsevents/speech/barr20230710a.htm

[3] In a letter dated December 27, 2023, see https://s3.amazonaws.com/brt.org/2023.12.21BRTComments_Basel-III.pdf

The capital exercise, also referred to as a recapitalization exercise, was a one-time policy announced by the European Banking Authority (EBA) on October 26, 2011, and required certain banks to increase the core tier 1 capital ratio from 7% to 9% by June 30, 2012.[4] To trace out the causal impact of higher capital requirements, we use transaction-level bond data as well as detailed portfolio holdings of German banks and study market-making activities of banks that were required to alter their capital ratio in the given time frame (*affected* banks) with those banks that were exempted from it (i.e. *unaffected* banks). Our primary analysis, essentially a difference-in-difference analysis, is conducted at the individual security level. The granularity afforded by our security level dataset allows us to track the *same* bond on the *same* day across different banks. By doing so, we can non-parametrically control for any time-varying bond characteristics and demand factors that have plagued previous research designs.

We find that the affected banks responded to the capital exercise event by reducing the volume of their inventory by 19% relative to the unaffected banks. The results are economically large and statistically significant. The results are robust to the inclusion of bond interacted with quarter fixed effects, a saturation that allows us to examine the differential behavior of affected banks and unaffected banks for the *same* bond in the *same* quarter. Overall, these results show that the patterns are driven by changes in affected banks' behaviour and not by changes in the immediacy demanded by investors.

We next explore transaction-level data to investigate banks' market-making activities around the capital exercise event. Compared to the portfolio holding dataset, which is at a quarterly frequency, this data contain detailed information on all trades conducted by German banks at a daily frequency. We find that the affected banks drastically reduced their market-making activities in all dimensions relative to the unaffected banks. Furthermore, affected banks' average absolute daily change in inventory decreased by 38%, average trade size decreased by 21%, and the average fraction of pre-arranged trades increased by 4.2 percentage points relative to unaffected banks. Together, these measures capture different aspects of the degree to which market makers absorb order imbalances and provide immediacy to market participants and they all point to affected banks providing less liquidity. To

[4]The policy affected 61 European banks, which included 12 German Banks.

rule out demand-side factors, our main specification includes bond interacted with day fixed effects. Thus, we compare the liquidity provision of affected banks in the same bond on the same day relative to unaffected banks.

The EBA capital exercise explicitly targeted larger banks, raising the concern that the treatment of a bank is not random, and to provide further evidence, we test our central hypothesis by using variations within the sample of affected banks. More specifically, we compare the set of banks with higher capital shortfall with those having lower capital shortfall in the EBA capital exercise. The two subsets of banks are evenly balanced on size and other covariates, assuaging concerns of biases that might be introduced by confounding variables. Our results are both qualitatively and quantitatively similar. Net trading volume decreases by 23%, and trade size decreases by 9% for high shortfall banks compared to low shortfall banks.

We also test whether banks' reaction was more pronounced for non-investment grade bonds, as they have higher risk-weights and therefore higher capital requirements. We find that all affected banks' liquidity measures deteriorate more strongly for speculative grade bonds relative to investment grade bonds. For example, net volume traded for non-investment grade bonds is reduced by 23% when compared to investment-grade bonds. By incorporating bank $\times$ day fixed effects in this specification, we systematically control for any concerns related to the differences between banks that are part of the affected and unaffected group.

As a final test, we compare market-making activities in times of stress and on regular days before/after the regulatory treatment. Academics, policymakers and market participants have noted that immediacy during times of stress is an essential measure of market liquidity.[5] We define a stress day as the trading day with the highest volume in a month for a particular bond and, as expected, find stronger effects on stress days.

After having shown that the increase in capital requirements decreased banks' liquidity provision, we investigate how persistent this effect is. During the four subsequent quarters following the announcement of the EBA capital exercise, there is a significant reduction in

[5] Bao et al. (2018) also study liquidity during times of stress before and after the implementation of the Volcker Rule. Acharya et al. (2013) suggest the existence of time-varying liquidity risk of corporate bond returns conditional on episodes of flight to liquidity.

market-making activities by affected banks. Once we focus on speculative grade bonds only, we find that the reduction remains statistically significant until the end of our sample period, six quarters later.

The results so far establish that the capital exercise led to a reduction in market-making by affected banks. This raises an important question: Does these banks' reduction in market-making translate into lower bond liquidity? The impact on overall bond liquidity will depend on the extent to which non-affected banks and unregulated institutions step in and take over the activities of the affected banks. To test for this, we suggest a differences-in-differences approach. We divide our sample bonds into two groups based on the effect capital exercise has on them, i.e. into less affected and more affected bonds based on the percentage of trading performed by affected banks in the pre-period. Liquidity fell only for those bonds where the affected banks were important market makers.

We provide several robustness checks that suggest that other confounding events do not drive our results during the same time. The European sovereign debt crisis and ECB's long term refinancing operation (LTRO) in particular seem not to explain our findings. To rule out sovereign debt crisis as an explanation of our results, we divide the affected and unaffected banks into quartiles by exposure to Greece, Ireland, Italy, Portugal and Spain (GIIPS) sovereign bonds and using GIIPS exposure $\times$ Day fixed effects; we compare banks with similar GIIPS exposure. We also analyze how GIIPS exposure impacts banks' market-making activities post-period by interacting the GIIPS exposure with a post-event dummy. We find that though GIIPS exposure has a negative impact on market-making, it was not different for affected and unaffected groups since our diff-in-diff estimate does not change much in size or significance. In addition, ECB's long term refinancing operation (LTRO) during our sample period does not affect our results since only one bank in our sample had an LTRO take-up. Finally, we perform a placebo test using German government bonds, which have zero risk-weights associated with them and find that trading in these bonds was not differentially impacted for affected and unaffected banks.

Having established that aggregate bond market liquidity goes down as a consequence of the increased capital requirement, we examine the impact on corporate bond credit spreads. Specifically, we regress the bond credit spread on our liquidity measures, one at a time, and

soak up credit risk by adding rating fixed effects. When we calculate the total impact of illiquidity of the capital exercise on credit spreads (as the change in illiquidity around the event times the credit spread sensitivity), we find that the average impact is less than 7bps. This shows that the economic impact of the increase in capital requirements on the funding costs of firms is small.

Our paper contributes to the literature on financial regulation and bond market liquidity. The empirical evidence on the link between bank regulation and secondary bond market liquidity is mixed. Mizrach (2015), Trebbi and Xiao (2017), Anderson and Stulz (2017) and Adrian et al. (2017b) find no deterioration in bond liquidity following regulatory tightening impact whereas Bao et al. (2018), Bessembinder et al. (2018), and Dick-Nielsen and Rossi (2019) find that corporate bond market liquidity has decreased. Bao et al. (2018) find a strong effect of the Volcker rule but no effect of the Basel rules. The conflicting results are not surprising because two obstacles hinder the effective evaluation of the impact of capital regulation on the market-making activities of banks. To start with, regulations are often bundled together, making it difficult to isolate the impact of a specific regulation. The empirical strategy requires to focus on a specific regulation introduced in narrow window along with a high-frequency dataset on corporate bonds transactions at a very granular level. This is a tough ask. Causal inference is further complicated by the fact that the equilibrium market-making activity is an outcome of both supply-side and demand-side factors. On the demand-side, banks cater to clients with different preferences for liquidity and the composition of the client pool may vary over time affecting the demand for liquidity.[6] To isolate the effect of regulation on market-making carried by banks, one must control for demand-side forces that are simultaneously at work. The following answer by then-Fed Chair Janet Yellen, when asked to "comment on Basel, the liquidity rules all working together that are causing a lack of liquidity" summarizes the difficult task clearly: "I am not ruling out the possibility that regulations could play a role here, it is simply we have not been able to understand through a lot of different factors and we need to look at it more to sort out just what is going on and what the different influences are, but I am not ruling that out."[7]

[6] A shift towards institutional ownership (patient capital), for instance, could result in a lower demand for liquidity.

[7] https://www.govinfo.gov/content/pkg/CHRG-114hhrg97154/pdf/CHRG-114hhrg97154.pdf.

We add to this literature by providing a causal identification of the link between regulatory capital requirements and corporate bond market liquidity.

Theoretically, the direction of the impact of tightened bank regulation on bond market liquidity is not clear-cut either. An increase in capital requirements directly increases the inventory holding costs adversely affecting the market activity of banks. This, however, is not the only possibility. It is possible that banks' higher capital requirements may potentially reduce banks' funding costs (Begenau (2020)) and increase market-making activities (Bahaj and Malherbe (2020)). Furthermore, bank regulations may lead to costly bank balance sheets being replaced with a more efficient form of financial intermediation (Saar et al. (2023)).

He and Krishnamurthy (2013) document the impact of equity capital constraint of financial intermediaries on asset prices. According to Goldberg and Nozawa (2021), liquidity supply shocks to dealer inventory capacity have explanatory power for the cross-sectional and time-series variation in expected bond returns. Another strand of literature theoretically shows the impact of higher capital requirements on bank lending and assets. We also add to the discussion regarding the intended and unintended consequences of higher capital requirements. Admati et al. (2013) argue that regulatory capital requirements should be higher to enhance financial stability and also add that this would not be socially expensive in the long-run. While several papers have studied intended as well as unintended consequences of increasing regulatory capital requirements, the impact of higher capital charges on banks' market-making activities and bond market liquidity remains an open question we tackle in this paper.[8]

Several papers highlight that tightening regulatory financial regulation may push intermediation to unregulated entities (e.g., so-called shadow banks) with potential adverse consequences on financial stability and overall welfare (Admati et al. (2018), Farhi and Tirole (2020), Martinez-Miera and Repullo (2018), Plantin (2015), for a summary see Adrian and

[8]Gropp et al. (2018) examine how banks' respond to higher capital requirements in terms of decreasing risk-weighted assets (most importantly corporate lending). Several other papers study the implications of higher capital requirements on banks' loan supply (e.g. Jimenez et al. (2017) investigate how higher dynamic provision rules result in a contraction in loan supply; see further Berrospide and Edge (2019) for a summary). Blattner et al. (2019) find that banks not only reduce lending but reallocate credit to distressed firms with underreported loan losses. Behn et al. (2021) document how capital requirements that rely on model-based regulation have affected the reporting standard for risk parameters, as well as lending to firms with low risk, weighted assets.

Ashcraft (2016)).[9] In line with Bessembinder et al. (2018) who show that non-bank dealers' role has increased in the US since the financial crisis, we document that this trend has been present in Europe as well, a significant part of which can be traced to the tightening of capital regulation.

Finally, there is a large literature on the impact of bond illiquidity on corporate bond credit spreads, see for example Bao et al. (2011), Dick-Nielsen et al. (2012), Schwert (2017), Feldhütter and Schaefer (2018), and Li and Yu (2023). Our contribution to this literature is to examine the relation between illiquidity and credit spreads around a change in capital requirements.

Our paper is structured as follows. Section 2 describes institutional details of the capital exercise carried out in 2011. Our data sets, as well as descriptive statistics, are presented in Section 3. The set-up of our empirical identification strategy is explained in Section 4. We present our results on banks' market-making activities and robustness tests in Section 5. Results on corporate bond liquidity and pricing are discussed in Section 6. Concluding remarks are in Section 7.

2 Institutional Background

The EBA capital exercise, also referred to as recapitalization exercise, was conducted to restore investor confidence and improve the stability of the European banking sector. The capital exercise was announced on 26th October 2011 (see Figure 1 for a timeline of the event) only three months after the 2011 stress test on a nearly identical sample of banks. Given that the results of the 2011 stress test had been deemed as "meaningless" by the financial press, European regulators considered this recapitalization exercise a necessity.[10]

The EBA required 61 European banks, 12 of which were German banks, to increase their

[9] Empirically, Irani et al. (2018) show that less-capitalized banks have reduced loan retention when unregulated entities step in, particularly for risky loans. With regards to mortgage lending, Buchak et al. (2018) develop a quantitative model of mortgage lending suggesting that regulation accounts for roughly 60% of shadow bank growth. Similarly, Gete and Reher (2017) document how liquidity regulation has attracted non-banks and originate-to-sell lenders towards the FHA market.

[10] See, e.g. Financial Times "EU bank stress tests", 19th July 2011.

core tier 1 capital ratio from 7% to 9% by June 2012.[11] The core tier 1 capital comprised of the highest quality capital instruments and included common equity, ordinary shares, newly issued contingent convertibles (CoCos) and government support measures, among others.[12]

While the timing of the capital exercise and the high capital requirements it mandated came as a surprise to banks and stakeholders (see, e.g. Blattner et al. (2019) and Gropp et al. (2018) on this issue), a recapitalization of the European banking sector had been discussed since the presentation of the stress test results in July 2011.[13] The exercise had a significant impact and led to an increase of banks' capital position by more than 200 Billion Euros. [14] In Germany, where 6 of the 12 selected banks fell short of the capital requirements set by the capital exercise, the increase in the Tier 1 capital ratio was achieved mainly by shrinking assets of affected banks – a trend not observed for non-affected banks in Germany during this period.

As stated earlier, the empirical analysis focuses on corporate bonds in Germany. We briefly describe how capital charges of these bonds were determined. Under the current European regulatory framework, banks must indicate whether a specific bond is part of their trading book or the credit book. Market-making activities of bank-affiliated dealers are generally allocated to a bank's trading book.[15] If a bank uses internal market risk models,

[11]The minimum CET1-to-RWA ratio under Basel II was 2%. Basel III raised this threshold to 7%. A countercyclical buffer of up to 2.5% was set, but the phasing in of the new requirements was planned to be progressive, with a first mandatory increase of the minimal CET1 ratio from 2 to 3.5% in January 2013 and a gradual implementation of the additional CET1 buffer thereafter. Eligible Core Tier 1 capital was defined in a methodological note issued on 8th December 2011.

[12]For exact details please refer to EBA's documentation which can be downloaded from: https://www.eba.europa.eu/documents/10180/26923/Sovereign-capital-shortfall_Methodology-FINAL.pdf/acac6c68-398e-4aa2-b8a1-c3dd7aa720d4

[13]See The Economics "Disease and cure", 21.07.2011 and Financial Times "Top banks say capital push too expensive" by Himanshu Singh from October 13^{th} 2011.

[14]Out of the 61 banks that were required to participate in the EBA capital exercise, 27 banks had an initial shortfall for the target ratio set by the EBA. These banks strengthened their capital position by 116 Billion Euros. The remaining banks that did not experience a shortfall found their capital ratio closer to the new minimum requirements and increased their capital position by 84 Billion Euros. Note that the EBA 2011 stress test also required banks to increase their capital requirements. However, the consequences of this event were considerably milder for the banks, i.e. the estimated shortfall for the stress test was 2.5 billion euros. Hence, we focus on the capital exercise as the event which increased capital requirements for a subset of German banks.

[15]If a bond is placed in the credit book, the risk weight depends on its external rating, which varies between 0% and 150% under the Standardized Approach(SA). Under the Internal Rating Based Approach (IRB), the probability of default (PD) and the loss given default are inputs in determining the risk weight. In any case, an increase in regulatory capital requirements increases the capital commitment for a bond inventory and, relatively more for an inventory of non-investment grade bonds.

a daily value at risk (VaR) model is calculated for its entire trading book to determine the fundamental review expected shortfall.[16] The higher this expected shortfall, the higher the regulatory capital requirements (European Parliament (2019)).[17] If a bank determines its capital charges under the standard approach for market risk, it has to hold equity capital between 0% and 12% depending on the rating of the bond (see Article 336 of CRR).[18] Importantly, irrespective of the regulatory approach chosen (SA or IRB), an increase in regulatory capital requirements increases banks' capital commitment for a given inventory of corporate bonds (unless bonds have an AAA rating, in which case they get assigned a risk weight equal to zero). In the following sections, we investigate how an increase in regulatory capital requirements affects the market-making of affected banks.

3 Market-Making Activities, Bond Market Liquidity and Data

3.1 Data and Bank-Level Descriptive Statistics

We use two proprietary datasets from the two institutions involved in regulating and supervising the German banking system. These are Deutsche Bundesbank and the German Federal Financial Supervisory Authority ("BaFin") for this study. The first dataset, the Security Holdings Statistics, comprises portfolio holdings of all German financial institutions on a security by security basis. Banks report all of their securities holdings, irrespective of where they are held, to Deutsche Bundesbank on a quarterly basis. The dataset provides information for different asset classes, such as bonds, equities, and mutual funds. We obtain the nominal amount for each security an individual bank holds at the end of each quarter from the database.

The principal dataset used for this study is called the Securities Transactions database, which is maintained by BaFin. The German Securities Trading Act (Wertpapierhandels-

[16] See Begley et al. (2017) for a more detailed description.

[17] The current rule for determining capital charges for market risk in the banking book can be found under: https://www.bundesbank.de/de/aufgaben/bankenaufsicht/einzelaspekte/eigenmittelanforderungen/marktrisiko

[18] If a bank cannot hedge against interest rate risk or duration risk, the bank has to further hold additional capital for each bond position (see Article 339 and 340 of CRR).

gesetz, "WpHG") mandates credit institutions, financial services institutions, branches of foreign institutions and central counterparties based in Germany, to report the following transactions: (i) instruments traded on an organized market; (ii) instruments included in the regulated market; (iii) instruments traded on the open market.[19]

The transactions dataset contains date and time, price, volume, buy or sell indicator, currency, exchange code or indicator for OTC trades of the transaction. It also has security information on the parties involved (identifier for the reporting institution and, where applicable, identifiers of client, counterparty, broker or intermediaries). Banks are further required to report for each trading activity whether (1) it acts on behalf of a client and takes the security on its book, (2) it acts on its own behalf, or (3) it acts like a riskless broker on behalf of a client without taking the security on its book. As our primary interest is in banks' market-making activities, we concentrate on all transactions of categories (1) and (2), given that these trades affect banks' balance sheets.

We merge this dataset using the unique International Securities Identification Number (ISIN) with the Centralized Securities Database (CSDB). The CSDB Database is managed jointly by the members of the European System of Central Banks (ESCB). It includes information about the issuer of the security, e.g. issuer sector and issuer country. Finally, we add detailed balance sheet and income statement information of our sample banks from Bundesbank's BAKIS database.

We focus on the market-making of corporate bonds issued by German firms with a CFI-code starting with "DB" (D for debt instruments and B for bonds) and drop all financial industry bonds.[20] We further consider all trades in Euros and the main non-Euro currencies: "AUD" (Australian dollar), "CHF" (Swiss franc), "GBP" (pound sterling), "USD" (US dollar), "CAD" (Canadian dollar), "JPY" (yen), "HKD" (Hong Kong dollar) and "SGD" (Singapore dollar). These trades are converted into "EUR" (Euro) using daily exchange rates.

Our sample period spans from 2010 to 2012. The pre-period ends on July 15^{th} 2011

[19]The open market refers to a segment of the German stock exchange that has lower transparency requirements for firms to be traded compared to the regular listed firms.

[20]We exclude convertible bonds ("DC"), other debt ("DM"), medium term notes ("DT"), bonds with warrants attached ("DW") and money market instruments ("DY").

(announcement of the results of the stress test), and the post-period starts on the announcement day of the capital exercise, October 26^{th} 2011. We further focus on banks that trade frequently. Overall, 95% of the total trading volume is handled by the 37 banks which form our sample. The EBA selected the 12 largest German banking groups to be included in the exercise. Since the capital exercise was conducted at the highest level of consolidation, we identify the subsidiaries of these 12 largest banks and classify them as the affected group. Out of the 37 banks in our sample, 11 belong to the affected banking groups, and the other 26 belong to unaffected banking groups.

Our dataset has comprehensive coverage of market-making in German corporate bonds. Most of the market-making in German corporate bonds is done by German entities in either Germany or the UK. We are potentially missing some market-making by non-German banks. For example, we would not observe in our dataset if BNP Paribas was acting as a market-maker for some German bonds in Paris. This is a very small sample that pertains only to very large German corporates. Further, it is essential to note that non-German European banks were also part of the EBA capital exercise. Therefore, our sample is not only comprehensive, but representative of the market-making activity carried out for German corporate bonds.

In the last part of the analysis, we also use daily data 2010–2012 from ICE for all bonds in their global corporate bond index ("ICE BofA Global Corporate & High Yield Index"). This data includes the option-adjusted credit spread (OAS) (which we use as credit spread), time-to-maturity, issuance data, amount outstanding, and credit rating.

Table 1, Panel A provides summary statistics for affected and unaffected banks. In this table, all summary statistics refer to pre-event figures. Affected banks are significantly larger with average total assets of 344 Billion Euros than unaffected banks with average total assets of 37 Billion Euros. The affected banks' pre-event capital ratio is slightly lower than the capital ratio of unaffected banks (10.1% vs 11.6%). While the loans to asset ratio is almost identical for these two groups with about 50%, the unaffected institutions hold on average more deposits (41% compared to 47% deposit to asset ratio). The market value of sovereign bond holdings from GIIPS countries relative to total assets is relatively similar for both types of banks (1.8% and 1.3% for affected and unaffected banks, respectively). We also collect information on banks' certificates of deposits, commercial paper and other short-term bank

notes (bearer debt securities). Affected banks' short-term funding amounts to 15.6%, while only 10.2% for unaffected banks. Table 1 further illustrates the volumes of banks' security holdings. The market value of corporate bond holdings in balance sheets is 21 billion Euros for affected banks compared to about 5 billion Euros for unaffected banks.

To understand how the EBA capital exercise affected banks' balance sheets, we compare changes of certain descriptive variables of affected and unaffected banks around the event in Table 1, Panel B. Both types of banks increased their capital in the post-event period. While affected banks increased their capital by 12%, unaffected banks increased their capital holdings by 7.8%. Statistically, this difference is not significant. Affected banks reacted to the EBA exercise by shrinking their total assets by 4.3%. During the same period, unaffected banks increased their total assets by 3%. In sum, the difference between affected and unaffected banks around the regulatory action is about 7.3%. This figure suggests that banks achieved the target core tier 1 ratio primarily by shrinking their assets and not through raising capital.[21] In the next step, we provide more direct evidence by constructing market-making measures based on the daily transaction data.

3.2 Measuring Market-Making Activities

In this section, we quantify banks' market-making activities that are based on the daily transaction data set. More specifically, we use the following measures:

- $log(net\ volume\ traded)_{ijt}$ - Log of net volume traded on trading day t by bank i in bond j. This is described as the change in inventory of the bank i in bond j from the previous day and can be thought of as deviations or shocks a bank can absorb in its inventory daily. If the net volume change at the end of the day was negative, we take the absolute value of the volume. For example, if a bank sold a bond for 20 euros but bought the same bond for 30 euros on a day, then the change in inventory at the end of the day is $|30-20| = 10$ euros. If the bank sold a bond for 60 euros and bought one for 40 euros, then the change in inventory at the end of the day is $|40-60| = 20$ euros. Bessembinder et al. (2018) use this measure to provide evidence on dealers' overnight

[21] Admati et al. (2018) find that banks' existing shareholders prefer to increase their capital ratios by reducing risk-weighted assets instead of raising new capital.

capital commitment. A decrease in this measure implies less capital commitment by banks.

- $log(average\ trade\ size)_{ijt}$ - Log of gross volume traded in a day divided by the number of transactions conducted in the day by a bank. Many market participants argue that banks perform smaller trades and provide less immediacy due to regulatory reforms.

- $\frac{Principal\ Trading\ Volume}{Total\ Volume}_{ijt}$ - Banks can act either as an agent (broker) where they match customers for trades or as a principal where they absorb the customer requirements into their own inventory and thereby exposing themselves to risk directly. Within the principal trades, there can also be riskless principal trades (as defined by Bessembinder et al. (2018) and Schultz (2017)) in which the bank places the securities on its balance sheet only for a short time before it is offset by trades in the opposite direction. In such a case, banks act like a riskless dealer.

  Since we only focus on balance sheet changing transactions in our sample, all trades are principal trades. However, we rely on the information provided in the dataset, which divides principal trades into riskless principal trades (securities are placed on the balance sheet for a short time) and all others. Please note that instead of using the methodology followed by Bessembinder et al. (2018) of detecting offsetting trades within one minute, we depend on the information provided by the bank to the supervisory authority in the dataset.

  We calculate principal trading volume (defined above) as a percentage of the total trading volume.

Panel C of Table 1 presents descriptive statistics of these three measures as well as the daily gross volume of corporate bonds traded. While affected and unaffected banks differ considerably in the daily gross trading volume (33 million Euros vs 6 million Euros), the daily net volume is around 1 million Euros for both types of banks. Interestingly, the average trade size is about twice as high for those banks that did not participate (343k Euros vs 649k Euros). Also, the fraction of transactions undertaken where banks act as a principal and not as a broker is quite similar (around 60%) for both groups of banks.

3.3 Liquidity measures

In order to evaluate whether potential changes in banks' market-making activities impact the overall liquidity of bond markets, we need to define quantitative estimates of bond market liquidity over time. We employ liquidity measures calculated using transactions data at a weekly frequency. This allows us to include bonds that are typically not traded daily. We focus on the following liquidity measures:

- The bid-ask spread calculated at the bond level as

$$BA_{jt} = \frac{\overline{P}_t^{sell} - \overline{P}_t^{buy}}{\frac{1}{2}(\overline{P}_t^{sell} + \overline{P}_t^{buy})} \tag{1}$$

  where $\overline{P}_t^{sell}$ is the volume-weighted average price banks sold the bond to in week t and $\overline{P}_t^{buy}$ is the volume-weighted average price banks bought the bond at in week t.

- The Amihud measure as developed in Amihud (2002):

$$Amihud_{jt} = \frac{1}{N_{jt}} \sum_{s=1}^{N_{jt}} \frac{|r_{sjt}|}{Vol_{sjt}} \tag{2}$$

  where N_{jt} is the number of trades of bond j in week t, and r_{sjt} and Vol_{sjt} are bond j's return and the trading volume of trade s, respectively. The higher the price impact of a trade of a given size, the higher the Amihud measure is and less liquid the bond. The Amihud measure is provided in units of percentage per million euros and obtained only for bond-week pairs with at least four transactions.

Panel D of Table 1 presents descriptive statistics of the underlying bond level data and the two liquidity measures. On average, the outstanding amount of a bond is 396 million euros, and 2.2 years have passed since the issuance of a bond. The average time to maturity of bonds is 4.1 years. The average Amihud measure is 2.7, implying that a trade of one million Euros moves the price by 2.7%, and the average bid-ask spread is 1.636%.[22]

[22]The average bid-ask spread is significantly higher than what Gündüz et al. (2018) finds. The reason is that they focus on the 100 most liquid German bonds while we have more than 1000 bonds in our sample and the bid-ask spread is significantly higher for the less liquid bonds.

4 Identification Strategy

4.1 Impact of the Capital Exercise on Market-Making Activity

We rely on the following difference-in-difference specification to estimate the effect of higher capital requirements on banks' market-making activities:

$$Y_{ijt} = \alpha_{ij} + \alpha_{jt} + \delta \times \textit{Capital Exercise}_i \times \textit{Post}_t + \epsilon_{ijt} \tag{3}$$

where i, j and t index banks, bonds and days, respectively. The main outcome variables Y_{ijt} are the three market-making measures discussed in Section 3.2. The explanatory variable is the interaction of $\textit{Capital Exercise}_i$, a dummy that takes a value of one for affected banks and $\textit{Post}_t$, a dummy variable that takes the value of one for trading days after October 26, 2011 (EBA announcement day). The coefficient δ measures the effect of the higher capital requirements on the affected banks relative to the unaffected banks' market-making activity for the same bond on the same day. The pre-event period is from January 1, 2010, until July 15, 2011, and the post-event period is from October 26, 2011, until December 31, 2012. We exclude the period between the publication of the EBA stress test results on July 15 and the announcement of the EBA capital exercise on October 26, given that a recapitalization of the banking sector has been potentially anticipated during this period as discussed in Section 2.

The Bond $\times$ Day fixed effects, α_{jt}, control for any time-varying heterogeneity across bonds. To illustrate an example, consider the case in which investors' demand for a certain bond changes over time. In this case, changes in the trading activity of this bond might be unrelated to our event. The Bank $\times$ Bond fixed effects, α_{ij}, control for relationship-specific patterns between the bank and the bond. Such relationship-specific patterns emerge if, e.g. a bank underwrites a specific bond and, therefore, trades the specific bond more actively.

We further saturate our main specification with lagged bank-level controls - Log(assets), Loan/total assets and Deposits/total assets. In order to allow for potential correlation among bonds traded by the same bank or within the same bond, standard errors are double clustered at the bank and bond level.

In specification (3), unaffected banks might be indirectly impacted by the capital exercise in case they take over trading activities from affected banks. We discuss how such a substitution of activities would impact our estimates in Section 5.

4.2 Potential Concerns and Further Empirical Strategies

A fundamental identification assumption behind our empirical strategy is that market-making activities of affected and unaffected banks follow similar patterns in the absence of the capital exercise. One might worry that, despite focusing only on sample banks that actively trade, both types of banks may differ because of their size. Notably, our data incorporates the exact time of every transaction. We can, thus, examine the timing of banks' reaction to the EBA capital exercise. If affected and unaffected banks' trading follows different patterns for other reasons than the capital exercise, it is unlikely that this would occur exactly at the same date as the EBA announcement. We, therefore, define a short event window of 30 days before/after the EBA announcement and conduct our main identification strategy for this short time period (see Table 2). Without discussing the empirical results in detail at this stage, all affected banks' market-making measures respond immediately following the announcement of the capital exercise. This evidence mitigates concerns about confounding factors.

Nevertheless, to sharpen the identification, we exploit cross-sectional variation in the capital requirements of bonds. Market-making activities of lower-rated bonds are likely to be more impacted by the capital exercise, given that these bonds tend to be more illiquid and have higher risk weights associated with them. To reach the mandated core tier 1 ratio, banks reduce inventory more in bonds that have higher risk weights and tie up more capital. Wang and Zhong (2019) provide a theoretical model which predicts that order rejection rate by banks would increase more for higher risk-weighted bonds when regulatory capital requirements increase. We use ratings data from Moody's. Bonds rated lower than Baa are non-investment grade bonds. We add to the interaction term in specification (3) a dummy, $\textit{Non-Investment Grade}_j$, that takes the value of 1 if the bond is non-investment grade and zero otherwise. By doing so, we can compare trading activities of two kinds of bonds within the same bank and include Bank $\times$ Day fixed effects (α_{it}). This systematically

controls for any bank-specific shocks. The coefficient of this interaction term measures how affected banks adjust their market-making activities differently for non-investment grade bonds compared to investment-grade bonds that require a lower capital charge.

Similarly, we exploit cross-section variation based on banks' market-making activities during times of stress. It has been widely discussed in the financial media that liquidity provision has fallen only on days when there is unusually high activity in the market. Bao et al. (2018) study bond liquidity in times of stress after the implementation of the Volcker rule.[23]

As the corporate bond markets tend to experience stress on a limited number of days only, the above observation has also been cited as a reason for not seeing any drop in bond liquidity. We define a stress day for a given bond occurs as a day where the daily trading volume is in its upper 5th percentile across all banks for that month, i.e., the trading day with the highest volume in a month for a particular bond ($Stress\ Day_{jt}$) and zero otherwise. This indicator variable is substituted for $Non\text{-}Investment\ Grade_j$. The coefficient of interest measures the change in the market-making behaviour of affected banks compared to unaffected banks when customers required more liquidity than usual.

As a final test, we use variation in capital shortfall among the affected group. We compare market-making activities by affected banks in the top tercile according to the capital shortfall (3 banks) with the other 9 affected banks. Note that among the banks selected by the EBA for the capital exercise, high shortfall banks have 358 billion in assets and low shortfall banks have 338 billion in assets, which suggests that these two groups are quite similar in size. We use an interaction term between the diff-in-diff estimate and a dummy which is equal to 1 if the bank was in the top tercile according to capital shortfall ($High\ Shortfall_i$) and zero otherwise. The coefficient of interest estimates the relative response to market-making activities of the affected banks that did experience a high capital shortfall compared to those affected banks that did not. Next, we introduce our tests to measure whether the capital exercise impacted aggregate bond market liquidity.

[23] Governor Jerome H. Powell, Board of Governors of the Federal Reserve System: " *"It may be also that, even if liquidity is adequate in normal conditions, it has become more fragile, or prone to disappearing under stress.."*

4.3 Estimating changes in bond market liquidity

To test whether liquidity has indeed fallen due to a reduction in banks' market-making activity, we estimate the following equation:

$$liquidity\ measure_{jt} = \alpha_j + Post_t + Controls_{jt} + \epsilon_{jt} \tag{4}$$

where j is bond, t is week, and $Post_t$ is a dummy which is equal to one after the announcement and 0 before. We also include the log of bond age (time since issue), the log of bond maturity and the log of the outstanding amount of the bond as control variables.

Time-series regressions provide some evidence on whether the capital exercise played a role in the reduced liquidity in the corporate bond market or not. To control for time-varying economic and market conditions, we divide bonds by the capital exercise's effect on them. We calculate the share of the trading volume performed by the affected banks in the pre-period for each bond. We classify a bond as more affected if its share of the trading volume by the affected banks is higher than the median for all bonds. We compare these two groups in a diff-in-diff setup, thereby controlling time-varying economic and market-wide conditions. We estimate the following specification:

$$liquidity\ measure_{jt} = \alpha_j + \alpha_t + Post_t \times High\ Share_j + Controls_{jt} + \epsilon_{jt}. \tag{5}$$

This specification compares liquidity measures for less and more affected bonds before and after the capital exercise.

5 Capital requirements and market-making activities

5.1 Evidence from security holdings

We begin by presenting evidence from the Security Holdings Statistics database. The dataset provides a detailed snapshot (security-by-security) of the entire portfolio holdings of banks' at a quarterly frequency. The dataset is comprehensive in its coverage and provides complete information on German banks' security holdings anywhere in the world.

Regression results on total corporate bond holdings are reported in Table 3. The coefficient in Column 1 suggests that affected banks reduced their corporate bond holdings by 38.8% relative to unaffected banks. In Column 2, we saturate the specification by adding Security × Quarter fixed effects. That is, we compare changes in corporate bond holdings of affected and unaffected banks for the *same* bond in the *same* quarter. This allows us to control for any demand-side factors that affect the holdings of bonds. We find that affected banks reduced their corporate bond holdings by 25.4% relative to unaffected banks. In columns 3, we further saturate this analysis by adding Bank × Security fixed effects. Our diff-in-diff estimate reduces to 22.4%. In our most stringent specification (column 4), where we further add lagged bank controls (i.e. Log(assets), Loan/total assets and Deposits/total assets), the magnitude of our coefficient is robust at 19.1%. The coefficients are economically highly significant and even higher than the reduction in loans by around 13% found in Gropp et al. (2018). There are at least two reasons for this. First, corporate bond holdings are more liquid than loans and easier to shed off. Second, corporate bond holdings are on average only 10-15% of the loans.

In Figure 2, we plot the dynamics of our treatment effect. The dotted vertical line depicts the quarter immediately before the EBA capital exercise (announced on October 26, 2011). The graph shows that the corporate bond inventory of affected and unaffected banks follows very similar trends before the capital exercise event, but there is a large reduction of corporate bond holdings by affected banks (relative to unaffected) after the event. The coefficients remain negative and statistically significant until the end of the sample.

The above results provide evidence that affected banks reduced their inventory of corporate bonds in response to higher regulatory capital requirements mandated by the EBA capital exercise. In the following subsection, we examine whether this change resulted in a lower provision of immediacy to investors in the German corporate bond market.

5.2 Market-making activity by banks in corporate bonds

In this section, we investigate the impact of the increase in capital charges on banks' market-making activities. Table 4 presents the results from estimating specification (3) for the three market-making variables. In Columns 1-4, the logarithm of net volume traded is

the left-hand side variable. In the broadest specification, affected banks reduced their net volume traded by 9.7% compared to non-affected banks following our event (Column 1). Saturating our specification with time-varying bond specific factors (Column 2) results in a much higher magnitude of the coefficient (23.2%). Once we further include bank × bond fixed effects (Column 3), our coefficient increases to 37.0%. In the strictest specification where we include bank controls (Log(assets), Loan/total assets and Deposits/total assets), affected banks reduce their net volume traded during the day relative to unaffected banks by 38.0% (Column 4).[24] The increase in the magnitude of the coefficient illustrates the importance of controlling for changes in the demand for bonds by investors and relationship-specific patterns in bond trading. Looking at aggregate figures instead of micro-level data would result in an underestimation of the impact of higher capital requirements on market-making.

Banks commit less capital to corporate bonds and their end of day inventory change has declined post the capital exercise. This implies that banks' ability to absorb changes in their desired inventory levels has considerably reduced due to the increase in capital requirements. The dynamics of the diff-in-diff estimate are plotted in Figure 3. The difference in the net volume traded for affected and unaffected banks is statistically not different from zero until our event. Following the capital exercise announcement, we observe a significant relative reduction in the net volume traded by affected banks in the subsequent four quarters.

In Columns 5-8, we repeat the previous analysis while substituting the log of the average trade size as the dependent variable in specification (3). In a most saturated specification with bank × bond fixed effects and bank controls, the coefficient is 20.7% (Column 8) and dynamic treatment effects for this measure are illustrated in Figure 3, Panel B. The graph shows a very similar pattern as Figure 3, Panel A: the treatment effect is not different from zero until the event and statistically negative in the three quarters following the announcement of the capital exercise.

Finally, we next report the results for the third market-making measure - principal trading volume as a proportion of total trading volume - in Columns 9-12. Dealer-like trading has reduced for affected banks compared to the control group by 4.1 percentage points

[24]It is important to highlight that the market-making by the unaffected group did not increase in the post-period. This allays concern that the decrease in market-making by the affected group could have been picked up by the unaffected banks leading to an upward bias in our estimated coefficient.

(Column 9). Including Bond × Day and Bank × Bond fixed effects and bank controls yields a coefficient of 4.2 percentage points (Column 12). Given the mean of the pre-event proportion of principal trading by affected banks is 0.596, a drop of 4.2 percentage points corresponds to a reduction in the principal or dealer-like trading by about roughly 7%.

In sum, all three measures exhibit a very similar pattern. We find that affected banks reduce their net volume traded, average trade size and the proportion of trades where securities are carried on their balance sheets. Given this, the previously documented reduction in banks' bond holdings implies a reduction not only in proprietary trading but in banks' market-making activities. This constitutes an unintended consequence of higher capital charges.

5.3 Cross-sectional evidence

The previous section shows that an increase in capital requirements reduced the market making-activities of banks. In this subsection, we exploit cross-sectional tests that rely on variation in banks' incentives to reduce specific trading activities in order to comply with the higher capital requirements. More specifically, we test whether, among the affected banks, those that experienced the highest capital shortfall during the exercise adjust their market-making activities more extensively. Furthermore, it is natural to expect that affected banks may refrain from providing immediacy, especially for those bonds that carry a high risk-weight. To examine this relationship, we compare banks' trading of non-investment grade with investment-grade bonds in response to the event. Finally, we exploit variation in the timing of market-making activities. On stress days, i.e. days, when there is high trading activity, the risk to large inventory holdings at the end of the day is the highest, and, therefore, trading activities for affected banks may be restricted the most on these days. These cross-sectional tests also allow us to learn about the underlying mechanism driving our main empirical findings.

(i) 'Capital shortfall' At the bank level, we exploit variation in capital shortfall generated by the exercise among the affected banks. We compare top quartile banks (3 banks) with the highest capital shortfall against the other three quartiles (9 banks), which leaves these two groups very similar in size (as mentioned in Section 4.2). Table 5 provides regression results

for the three market-making measures. In Column 1, we include an interaction between the high capital shortfall dummy and a dummy for affected banks. We find that this interaction term is statistically significant. The magnitude of the coefficient implies that the net volume traded by affected banks with a high capital shortfall is reduced by 22.7% compared to affected banks that did not experience a high shortfall. Similarly, banks with a higher capital shortfall reduced their average trade size by 9.1% more than the other affected banks (Column 4). While the interaction term is statistically insignificant for our third measure, the proportion of principal trading, the coefficient points in the same direction, indicating that affected banks with a capital shortfall have adjusted their market-making more drastically (Column 7). In sum, the response to the regulatory announcement is more pronounced among those banks most affected by this event. Given that this effect is identified within the group of affected banks, this test also allays concerns regarding size differences of affected and unaffected banks.

(ii) 'Non-investment grade bonds' For the bond-level cross-sectional test, we compare bonds that are rated as non-investment grade by Moody's with investment-grade bonds. Ratings are used as a proxy for the risk-weights associated with bonds - the lower the bond's rating, the higher its risk-weight.[25] As the denominator of the capital ratio is determined by risk-weighted assets, the impact of the exercise could vary across differently rated bonds. Lower rated bonds also tend to be more illiquid. It is hard to find a trading partner for illiquid corporate bonds, and sometimes, the gap between two such trades can be days.

We indeed find that affected banks reduced their net volume traded in non-investment grade bonds by 23.0% (see Table 5, Column 2) more than investment-grade bonds. It is important to note that the sample size is reduced since ratings are not available for all bonds in our sample. This cross-sectional test allows us to include Bank $\times$ Day fixed effects controlling for time-varying bank-specific shocks. We find similar results once we substitute the dependent variable with the natural logarithm of the average trade size. The drop in average trade size is 20.0% sharper for non-investment grade bonds (Column 5). In line with previous results, the principal trading volume as a proportion of total trading

[25]See Section 2 for a discussion on how banks' regulatory capital requirements are determined for corporate bond positions.

volume declined by 2.3 percentage points more for non-investment grade bonds than for investment-grade bonds in our strictest specification (Column 8). These findings show that our estimated effects are the strongest for those bonds where small reductions in inventory holdings translate into large reductions in risk-weighted assets.

In Figure 3, Panel C, we plot the dynamics of our diff-in-diff estimate for the non-investment grade bonds using average trade size as our dependent variable. As can be seen, there is no difference between the affected and unaffected groups in the pre-event period, but a significant negative effect after the capital exercise. A comparison of this plot with Figures 3, Panels A and B, where we examine all corporate bonds, shows that banks reduced market-making for all bonds as an immediate response to the capital exercise and then specialized on the market-making for investment-grade bonds (i.e. low risk-weight bonds).

(iii) 'Stress days'

Lastly, we analyze the market makers' behavior on days with particular high trading volume, i.e. stress days, around the capital exercise. This cross-sectional test is founded on the hypothesis that liquidity provision has fallen, especially on unusually high market activity days.

Regression results for this test are shown in Table 5. Affected banks reduce their trading volume on a stress day by 30.7% (Column 3) compared to a normal day. This cross-sectional test also allows us to control for bank-specific time-varying shocks. The wide difference between trading activity on a normal day versus a stress day explains why many academic papers do not find any evidence of a reduction in the overall trading activity of corporate bond markets after the crisis. Firstly, these papers do not compare a bank that faces a regulatory burden versus a bank that is not governed by the same regulation. Secondly, stress day events are infrequent. Here, we causally document that banks experiencing higher capital requirements provide less liquidity on a stress day. These results provide support to the concerns raised by analysts that more regulation has resulted in excessive bond market volatility in stressful times.[26] Once we focus on the average trade size of affected banks, we obtain very similar findings. On a stress day, the average trade size drops by 16.5%

[26]See, e.g. Financial Times "Banks blame bond volatility on tighter regulation" by Tom Braithwaite and Vivianne Rodrigues from October 16^{th} 2014.

compared to a normal day (Column 6). We, however, did not obtain statistically significant results for the share of principal trading for this test.

Overall, we show in this subsection that the reduction in market-making due to an increase in regulatory capital charges is most pronounced when the marginal costs of the higher capital charges are the highest. The inclusion of Bank × Day interactions implies relying on identification within a bank. This addresses any concerns about time-varying omitted factors that could affect the selection of affected and unaffected banks by the regulator.

5.4 Robustness checks

5.4.1 Sovereign Debt Crisis and Other Related Events

There are other events besides the capital exercise that occurred during our sample period that may have impacted banks' trading and inventory holdings. First, during the European sovereign debt crisis, several Eurozone member states (Greece, Ireland, Italy, Portugal and Spain (GIIPS)) were unable to repay or refinance their government debt or to bail out over-indebted banks. German banks with GIIPS sovereign debt might have shut down market-making activities to economize on regulatory capital to compensate for these losses. Second, German banks dependent on US money market funds for funding experienced significant funding withdrawals, which could have affected market-making activities by bank-affiliated dealers. Finally, the Basel III regulatory framework was rolled out during our sample period. We provide an analysis below to rule out the possibility of these events explaining our main findings.

In Table 6 we address the concerns raised above. In Columns 1, 4, and 7, we divide our sample banks into quartiles based on their GIIPS exposure/total assets (GIIPS exposure ratio) and, based on this classification, define GIIPS exposure × day fixed effects. Hence, we compare banks with similar exposure in the affected group and unaffected group. In fact, coefficients for net volume traded and average trade size increase. As an additional test, we also use Post × GIIPS exposure as an explanatory variable along with the diff-in-diff estimate in Columns 2, 5, and 8. We find that there is not much change in the magnitude of the diff-in-diff estimate.

Based on data used by Carpinelli and Crosignani (2021), only one bank in our sample had a longer-term refinancing operations (LTRO) uptake; hence LTRO operations seem to not matter for our analysis. The Securities Market Programme was another ECB program launched around the same time, but ECB only bought securities from GIIPS countries during our sample period.

According to Ivashina et al. (2015), those European banks whose funding have some dependency on US money market funds may have experienced the greater withdrawal of funding which would affect their market-making activities. We use bearer debt securities holdings over total assets to measure banks' dependence on wholesale funding and interact it with the *Post dummy*. We find that the magnitude of the diff-in-diff coefficient remains largely unaffected (see Columns 3, 6, and 9).

Finally, we also consider other potentially confounding regulatory actions that affected German banks during our sample period. The revision of the Basel market risk framework (informally called Basel 2.5) coincided with the EBA capital exercise. It introduced an incremental risk capital (IRC) charge for unsecuritized credit products and stressed the value-at-risk requirement from January 1, 2011. Thus, the only channel through which the IRC affected our sample banks was higher capital requirements.[27] Further, the IRC affected and unaffected banks in the same way.

No other relevant regulatory reforms were implemented during our sample period. More specifically, the EU started with the gradual introduction of Basel III in 2013 (Capital Requirements Directive IV). Liquidity regulations like the Liquidity Coverage Ratio (LCR) and Net Stable Funding Ratio (NSFR) also came into effect after 2014. Extra capital buffers for systemically important domestic banks were applied starting in 2017. The Markets in Financial Instruments Directive (MiFID) II was finalized in 2014 but has not been implemented yet.

5.4.2 Placebo Test

German government bonds had zero risk-weights at that time. An obvious implication of this is that an increase in capital requirements should not cause any reduction in banks'

[27] Please refer to CGFS (2014) for further details.

market-making activities. We test for changes in affected banks' market-making of German government bonds for our three measures in Table 7. As can be seen, there was no change in any measure for affected banks relative to unaffected banks – all presented coefficients are statistically not different from zero.

6 Capital Requirements, Bond Liquidity, and Bond Pricing

So far we have shown that affected banks reduce their market-making activities in response to higher capital requirements. In this section, we investigate the impact on bond market liquidity and corporate bond spreads.

A priori, the impact on overall bond market liquidity will depend on the extent to which unaffected banks and unregulated institutions step in and take over affected banks' activities. Such unregulated institutions constitute entities with limited regulatory oversight, e.g. shadow banking companies, hedge funds, pension funds. The migration of these activities could potentially take time and, in the short-term, cause market liquidity to deteriorate.

Figure 4 shows the bid-ask spread and Amihud measure for German corporate bonds. Although our sample period is until the end of 2012, we plot the liquidity measures until the end of 2016 to assess the impact of the capital exercise for a more extended time series. Both graphs indicate a decrease in liquidity around the capital exercise. Liquidity levels do not seem to revert to their original levels but remain low until the end of our sample period.

To formalize our observation, we present regression results of specification (4.3) for our liquidity measures in Table 8. The bid-ask spread rises by 0.068 percentage points which is 4.2% of the mean value before the capital exercise (Table 8, Panel A, Column 1). If bond fixed effects are included (Column 2) in addition to bond controls, the coefficient changes to 0.029 percentage points. The Amihud ratio also increases by 1.647 percentage points per million euros in a before-after capital exercise comparison (Panel B, Column 1). This is 61.9% of the mean value of the pre-event Amihud ratio. Adding bond fixed effects and bond controls results in a very similar coefficient (Column 2).

Previous analyses on bond market liquidity do not allow us to control for any time-varying factors like the sovereign debt crisis or other confounding events. To improve the identification, we suggest a similar diff-in-diff approach for the bond liquidity analysis by dividing our sample bonds into two groups. We calculate the share of trading volume handled by affected banks averaged over the pre-period for each bond. We classify bonds as 'more affected' that had an above median share of trading volume performed by affected banks in the pre-period. We compare these two groups in a diff-in-diff setup, thereby controlling time-varying economic and market-wide conditions.

As a starting point, the bid-ask spread and Amihud measure are plotted for these two groups in Figure 5. As mentioned above, bonds with a below median share of trading by affected banks should be affected less if our hypothesis is true. Liquidity of bonds in which the affected group had a higher share of trading volume than the median were affected more. This is true for both the bid-ask spread and Amihud measure.

We test this more formally by estimating specification (5) in Columns 3 and 4 of Table 8. Bond liquidity declined only in bonds where the affected banks played an important role as market makers before the event (Column 3) since the coefficient of dummy Post $\times$ Higher Share is positive and statistically significant while the intercept is statistically insignificant.

This setup allows us to control for time-varying economic and market-wide conditions (Column 4) by including week fixed effects (liquidity measures calculated at a weekly level). Bonds from the affected banks with a higher share of trading exhibit a 0.085 percentage point increase in the bid-ask spread (Panel A, Column 4), which is 5.2% of the pre-event average value. Similarly, the Amihud measure (Panel B, Column 4) increased by 1.895 percentage points per million euros for bonds with a higher pre-event share of affected banks in market-making. This is 71.2% of the pre-event average value. Large and statistically significant increases in liquidity measures (decrease in liquidity) for the more affected group of bonds shows that an increase in capital requirements for banks leads to a reduction in corporate bond liquidity due to reduced market-making by banks.

Next, we investigate whether non-bank broker-dealers step in and increase their market share as a response to the capital exercise. We analyse the proportion of traded volume performed by non-bank broker-dealers during our sample period. The percentage of trading

volume performed by non-bank broker-dealers has increased considerably from 11.6% in 2010 to 28.7% in 2016 (Table 9). The capital exercise was announced on October 26, 2011, and hence, we should see an increase in non-bank activities from 2011 to 2012 and 2013. There is a modest increase from 12.8% in 2011 to 13.7% and 17.3% in 2012 and 2013, respectively. Once we focus on non-investment grade bonds, we observe a stronger pattern. While unregulated institutions had a market share of 9.3% in 2011, this figure increased to 19.5% in 2012. This observation is in line with our previous results that suggest stronger magnitudes for non-investment grade bonds. By the end of 2016, 35.5% of trading in riskier bonds is being conducted by non-bank broker-dealers.

These findings document an unintended consequence of higher regulatory capital requirements in the form of lower bond market liquidity. Even though only the largest banks were affected by the regulatory action, neither the remaining banks nor unregulated institutions could substitute for the reduced market-making activities of affected banks.[28] It is worth noting that dealers rely on being able to trade with other dealers to be able to provide immediacy. Inter-dealer networks and specialization in certain bonds are difficult to build without prior interactions with other dealers (Hollifield et al. (2012), Di Maggio et al. (2017), Di Maggio (2017), Hendershott et al. (2020)). These mechanisms may also help explain the decrease in liquidity in the more affected bonds and non-bank broker-dealers not being able to fill the gap. The effect on bond market liquidity seems to last at least until the end of our sample period.

An important question is how the decrease in bond liquidity impact corporate bond credit spreads and, hence, the cost of capital of firms. To address this question we follow Dick-Nielsen et al. (2012) and Schwert (2017) and estimate the regression

$$s_{it} = \alpha + \lambda L_{it} + Rating_{it} + Bond_i + Week_t + \epsilon_{it},$$

where s_{it} is the credit spread of bond i in week t, L_{it} is the liquidity of bond i in week t (as measured through the Amihud measure or the bid-ask spread), *Rating* includes dummies for each rating category present in the data (AAA, AA+, AA, AA-, A+, ..., CCC-), *Bond*

[28] Similarly, Bessembinder et al. (2018) argue for the US that non-banks fill in the void created by banks only partially due to their small size.

includes a dummy for each bond, and $Week$ includes a dummy for each week.[29] The credit rating controls mitigate omitted variable bias that would otherwise be present if there is any correlation between liquidity and creditworthiness.

Table 10 shows the regression results. The table shows consistent results, whether we focus on the Amihud measure or bid-ask spread: the liquidity measures are statistically insignificant and thus liquidity appears not to be priced. This is consistent with Dick-Nielsen et al. (2012) finding that the impact of bond liquidity on corporate bond spreads is small outside the financial crisis.

It may be that liquidity is priced, but we find insignificant results because we have a limited number of observations in a regression soaked with controls. We address this concern in two ways. First, we calculate an upper bound on the impact on bond yields of the change in liquidity around the event as follows For the bid-ask spread, we use the tightest specification (3) to calculate an upper bound on the price of liquidity as $-3.138 + 4.574 * 1.65 = 4.41$ where 1.65 is the 95% percentile in the standard normal distribution, i.e. 4.41 is the upper end of a one-sided confidence band on the price of liquidity. An upper bound of the average increase in credit spreads that we can attribute to an increase in illiquidity after the capital exercise exercise is $4.41 * 0.029 = 0.13bps$ where we have used the increase in the bid-ask spread of 0.029 after the event in Table 8 Panel A (2). For the Amihud measure the upper bound of the price of liquidity is $0.198 + 0.451 * 1.65 = 0.94$ and $0.94 * 1.577 = 1.48bps$ for the average increase in credit spreads. Thus, the impact of the increase in illiquidity around the event on bond yields is less than 2bps. Second, we use estimated yield sensitivities from Dick-Nielsen et al. (2012) and Li and Yu (2023). The reported yield sensitivities reported in Dick-Nielsen et al. (2012) is 47.47 and 4.14 for the bid-ask spread and Amihud measure, respectively, and 70 for the bid-ask spread in Li and Yu (2023).[30] In this case the impact of the increase in bid-ask spread is $47.47 * 0.029 = 1.4bps$ and $70 * 0.029 = 2.0bps$ and the impact of the Amihud measure $4.14 * 1.577 = 6.5bps$, again a modest increase in the yield spread. Overall, the results show that aggregate bond liquidity goes down after the event,

[29] All variables except the liquidity measure are from ICE and the credit spread is the option-adjusted credit spread (OAS). The weekly observations are an average of daily spreads.

[30] The highest estimate for any investment grade category in Tabel 3, Panel A in Dick-Nielsen et al. (2012) and Figure 2, Panel A (investment grade) in Li and Yu (2023).

but the average impact on the funding cost of firms is economically small.

7 Conclusion

In this paper, we examine how the tightening of capital requirements affects corporate bond liquidity. We exploit that the EBA conducted a capital exercise event and use proprietary data sets from the Deutsche Bundesbank to investigate this question. We find that an increase in capital requirements unequivocally reduces the market-making activity of banks; their corporate bond holdings are reduced and their trade less, trade in smaller sizes, increase their bid-ask spreads, and pre-arrange trades more. Furthermore, we find that the effects are more pronounced for non-investment grade bonds and around stress days (days of unusually high trading demand).

We next examine how non-bank affiliated dealers respond to this event. Interestingly, we find that while the non-bank affiliated dealers increase the share of the market-making activity, they are not able to offset the reduction in market-making of affected banks. Consequently, overall corporate bond liquidity declines.

Finally, we examine the impact of the event on credit spreads. We find a weak relation between bond illiquidity and credit spreads and the impact on credit spreads of the increase in bond illiquidity around the event is less than 7bps. This shows that the adverse effect of the increase in capital requirements on the funding costs of firms is small.

While the overall effect of a decrease in corporate bond liquidity translate into a modest increase in the overall cost of capital of firms, we refrain from making any welfare claims here. Perhaps the migration of market-making to the financial institutions not under the purview of a national regulator could have unpredictable and potentially important adverse consequences for financial stability (see Duffie (2012)). Understanding the boundaries of the bank – what tasks should be carried out inside the bank and what should be done outside it – is an important area for future research.

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Figure 1: Timeline of the EBA capital exercise

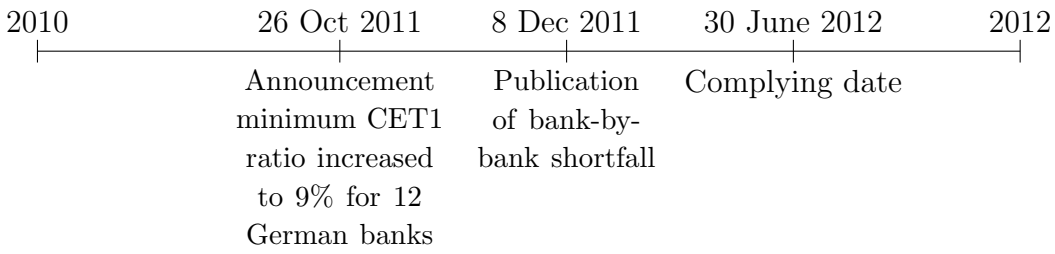
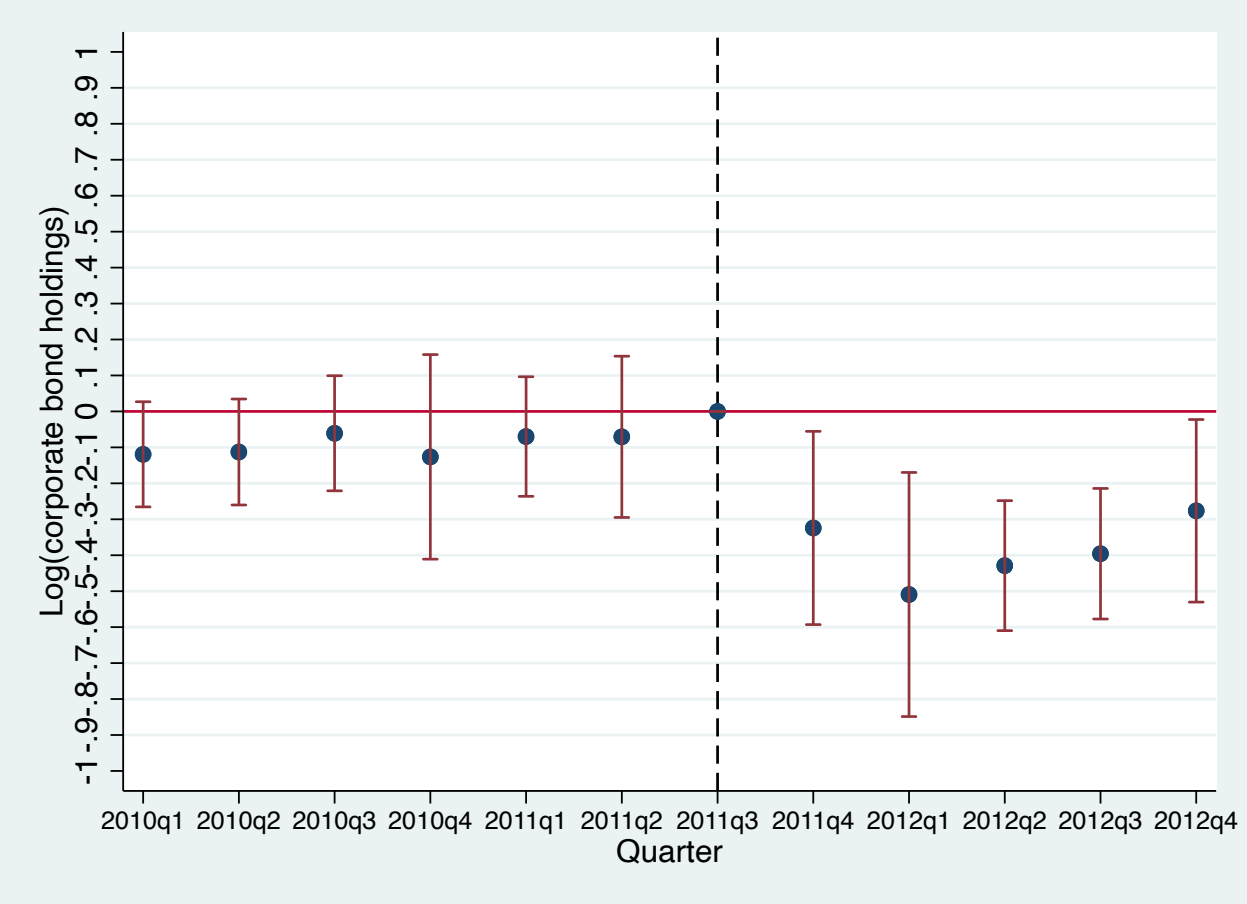
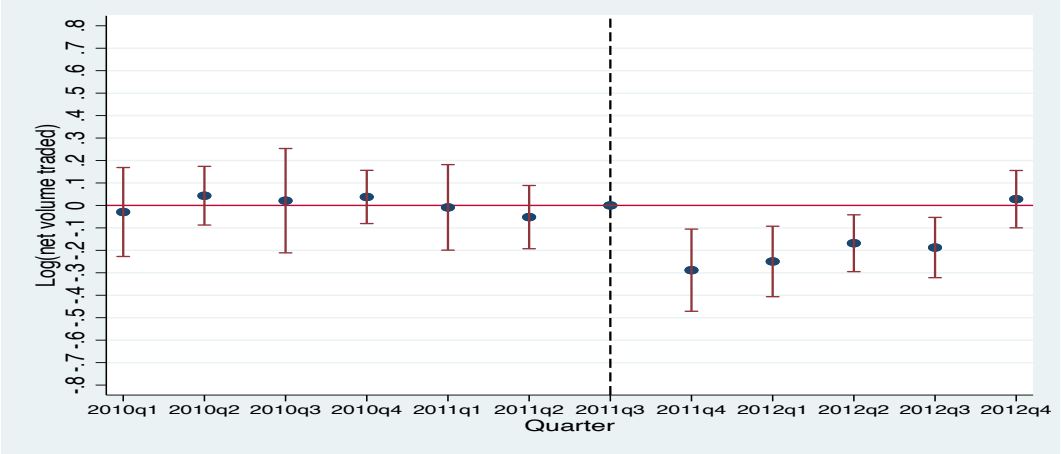


Figure 2: Changes in corporate bond holdings due to higher capital requirements

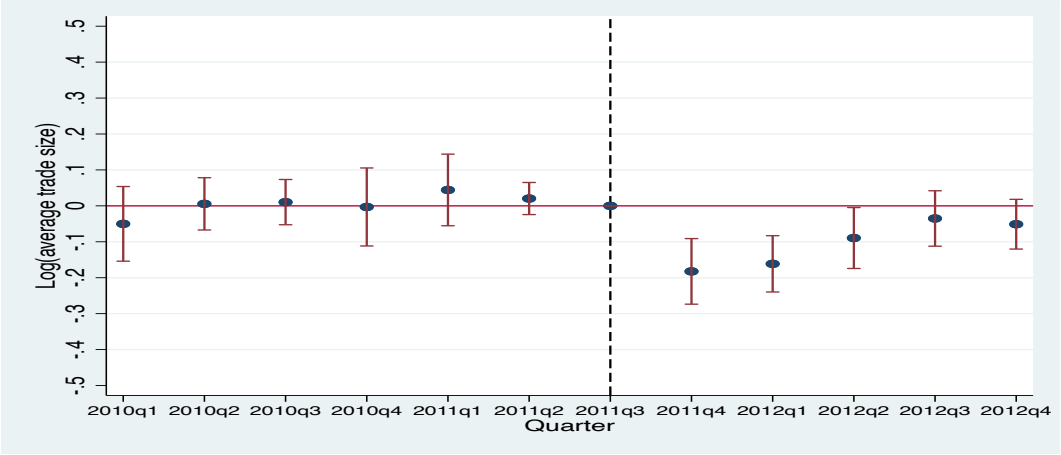


This figure plots dynamic treatment effects on corporate bond holdings using Equation (3) around the quarter prior to the announcement of the capital exercise. The vertical line at 2011Q3 marks the quarter immediately before the EBA 2011 Capital Exercise.

Panel A: Net volume traded



Panel B: Average trade size



Panel C: Average trade size for non-investment grade bonds

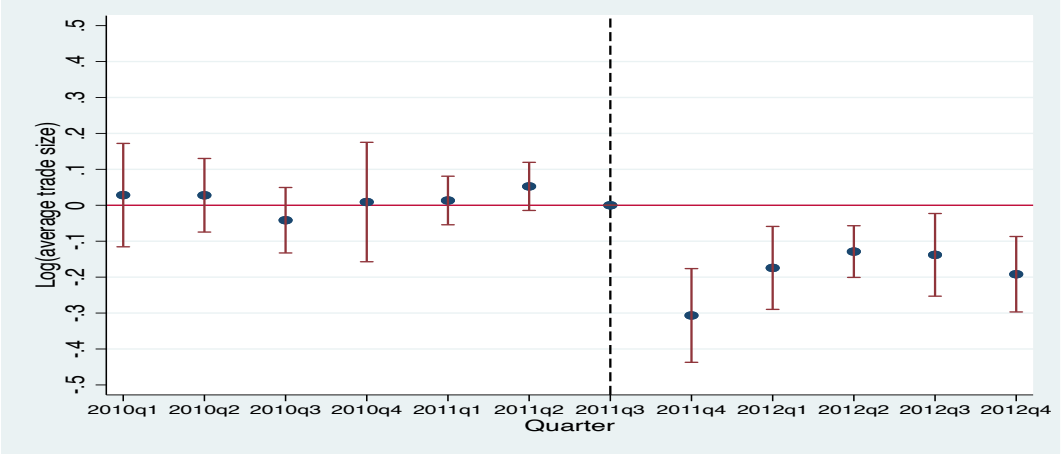
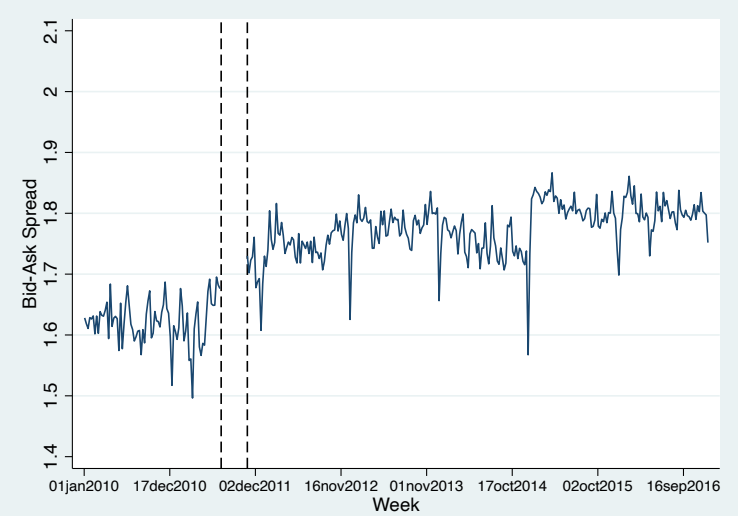


Figure 3: This figure plots dynamic treatment effects on market-making measures. Panel A, B and C plot net volume traded, average trade size and average traded size for non-investment grade bond using Equation (3) around the quarter prior to the announcement of the capital exercise, respectively. The vertical line at 2011Q3 marks the quarter immediately before the EBA 2011 Capital Exercise.

Panel A: Bid-ask spread



Panel B: Amihud measure

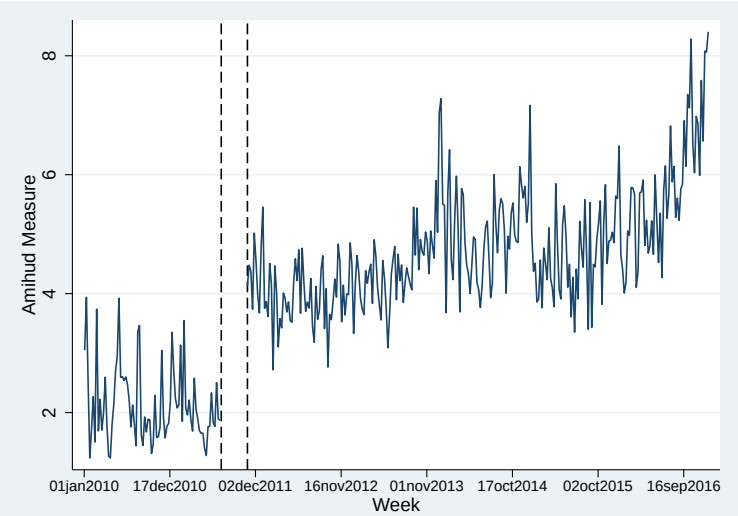
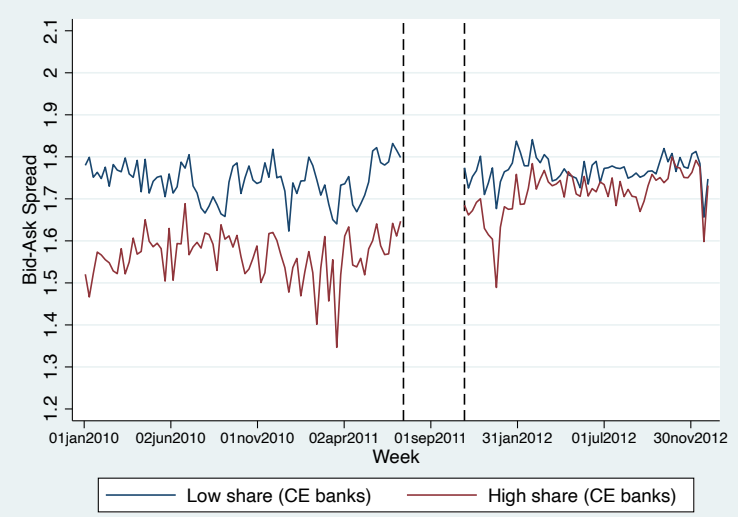


Figure 4: This graph shows the time series of the average bid-ask spread and Amihud measure plotted weekly. The two dotted vertical lines at July 8, 2011, and October 21, 2011, mark the weeks immediately before the EBA 2011 stress test and the EBA 2011 Capital Exercise, respectively.

Panel A: Bid-ask spread



Panel B: Amihud measure

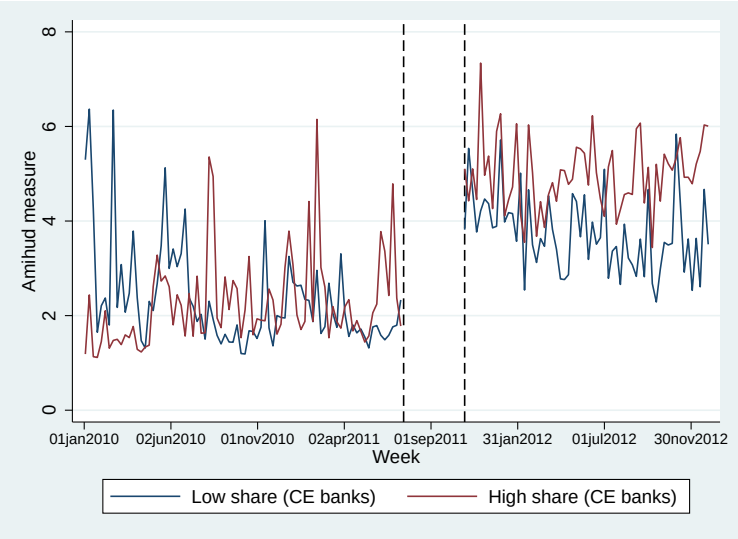


Figure 5: This graph shows the time series of the average bid-ask spread and Amihud measure for bonds affected differently by the capital exercise. 'High share' ('low share') bonds have a share of trading performed by affected banks in the pre-period above (below) the median share. The two dotted vertical lines at July 8, 2011, and October 21, 2011, mark the weeks immediately before the EBA 2011 stress test and the EBA 2011 capital exercise, respectively.

Table 1: Summary statistics

Descriptives are provided before the announcement of the capital exercise. An affected bank is one that took part in the EBA capital exercise. Panel A shows descriptives from security holdings data and bank balance sheet statistics. Panel B provides a means comparison test from before and after the announcement of the Capital Exercise for both sets of banks and Diff-in-Diff coefficient for each variable using the means t-test. Panel C shows descriptives for two sets of banks from transactions data. Panel D presents Bond descriptives from the Centralized Securities Database (CSDB) and liquidity descriptives from transactions data. Note: ** indicates statistical significance at the 5% level and *** at the 1% level.

Panel A: Bank balance sheet and security holdings descriptives					
	Affected banks		Unaffected banks		
	Mean	S.D.	Mean	S.D.	
Total assets (billions)	343.807	372.787	37.101	87.953	
Capital ratio	0.101	0.108	0.116	0.272	
Loans/TA	0.497	0.188	0.499	0.467	
Deposits/TA	0.406	0.236	0.471	0.616	
GIIPS sovereign bond holdings/TA	0.018	0.023	0.013	0.023	
Bearer debt securities issued/TA	0.156	0.078	0.102	0.076	
Corporate bond holdings (billions)	20.669	24.014	4.977	4.655	
Panel B: Impact of capital exercise on banks' balance sheets					
	After - Before		After - Before		Diff-in-Diff
Log(capital)	0.120		0.078***		0.042
	(0.104)		(0.026)		(0.112)
Log(total assets)	-0.043**		0.030***		-0.073***
	(0.021)		(0.007)		(0.028)
Panel C: Market-Making measures					
	Mean	S.D.	Mean	S.D.	
Daily net volume (millions)	0.940	5.828	1.045	4.239	
Daily gross volume (millions)	33.341	668.495	6.347	38.486	
Average trade size (millions)	0.343	1.481	0.649	1.069	
Principal volume/gross volume	0.596	0.322	0.614	0.326	
Panel D: Bond and liquidity measures descriptives					
	Mean	S.D.			
Amount outstanding (millions)	395.671	369.274			
Age (years)	2.175	2.384			
Time to maturity (years)	4.110	7.466			
Amihud (percentage per million euros)	2.660	4.711			
Bid-Ask Spread (percentage)	1.636	0.294			

Table 2: Change in market-making measures: one month before and after the announcement of capital exercise

The sample includes corporate non-financial bonds from affected banks and other banks for one month before and after the announcement of the capital exercise. The dependent variables are log(net volume traded), log(average trade size), and principal trading volume as a proportion of total trading volume. The dummy variable *Capital Exercise*$_i$ is one for affected banks and zero otherwise, and the dummy variable $Post_t$ takes the value of one after October 26, 2011, and 0 otherwise. Robust standard errors adjusted for double clustering at the bank and bond level are reported in parentheses. Note: * indicates statistical significance at the 10% level, ** at the 5% level and *** at the 1% level.

	Log(net volume traded)	Log(average trade size)	Principal trading
	(1)	(2)	(3)
Post × Capital Exercise	-0.457***	-0.235**	-0.059***
	(0.120)	(0.093)	(0.021)
Adj. R-squared	0.564	0.566	0.656
Obs.	6,372	6,372	6,372
Bond × Day fixed effects	Yes	Yes	Yes
Bank × Bond fixed effects	Yes	Yes	Yes
Bank Controls	Yes	Yes	Yes

Table 3: Change in security holdings

The sample includes corporate non-financial bonds from affected banks and other banks from 2010 to 2012. The dependent variable in all regressions is log(corporate bond holdings). The dummy variable *Capital Exercise*$_i$ is one for affected banks and zero otherwise, and the dummy variable *Post*$_t$ takes the value of one after October 26, 2011, and 0 otherwise. Robust standard errors adjusted for double clustering at the bank and bond level are reported in parentheses. Note: * indicates statistical significance at the 10% level, ** at the 5% level and *** at the 1% level.

	Log(corporate bond holdings)			
	(1)	(2)	(3)	(4)
Post × Capital Exercise	-0.388***	-0.254***	-0.224***	-0.191***
	(0.064)	(0.070)	(0.068)	(0.072)
Adj. R-squared	0.682	0.597	0.829	0.829
Obs.	20,093	15,376	15,376	15,376
Security fixed effects	Yes	-	-	-
Quarter fixed effects	Yes	-	-	-
Bank fixed effects	Yes	Yes	-	-
Security × Quarter fixed effects	No	Yes	Yes	Yes
Bank × Security fixed effects	No	No	Yes	Yes
Bank Controls	No	No	No	Yes
Bank × Quarter fixed effects	No	No	No	No

Table 4: Change in market-making measures

The sample includes corporate non-financial bonds from affected banks and other banks from 2010 to 2012. The dependent variable is log(net volume traded), log(average trade size), and principal trading volume as a proportion of total trading volume in columns 1-4, 5-8, and 9-12, respectively. The dummy variable $Capital\ Exercise_i$ is one for affected banks and zero otherwise, and the dummy variable $Post_t$ takes the value of one after October 26, 2011, and 0 otherwise. Robust standard errors adjusted for double clustering at the bank and bond level are reported in parentheses. Note: * indicates statistical significance at the 10% level, ** at the 5% level and *** at the 1% level.

	Log(net volume traded)				Log(average trade size)				Principal trading			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Post × Capital Exercise	-0.097***	-0.232***	-0.370***	-0.380***	-0.038***	-0.127***	-0.195***	-0.207***	-0.041***	-0.059***	-0.035***	-0.042***
	(0.028)	(0.043)	(0.054)	(0.055)	(0.014)	(0.022)	(0.027)	(0.028)	(0.005)	(0.006)	(0.007)	(0.007)
Adj. R-squared	0.429	0.474	0.559	0.559	0.467	0.513	0.578	0.579	0.406	0.484	0.622	0.623
Obs.	180,108	100,247	100,247	100,247	180,108	100,247	100,247	100,247	180,108	100,247	100,247	100,247
Bond fixed effects	-	-	-	-	Yes	-	-	-	Yes	-	-	-
Day fixed effects	Yes	-	-	-	Yes	-	-	-	Yes	-	-	-
Bank fixed effects	Yes	Yes	-	-	Yes	Yes	-	-	Yes	Yes	-	-
Bond × Day fixed effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Bank × Bond fixed effects	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Bank Controls	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes

Table 5: Change in market-making measures: cross-sectional variation

The sample includes corporate non-financial bonds from affected banks and other banks from 2010 to 2012. The dependent variable is log(net volume traded), log(average trade size), and principal trading volume as a proportion of total trading volume in columns 1-3, 4-6, and 7-9, respectively.). The dummy variable *Capital Exercise*$_i$ is one for affected banks and zero otherwise, and the dummy variable *Post*$_t$ takes the value of one after October 26, 2011, and 0 otherwise. *High Shortfall* is a dummy which is 1 for 3 participating banks (top quartile among participating banks) with the highest capital shortfall and 0 for other banks. *Non-Investment Grade* is a dummy which is 1 for bonds with rating lower than Baa by Moody's and 0 for other bonds. *Stress day* is a dummy which is 1 for the trading day with the highest monthly volume for a particular bond. Robust standard errors adjusted for double clustering at the bank and bond level are reported in parentheses. Note: * indicates statistical significance at the 10% level, ** at the 5% level and *** at the 1% level.

	Log(net volume traded)			Log(average trade size)			Principal trading		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Post × Capital Exercise	-0.303***			-0.177***			-0.035***		
	(0.062)			(0.032)			(0.007)		
Post × Capital Exercise × High Shortfall	-0.227***			-0.091**			-0.009		
	(0.071)			(0.046)			(0.017)		
Post × Capital Exercise × Non-Investment grade		-0.230**			-0.200***			-0.023*	
		(0.108)			(0.055)			(0.013)	
Post × Capital Exercise × Stress Day			-0.307***			-0.165***			0.010
			(0.063)			(0.032)			(0.009)
Capital Exercise × Stress Day			-0.014			0.173			0.030
			(0.240)			(0.137)			(0.032)
Adj. R-squared	0.559	0.595	0.573	0.579	0.580	0.600	0.623	0.650	0.657
Obs.	100,247	45,249	100,247	100,247	45,249	100,247	100,247	45,249	100,247
Bond × Day fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank × Bond fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank × Day fixed effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Bank Controls	Yes	-	-	Yes	-	-	Yes	-	-

Table 6: Robustness check: sovereign debt crisis

The table presents robustness checks concerning the European sovereign debt crisis. The dummy variable *Capital Exercise*$_i$ is one for affected banks and zero otherwise, and the dummy variable *Post*$_t$ takes the value of one after October 26, 2011, and 0 otherwise. *GIIPS exposure* is the market value of sovereign bond holdings from GIIPS countries as a percentage of total assets. *Bearer Debt Securities Ratio* is the value of bearer debt securities issued by the bank as a percentage of total assets. Robust standard errors adjusted for double clustering at the bank and bond level are reported in parentheses. Note: * indicates statistical significance at the 10% level, ** at the 5% level and *** at the 1% level.

	Log(net volume traded)			Log(average trade size)			Principal trading		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Post × Capital Exercise	-0.375***	-0.401***	-0.424***	-0.244***	-0.217***	-0.218***	-0.031***	-0.039***	-0.036***
	(0.056)	(0.055)	(0.059)	(0.031)	(0.028)	(0.029)	(0.008)	(0.007)	(0.007)
Post × GIIPS Exposure		-7.546***	-7.283***		-0.950	-0.958		-0.793***	-0.759***
		(1.243)	(1.236)		(0.600)	(0.602)		(0.146)	(0.147)
Post × Bearer Debt Securities Ratio			-0.404**			-0.012			0.052***
			(0.175)			(0.083)			(0.019)
Adj. R-squared	0.566	0.560	0.560	0.583	0.579	0.579	0.630	0.623	0.623
Obs.	100,247	100,247	100,247	100,247	100,247	100,247	100,247	100,247	100,247
Bond × Day fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank × Bond fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
GIIPS Exposure × Day fixed effects	Yes	No	No	Yes	No	No	Yes	No	No

Table 7: Placebo test: German government bonds

The table presents a placebo test of the main dependent variables in the German government bond market. The dummy variable *Capital Exercise*$_i$ is one for affected banks and zero otherwise, and the dummy variable $Post_t$ takes the value of one after October 26, 2011, and 0 otherwise. Robust standard errors adjusted for double clustering at the bank and bond level are reported in parentheses. Note: * indicates statistical significance at the 10% level, ** at the 5% level and *** at the 1% level.

	Log(net volume traded)	Log(average trade size)	Principal trading
	(1)	(2)	(3)
Post × Capital Exercise	0.039	0.069	-0.018
	(0.136)	(0.175)	(0.023)
Adj. R-squared	0.431	0.435	0.396
Obs.	156,836	156,836	156,836
Bond × Day fixed effects	Yes	Yes	Yes
Bank × Bond fixed effects	Yes	Yes	Yes
Bank Controls	Yes	Yes	Yes

Table 8: Changes in bond liquidity after the capital exercise

The table shows how the bid-ask spread and Amihud measure change after the capital exercise. The dependent variable in Panel A is the bid-ask spread measured in percentage and the Amihud measure in Panel B. *Post* is a dummy which is 1 for the weeks after the announcement of the capital exercise and 0 before. *High Share* is a dummy which is 1 for bonds that have an above the median share of trading volume performed by affected banks in the pre-period. Standard errors adjusted for clustering at the bond level are reported in parentheses. Note: * indicates statistical significance at the 10% level, ** at the 5% level and *** at the 1% level.

Panel A: Bid-ask spread

	(1)	(2)	(3)	(4)
Post	0.068***	0.029**	-0.003	
	(0.015)	(0.011)	(0.012)	
Post × High Share			0.078***	0.085***
			(0.020)	(0.020)
Adj. R-squared	0.0808	0.545	0.548	0.566
Obs.	12,093	12,093	12,093	12,093
Bond fixed effects	No	Yes	Yes	Yes
Week fixed effects	No	No	No	Yes
Bond Controls	Yes	Yes	Yes	Yes

Panel B: Amihud measure

	(1)	(2)	(3)	(4)
Post	1.647***	1.577***	0.754	
	(0.393)	(0.357)	(0.469)	
Post × High Share			1.835**	1.895**
			(0.878)	(0.886)
Adj. R-squared	0.0349	0.328	0.331	0.334
Obs.	11,460	11,460	11,460	11,460
Bond fixed effects	No	Yes	Yes	Yes
Week fixed effects	No	No	No	Yes
Bond Controls	Yes	Yes	Yes	Yes

Table 9: Percentage of trading volume by non-bank broker dealers

The table shows the percentage of trading volume by non-bank broker-dealers from 2010 to 2016.

Year	Proportion of overall trading volume	Proportion of trading volume in non-investment grade bonds
2010	0.116	0.102
2011	0.128	0.093
2012	0.137	0.195
2013	0.173	0.246
2014	0.185	0.265
2015	0.297	0.359
2016	0.287	0.355

Table 10: Pricing of liquidity in cost of capital

The table shows how the cost of capital is related to bid-ask spread and Amihud measure. The dependent variable in both panels is option-adjusted spreads. Standard errors adjusted for clustering at the bond level are reported in parentheses. Note: * indicates statistical significance at the 10% level, ** at the 5% level and *** at the 1% level.

Panel A

	(1)	(2)	(3)
Bid-Ask Spread	37.636	-17.385	-3.138
	(28.821)	(17.093)	(4.574)
Adj. R-squared	0.00371	0.550	0.855
Obs.	10,981	10,981	10,946
Rating FEs	No	Yes	Yes
Bond FEs	No	No	Yes
Week FEs	No	No	Yes

Panel B

	(1)	(2)	(3)
Amihud measure	1.596	0.332	0.198
	(2.446)	(1.021)	(0.451)
Adj. R-squared	0.000151	0.533	0.850
Obs.	9,462	9,461	9,443
Rating FEs	No	Yes	Yes
Bond FEs	No	No	Yes
Week FEs	No	No	Yes