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Johannes Breckenfelder, Victoria Ivashina

Bank balance sheet constraints and bond liquidity

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We explore the ties between bonds and individual dealers formed through home advantage and the persistence of previous underwriting relationships. Building on these connections, we show that the introduction of the leverage ratio for the European banks had a large impact on exposed bonds' liquidity. Moreover, based on these ties, we show that bond mutual fund panic following the 2020 pandemic outbreak affected substantially more mutual funds with the larger exposures to dealer banks' balance sheet constraints.

Keywords: Bond liquidity; market-making; capital requirements; leverage ratio; mutual funds; COVID-19

JEL Classification: G12, G18, G21

Non-technical summary

The regulatory overhaul in the aftermath of the 2008 global financial crisis (GFC) raised banks' minimum capitalization requirements and curtailed their broader risk exposure. One of the unintended consequences of these new regulations has been reduced liquidity in the bond markets, as bank-affiliated dealers reduced balance sheet space available for market-making, and costs faced by some counterparties have increased. Consistent with these observations, as of 2017, primary dealer inventories of corporate bonds appeared to be at an all-time low, relative to the market size.

Practitioners and policy-makers have specifically cited the Basel III leverage ratio and the Volcker Rule in the U.S. as key drivers of reduced market liquidity. As part of the broker-dealer activities, banks maintain inventories of securities. The aggregate decline in the size of the inventories is the concern. The capacity and willingness of dealers to warehouse securities, especially for the bond market which relies heavily on principal-based market-making services, are essential for liquidity. Because of its non-risk-weighted nature, the leverage ratio—which requires banks to maintain a minimum equity capital as a fraction of its assets—makes it less profitable for banks to engage in low profit margin activities. An illustration of this mechanism can be seen in March 2020, when the inflow of deposits inflated bank assets, making the leverage ratio more binding. As a result, banks were believed to have been pushed to offload lower-yielding Treasury bonds, among other things. Thus, we will use slack under the leverage constraint as our central explanatory variable.

The contribution of our paper to the debate about the regulatory impact on the bank market-making activities and, ultimately, bond market liquidity is two-fold. The structural shifts in the bank bond inventories are unmistakable. However, the connection to specific bank constraints is harder to establish for several reasons, including other market shifts that might have influenced the broker-dealer role over the same period. On the other hand, in absence of bond-to-dealer "stickiness," bonds would be transacted through the least constrained dealer, making balance-sheet constraints of individual dealers (and cross-sectional analysis) irrelevant. As our first contribution, we overcome this problem by looking at (i) the home bias among the dealers, and (ii) the persistence in dealing activities among bond underwriters as a source of plausibly exogenous assignment between dealers and bonds. Simply put, we should see that the bulk of French bonds are likely to be transacted by French dealer banks. Similarly, if a German bank was the underwriter of a French bond issue, it is very likely that it is also the key dealer for these bonds long after the initial placement.

We provide two sets of results. First, armed with the plausibly exogenous matching between bonds and dealers, we anchor a set of tests around December 31, 2013, the date when as a result of 2014 Comprehensive Assessment exercise the leverage ratio became effectively binding for the euro area banks for the first time. We find that for countries where bank dealers are one percentage point closer to the regulatory requirement, the bid-ask spread is 8 basis points higher (about a quarter of the median bid-ask spread in our sample). In addition, we look at the leverage ratio of past bond underwriters, which provides additional support for our hypothesis. We find that if the bond dealer with existing underwriting ties is one percentage points closer to the regulatory requirement, the bid-ask spreads of the bond increases by 4 basis points (about 6.8 % of the mean).

The first set of results identifies the impact of dealer banks' regulatory constraints on bond liquidity. In the second set of results, we connect the 2020 outflows and selling behavior of fixed income mutual funds to illiquidity due to the dealer bank balance-sheet constraints. To do so, once again, we rely on the importance of the home advantage, as well as past bond underwriting relationships. We show that fund outflows and bond selling pressure were significantly more severe for mutual funds exposed to dealer illiquidity through banks' balance sheet constraints.

1. Introduction

The regulatory overhaul in the aftermath of the 2008 global financial crisis (GFC) raised banks' minimum capitalization requirements and curtailed their broader risk exposure. One of the unintended consequences of these new regulations has been reduced liquidity in the bond markets, as bank-affiliated dealers reduced balance sheet space available for market-making, and costs faced by some counterparties have increased (e.g., Powell, 2015; Duffie, 2016; European Commission, 2017).[1] Consistent with these observations, as of 2017, primary dealer inventories of corporate bonds appeared to be at an all-time low, relative to the market size. Figure 1 provides statistics for the euro area banks' bond holdings and the overall size of the euro area bond market.[2] As can be seen in 2017, banks' average holdings were approximately 6% of market size compared to approximately 30% in 2009. Over the same period, the euro area long-term bond market size increased by EUR 950 billion or roughly 80%.

[FIGURE 1]

Practitioners and policy-makers have specifically cited the Basel III leverage ratio and the Volcker Rule in the U.S. as key drivers of reduced market liquidity.[3] (Our

[1] In his 2015 speech Jerome Powell stated that: "many point to post-crisis regulation as a key factor driving any recent decline in liquidity (…) I would agree that it is one factor driving recent changes in market making." The European Commission report concludes that "[b]anks and dealers have more limited balance sheet capacity now than prior to the financial crisis. In general, it is more difficult for investors to trade in large sizes. […] Traders that require immediate executions in large size now pay more in price impact because the cost of liquidity has risen post-crisis."
[2] Similar patterns were highlighted for the U.S. in *Liberty Street Economics* blog, August 21, 2015, "What's Driving Dealer Balance Sheet Stagnation?" by Tobias Adrian, Michael Fleming, Daniel Stackman, and Erik Vogt, https://libertystreeteconomics.newyorkfed.org/2015/08/whats-driving-dealer-balance-sheet-stagnation.html.
[3] For example, see "The Impact of the Basel III Leverage Ratio on Risk-Taking and Bank Stability," Special Feature in the ECB Financial Stability Review (November 2015).
https://www.ecb.europa.eu/pub/pdf/fsr/art/ecb.fsrart201511_01.en.pdf?8dbb0ec

study focuses on the euro area banks, so the latter is not directly relevant to us.) As part of the broker-dealer activities, banks maintain inventories of securities. The aggregate decline in the size of the inventories is precisely the concern illustrated in Figure 1. The capacity and willingness of dealers to warehouse securities, especially for the bond market which relies heavily on principal-based market-making services, are essential for liquidity. Because of its non-risk-weighted nature, the leverage ratio—which requires banks to maintain a minimum equity capital as a fraction of its assets—makes it less profitable for banks to engage in low profit margin activities. An illustration of this mechanism can be seen in March 2020, when the inflow of deposits inflated bank assets, making the leverage ratio more binding. As a result, banks were believed to have been pushed to offload lower-yielding Treasury bonds, among other things. This prompted the U.S. Federal Reserve to temporarily exempt Treasuries and other safe securities from leverage calculations.[4] Thus, we will use slack under the leverage constraint as our central explanatory variable. However, leverage ratio was part of a broader regulatory package, and we will discuss farther the role of other constraints at the dealer level.

The contribution of our paper to the debate about the regulatory impact on the bank market-making activities and, ultimately, bond market liquidity is two-fold. As Figure 1 illustrates, structural shifts in the bank bond inventories are unmistakable. However, the connection to specific bank constraints is harder to establish for several reasons, including other market shifts that might have influenced the broker-dealer role over the same period. On the other hand, in absence of bond-to-dealer "stickiness," bonds would be transacted through the least constrained dealer, making balance-sheet constraints of individual dealers (and cross-sectional analysis) irrelevant. As our first contribution, we overcome this problem by looking at (i) the

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[4] See "Federal Reserve Board Announces Temporary Changes to Its Supplementary Leverage Ratio Rule to Ease Strains in the Treasury Market Resulting from the Coronavirus and Increase Banking Organization's Ability to Provide Credit to Households and Businesses", April 1, 2020, https://www.federalreserve.gov/newsevents/pressreleases/bcreg20200401a.htm.

home bias among the dealers, and (ii) the persistence in dealing activities among bond underwriters as a source of plausibly exogenous assignment between dealers and bonds. Simply put, we should see that the bulk of French bonds are likely to be transacted by French dealer banks. Similarly, if a German bank was the underwriter of a French bond issue, it is very likely that it is also the key dealer for these bonds long after the initial placement. (To the best of our knowledge, the evidence supporting the latter fact is novel to the academic literature.) As we elaborate in Section 3, these mechanisms make dealers hard to replace. Ultimately, this enables us to use cross-sectional heterogeneity in bond exposure to banks' balance sheet constraints, and trace its impact on the liquidity. This approach potentially provides an alternative to measurement of bond liquidity in future studies, as bonds are generally illiquid and lack consistent data. Our methodology provides an insight for measuring liquidity using dealer-level information.

We will show that cross-sectional differences in liquidity due to dealer's constraints are sizable. However, it is hard to argue that, in nearly a decade following the implementation of the leverage ratio, the aggregate impact on bond liquidity was a major impediment to bond market growth illustrated in Figure 1.[5] (Same applies to the US market.) Indeed, the primary concern with the consequences of the reduced banks' market-making capacity was not the immediate illiquidity costs, but instead the build-up of financial fragility. This is consistent with Bao, O'Hara, and Zhou (2018) and Dick-Nielsen and Rossi (2019) who emphasize that the liquidity matters the most during market stress or illiquidity events. The specific mechanism at play for mutual funds was articulated by Goldstein, Jiang and Ng (2017), and more recently by Ma, Xiao and Zeng (2020). The basic idea is that illiquidity and its uneven distribution among portfolio assets expose mutual funds holding such assets to

[5] Between 2013 and 2019 the euro area non-financial corporate bond market has nearly doubled in size, growing from EUR 1.17 trillion to EUR 2.05 trillion in amounts outstanding, corresponding to roughly a 10% cumulative annual growth.

significant fund outflows. Until 2020, such fragility was largely hypothetical. But, in early 2020, mutual funds in the U.S. and Europe faced significant fund outflows, a dynamic that is believed to have contributed to the broader bond market distress. Indeed, in both sovereign and corporate bond markets, the central banks had to intervene in a sizable and unprecedented way to stabilize the bond markets. A run on mutual funds in early 2020, therefore, constitutes a key economic setting to study the role of dealer banks' balance sheet constraints in propagating financial fragility by *amplifying* the run dynamic. Our second contribution, therefore, is to show that fixed income funds that were exposed to dealer balance-sheet constraints in their portfolio faced bigger selling pressure.

In line with these two main contributions, we provide two sets of results. First, armed with the plausibly exogenous matching between bonds and dealers, we anchor a set of tests around December 31, 2013, the date when as a result of 2014 Comprehensive Assessment exercise the leverage ratio became effectively binding for the euro area banks for the first time. Our results include bond fixed effects; that is, we compare the shift in liquidity for the same bond two years before and two years after the leverage ratio is reported to bank supervisors. We find that for countries where bank dealers are one percentage point closer to the regulatory requirement (about one standard deviation), the bid-ask spread is 8 basis points higher (about a quarter of the median bid-ask spread in our sample). This result is robust to several ways of identifying a broker-dealer bank in the data, and to constructing bank balance-sheet constraint at the bond level. We also show that the effect comes through the domestic dealer banks, but not through other domestic banks. We control for a range of contemporaneous macro variables including bond's domestic country GDP growth, equity market and banking sector growth, volatility index and sovereign spreads. This helps us to make sure that bond liquidity and the banks' constraints are not trivially correlated in the country-level analysis. In addition, we look at the leverage ratio of past bond underwriters, which provides additional support for our hypothesis. We find that if the bond dealer with existing underwriting ties is one percentage points closer to the regulatory requirement, the bid-ask spreads of the bond increases by 4 basis points (about 6.8 % of the mean).

The first set of results identifies the impact of dealer banks' regulatory constraints on bond liquidity. In the second set of results, we connect the 2020 outflows and selling behavior of fixed income mutual funds to illiquidity due to the dealer bank balance-sheet constraints. To do so, once again, we rely on the importance of the home advantage, as well as past bond underwriting relationships. We show that fund outflows and bond selling pressure were significantly more severe for mutual funds exposed to dealer illiquidity through banks' balance sheet constraints.

Overall, our paper contributes to and interconnects two strands of research: (i) studies focused on the impact of Basel III regulatory constraints on bond liquidity, and (ii) fragility of bond mutual funds due to illiquidity.

Using US corporate bond data, Schultz (2017) shows that after the Volcker Rule was finalized, dealers were more reluctant to take bonds into their inventory and unwound inventory positions more quickly. Adrian, Boyarchenko and Shachar (2017) is the closest study to our first insight. Their paper links changes in the liquidity of individual US corporate bonds to financial institutions' balance sheet constraints and find that bonds traded by more levered institutions are less liquid, especially after the financial crisis. Their paper takes the assignment of bonds to dealers as given. Our contribution is to micro-found bond-dealer matching, which is not trivial. As explained earlier, it is not fully clear why individual bank constraints matter for bond intermediation. Indeed, Bessembinder, Jacobsen, Maxwell and Venkataraman (2018) show that while the bank-affiliated dealers decreased their "capital commitment" in US corporate bond markets, nonbank dealers (unaffected by regulations) have increased their market commitments. Aggregate impact on market liquidity remains debated. According to Bao, O'Hara and Zhou (2018), the net effect in the aftermath of the bank regulatory adjustment has been negative and, overall, corporate bonds in the US have become less liquid during times of stress. But Trebbi and Xiao (2019), Adrian, Fleming, Shachar and

Vogt (2017) find only limited evidence of a deterioration in market liquidity. Choi and Hu (2019) point out that customers, rather than dealers, increasingly provide liquidity to other customers. However, for those trades in which dealers do provide liquidity using their inventory capacity, they document an increase in transaction costs after the financial crisis. (Bank market-making is not constrained to bonds, and derivative markets offer additional settings to analyze regulatory impact.[6])

In our study we directly explore the assignment of bonds to specific dealers, and identify cross-sectional variation in the regulatory impact on bond liquidity. Furthermore, we specifically focus on the compliance with the minimum leverage ratio. Ultimately, our specific interest lies in understanding consequences of bond illiquidity for stability of mutual fund investing. Bao et al. (2018) and Dick, Nielsen and Rossi (2019) stress that the liquidity matters most during specific market stress or liquidity events. Mutual funds worldwide had faced a significant shock with the COVID-19 related economic lockdown. This has been studied by Falato, Goldstein, and Hortaçsu (2020) in the US context. Our specific focus is on the role of the banks' constrains in bond market making and its connection to specific pressures faced by the mutual funds. In this sense our work is closest to O'Hara and Zhou (2020) who also seek to understand the role of frictions among the market makers in driving the bond market turmoil in March of 2020.

The rest of the paper is organized in six sections. Section 2 discusses the data sources used for this study. Section 3 provides more background on the leverage ratio requirement and builds the case for the "stickiness" of the dealers at the bond level. Section 4 presents the set of results that measure the impact of bank leverage ratio requirement on bond liquidity. Section 5 looks into how bank leverage constraints differentially affected the liquidity of bond mutual fund holdings during

[6] For example, Acosta Smith, Ferrara and Rodriguez-Tous (2018) show that leverage-constrained banks are less willing to clear derivatives on behalf of their clients. Cendese, Della Corte and Wang (2018) show that a tighter dealers' leverage ratio is associated with a deterioration in FX trading activity and an increase in short-term CIP deviations.

the COVID-19 pandemic shock. Section 6 concludes.

2. Data

We employ a range of datasets in this study:

To identify broker-dealers we use the *Eurosystem Asset Purchase Database,* which is proprietary Eurosystem data on all executed trades under the European Central Bank's (ECB) and the euro area national central banks' Asset Purchase Program (APP). The purchases are conducted with eligible counterparties which we define as broker-dealers. We use two alternative definitions. First, we use broker-dealer banks that engage in trading of corporate bonds under the Corporate Sector Purchase Program (CSPP), i.e., these are market makers in the corporate bond market. The second definition uses the sample of broker-dealer banks that engage in trading of sovereign bonds under the Public Sector Purchase Program (PSPP). Note that both programs take place after the introduction of the leverage ratio, so, we are implicitly assuming that being a large bank dealer is a persistent characteristic. This is in line with Di Maggio, Kermani and Song (2017) who find that the bond dealer market in the U.S. is highly concentrated, with a few core dealers intermediating most of the transactions.

Based on this criterion, we identify 14 broker dealers using corporate bond purchase program, and 41 using the sovereign bond purchase program. Overall, the sample contains 116 (dealer and non-dealer) banks. Our methodology likely only picks up the largest broker-dealer banks, however, as we will show later, it picks up a substantial share of bond holdings (which is again in line with the "core-periphery" structure of the dealer segment documented in the previous literature).

We rely on *DataScope* to collect daily corporate bond bid-ask spreads for the euro area. For information on bond characteristics, we use the *Centralized Securities Database (CSDB)*, a security-by-security level Eurosystem database that contains data on instruments and issuers including maturity and issuance date, bond type (e.g., zero coupon), currency, ratings, and issuer information (location, issuer organization number, name).

To obtain regulatory leverage ratios for euro area banks, we use the confidential *SSM Supervisory Statistics*, as well as leverage ratios gathered during the 2014 stress tests and asset quality review of euro area banks. These data are used to measure slack under the leverage ratio constraint. How we aggregate the leverage ratio across dealers to the bond level, as well as construction of mutual fund level exposure to dealer's balance sheet constraints, is important and we will discuss it in the results section.

The granular fund performance and fund flows data for mutual funds is from the *Thomson Reuters Lipper Database.*

Our macroeconomic variables and underwriter information come from *Bloomberg*. Country-specific time-varying variables are: local GDP, local equity indexes, local bank indexes, and 1-, 3-, 5- and 10- year local government bond spreads.

Security Holdings Statistics (SHS) is a security-level database that provides information on holdings by groups of euro area investors. The data have been collected quarterly since 2013:Q4. The data are broken down by instrument type, and issuer country and allows us to track security holdings of banks over time as well as in relation to other investors.

3. Institutional details

3.1. Leverage ratio

In the wake of the 2008 Global Financial Crisis the Basel Committee of Banking Supervision (BCBS) undertook a significant program of reform for banking regulation known as Basel III. The reform introduced new international regulatory standards for both capitalization and liquidity risk management. One of the key regulatory reforms was the introduction of the leverage ratio, which is our main focus. The leverage ratio aims to insure minimal bank equity capitalization.

However, as opposed to the risk-based capital requirement, the leverage ratio seeks to recognize limitations in one's ability to measure risk (i.e., the "model risk"), and therefore it is not risk-weighted. Instead, it is a simple ratio of Tier 1 capital to book value of total assets (including both on-balance sheet exposures and some off-balance sheet items).[7] The problem is that —due to the non-risk weighted nature— the leverage ratio makes it more costly for banks to engage in low margin activities. Specifically, it has been argued that the leverage ratio could constrain bond intermediation as the margin on bond dealing—and especially dealing in safe bonds—is low, yet, it expands banks' balance sheets and therefore attracts a capital charge under the leverage ratio. This is the reason why in studying the regulatory impact on bond liquidity we focus on the leverage ratio as the relevant constraint at the bank level.

Our first set of results is using difference-in-differences methodology. In particular, we look at the bond liquidity two years before (2012:Q1-2013:Q4) and two years after (2014:Q1-2015:Q4) December 31, 2013. This is the date when European banks were required to report their leverage ratio to their supervisor for the first time as a part of the Comprehensive Assessment exercise, the first standardized euro area-wide assessment of the health of bank balance sheets.

Ideally, the introduction of the leverage regulation would be isolated and unexpected. Alas, that is not the case, as the Basel Committee first indicated that it planned to introduce a leverage ratio in a consultation document in 2009 and proposed a 3 percent target in 2010 (BCBS, 2009 and 2010). Figure 2 gives an overview of the implementation of different policy and regulatory measures including the timeline of the regulatory leverage ratio across the European Union, the United Kingdom, and the U.S. Overall, our results are unlikely to be impacted

[7] In corporate finance, a "leverage ratio" has debt in the denominator (in this context, Debt/Assets) thus, borrowers' constraints on leverage are typically set as a *maximum* leverage ratio. Bank regulatory leverage ratio has equity in the denominator, which is effectively (1-Debt/Assets). So, in the banking context, we talk about a *minimum* leverage ratio.

by the ECB purchasing programs; as Figure 2 illustrates, these programs took place at the later stage: the sovereign bonds purchase program (PSPP) starts in March 2015, over one year and three months after the leverage ratio becomes binding, and the corporate bonds purchase program (CSPP) starts in mid-2016 and is outside of the analysis window. However, we cannot rule out that regulatory measures other than the leverage ratio were at play. The EU introduced a package of capital requirements directives in July 2013.[8] This was the third set of amendments to the original banking directive which transposed Basel III recommendations into EU law, which set out the rules for calculating capital requirements and reporting and general obligations for liquidity requirements. Where possible, we will explore differential predictions that arise due to risk-weighting. In addition, in the last set of results, we will look at deposits inflows in the context of 2020 economic uncertainty that put pressure on the leverage ratio compliance due to a sudden increase in the size of the balance sheet.

[FIGURE 2]

There are also reasons to believe that over the period of our analysis the leverage was the binding constraint. Following the Comprehensive Assessment, several banks with low leverage ratio were asked to develop a plan to improve their slack. The capital plans provided by banks fed into the Supervisory Review and Evaluation Process for purposes of calculating their capital requirements.[9] In line with this observation, Figure 3 shows that, as of 2013, three of the eight largest broker-dealers had a leverage ratio below 3.5%. Table 1 shows that the average statistics in the broader sample of broker-dealers are even more binding. For 14 corporate bond dealers that participated in the CSPP, the average distance to the regulatory requirement is 0.87 percentage points. This is about half of the distance for non-dealer banks. Ultimately, the numbers were disclosed to the public, with the

[8] This package known as CRD IV included Directive 2013/36/EU and Regulation (EU) N° 575/2013.

[9] For more details on the ECB's Comprehensive Assessment see Breckenfelder and Schwaab (2019.)

message that the steps toward compliance are on the way, but still faced substantial public scrutiny (e.g., Acharya and Steffen, 2014.) In contrast, the phasing-in of the liquidity coverage ratio (LCR) was gradual: banks started reporting the ratio to supervisors in 2014, but this number was not made public. LCR became 60% binding as of October 2015 and phased in to 100% by 2018.

It is also relevant to recall that at the end of 2013 European banks were under substantial stress.[10] In fact, the Comprehensive Assessment for which the regulatory leverage ratio had to be submitted was a one-off exercise of unprecedented scope and granularity, aimed at achieving the goals of establishing transparency on the condition of bank balance sheets and restoring confidence in the European banking sector.[11] Thus, banks did not have much capacity to prepare for the regulatory compliance.

[FIGURE 3 & TABLE 1]

3.2. Dealer-bond ties

An important challenge of cross-sectional identification is to establish a source of quasi-exogenous assignment of bonds to broker-dealers: for individual banks' constraints to have impact on bond liquidity, there has to be something that ties the bond to an individual dealer, making it difficult to switch. In the absence of such ties, all bonds would be intermediated by unconstrained dealers since they charge the lowest price for the intermediation. The existing research offers multiple explanations for how broker-dealers facilitate trade. Specifically, we build on the importance of dealers in reducing search costs (e.g., Rubinstein and Wolinsky, 1987, Duffie, Garleanu, and Pedersen, 2005) and information asymmetry (e.g., Kyle, 1985; Glosten and Milgrom, 1985; and Biglaiser, 1993) in bilateral trades. Keep in mind that

[10] Mario Draghi's famous "whatever it takes" speech which sets the recovery phase for the euro area dates back to July 26, 2012, and bond purchase programs were not implemented until 2015.

[11] The results of the Comprehensive Assessment and the capital plans provided by banks fed into the Supervisory Review and Evaluation Process (SREP) for purposes of calculating capital requirement.

bond market is a quote-based, over-the-counter (OTC) market, that is, it is non-centralized and non-standardized. This amplifies market frictions that underpin the economic role of dealers. Building on these observations, we propose two ways of filtering bond-dealer pairings that are a result of persistent connections and are likely to be exogenous to the impact of regulatory changes on individual dealers. Both of these explanations rely solely on dealer's information extraction from order flow. To the best of our knowledge, persistence of the bond-dealer connections is a novel insight of our paper.

First, in view of the long literature building on the local and country bias, we look at whether domestic dealers are the most relevant for bond intermediation. A home bias for dealer activities could be tied to search cost, or to the importance of connections to a network of institutional investors. The role of these connections is central at the underwriting stage (Benveniste and Spindt, 1989) but, as emphasized below, they are also likely to carry over to the secondary market. Table 2 shows a striking pattern: on average, as of the end of 2013, the large domestic dealers held about 46.5% of the bond, whereas the largest holding of a foreign dealer was about 2.1%. The economic size of the difference between domestic and foreign dealers is large and consistent throughout the sample. (It is worth emphasizing that because we look within the euro area, such difference cannot be explained by currency denomination.)

[TABLE 2]

Second, through the interviews with several experienced market participants we have learned that bond underwriters continue to play an important role in the secondary market. This is best understood if one puts themselves in the shoes of a bond investor. To start, any sizable institutional investor has a representative at each underwriter/dealer. Although some of these relations might be more important than others, investors' access to any dealer in today' market does not appear to be an issue. So, if an investor wants to buy bonds at issuance which is being underwritten and placed by JPMorgan, it would be natural for them to reach out to JPMorgan directly.

Now, imagine instead that the bond was already placed, and the investor is trying to purchase it in the secondary market. The choice of the dealer to call is informed by two factors: the first is the quoted price, and the second is the probability of order fulfillment at that price within a given time window. This is because quotes are not binding and, most likely, only a fraction of the order will be filled at the quoted price. To the degree that the investor values certainty and speed of the execution on the full order, it would want to reach out to the dealer that has the best understanding of "where the bodies are buried," and this is where the underwriter (JPMorgan) comes into focus again. (Note that the identity of the underwriter is on display on the same screen together with quotes throughout the life of the bond.) In other words, the information about the initial demand and placement of the bond in this decentralized OTC market gives the underwriter a private insight that is relevant to the investors in the secondary market. This is likely to diminish over time, but anecdotally this appears to persist for a few years.

We can provide some evidence for this account by looking at the dealers' activity in the ECB's corporate bond purchase program, CSPP. The data is proprietary ECB's trade-by-trade data containing all trades executed by the Eurosystem from June 2016 to March 2017. (The buyer is the Eurosystem.) The starting sample contains 637 bonds; conditional on having an issue date we end up with 569 ISINs. For each bond, we construct a variable that measures the share of the total CSPP bond volume that was intermediated by a given dealer.

The analysis is presented in Table 3. In the first two columns, the explanatory variable of interest is an indicator of whether the dealer is also the bond underwriter. The hypothesis is that—even though we are looking at the secondary market—the transaction volume is tilted toward bonds underwritten by the dealer. Consistent with this hypothesis, we find that, on average, dealer banks have about 25% higher transaction volume in bonds where the dealer was also an underwriter relative to transaction volumes in bonds underwritten by other banks. In column (3), we include interaction terms indicating whether the bond was outstanding for one year, or two to three years since issuance. Although the special role of the underwriter dissipates over time, even for bonds that have been outstanding between two and three years the differential effect is substantial and statistically significant. For bonds outstanding less than a year, we see that underwriters intermediate an astonishing 78% (=56%+(100%-56%)/2) of the CSPP volume (statistically significant at 1% level).

[TABLE 3]

The fact that the underwriter plays a special role as a dealer in the secondary market helps us separate the choice of the dealer from bank-level constraints. Moreover, the underwriting relationships tend to be "sticky". For example, Drucker and Puri (2005) results indicate that in 45% of the follow-up equity offerings, issuers keep the same underwriter (57% for deals with previous concurrent lending, which is the focus of their study).

Figure 4 presents the probability that an issuer picks the same lead bond underwriter as the one it used in the past. In any given year (*T*) we take firms that issue bonds, and we consider firms that also issued a bond one year ago *(T-1)*. Looking at the firms that issued a bond at *T* and *T-1*, we create a variable that takes on the value of 1 if the firm used the same lead underwriter, and 0 otherwise. We then take an average across all issuers. We repeat this exercise for up to 10 years in the past, that is, from *T-1* to *T-10*. The overall sample covers 2001-2017 period. Figure 4 displays the time-series average, and the 95% confidence bounds for bonds issued between 2008 and 2017. The result indicates that in about 46-50% of the cases firms use the same lead underwriter as they used 1-3 years ago. The relevant benchmark is a random choice from a potential pool of underwriters that could be at least as large as 9 (the number of large broker dealers in our sample.) As Figure 4 shows, the stickiness of the choice of underwriters decays over time, but even 10 years out it is about 30%, and for issues 5 years out it is 40%.

[FIGURE 4]

The stickiness in bond underwriting could be a result of search costs, although it is unlikely that search costs are high in this setting. It could also be a result of proprietary information production. Indeed, certification is one of the fundamental roles performed by the underwriters. Relatedly, Drucker and Puri (2005), and Gande, Puri, Saunders, and Walter (2015) emphasize the information production synergies between underwriting and lending. To be clear, it is less relevant to us what exactly leads to issuer-underwriter stickiness, as long as there is a switching cost. All in all, the idea is that we can rely on past underwriting relationships to filter bond-dealer pairings which were unlikely to be influenced by the bank slack under the leverage ratio as a source of quasi-exogenous assignment. This approach also helps us distance from country-level factors that might impact liquidity through channels other than balance sheet cost.

4. Leverage ratio and bond liquidity

Our first set of results examines the impact of bank compliance with the minimum leverage ratio on bond liquidity. To trace the causal connection we focus on cross-bank variation, that is, we effectively sort banks into those for which leverage ratio is more and less binding and then compare changes in bond liquidity following the regulatory change. More concretely, we estimate the following regression:

$$Bid\text{-}ask\ spread_{i,t} = \alpha_1 Bank\ constraint_i * Post_t + \delta_i + X_{i,t} + \cdots + \epsilon_{i,t} \quad (1)$$

where i identifies the bond and t the date. The $Bid\text{-}ask\ spread_{i,t}$ is the daily bid-ask spread, which is our measure of illiquidity. It is commonly used as a central measure of bond illiquidity (e.g., Falato, Goldstein, and Hortaçsu, 2020.) The $Bank\ constraint_i$ is the dealers' constraint measured as distances to their required leverage ratios as of the end of 2013. In our hypothesis, smaller slack under the leverage ratio should lead to lower liquidity, which means higher bid-ask spread; i.e., the predicted sign (after the constraint comes into effect) is negative. $Post_t$ is a dummy variable equal to 1 for the period following December 31, 2013 (the first time banks calculated and reported their regulatory leverage ratio to their supervisor), and 0 otherwise. The overall sample period for the first set of tests is 2012:Q1 through 2015:Q4 – a two year window before and after the leverage ratio becomes binding. The regression also includes bond fixed effects (δ_i), and bond time-varying characteristics ($X_{i,t}$), namely its remaining maturity. Depending on the measurement of bank constraints we will use additional controls that we will explain as we present the results. Standard errors are clustered at bond level. For our benchmark results we include all bonds regardless of whether they are outstanding for the full period. (In the appendix we show that the analysis is robust if we zoom in on surviving bonds only.)

4.1. Domestic dealers

Our main explanatory variable is *Bank Constraint*. To capture bank constraints at the country level, we use within-country weighted averages of dealer distances to the 3% leverage ratio (the regulatory requirement). The results are reported in the lower panel of Table 1. Lines (i) through (iv) correspond to alternative ways weights are used to construct averages; namely, for dealers participating in the corporate bond purchasing program the averages are: (i) weighted by total assets; (ii) weighted by trading volume under the CSPP; (iii) correspond to the top-1 dealer in a country by share of trading volume in the CSPP; (iv) correspond to the top-2 dealers in the country weighted by the trading volume in the CSPP.

Table 4 shows the regression result of the impact of the leverage ratio regulation on corporate bond market liquidity by focusing on the domestic banks that were dealers in the corporate bond purchasing program. Overall, we have nine countries. The average distance to regulatory requirement ranges from 1.07 to 1.14 percentage points. In columns (1) to (3) we gradually introduce bond-level and time fixed effects. Not surprisingly, the regression explanatory power jumps to 80% when we include bond fixed effects. Column (4) controls for bond remaining maturity. As mentioned earlier, one concern with focusing on domestic banks is that changes in bond liquidity might be reflecting country-level factors, albeit such factors would have to be contemporaneous to the leverage ratio implementation schedule. To moderate this concern, in column (5) we introduce a range of country-level time varying measures. Performance of local equity markets, volatility index, and the yield curve are statistically significant. However, the coefficient measuring the shift in bond liquidity is robust to these controls. The estimate of -0.08 indicates that for countries where banks are one percentage point closer to the regulatory requirement (about once standard deviation, according to Table 1), the bid-ask spread is 8 basis points higher. The average bid-ask spread in our sample is 59 basis points and the median is 37 basis points.

[TABLE 4]

Figure 5 shows point estimates for individual quarters, that is, it displays coefficients on interaction terms from estimating the following regression:

$$Bid\text{-}ask\ spread_{i,t} = \sum_{t=2012:Q1}^{2015:Q4} \alpha_{1,t}\, BankConstraint_I * Quarter_t + \delta_i + \cdots + \epsilon_{i,t} \tag{2}$$

where *Quarter* is a time fixed effect. The solid line in Figure 5 depicts the point estimates, and the dashed lines depict the corresponding 95% confidence band. This figure illustrates a significant and permanent shift in bond liquidity based on how binding the leverage constraint for domestic dealers is.

[FIGURE 5]

While Table 4 includes a comprehensive set of country time-varying controls, another way to distance ourselves from potential country-level effects is to look at domestic non-dealer banks. To the degree that bank constraints are picking up something that is specific to the banking sector overall, this would show up for all banks. “Placebo” bank constraints are based on the regulatory leverage ratio by non-dealer banks, weighted by total assets. But, as Table 5 shows, the impact on bond liquidity is coming through the balance sheet of the dealer banks. The economic and statistical significance of the coefficients disappears once we look at large domestic non-dealer banks.

[TABLE 5]

Table 6 presents robustness of the results to alternative dealer bank classifications presented in Table 1. As one can see, the estimate is very stable regardless of the weights used to aggregate banks constraints. The results are also economically and statistically similar if we use dealer banks that participated in the corporate bond purchase program or a larger sample of dealers that participated in the sovereign bond purchase program.

[TABLE 6]

Table 7 re-examines results in Table 4 separately for non-investment grade and investment grade bonds. This test is aimed at reinforcing that we are measuring the effect of leverage ratio. The idea is that if banks are less likely to engage in low margin activities as a result of compliance with the minimum leverage ratio, it should have a higher impact on less risky bonds.[12] Risk-weighted capital requirements, or demand for liquidity pushes banks to hold safer bonds instead. Table 7 shows that the liquidity impact is primarily concentrated in investment grade bonds. Figure 6 displays a more granular insight by showing coefficients for different ratings. To construct Figure 6 we estimate a regression similar to equation (2), but instead of quarter dummies we use rating dummies. Consistent with the idea that the leverage ratio is the binding constraint, there is a ranking in the impact on different rating categories, with AAA rated bonds affected the most.

[TABLE 7 & FIGURE 6]

4.2. Bond underwriters

Our earlier results are robust to the inclusion of a wide range of macro-variables, but they could still be sensitive to country-level developments that simultaneously correlate with banks' capitalization or balance sheet size, and bond liquidity. To shift away from the country-level aggregation, we instead look at bond

[12] Acosta Smith, Grill and Grill et al. (2017) and Choi, Holcomb and Morgan (2018) document that the leverage ratio incentivizes banks to shift their portfolio to riskier assets, but it does not increase overall bank risk.

underwriters. Using both methods, country of issuance and bond underwriter identity to assign the leverage constraint of the dealer, allows us to overcome different shortcomings. In particular, while using underwriting connection leads to a cleaner identification, this analysis applies to a narrower sample of bonds.

As discussed earlier, underwriters play a special role not only on the primary but also on the secondary market. In addition, underwriting relationships are sticky. Thus, we look at the constraints of lead underwriters, which we identify in the Bloomberg data as those assigned the role of "lead manager" or "book runner" during the bond issue. We match issuers (vs. bonds) and banks based on their 2010-2011 underwriting relationships. The idea is to strike a balance between looking at a sufficiently close window when underwriter stickiness is particularly high, but at the same time avoid getting too close to the date when leverage ratio comes into force. (Table A.2 presents robustness of our results to using 2010-2012 window instead.)

Out of the 116 banks in our dealer sample (see Table 1), we find nearly 90 with some underwriter role (the remaining banks are small or specialized). Because underwriters also act as dealers, we no longer need to rely on the purchase programs data to identify dealer banks. We use the constraint of the largest underwriter for a given firm based on the number of transaction. The results of the analysis using this alternative connection between bonds and banks are reported in Table 8.

[TABLE 8]

The structure of this table is exactly as Table 4; the change is the mapping between bonds and banks and, relatedly, the sample of the bonds. The estimated coefficient is economically large, robust and statistically significant. If the bond dealer with existing underwriting ties is one percentage points closer to the regulatory requirement, the bid-ask spreads of the bond increases by 4 basis points (about 6.8 % of the mean). Underwriter constraints range from about -0.3 to about 6 percentage points with the mean of 3.57 and standard deviation of 1.81. An alternative way of thinking about economic magnitudes of the estimates is that one standard deviation change in the underwriter constraint alters the bid-ask spreads by about 7.2 basis points (about 12.4 % of the mean).

5. Bond liquidity and 2020 mutual fund outflows

Bank regulatory adjustments that followed the global financial crisis raised concerns in the public debate about the reduced ability of banks to make markets in the bond space. These concerns were raised against the background of the rise in mutual funds holding, documented in Figure 1. Specifically, the anticipated problem was if mutual funds face significant and sudden redemptions they would need to exit their bond holdings. If banks are limited in their ability to temporarily take these bonds on their balance sheet (i.e., inflate their balance sheet which is restricted under the leverage ratio), this would impact bond valuations, potentially precipitating farther withdrawals and sales.

The onset of the COVID-19 pandemic represents a clear instance when mutual funds faced pressure of fund outflows. Importantly, there is plenty of evidence that—at least in the initial stage of the pandemic crisis—this was a liquidity shock to the firms (e.g., Li, Strahan and Zhang, 2020). In the US market, Falato, Goldstein, and Hortaçsu (2020) analyze large capital outflows from mutual funds following the outbreak of the pandemic, indicating that both the illiquidity of fund assets and the vulnerability to fire sales were important factors in explaining redemptions during this episode. Figure 7 shows that a similar panic took place in Europe. In this figure, daily flows are calculated as:

$$Flows_{i,t} = (TNA_{i,t} - (1 + r_{i,t}) * TNA_{i,t-1}) \, / \, TNA_{i,t-1} \qquad (3)$$

where $TNA_{i,t}$ is total net assets of fund i at day t, and $r_{i,t}$ is the fund's daily return. Figure 7 also shows that—similar to the U.S. market—extraordinary direct government interventions in corporate-bond markets mark the reversal of the fund outflows. The earliest vertical dashed line depicts the date of the ECB announcement of the Pandemic Emergency Purchase Program (PEPP) on March 18, 2020.

In this study, we are especially interested in the role of bank balance sheet constraints on the mutual funds sell-off pressure. To examine this point, we build on the cross-sectional variation in bond exposure to dealers' constraints identified using home bias, and previous underwriting relationships. Note that, previously, we were looking at the bond level illiquidity. In this section, we look at the mutual funds which hold portfolios of bonds. So, as a first step, we assign a constraint to a bond exactly as we did in the previous analysis. When using domestic dealers as the relevant match we can easily assign a constraint measure for most of the bonds in the portfolio. In this analysis, the slack under the leverage ratio is measured as of December 2019. We then aggregate this measure of illiquidity based on banks' balance-sheet capacity at the mutual fund level. To do so we use mutual fund portfolio weights from Lipper as of January 31, 2020, i.e., the weights before the COVID shock. This enables us to rank mutual funds based on their exposure to the lack of depth in liquidity due to dealers' balance sheet constraints. Accordingly, we classify mutual funds with above median exposure values as funds with *Illiquidity exposure*. (It is worth reiterating that we are not measuring bond liquidity directly, but instead measure the dealers' slack under the leverage ratio.)

Asset illiquidity is at the heart of the fixed income mutual fund instability; this is the focus of Falato, Goldstein, Hortacsu, 2020, and Ma, Xiao, Zeng, 2020. We are interested in the dealer's balance sheet constraint as an *amplifier* of this effect. The result can be seen in Figure 7. The blue line depicts the average change in market value (Panel A) and change in fund flows (Panel B) of mutual funds that are relatively more exposed to constrained dealers and the red line gives these values for funds that are relatively less exposed to constrained dealers. Whereas leading to March 2020, all funds closely track each other in terms of valuations and fund flows, the COVID-19 shock results in decoupling, with funds exposed to banks with lower balance sheet capacity emerging as particularly affected.

[FIGURE 7]

We further zoom in on funds selling off liquid bonds, where liquidity is measured as bonds issued by countries with the least constrained domestic dealers.

Note that since liquidity in this first part of the analysis is indicated by the country of issuance and it is the same for all funds, effectively we are looking at the selling behavior in very similar, if not the same bonds. This makes it less likely that our results could be explained by country-level factors. Our hypothesis is that—conditional on their pre-crisis cash positions—mutual funds that were relatively more exposed to dealers with lower market making capacity faced higher sell-off pressures in their liquid bonds. In other words, looking beyond cash and cash-like securities, if additional liquidations are necessary and part of the bond portfolio is exposed to illiquidity due to the dealers' constraints, the fund will prioritize selling bonds that are less exposed to such constraints.

In Table 9 we estimate the following regression:

$$\Delta\, Liquid\ bonds_{k,t} = \alpha_1 Illiquidity\ exposure_{\,k} * COVID\ shock_t + \delta_k + \epsilon_{k,t} \quad (4)$$

where $\Delta\, Liquid\ bonds_{k,t}$ is the monthly (t) change in holdings of liquid bonds by mutual fund k. *Liquid bonds* are defined as bonds issued by companies with the least (above median) constrained domestic dealers. In this analysis, we look at the first three month of 2020; *COVID shock* is equal to 1 for March and to 0 otherwise. δ_k are fund fixed effects.

[TABLE 9]

The results in Table 9 are consistent with our hypothesis showing that funds that had a bigger exposure to illiquidity due to banks' market making constraints had to sell their liquid positions more. Table 9, column (6) indicates that investment into liquid bonds drops by 1.27 percentage points for funds facing an illiquidity constraint. The average fund holding of liquid bonds for these funds is 22.97%. This implies that liquid bonds holdings decline by 5.5% (=1.27/0.2297) more for funds with exposure to bank balance constraints.

Finally, in Table 10, instead of assigning bank constraints based on the country of the bond issuer, we measure it based on the constraint of the bond underwriter. Naturally, it is substantially harder to assign an underwriter to a bond than the country of issuance. On average, we have underwriter constraints for 31% of funds' corporate bond portfolio. In case there is more than one constraint associated with a bond, we take the average of the underwriter constraints at the bond level. Overall, we have 732 funds that hold 1,373 individual bonds with an assigned leverage ratio slack.

The results are consistent with findings in Table 9 and with the hypothesis that corporate bonds that had less exposure to illiquidity due to banks' market making constraints sold more liquid bonds. The unit of observation is fund-bond-month, and we look at log differences of the nominal allocation to individual liquid bonds. Table 9, column (6) indicates funds reduce their holdings of "liquid" bonds by 8.3 percent. In the last two columns we try to overcome the partial coverage of the fund portfolio by looking at funds that have a portfolio where we could identify at least 50 bonds that are linked to the underwriter constraint measure. Column (8) suggests that, on average, these funds sold 4.5 percentage point more of their liquid bonds than of their relatively illiquid bonds.

[TABLE 10]

In the analysis focused on the 2020 mutual funds run we relied on the surge in selling pressure, but we did not directly speak to whether the leverage constraint was binding at the dealer level, the way we did in our earlier analysis. As a result, there is a remaining concern that dealer's slack under the leverage ratio might be correlated to the bonds' characteristics, and so the selling behavior that we observe is not causally tied to the constraint. In the last two columns of Table 10 we look directly at the bank balance sheet. As it is well known, periods of macro-economic uncertainty trigger inflow of deposits into banks (due to the deposit insurance), a fact that was originally documented by Gatev and Strahan (2006). 2020 was no exception, for example American Bankers Association pointed out that in 2020 bank deposits increased by a record 22.6%.[13] Because leverage ratio requires capitalization as a proportion of bank balance sheet size, this deposit inflow reduces the slack under that leverage ratio.

[13] https://bankingjournal.aba.com/2021/02/aba-data-bank-deposits-rise-by-a-record-22-6-in-2020/.

Indeed, for the euro area banks in our sample, we see that 24 banks experienced an increase in deposits (as a fraction of assets) already by March 2020, with an average deposit growth of 14% for this sample. Given that the macroeconomic shock underpinning this inflow was not anticipated, and the fact that deposit insurance applies to all banks, we can treat deposits inflows as a source of exogenous variation in slack under the leverage constraint. That is, conditional on the pre-crisis slack under the leverage constraint, banks experiencing higher deposit inflows would have a more binding leverage ratio and, therefore, would be more likely to scale down their market making activities.

In line with this intuition, we find that the cross-sectional correlation between the change in the deposit ratio (including household deposits and non-financial corporate deposits) and the change in the leverage ratio in 2020:Q1 is -0.41. In Table 10, columns (9) and (10), the assignment of bonds to dealers is still done using past underwriting relations. However, instead of the slack under the leverage ratio measured as of the end of 2019, we use the change in the deposit inflow in 2020:Q1 as an instrument. Column (9) is a simple regression, and column (10) is weighted by bank asset size. Conditional on a dealer bank experiencing deposit inflows, funds sell 6.1% bonds linked to underwriters that experience below the median deposit inflows (i.e., more liquid bonds) relative to bonds that are linked to dealers experiencing above median deposit inflows.

6. Conclusion

Mutual fund runs in the U.S. and Europe in 2020 put an unprecedented pressure on the bond market and culminated with a sweeping policy intervention designed to stabilize the markets on both sides of the Atlantic. Much of this dynamic is rooted in the expansion of retail investing in the bond market and illiquidity of the bond asset class. In that sense, some of what we have seen would have unfolded regardless of the bank regulatory changes that followed the Great Financial Crisis. However, for over a decade leading to the 2020 episode there has been a concern that banks regulatory adjustments, and leverage ratio in particular, have impacted bond liquidity by raising the cost of expanding bank balance sheet. Hence, we are interested in understanding how much bank balance sheet constraints for market making had added to the mutual fund instability and sell-off pressure.

We shed new light on this question by exploring persistent connections between bonds and individual dealers formed through the home bias and previous underwriting relationships. Building on these connections we are able to show that the introduction of leverage ratio for the European banks had a large impact on exposed bonds liquidity. Using the same connections, we show that, during the 2020 run episode, mutual funds with larger exposures to bank balance sheet constraints faced bigger redemptions and sell-offs of liquid bonds.

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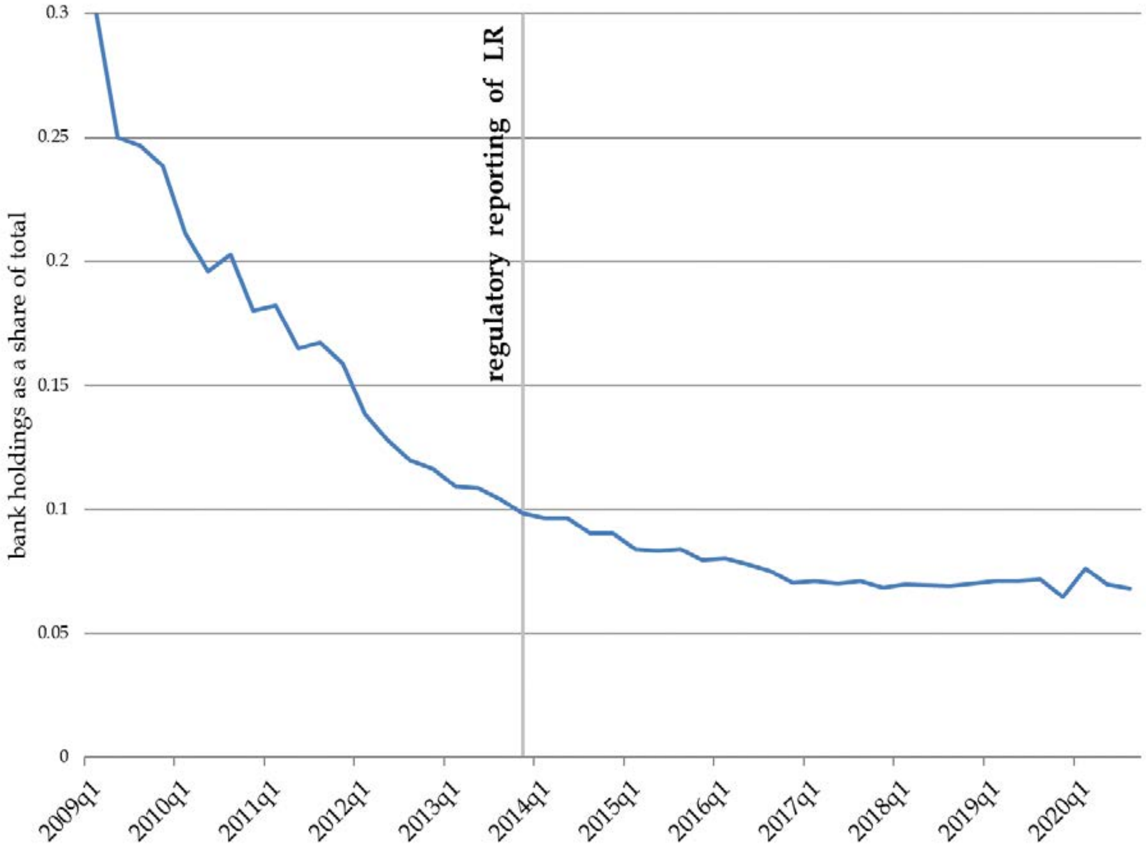
FIGURE 1 – BANK HOLDINGS OF NON-FINANCIAL CORPORATE BONDS

This figure gives average bank holdings of non-financial corporate bonds (share of total, Panel A) as well as holdings of non-financial corporate bonds by all investors, the banking sector and the investment fund sector (EUR bn, Panel B). Source: ECB Security Holdings Statistics (SHS).

Panel A: Average bank holdings of corporate bonds (share of total)



Panel B: Total, banking and investment fund sector holdings of corporate bonds (EUR bn)

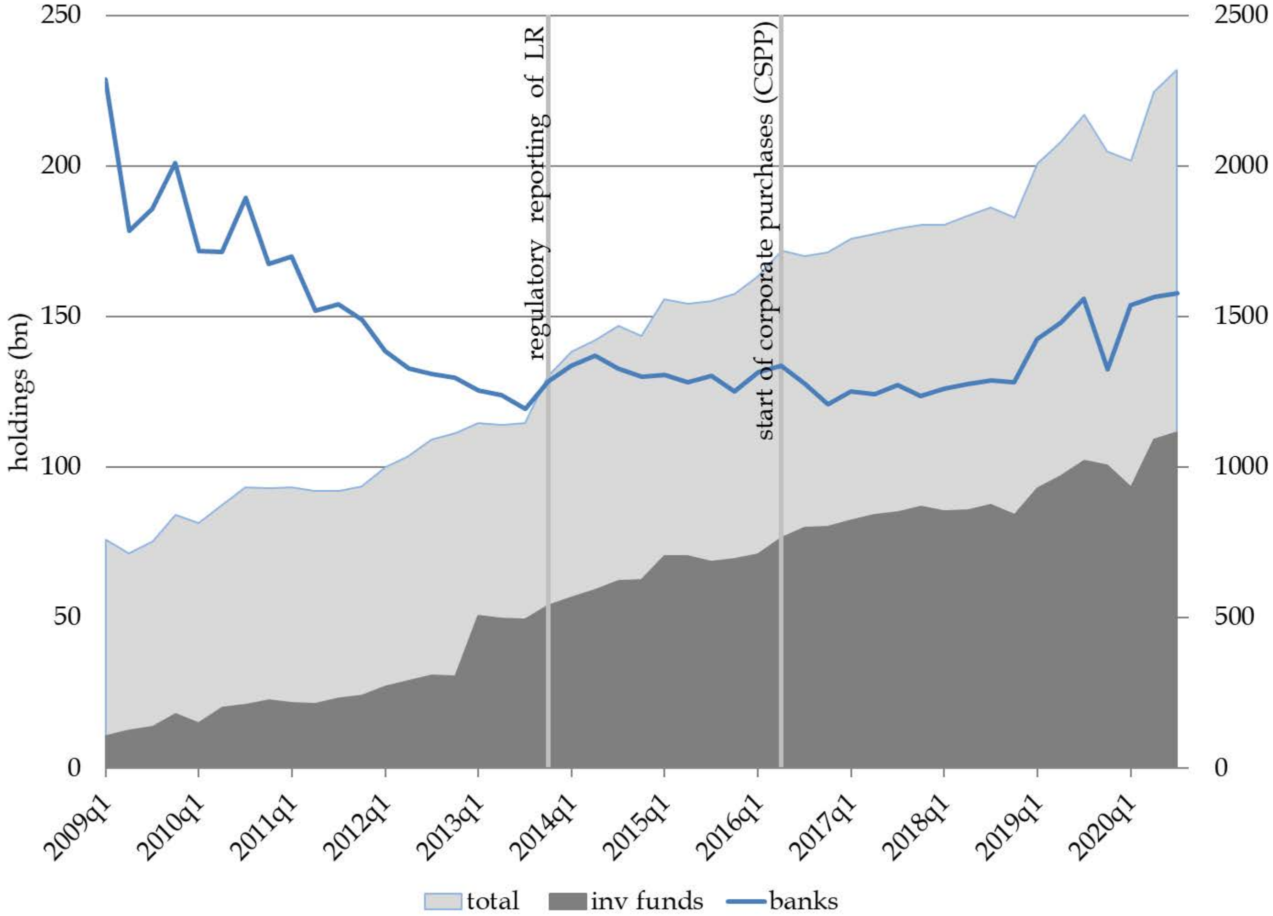


FIGURE 2 – LEVERAGE RATIO IMPLEMENTATION TIMELINE

This figure gives an overview of the implementation timeline for the regulatory Leverage Ratio (LR) across the European Union, the United Kingdom, and the United States. The figure shows both the baseline requirement of 3 percent and additional LR requirements across regulatory jurisdictions. The grey bars depict the Eurosystem Asset Purchase Programs, the Public Sector Purchase Program (PSPP) and additionally the Corporate Sector Purchase Program (CSPP). (*) The UK leverage ratio requirements (quarterly reporting) were reported as monthly averages, but as of January 2018 as daily averages. (**) Fed's rule is for US top-tier bank holding company (SLR 5%) with more than 700 billion dollars in consolidated assets or more than 10 trillion in assets under custody and for IDI subsidiaries (SLR 6%) of covered BHCs.

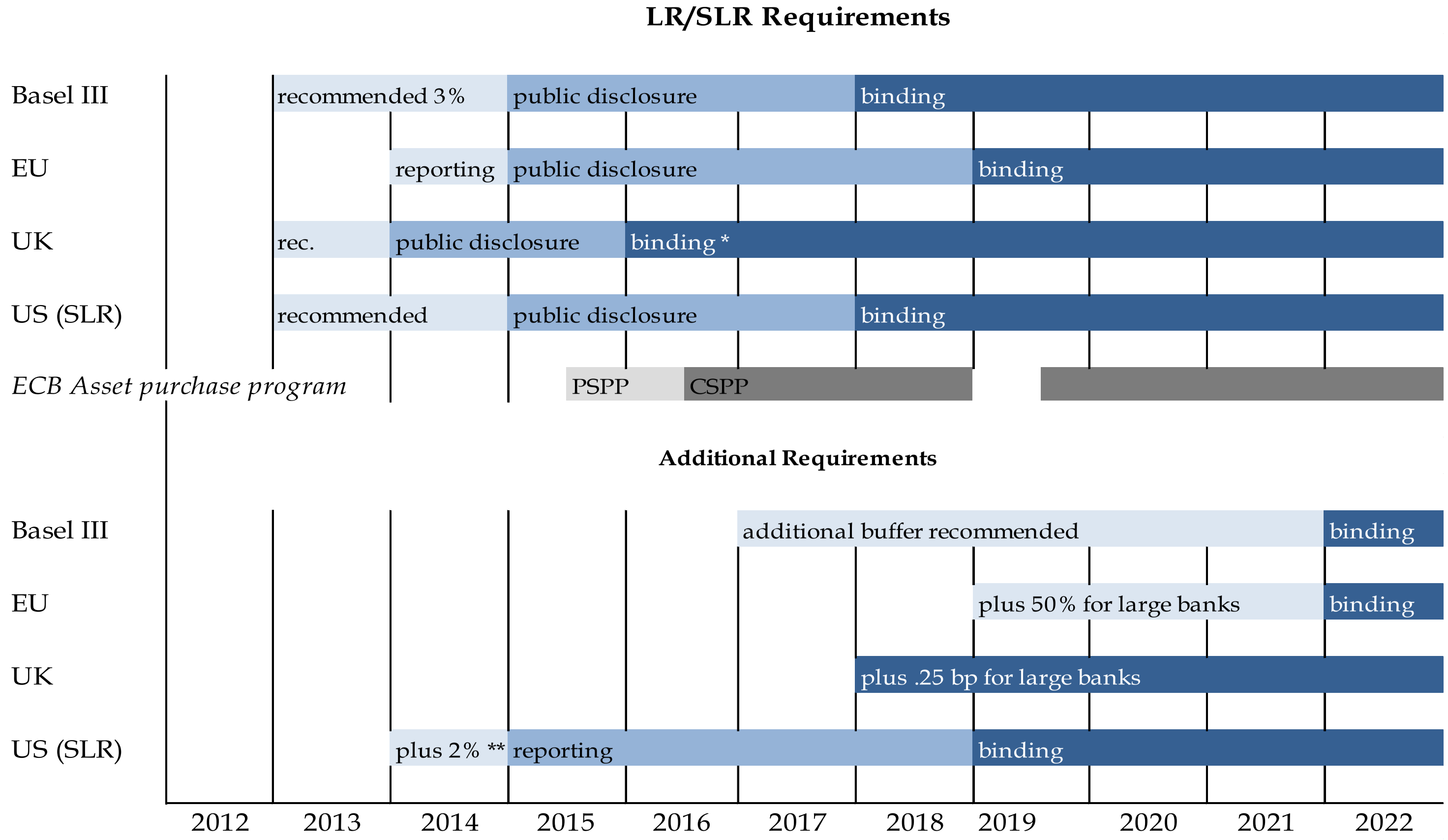


FIGURE 3 – LEVERAGE RATIO OF LARGEST DEALER BANKS OVER TIME

This figure depicts the regulatory leverage ratio of the largest euro area dealer banks from 2013 q4 to 2020 q1. The thick grey line is the regulatory target for large banks in Europe.

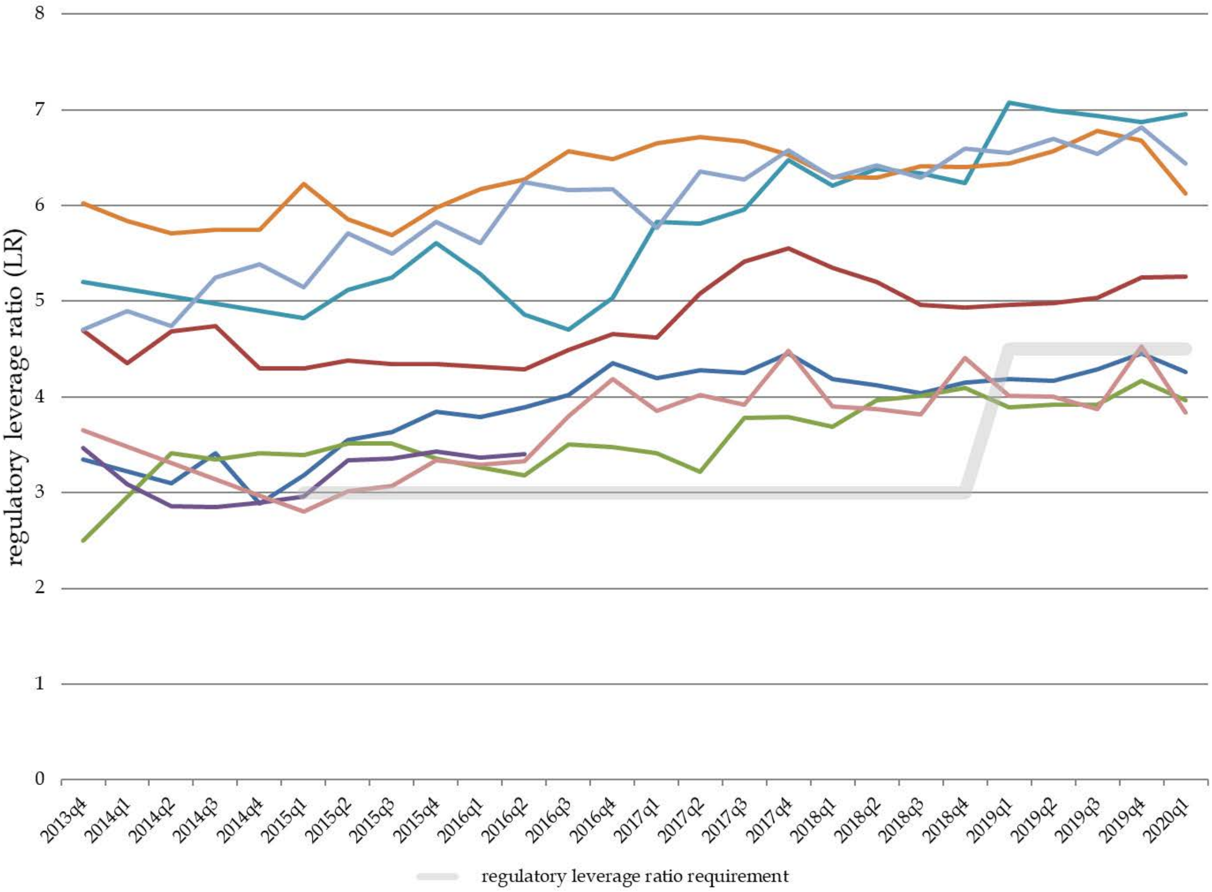


FIGURE 4 – PERSISTENCE OF BOND UNDERWRITING RELATIONSHIPS

This figure presents probability that a company picks the same lead bond underwriter as the one it used in the past. The overall sample corresponds to 2001-2017. As an example, in year 2017, we look at firms that also issued a bond in 2016 (1 year back) and assign a value of 1 if the firm used the same lead underwriter, and 0 otherwise. We then take an average across all issuers for 2017. We repeat this exercise for up to 10 years in the past, which in this example would mean for years 2016 (1 year back) through 2007 (10 years back). At the end we have these series for firms with bond issues between 2008 and 2017. The figure plots the average across the years and the corresponding 95% confidence intervals.

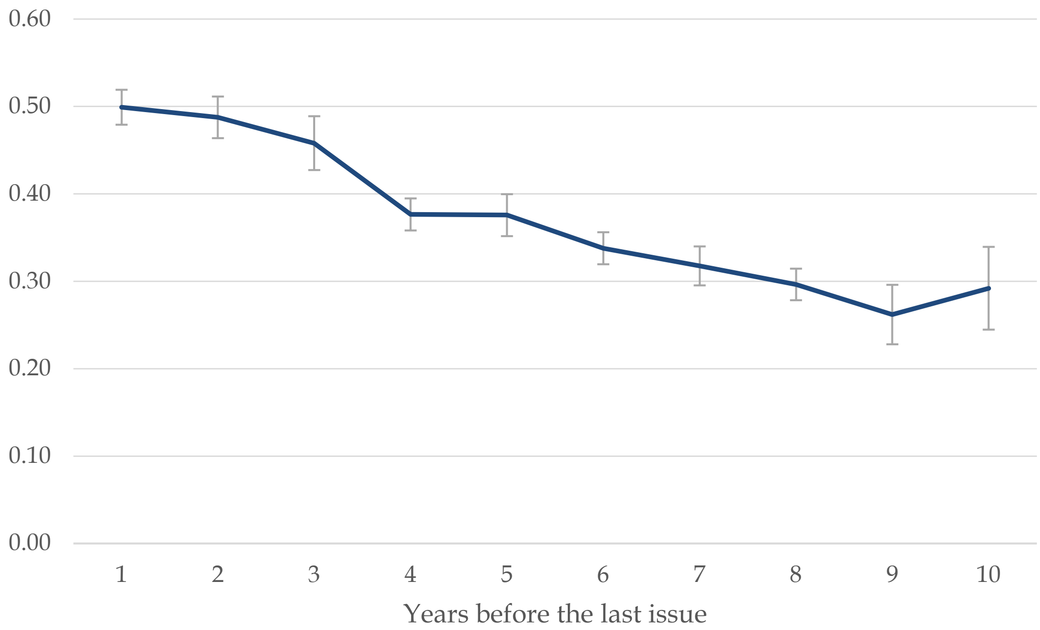


FIGURE 5 – IMPACT OF THE LEVERAGE RATIO ON BOND MARKET LIQUIDITY

The figure shows the main regression result of the impact of the leverage ratio regulation on corporate bond market liquidity. The graph gives the point estimates for quarterly distances around the first time banks calculated and reported their leverage ratio to their supervisor. The regression specification is as follows:

$$Bid\text{-}ask\ spread_{i,t} = \sum_{t=2012:Q1}^{2015:Q4} \alpha_{1,t}\, BankConstraint_I * Quarter_t + Controls + \epsilon_{i,t},$$

where i is bond and t is days. The $Spread_{i,t}$ is bid-ask spreads; the $Bank\ Constraint_I$ is the dealers' constraints in the issuer's domestic country measured as distances to their required leverage ratios as of the end of 2013. The regression also includes firm fixed effects, country- and security-specific time-varying controls. The y-axis gives the spread change relative to the period prior to the event depending on the distance to the regulatory leverage constraint. The solid line depicts the point estimates and the dashed lines the corresponding 95% confidence band. Standard errors are clustered at bond level.

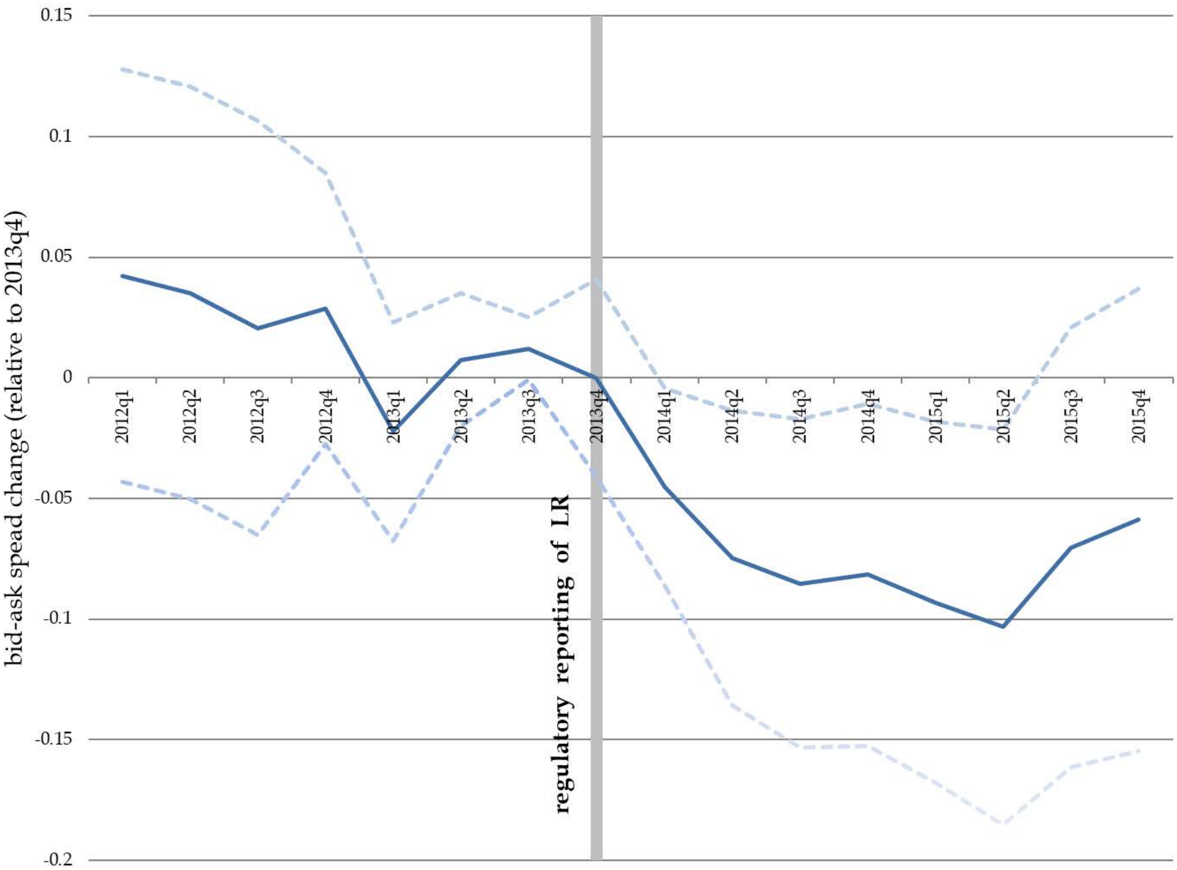


FIGURE 6– DIFFERENTIAL IMPACT OF BOND RATINGS

The figure shows the regression result of the impact of the leverage ratio regulation on corporate bond market liquidity for different bond ratings. That is, instead of investment grade, non-investment grade split used in Table 6, we re-run the same regression as in column (3) but using more granular rating groups. The solid diamonds depict the point estimates and the dashed lines the corresponding 95% confidence band. Standard errors are clustered at bond level.

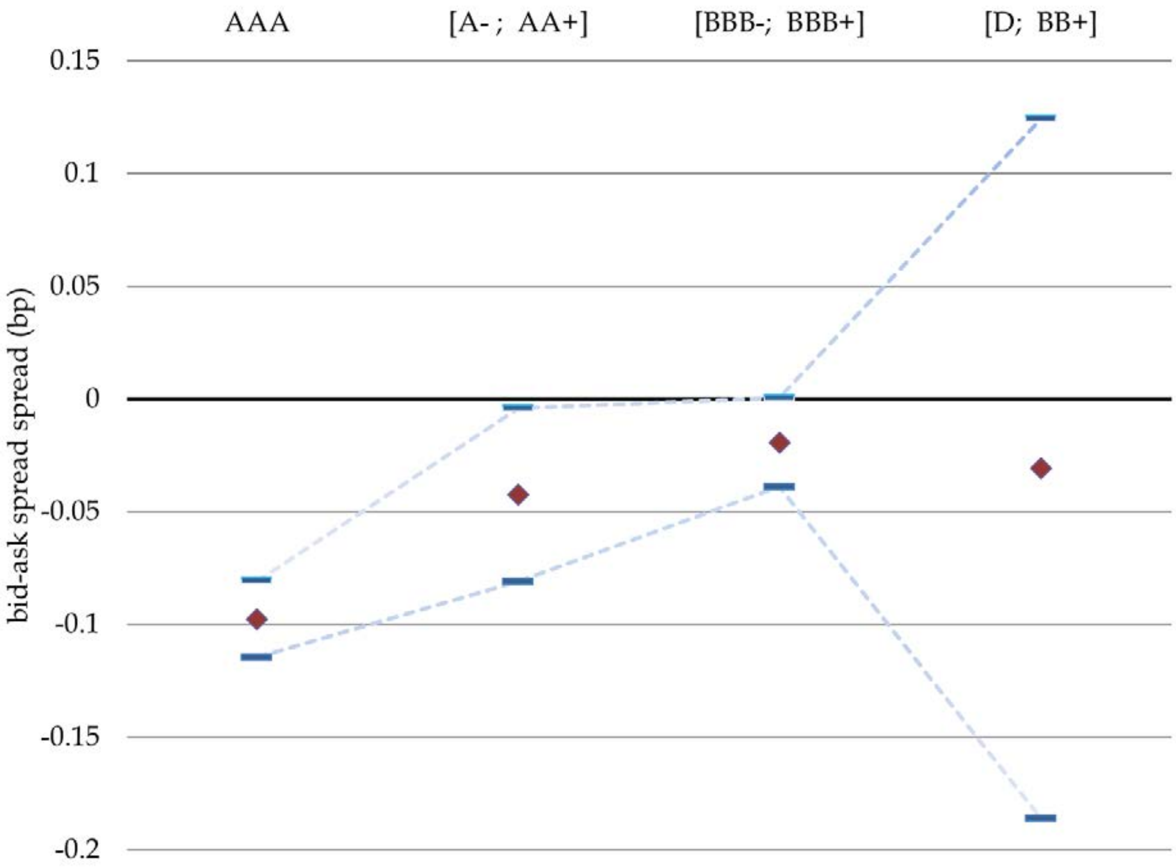


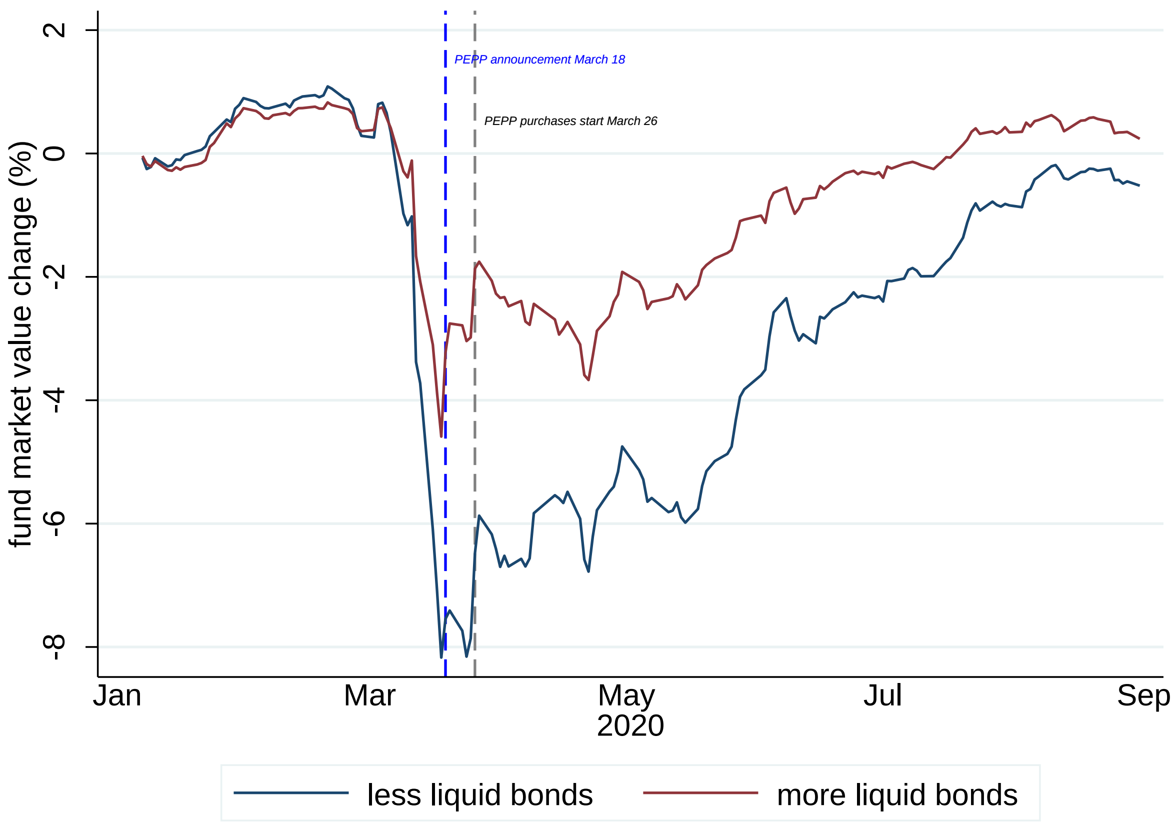
FIGURE 7 – MUTUAL FUND VALUE AND FLOW

This figure gives the evolution of corporate bond mutual funds value (Panel A) and flows (Panel B) before and after the COVID-19 shock. The novel result is the difference in fund value and outflows depending on their holdings of bonds exposed to illiquidity through dealers' balance sheet. The blue line depicts average flows of corporate bond mutual funds that are relatively more exposed to "illiquid" bonds and the red line gives average flows of mutual funds that are relatively less exposed to "illiquid" bonds. Daily flows are calculated as:

$$Flows_{i,t} = (TNA_{i,t} - (1 + r_{i,t}) * TNA_{i,t-1}) / TNA_{i,t-1}$$

where $TNA_{\mathrm{i,t}}$ is total net assets of fund i at day t and $r_{i,t}$ is the fund's daily return. The vertical dashe lines depict the announcement and beginning of the ECB's Pandemic Emergency Purchase Program (PEPP).

Panel A. Changes in corporate bond fund market value



Panel B. Changes in corporate bond fund flows

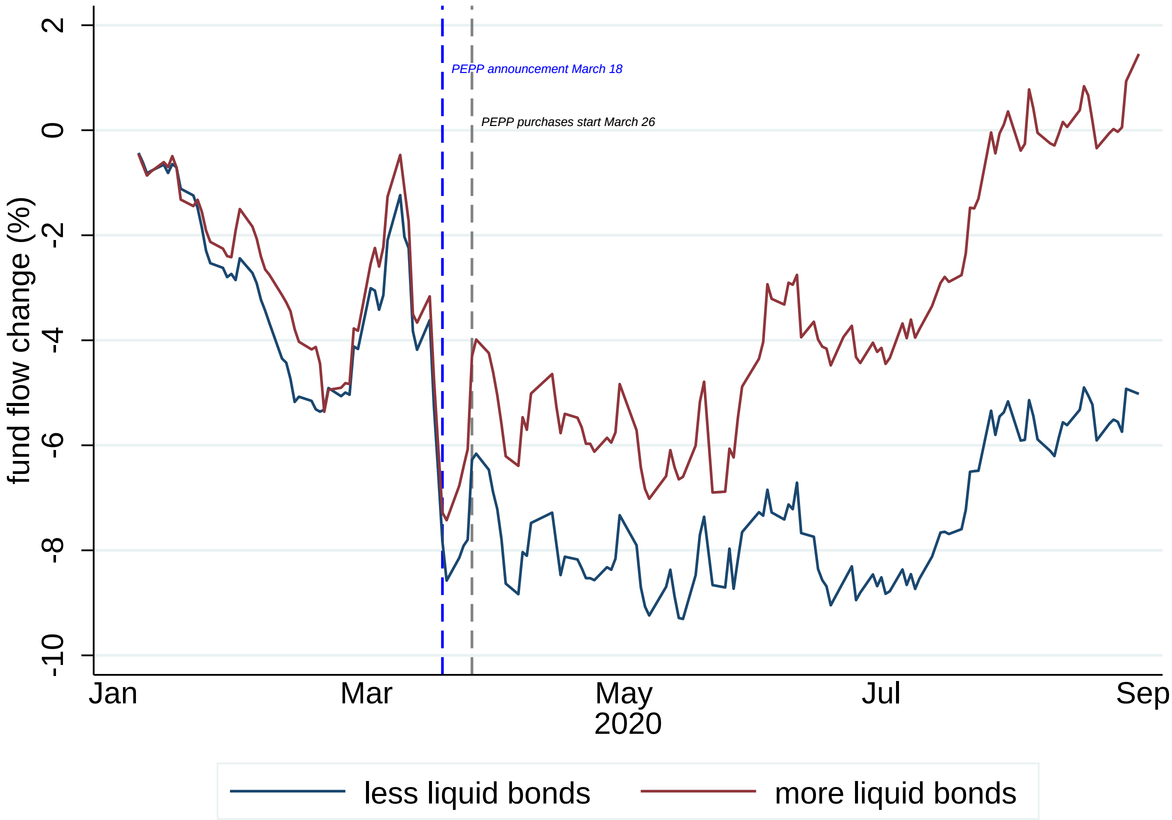


TABLE 1 – SUMMARY STATISTICS, AS OF 12/31/2013

This table reports baseline summary statistics for the regulatory leverage ratio and bank constraints measured as the distance to the regulatory requirement. Panel A shows statistics for the overall sample and for dealer banks and non-dealer banks separately. Dealer banks and non-dealer banks are defined in two ways: Definition 1 categorizes dealer banks as banks that engage as dealers with the Eurosystem in the corporate bond market for the Corporate Sector Purchase Program (CSPP). Definition 2 categorizes dealer banks as banks that engage as dealers with the Eurosystem in the sovereign bond market for the Public Sector Purchase Program (PSPP). For country level bank constraints (Panel B), we consider four alternative ways of aggregating the data: (i), weighted by total assets, (ii), weighted by dealers' trading volume under the CSPP, (iii), largest dealer bank by CSPP trading volume in a country, (iv), two largest dealer banks by CSPP trading volume in a country. "Placebo" bank constraints are based on regulatory leverage ratios of non-dealer banks weighted by total assets.

Panel A. Overall sample

	Obs.	Mean	SD	5th %	95th %
Leverage ratio (2013:Q4)	116	5.80	7.29	2.16	9.50
Distance to requirement					
Dealer banks: Banks acting as dealers in the corporate bonds purchase program					
Full sample	92	1.78	2.52	-0.85	4.84
Dealer banks	14	0.87	0.97	-0.62	3.03
Non-dealer banks	78	1.94	2.68	-1.03	5.34
Dealer banks: Banks acting as dealers in the sovereign bonds purchase program					
Full sample	116	2.80	7.29	-0.84	6.50
Dealer banks	41	1.67	1.72	-0.30	4.78
Non-dealer banks	75	3.41	8.95	-0.85	8.62

Panel B. Country-level bank constraints

			Dealer banks		Non-dealer banks ("placebo")	
		Obs.	Mean	SD	Mean	SD
Dealer banks: Banks acting as dealers in the corporate bond purchase program						
(i)	Weighted by assets	9	1.08	0.81	1.99	1.71
(ii)	Weighted by trading volume	9	1.14	0.95	1.99	1.71
(iii)	Top-1 dealer	9	1.07	1.14	1.99	1.71
(iv)	Top-2 dealers	9	1.12	0.99	1.99	1.71
Dealer banks: Banks acting as dealers in the sovereign bond purchase program						
(i)	Weighted by assets	15	1.96	1.55	3.53	3.70
(ii)	Weighted by trading volume	15	1.93	1.48	3.53	3.70
(iii)	Top-1 dealer	15	1.76	1.59	3.53	3.70
(iv)	Top-2 dealers	15	1.86	1.51	3.53	3.70

TABLE 2 – DOMESTIC CONCENTRATION OF CORPORATE BOND HOLDINGS

This table shows summary statistics of corporate bond holdings over time. Domestic concentration and largest foreign country concentration (shares of total holdings) are reported as quarterly means and standard deviations. *** indicate significance at the 1% level.

	Home		Foreign (largest)				
Date	Mean	SD	Mean	SD	Diff		Obs.
2009q1	0.612	0.009	0.043	0.003	0.569	***	2,436
2009q2	0.573	0.010	0.044	0.003	0.530	***	2,176
2009q3	0.650	0.009	0.034	0.002	0.616	***	2,498
2009q4	0.642	0.009	0.033	0.002	0.609	***	2,587
2010q1	0.639	0.009	0.031	0.002	0.608	***	2,664
2010q2	0.653	0.008	0.032	0.002	0.621	***	2,852
2010q3	0.647	0.008	0.032	0.002	0.615	***	3,070
2010q4	0.646	0.008	0.029	0.002	0.617	***	3,275
2011q1	0.648	0.008	0.031	0.002	0.617	***	3,237
2011q2	0.616	0.008	0.031	0.002	0.586	***	3,071
2011q3	0.591	0.008	0.034	0.002	0.557	***	2,864
2011q4	0.589	0.009	0.030	0.002	0.559	***	2,810
2012q1	0.586	0.008	0.028	0.002	0.558	***	2,909
2012q2	0.573	0.008	0.028	0.002	0.545	***	2,937
2012q3	0.522	0.009	0.030	0.002	0.492	***	2,771
2012q4	0.510	0.009	0.028	0.002	0.482	***	2,839
2013q1	0.493	0.008	0.018	0.001	0.476	***	2,903
2013q2	0.474	0.008	0.019	0.001	0.455	***	2,897
2013q3	0.486	0.008	0.020	0.001	0.466	***	2,999
2013q4	0.465	0.008	0.021	0.001	0.444	***	3,120
2014q1	0.476	0.008	0.021	0.001	0.455	***	3,434
2014q2	0.463	0.008	0.022	0.001	0.442	***	3,484
2014q3	0.457	0.007	0.022	0.001	0.435	***	3,757
2014q4	0.447	0.008	0.019	0.001	0.428	***	3,156
2015q1	0.460	0.008	0.018	0.001	0.442	***	3,404
2015q2	0.467	0.008	0.018	0.001	0.449	***	3,508
2015q3	0.476	0.008	0.017	0.001	0.459	***	3,600
2015q4	0.464	0.008	0.018	0.001	0.446	***	3,349
2016q1	0.486	0.008	0.017	0.001	0.469	***	3,544
2016q2	0.476	0.008	0.017	0.001	0.459	***	3,560
2016q3	0.471	0.008	0.016	0.001	0.455	***	3,696
2016q4	0.451	0.008	0.016	0.001	0.435	***	3,564
2017q1	0.468	0.007	0.016	0.001	0.453	***	3,851
2017q2	0.468	0.007	0.016	0.001	0.452	***	3,813
2017q3	0.463	0.007	0.016	0.001	0.447	***	3,793
2017q4	0.457	0.007	0.017	0.001	0.440	***	3,660

TABLE 3 – BOND UNDERWRITERS AND SECONDARY MARKET BROKER-DEALER ACTIVITIES

The goal of this table is to illustrate that the bond underwriters (primary dealers) continue to play a special role in the secondary market. The sample consists of trades executed by the Eurosystem from June 2016 to March 2017 as part of the corporate bond purchase program. Unit of observation is bond-dealer. The dependent variable is the fraction of the total transaction volume that was intermediated by a given dealer. In the first two columns, the explanatory variable of interest is an indicator of whether the dealer is also bond underwriter. In column (3), we include interaction terms indicating whether the bond was outstanding for one, or two to three years from issuance. Standard errors are clustered at dealer bank level. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively.

Dependent variable	Share of transaction volume		
	(1)	(2)	(3)
Dealer bank is underwriter	0.248***	0.252***	-0.093
	(0.076)	(0.075)	(0.120)
Underwriter * 1 year from issuance	--	--	0.557***
			(0.203)
Underwriter * 1-3 years from issuance	--	--	0.234*
			(0.119)
Log(amount outstanding)	-0.088**	-0.090**	-0.091**
	(0.043)	(0.043)	(0.044)
Fixed effect: Dealer/Years from issuance	Yes/--	Yes/Yes	Yes/Yes
Obs.	4,137	4,137	4,137
R-squared	0.0379	0.0387	0.0428

TABLE 4 – IMPACT OF THE LEVERAGE RATIO ON BOND MARKET LIQUIDITY

This table shows the main regression result of the impact of the leverage ratio regulation on corporate bond market liquidity. The regression specification is as follows:

$$Bid\text{-}ask\ spread_{i,t} = \alpha_1 Bank\ constraint_I * Post_t + \delta_i + X_{i,t} + \cdots + \epsilon_{i,t}$$

where i is the bond, t is the date, the $Bid\text{-}ask\ spread_{i,t}$ is the measure of bond liquidity, the $Bank\ constraint_I$ is the bank constraint of country I (calculated as the weighted averages of broker dealer distances to their required leverage ratios), $Post_t$ is a dummy variable (1 for indicating the period after the first time banks calculated and reported their regulatory leverage ratio to their supervisor and 0 otherwise). δ_i are bond fixed effects and $X_{i,t}$ is bond remaining maturity, i.e., its time-varying characteristic. Standard errors are clustered at bond level. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively.

Dependent variable			Bid-ask spread		
	(1)	(2)	(3)	(4)	(5)
Bank constraint x Post	-0.099***	-0.062***	-0.055**	-0.055**	-0.080***
	(0.032)	(0.022)	(0.022)	(0.022)	(0.019)
Post	0.034	-0.073***	--	--	--
	(0.032)	(0.018)			
Bank constraint	0.041	--	--	--	--
	(0.035)				
Residual bond maturity	--	--	--	0.012	-0.004
				(0.021)	(0.023)
Δ Log(Local GDP)	--	--	--	--	0.201
					(0.159)
Δ Log(Local equity index)	--	--	--	--	0.586***
					(0.203)
Δ Log(Local bank index)	--	--	--	--	-0.119*
					(0.064)
Δ Log(Local volatility index)	--	--	--	--	1.472***
					(0.419)
Δ Log(Local government spread, 10Y)	--	--	--	--	-0.201***
					(0.043)
Δ Log(Local government spread, 5Y)	--	--	--	--	0.264***
					(0.085)
Δ Log(Local government spread, 3Y)	--	--	--	--	-0.065
					(0.043)
Δ Log(Local government spread, 1Y)	--	--	--	--	-0.138***
					(0.041)
Fixed effects: Bond	--	Yes	Yes	Yes	Yes
Fixed effects: Day	--	--	Yes	Yes	Yes
Obs.	1,368,161	1,368,161	1,368,161	1,368,161	1,033,192
R-squared	0.0017	0.8003	0.8050	0.8050	0.7486

TABLE 5 – PLACEBO BROKER DEALER CLASSIFICATION

This table re-examines results in Table 4, but using leverage ratio constraint of the domestic non-dealer banks. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively.

Dependent variable	Bid-ask spread			
	(1)	(2)	(3)	(4)
Bank constraint x Post	-0.016	-0.003	-0.002	-0.010
	(0.013)	(0.007)	(0.007)	(0.008)
Post	-0.010	-0.116***	--	--
	(0.026)	(0.016)		
Bank constraint	0.059***	--	--	--
	(0.013)			
Residual bond maturity	--	--	--	-0.005
				(0.023)
Δ Log(Local GDP)	--	--	--	0.289*
				(0.155)
Δ Log(Local equity index)	--	--	--	0.755***
				(0.218)
Δ Log(Local bank index)	--	--	--	-0.146**
				(0.066)
Δ Log(Local volatility index)	--	--	--	1.618***
				(0.435)
Δ Log(Local government spread, 10Y)	--	--	--	-0.177***
				(0.044)
Δ Log(Local government spread, 5Y)	--	--	--	0.259***
				(0.086)
Δ Log(Local government spread, 3Y)	--	--	--	-0.071
				(0.044)
Δ Log(Local government spread, 1Y)	--	--	--	-0.124***
				(0.041)
Fixed effects: Bond	--	Yes	Yes	Yes
Fixed effects: Day	--	--	Yes	Yes
Obs.	1,368,161	1,368,161	1,368,161	1,033,192
R-squared	0.0057	0.8000	0.8048	0.7480

TABLE 6 – ALTERNATIVE BROKER DEALER CLASSIFICATIONS

This table re-runs Table (3), specification (5) using alternative constructions of the *Bank constraint*. We report the coefficient of interest, which is the coefficient estimate on the interaction term between *Bank constraint* and *Post*. Each number corresponds to a different regression. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively.

			Coeff.	SE
Dealer banks: Banks acting as dealers in the corporate bond purchase program				
Table 4, column (5)	**(i)**	**Weighted by assets**	**-0.080*** **	**(0.019)**
	(ii)	Weighted by trading volume	-0.083***	(0.024)
	(iii)	Top-1 dealer	-0.084***	(0.030)
	(iv)	Top-2 dealers	-0.081***	(0.022)
Dealer banks: Banks acting as dealers in the sovereign bond purchase program				
	(i)	Weighted by assets	-0.074***	(0.019)
	(ii)	Weighted by trading volume	-0.083***	(0.024)
	(iii)	Top-1 dealer	-0.088***	(0.030)
	(iv)	Top-2 dealers	-0.086***	(0.025)

TABLE 7 – DIFFERENTIAL IMPACT OF BOND RATINGS

The focus of this table is on the differential impact of the leverage ratio constraint on liquidity of investment grade (IG) and non-investment grade (NIG) bonds. Columns (1), (2) and (3) show regression results for non-investment grade bonds, investment grade bonds and the full sample, respectively. The specification in columns (1) and (2) is the same as in Table 4, column (5). In column (3), the variable of interest is *IG bond* which is a dummy equal to 1 if the bond credit rating is investment grade and 0 otherwise. The focus is on the triple interaction term, which shows the estimate for the differential effect for investment grade bonds (as compared to non-investment grade bonds). Standard errors are clustered at bond level. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively.

Dependent variable	Bid-ask spread		
Sample	NIG bonds	IG bonds	All
	(1)	(2)	(3)
Bank constraint * IG bond * Post	--	--	-0.095**
			(0.043)
Bank constraint * Post	-0.027	-0.060***	0.046
	(0.055)	(0.018)	(0.048)
Bank constraint * IG bond	--	--	0.039
			(0.109)
IG bond* Post	--	--	0.357**
			(0.169)
IG bond	--	--	-0.367
			(0.448)
Macro controls (Table 4, column (5))	Yes	Yes	Yes
Fixed effect: Bond/Day	Yes/Yes	Yes/Yes	Yes/Yes
Obs.	46,901	394,608	441,509
R-squared	0.8812	0.7823	0.7923

TABLE 8 – IMPACT OF UNDERWRITERS' LEVERAGE RATIO ON BOND MARKET LIQUIDITY

In this table, instead of looking at the dealers' leverage ratio constraint at the country level, we look at the constraint of the bond underwriter. The regression specification is as follows:

$$Bid\text{-}ask\ spread_{i,t} = \alpha_1 Bank\ constraint_i * Post_t + \delta_i + X_{i,t} + \cdots + \epsilon_{i,t}$$

where i is the bond, t is the date, and the $Bid\text{-}ask\ spread_{i,t}$ is the measure of bond liquidity. The main change is the granularity and definition of the $Bank\ constraint_i$. Specifically, we look at the leverage ratio as of 12/31/2013 for the main underwriter/primary dealer bank identified using a two-year window (2010-2011). As before, $Post_t$ is a dummy variable (1 for indicating the period after the first time banks calculated and reported their regulatory leverage ratio to their supervisor and 0 otherwise). δ_i are bond fixed effects and $X_{i,t}$ is bond remaining maturity, i.e., its time-varying characteristic. Standard errors are clustered at bond level. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively.

Dependent variable	Bid-ask spread				
	(1)	(2)	(3)	(4)	(5)
Bank constraint x Post	-0.050	-0.032**	-0.031**	-0.032**	-0.040**
	(0.035)	(0.014)	(0.014)	(0.014)	(0.017)
Post	0.198	0.033	--	--	--
	(0.199)	(0.075)			
Bank constraint	-0.005	--	--	--	--
	(0.019)				
Residual bond maturity	--	--	--	0.010	-0.039
				(0.030)	(0.071)
Δ Log(Local GDP)	--	--	--	--	0.387
					(0.503)
Δ Log(Local equity index)	--	--	--	--	-0.761*
					(0.423)
Δ Log(Local bank index)	--	--	--	--	0.361*
					(0.212)
Δ Log(Local volatility index)	--	--	--	--	1.724
					(1.538)
Δ Log(Local government spread, 10Y)	--	--	--	--	-0.005
					(0.103)
Δ Log(Local government spread, 5Y)	--	--	--	--	0.415*
					(0.215)
Δ Log(Local government spread, 3Y)					-0.300
					(0.184)
Δ Log(Local government spread, 1Y)					-0.128*
					(0.075)
Fixed effects: Bond	--	Yes	Yes	Yes	Yes
Fixed effects: Day	--	--	Yes	Yes	Yes
Obs.	141,417	141,417	141,417	138,037	138,037
R-squared	0.0058	0.8375	0.8423	0.8434	0.8460

TABLE 9 – IMPACT OF DEALER BANKS' LEVERAGE RATIO CONSTRAINTS ON FUND SELLS, DOMESTIC DEALERS

This table shows regression results examining how leverage-ratio constrained dealer banks impact fund sell-offs during the start of the COVID-19 crisis. Analysis considers euro area corporate bond mutual funds. The unit of observation is fund*month. The core sorting variable is *Illiquidity exposure* which sorts funds into those above the median (equal to 1) and below the median (equal to 0) exposure to constrained dealers. The dependent variable is how much these funds sell "liquid" bonds:

$$\Delta\, Liquid\ bonds_{k,t} \;=\; \alpha_1 Illiquidity\ exposure_k * COVID\ Shock_t + \delta_k \;+\; \epsilon_{k,t}$$

where $\Delta\, Liquid\ bonds_{k,t}$ is the monthly (t) change in holdings of mutual fund k. The variable δ_k are fund fixed effects. Standard errors are clustered at the fund level. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively.

Dependent variable	Change in liquid bonds holdings					
Sample (funds)	Exposed	Less exposed	All	Exposed	Less exposed	All
	(1)	(2)	(3)	(4)	(5)	(6)
Illiquidity exposure * COVID shock	--	--	-1.266***	--	--	-1.268***
			(0.169)			(0.272)
COVID shock (March 2020)	-1.189***	0.027	0.060	-1.157***	0.009	0.030
	(0.131)	(0.104)	(0.103)	(0.197)	(0.189)	(0.195)
Fund cash position	-0.093***	-0.026***	-0.060***	-0.281***	-0.053*	-0.135***
	(0.013)	(0.006)	(0.007)	(0.047)	(0.029)	(0.033)
Illiquidity exposure	--	--	0.432***	--	--	--
			(0.099)			
Fixed effects: Bond	--	--	--	Yes	Yes	Yes
Obs.	2,342	2,264	4,606	2,342	2,264	4,606
R-squared	0.0838	0.0068	0.0523	0.4500	0.3600	0.4100

TABLE 10 – IMPACT OF DEALER BANKS' LEVERAGE RATIO CONSTRAINTS ON FUND SELLS, UNDERWRITERS

Similar to Table 9, this table shows regression results examining how leverage-ratio constrained dealer banks impact fund sell-offs during the start of the COVID-19 crisis. The difference is that here we use underwriter level constraints. Analysis considers euro area corporate bond mutual funds. The unit of observation is fund*month*security. Standard errors are clustered at the fund portfolio level. Otherwise, the specifications are the same as in Table 8. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively.

Dependent variable	Change in bonds holdings									
Sample (funds)	Exposed	Less exposed	All	Exposed	Less exposed	All	>50 critical holdings		IV	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Illiquidity exposure * COVID Shock	--	--	-0.079**	--	--	-0.083**	-0.041**	-0.045**	-0.034*	-0.061**
			(0.035)			(0.043)	(0.018)	(0.020)	(0.019)	(0.029)
COVID Shock (March 2020)	-0.073*	0.02	-0.041	-0.073*	0.021	0.016	-0.078	-0.076	-0.004	0.014
	(0.040)	(0.057)	(0.032)	(0.040)	(0.058)	(0.056)	(0.060)	(0.060)	(0.044)	(0.047)
Illiquidity exposure	--	--	0.023	--	--	--	0.005	--	--	--
			(0.015)				(0.006)			
Fund cash position	-0.04	-0.069	-0.019	-0.046*	-0.013	0.006	0.06	0.064	0.002	-0.013
	(0.026)	(0.118)	(0.040)	(0.027)	(0.124)	(0.048)	(0.073)	(0.087)	(0.004)	(0.018)
Fixed effect: Fund/Bond	--/Yes	--/Yes	--/Yes	Yes/Yes	Yes/Yes	Yes/Yes	--/Yes	Yes/Yes	Yes/Yes	Yes/Yes
Obs.	15,860	18,618	34,469	15,860	18,618	34,469	17,842	17,785	13,271	13,272
R-squared	0.1264	0.2917	0.2549	0.1496	0.3	0.2666	0.0601	0.1013	0.2292	0.2296

APPENDIX

TABLE A.1 – IMPACT OF THE LEVERAGE RATIO ON BOND MARKET LIQUIDITY, SURVIVING BONDS

This table re-examines results in Table 4, specifications (3) and (5) for a subset of bonds that are outstanding for a minimum of (i) two years before and two years after the event (December 31, 2013), i.e., full sample; (ii) one year before and one year after the event; and (iii) six months before and six months after the event.

	Minimum bond survival around event					
Sample (bonds)	2 years		1 year		6 months	
	(1)	(2)	(3)	(4)	(5)	(6)
Bank constraint x Post	-0.065**	-0.076***	-0.091***	-0.094***	-0.060***	-0.084***
	(0.027)	(0.023)	(0.022)	(0.019)	(0.021)	(0.019)
Residual bond maturity	--	0.025	--	0.010	--	0.002
		(0.036)		(0.032)		(0.027)
Macro controls (Table 4, column (5))	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects: Bond /Day	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes
Obs.	460,391	382,005	809,886	614,309	982,446	751,676
R-squared	0.7309	0.6995	0.8605	0.7059	0.8489	0.7232

TABLE A.2 – IMPACT OF UNDERWRITERS' LEVERAGE RATIO ON BOND MARKET LIQUIDITY

This table shows robustness of results in Table 8 to the use of an alternative window for detecting core underwriting ties. In Table 8, we use a two-year window (2010-2011) to look at other bond issues. Here, we look at a three-year window (2010-2012) instead. Everything else is the same. Standard errors are clustered at bond level. ***, **, and * indicate statistical significance at 1%, 5% and 10%, respectively.

Dependent variable	Bid-ask spread				
	(1)	(2)	(3)	(4)	(5)
Bank constraint x Post	-0.056**	-0.054**	-0.054**	-0.054**	-0.053**
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Post	0.099	0.091	--	--	--
	(0.108)	(0.108)			
Bank constraint	0.044	--	--	--	--
	(0.036)				
Residual bond maturity	--	--	--	0.013	0.022
				(0.032)	(0.035)
Δ Log(Local GDP)	--	--	--	--	0.415
					(0.255)
Δ Log(Local equity index)	--	--	--	--	0.195
					(0.268)
Δ Log(Local bank index)	--	--	--	--	-0.135
					(0.135)
Δ Log(Local volatility index)	--	--	--	--	0.355
					(0.454)
Δ Log(Local government spread, 10Y)	--	--	--	--	-0.119*
					(0.065)
Δ Log(Local government spread, 5Y)	--	--	--	--	0.157
					(0.253)
Δ Log(Local government spread, 3Y)	--	--	--	--	-0.108
					(0.238)
Δ Log(Local government spread, 1Y)	--	--	--	--	-0.025
					(0.047)
Fixed effects: Bond	--	Yes	Yes	Yes	Yes
Fixed effects: Day	--	--	Yes	Yes	Yes
Obs.	181,921	181,921	181,921	180,877	145,718
R-squared	0.0193	0.6684	0.6865	0.6880	0.7086

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Johannes Breckenfelder
European Central Bank, Frankfurt am Main, Germany; email: johannes.breckenfelder@ecb.europa.eu

Victoria Ivashina
Harvard Business School, Boston, United States; National Bureau of Economic Research, Cambridge, United States; Centre for Economic Policy Research, London, United Kingdom; email: vivashina@hbs.edu

Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website www.ecb.europa.eu

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