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Liquidity in the German corporate bond market: has the CSPP made a difference?

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Non-technical summary

Research question

The Eurosystem purchased €178 bn of corporate bonds between June 2016 and December 2018 during the Corporate Sector Purchase Programme (CSPP). Did these purchases adversely affect liquidity conditions in the corporate bond market, thus raising concerns about unintended consequences of large-scale asset purchases? Our results suggest that purchases conducted under the CSPP have led to an improvement of liquidity conditions in the short run. In the long run, however, CSPP purchases might have deteriorated liquidity to some extent.

Contribution

To analyse the impact of CSPP purchases on market liquidity in the market for German corporate bonds, we combine the Bundesbank's detailed CSPP purchase records with a range of liquidity indicators. We assess both ``flow'' and ``stock'' effects of the purchases, where flow effects measure the contemporaneous impact of the Bundesbank's purchases on market liquidity. In contrast, stock effects measure the accumulated impact of the purchases on liquidity conditions prevailing in the German corporate bond market after the end of CSPP net purchases in December 2018 compared to before these purchases had begun. In addition, the granularity of our dataset allows us to explore how the effect of CSPP purchases on market liquidity varies across market conditions and bond characteristics.
Assessing the impact of CSPP purchases on market liquidity can improve our understanding of the transmission mechanism of unconventional monetary policies. In particular, liquidity premia are often mentioned in addition to duration or local supply effects as one channel through which corporate bond purchases affect corporate bond yields.

Results

We find that initially, the Bundesbank's corporate bond purchases improved contemporaneous liquidity conditions in the market for German corporate bonds (flow effect) albeit the estimated effects are relatively small. For an average purchase size of €7m, bid-ask spreads of purchased bonds tightened by 0.7bps on the day of the purchase. However, liquidity conditions deteriorated as the Bundesbank reduced the stock of corporate bonds available for trading in the secondary market (stock effect). For the average volume purchased by bond over the lifetime of the CSPP (€29m), we find that the bid-ask spread increased by around 1 bps.
The results of our analysis also show that the liquidity of old (and already illiquid) bonds has deteriorated in the short- and long-run while it has improved for newly issued bonds.

Nichttechnische Zusammenfassung

Fragestellung

Im Rahmen des Corporate Sector Purchase Programme (CSPP) hat das Eurosystem im Zeitraum zwischen Juni 2016 und Dezember 2018 Unternehmensanleihen im Wert von €178 Mrd angekauft. Dabei stellt sich die Frage, ob diese großen Ankäufe die Liquidität am Markt für Unternehmensanleihen verschlechtert haben? Die Ergebnisse dieser Studie legen eine kurzfristige Verbesserung der Liquidität nahe. Langfristig führen die Anleihekäufe hingegen zu einer Verschlechterung der Liquidität.

Beitrag

In dieser Studie verwenden wir einen granularen Datensatz von der Deutschen Bundesbank zu den im Rahmen des CSPP angekauften Anleihen in Kombination mit einer Reihe von Liquiditätsmaßen, um den Einfluss von Anleihekäufen auf die Marktliquidität zu analysieren. Wir schätzen sowohl den „Flow-“ als auch den „Stock“-Effekt der Anleihekäufe, wobei der Flow-Effekt den zeitgleichen Effekt der Anleihekäufe auf die Marktliquidität misst. Der Stock-Effekt hingegen misst den kumulierten Effekt der Anleihekäufe auf die Liquidität zwischen dem Beginn und dem Ende der Netto-Anleihekäufe. Aufgrund der Granularität des Datensatzes können wir untersuchen, wie Anleihekäufe die Marktliquidität in Abhängigkeit von Marktbedingungen und Anleihecharakteristika beeinflussen.
Eine Bewertung des CSPP-Einflusses auf die Marktliquidität kann dazu beitragen, das Verständnis des Transmissionsmechanismus unkonventioneller Geldpolitik zu verstehen. Der Einfluss der Anleihekäufe auf die Renditen von Unternehmensanleihen wird gemäß Literatur insbesondere über die Liquiditätsprämie und Duration einer Unternehmensanleihe sowie durch lokale Angebotseffekte transportiert.

Ergebnisse

Die Ergebnisse unserer Studie zeigen, dass die Ankäufe von Unternehmensanleihen die Liquidität am deutschen Unternehmensanleihemarkt kurzfristig verbessert haben (Flow-Effekt), wobei die geschätzten Effekte vergleichsweise klein sind. So verringerten sich die Geld-Brief-Spannen bei einem durchschnittlichen Ankaufsvolumen von €7 Mio um 0.7 Basispunkte am Tag der Anleihekäufe. Die Liquiditätsbedingungen verschlechterten sich jedoch nach dem Ende der Netto-Anleihekäufe, da sich das am Sekundärmarkt verfügbare Handelsvolumen reduzierte (Stock-Effekt). Bei einem über die gesamte Laufzeit des CSPP durchschnittlichen Ankaufsvolumen pro Anleihe in Höhe von €29 Mio stieg z.B. die Geld-Briefspanne um 1 Basispunkt.
Die Ergebnisse unserer Analyse zeigen auch, dass sich die Liquidität von älteren und ohnehin illiquiden Anleihen sowohl kurz- als auch langfristig verschlechtert hat. Hingegen hat sich die Liquidität kürzlich emittierter und vergleichsweise liquider Anleihen verbessert.

Bundesbank Discussion Paper No 08/2021

Liquidity in the German corporate bond market: has the CSPP made a difference?*

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Abstract

The Eurosystem purchased €178 billion of corporate bonds between June 2016 and December 2018 under the Corporate Sector Purchase Programme (CSPP). Did these purchases lead to a deterioration of liquidity conditions in the corporate bond market, thus raising concerns about unintended consequences of large-scale asset purchases? To answer this question, we combine the Bundesbank's detailed CSPP purchase records with a range of liquidity indicators for both purchased and non-purchased bonds. We find that while the flow of purchases supported secondary market liquidity, liquidity conditions deteriorated in the long-run as the Bundesbank reduced the stock of corporate bonds available for trading in the secondary market.

Keywords:
Corporate Bond Market, Central Bank Asset Purchases, Market Liquidity

JEL classification: E52, F30, G12

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1 Introduction

In 2016, the Eurosystem launched the Corporate Sector Purchase Programme (CSPP) as part of its large-scale Asset Purchase Programme (APP) with the objective to bring inflation back to levels in line with the ECB's target. But besides their intended impact on economic activity, central bank asset purchases are likely to also affect market functioning by providing a predictable source of demand for bonds, for example. Because of this 'back-stop' buyer effect, dealers are more willing to hold larger inventories to facilitate market-making. In addition, asset purchases can stimulate trading activity as dealers are likely to purchase another bond after selling one to the Eurosystem. On the other hand, asset purchases can also lead to a deterioration of market liquidity in particular if the purchase programme is relative large. If a large proportion of corporate bonds is held by the Eurosystem, sourcing a particular bond can become more costly for dealers (Ferdinandusse, Freier, and Ristiniemi (2017)).

In view of these ambiguous predictions, this paper estimates the impact of CSPP purchases on market liquidity in the market for German corporate bonds using a granular dataset of the Bundesbank's individual CSPP purchases. We assess both "flow" and "stock" effects of the purchases, where flow effects measure the contemporaneous impact of the Bundesbank's purchases on market liquidity. In contrast, stock effects measure the accumulated impact of the purchases on liquidity conditions prevailing in the German corporate bond market after the end of CSPP net purchases in December 2018 compared to before these purchases had begun. In addition, the granularity of our dataset allows us to explore how these effects of CSPP purchases on market liquidity vary across market conditions and bond characteristics.

Identification of flow effects of central bank asset purchases on liquidity is inherently difficult (Boneva, Elliott, Kaminska, Linton, McLaren, and Morley (2018)). Specifically, the impact of purchases on liquidity is likely to be confounded by reverse causality that arises if, for example, financial institutions prefer to sell more illiquid bonds to the central bank that are more difficult to sell in secondary markets. Also, reversed causality is a concern if liquidity considerations play a role in the purchasing decision of the central bank due to risk management considerations, for example. We follow Boneva, Elliott, Kaminska, Linton, McLaren, and Morley (2018) and tackle these identification challenges by using our granular dataset containing a wide range of information about the purchase process to construct proxies for supply and demand to control for reverse causality.

We find that initially, the Bundesbank's corporate bond purchases improved contemporaneous liquidity conditions in the market for German corporate bonds (flow effect) albeit the estimated effects are relatively small. For an average purchase size of €7m, bid-ask spreads of purchased bonds tightened by 0.7bps on the day of the purchase compared to

an average bid-ask spread of 35bps and trading volume increased by €0.6m compared to an average of 2.5 for purchased bonds. However, liquidity conditions deteriorated as the Bundesbank reduced the stock of corporate bonds available for trading in the secondary market (stock effect). This is particularly true for the resilience measures studied. For the average volume purchased by bond over the lifetime of the CSPP (€29m), we find that the number of quotes received for a purchased bond compared to a not purchased bond fell by around 2.2 and the number of dealers quoting the bond fell by around 0.3, compared to their averages of 137 and 12, respectively. These findings are consistent with Ferdinandusse, Freier, and Ristiniemi (2017) who develop a search-theoretic framework to study the impact of asset purchases by central banks on prices and liquidity. In line with our results, their model predicts that liquidity improves initially as the central bank constitutes another large player in the market that stands ready to buy. After the end of the central bank purchases, their model predicts that liquidity is worse than before the start of the purchases because of the lower free-float available for private investors.

The purchases were carried out both during tranquil periods and periods of heightened market volatility. For example, the UKs vote to leave the EU, the Italian elections in early 2018, and the US-China trade war all took place during the purchase period. In addition, the eligibility criteria for the CSPP are relatively broad, covering bonds with a wide range of different characteristics. One reason for this broad approach is the concept of market neutrality underlying the CSPP implementation aiming at minimizing potential unintended side effects on market functioning. Therefore, we also assess how the impact of the purchases varied across market conditions and bond characteristics. Considering the flow effect, for example, CSPP purchases tightened bid-ask spreads for a bond with an average age of around 3 but bid-ask spreads widen instead for bonds with an age of 4.7 and older. One explanation for this result could be that bonds are traded more frequently when newly issued. As they age, bonds are traded less frequently as a significant portion is purchased by buy-and-hold investors who reduce the free float available for trading by other investors (Mahanti, Nashikkar, Subrahmanyam, Chacko, and Mallik (2008)). Thus, central bank purchases of old bonds may reduce their liquidity further. Moreover, this could imply that the CSPP has mainly improved the liquidity of already more liquid bonds, thereby potentially favouring a "bifurcation" of corporate bond liquidity. Regarding the stock effect, the CSPP impact also seems to depend strongly on age. For example, the Amihud illiquidity measure increases for an average age of 2 years, and the number of quotes increases for bonds since issuance.

These findings add to our understanding of the transmission mechanism of unconventional monetary policies. In particular, liquidity premia are often mentioned in addition to duration or local supply effects as one channel through which corporate bond purchases

affect corporate bond yields. Our results provide evidence that central bank purchases of corporate bonds can affect these premia both in the short- and long run.

There is a growing literature that assesses the impact of central bank asset purchases of sovereign bonds on secondary market liquidity, often reaching contrasting results. For example, Eser and Schwaab (2011), De Pooter, Martin, and Pruitt (2018) and Steeley (2015) find that government bond purchases improved liquidity while Han and Seneviratne (2018) and Kurosaki, Kumano, Okabe, and Nagano (2015) find that the Bank of Japan's sovereign bond purchases damaged liquidity. Some papers find mixed evidence within a single purchase programme, including Schlepper, Hofer, Riordan, and Schrimpf (2020), Pelizzon, Subrahmanyam, Tobe, and Uno (2018), Christensen and Gillan (2018) and Iwatsubo and Taishi (2016). In part, these contrasting results are perhaps due to differences in purchase size and design across countries, consistent with Ferdinandusse, Freier, and Ristiniemi (2017). Also, the period when as asset purchase programme is carried out and the length of its application play an important role. Accordingly, central banks purchases tended to improve market functioning particularly in markets with high liquidity premia including those experiencing periods of stress and for less liquid securities such as private sector assets or off-the-run government securities. A case in point are Eser and Schwaab (2011), De Pooter, Martin, and Pruitt (2018) who analyze the effects of the SMP programme in different euro area bond markets during the euro debt crisis and find a positive effect. On the other hand, declines in market making and reduced investor participation have occurred in some markets, in particular where policies were in place for an extended period of time (BIS Markets Committee (2019)).

Compared to sovereign bonds, the literature on the impact of non-sovereign bond purchases on liquidity is still relatively scarce. Exceptions include Kandrac (2013) and Kandrac (2018) who find that the Federal Reserve's MBS purchases damaged liquidity in these markets. In contrast, Todorov (2018) finds that liquidity of CSPP-eligible bonds increased at the announcement of the scheme. Also, Beirne, Dalitz, Ejsing, Grothe, Manganelli, Monar, Sahel, Susec, Tapking, and Vong (2011) find positive effects of the Eurosystem's covered bond purchase scheme on market liquidity and covered bond spreads. In addition, Boneva, Elliott, Kaminska, Linton, McLaren, and Morley (2018) document that Bank of England's corporate bond purchases improved market liquidity in the Sterling corporate bond market just after the purchases took place, but do not detect any longer term effect of these purchases. They pioneered the use of granular data from central bank purchase operations to tackle reversed causality issues and our paper follows their approach. Using a similar methodology, we also find a positive effect of central bank purchases in the short-run. But our results for the long-run effect of central bank corporate bond purchases on liquidity in the German corporate bond market contrast sharply with

those for the sterling market. In particular, we present evidence for sizable longer term or stock effects from the Bundesbank's CSPP purchases while Boneva, Elliott, Kaminska, Linton, McLaren, and Morley (2018) do not detect any longer term impact in case of the Bank of England's CBPS purchases. We attribute this difference to the difference in the overall amount purchased relative to the size of the eligible universe. The Bank of England purchased only 5% of eligible Sterling corporate bonds (Belsham, Maher, and Rattan (2017 Q3)) while the corresponding number for the Eurosystem's corporate bond purchases is much larger with around 16%[1].

Finally, there is also a range of papers examining the impact of the CSPP on corporate bond spreads and issuance of euro-denominated corporate bonds (De Santis, Geis, Juskaite, and Vaz Cruz (2018), Hammermann, Leonard, Nardelli, and von Landesberger (2019), Zaghini (2017), Arce, Gimeno, and Mayordomo (2017), Grosse Rueschkamp, Steffen, and Streitz (2019) and Abidi and Miquel Flores (2018)). In contrast to their work, we study the CSPP through the lens of a granular dataset containing information about the purchase process to tackle the identification challenges discussed above.

The remainder of this paper is organized as follows. Section 2 provides an overview of the CSPP and how the purchases at the Bundesbank are carried out which informs our identification strategy. Section 3 introduces both the data on the Bundesbank's CSPP purchases and our liquidity measures for the German corporate bond market. Section 4 studies flow effects by relating CSPP purchases to contemporaneous liquidity conditions prevailing in the German corporate bond market. Section 5 examines the longer term or so-called stock effects of the Bundesbank's CSPP purchases on market liquidity. Section 6 concludes.

2 The ECB's Corporate Sector Purchase Programme: overview and design

2.1 Overview

The ECB announced its Corporate Sector Purchase Programme in March 2016 against a backdrop of deflationary pressure and headwinds to growth in order to ease financing conditions in the euro area, hence supporting investment and growth and facilitating the return of euro area inflation to its target level to below, but close to, 2 percent over the medium term.

The CSPP was part of a broader set of policy measures that were introduced in order

[1]This figure also broadly represents the individual National Central Banks' share of CSPP purchases relative to the eligible universe of the respective corporate bond market.

to achieve the price stability target of the Eurosystem: (i) a cut in key ECB interest rates; (ii) a new series of four targeted longer-term refinancing operations and (iii) an increase in the monthly net sovereign bond purchases under the APP from €60 billion to €80 billion.

Eligibility criteria for the CSPP are broad-based and cover a wide range of euro-denominated bonds that are issued by euro area non-bank corporations. Specifically, corporate bonds are eligible for the CSPP if they fulfill the following criteria (ECB (2016)): they are eligible as collateral for Eurosystem credit operations; they are denominated in euro; they have a minimum first-best credit assessment of at least BBB- or equivalent obtained from an external credit assessment institution; they have a minimum remaining maturity of six months and a maximum remaining maturity of 30 years at the time of purchase; the issuer is a corporation established in the euro area, defined as the location of incorporation of the issuer[2] and not exceed the upper bound on the Eurosystem's holdings of 70 percent per security[3]. Corporate bonds issued by credit institutions, institutions with a parent qualifying as a credit institution, asset management vehicles, or national asset management and divestment funds established to support financial sector restructuring and/or resolution are not eligible for purchases under the CSPP.

CSPP purchases started on 8 June 2016 and took place in both the primary and secondary market, and were implemented by the Bundesbank, Banque de France, Banca D'Italia, Banco de Espana, Suomen Pankki, and Banque Nationale de Belgique on behalf of the Eurosystem. In terms of efficiency, the Eurosystem decided that not all 19 national central banks (NCB) and the ECB carry out the purchases, also due to a very small universe of the corporate bond markets in some jurisdictions. National central banks had some discretion regarding how to implement the purchases operationally while the Eurosystem coordinated the purchases by establishing a common set of eligibility criteria and setting the overall amount to be purchased by each NCB in a particular month.

An important criterion guiding the CSPP purchases is market neutrality aimed at minimizing the impact on relative prices within the eligible universe and potential unintended side effects on market functioning (Hammermann, Leonard, Nardelli, and von Landesberger (2019)). For the CSPP, market neutrality implies that NCBs participating in the purchases aimed at keeping their holdings by issuer and sector as close as possible to their respective market shares in the eligible universe of the respective corporate bond market. To further limit negative effects on market functioning, CSPP holdings are avail-

[2]Corporate debt instruments issued by corporations incorporated in the euro area whose ultimate parent is not based in the euro area are also eligible for purchase under the CSPP, provided they fulfill all the other eligibility criteria.

[3]The threshold of 70 percent is applied to bonds issued by private corporations and is lower for public issuers.

able for securities lending by the relevant purchasing national central banks, who publish a list of the individual bonds they hold on a weekly basis without revealing the size of their holdings in each bond.

In December 2018, the ECB's Governing Council announced to end net asset purchases under the asset purchase programme that also includes the CSPP, while continuing to reinvest principal payments from maturing securities purchased. But purchases under the APP were restarted as of November 2019 against a backdrop of muted inflationary pressure and weakness of the euro area economy.

During the initial phase of the APP (2015-2018), the total purchase volume has been adjusted several times until net purchases have ended in December 2018. With this gradual reduction the CSPP purchase volume has also declined, although by less in relative terms compared to the Public Sector Purchase Programme (PSPP).

2.2 The Bundesbank's CSPP purchases

The Bundesbank purchases eligible corporate bonds both on the secondary and primary market, with the former constituting the majority of its purchases. To purchase corporate bonds from the secondary market, the Bundesbank collects individual dealer's offers of eligible ISINs obtained via email on a regular, usually daily, basis. The decision of which eligible bond to purchase depends on different factors. One factor is market neutrality that requires the Bundesbank to keep its holdings by issuer as close as possible to their market shares in the universe of eligible collateral for tender operations. Other relevant factors include the offered volume and the monthly volume target provided by the ECB. All factors are equally important.

After the ISINs to be purchased are chosen, the Bundesbank usually sends request for quotes (RFQ) to those dealers who clearly display their inventories in the respective ISIN to the Bundesbank or who are known to be active in this particular bond segment. In rare occasions, the Bundesbank contacts the dealers directly through chat or phone to request their prices and to trade with the dealer. The Bundesbank decides about the quantity to purchase based on its monthly volume targets provided by the ECB. One bond may be purchased more than once per day.

The Bundesbank also buys a certain amount of bonds on the primary market. Between January 2017 and October 2018 the Bundesbank participated in several corporate bond auctions of non-public owned companies. Among all 51 issuers, 6 issuers are public which is why these bonds cannot be purchased on the primary market, i.e. due to the restriction of "no monetary financing of the public sector".

3 Data

3.1 Purchase data

While the Bundesbank purchases bonds both on the primary and on the secondary market, we only use secondary market purchases as they can be directly linked to the secondary market liquidity that is the focus of our paper.[4]

Figure 1 shows the aggregate monthly purchase volume splitted by sectors (in €m). The highest share of purchases by the Bundesbank is carried out for the consumer cyclicals sector, although the relative shares vary also over time. The financial sector refers to insurance companies and real estate, banks are excluded.

Table 1 and Figure 2 report descriptive statistics for both the RFQ process and purchases for all secondary market transactions. On a typical day, the Bundesbank sends a RFQ to 22 different dealers for each bond it is interested in purchasing. These RFQs are usually sent via two different trading systems. The RFQ process is carried out for on average 8 different bonds per day. However, this number varies strongly over time in a range between 1 and 24, probably also dependent on Bundesbank's specific volume targets. The offered volume by bond is around €76m on average. Turning to the purchases, each bond is purchased on average 2.5 times per day. The average purchase size is around €3m but exhibits a relatively high volatility as well. The overall traded volume by bond varies relatively strongly, too: while the average is around €7m, there are cases when no trade occurs at all and transactions with high volumes of up to €262m. This suggests that the trades indeed may depend on quantities offered and on market conditions. Finally, the coverage ratio is calculated by dividing the overall volume purchased of a specific bond by the total volume offered in the RFQ process. It is on average 0.10, meaning that the Bundesbank roughly purchases 10% of what the banks offer. Figure 2 shows that most of these RFQ and trade statistics are nearly equally spread over maturity buckets. While more trades are carried out in the small bucket of 0-3 years residual maturity, more volume has been purchased at larger ticket size in the large maturity bucket ($>$ 7 years residual maturity).

Table 2 provides more detailed information on the frequency of the Bundesbank's CSPP purchases. In around 4% of all trading days, no transaction occurred. One reason for why this can happen is that the prices offered by dealers are too unattractive. Another

[4]Our RFQ and trade dataset doesn't contain any identification of primary purchases which is why we have to apply different criteria obtained from Bundesbank portfolio managers to exclude them. Primary purchase data is excluded by dropping (1) all purchases larger than €10m, and (2) all purchases that take place within the first 7 days after bond issuance. Usually, the acquisition of corporate bonds on the primary market takes place via auctions or bilateral purchases on or close to the issuance day and at large volumes.

reason is that there might be too few prices offered to Bundesbank or finally, the difference to the previous transaction price is too high. In any of these cases, the Bundesbank rejects the offer and the RFQ process does not result in a trade. The case observed most frequently is that one or two trades per bond are observed per day. In 90% of the cases, no more than four and in 99% no more than nine trades take place in a specific ISIN on a daily frequency. In our study period from the start of the CSPP in June 2016 to December 2018 overall 362 bonds have been purchased by Bundesbank.

3.2 Liquidity measures

In order to measure liquidity in the German corporate bond market at the individual bond level, we use daily price-based data (dealer quotes) from Markit and trading activity data from Euroclear. Overall, our dataset consists of 246 senior unsecured fixed coupon investment grade (IG) bonds issued by German non-financial corporations, denominated in euro, with a remaining maturity between one and ten years, a maturity at issuance of at least 1.5 years and a minimal amount outstanding of €500m. Moreover, the dataset also includes 28 senior unsecured fixed coupon high yield (HY)bonds issued by German non-financial corporations, denominated in euro, exhibiting a minimal amount outstanding of €250m. A bond is classified as HY if its average credit rating is at or below BB+. We use HY bonds in the subsequent analysis as some of these bonds fulfil the ECB eligibility criterion of exhibiting a first-best rating of at least BBB- and can thus be purchased under the CSPP. Furthermore, we use HY ineligible bonds as control group in our analysis in addition to the baseline group of eligible non-purchased bonds. In our dataset, the non-financial sector does not include real estate companies and bonds issued by non-bank financial institutions (such as insurances). Compared to the overall size of the corporate bond market as measured by our dataset, the German subset comprises around 21% of the overall IG universe and around 12% of the overall HY universe.

Liquidity is multifaceted and therefore a unique definition does not exist. In general one can distinguish between four liquidity dimensions, i.e. tightness, immediacy, depth, and resilience.[5] We use the bid-ask spread, i.e. the difference between ask price and bid price of a bond as a proxy for tightness. This measure can be interpreted as the costs of executing a trade. The lower the spread the easier a bond should be purchased and sold and, thus, the better should be the liquidity conditions. As a further measure of tightness we also employ the effective bid-ask spread proposed by Roll (1984). As Roll (1984) shows, under certain conditions the effective bid-ask spread corresponds to two

[5] As a fifth dimension sometimes breadth is used. It implies that in a liquid market big orders should not have a significant impact on prices. Following the CGFS (2016) we use depth and breadth as one facet of liquidity.

times the square root of the negative first-order autocovariance of returns.

In order to capture immediacy we use the range of high and low prices during a day. The idea behind it is that in case of poor immediacy, trades cannot easily be executed. However, once executed price fluctuations are high and, thus, a wide range should be an indicator of poor immediacy and vice versa (see Broto and Lamas (2016), and Broto and Lamas (2019)). As a second proxy for immediacy, we employ the variable time to unwind, defined as the number of days to exit a €5m position. Markit calculates this measure as €5m divided by the expected daily trading volume. The latter is defined as trades per day times the average ticket size (in €m) over the last 30 days.

Trading volume-based liquidity measures (which have been transformed to daily basis), i.e. the 30 day trading volume of daily transactions, and the illiquidity measure of Amihud (2002) have been employed in order to capture the aspect of depth. In general, higher trading volumes are considered positive from the liquidity perspective, while high price sensitivity in response of a bond purchase or selling suggests a poor liquidity and vice versa. Thus, an increase of the Amihud illiquidity measure (defined as the absolute one day price return (in bps) divided by the trading volume) suggests a deteriorating liquidity and vice versa.

The aspect of resilience is represented by the liquidity measures average ticket size, the number of dealers quoting the bond averaged over one business day, and the number of unique quotes received for an instrument over one business day. High values of these measures indicate a high liquidity and low values a poor liquidity on the corporate bond market.[6] Table 3 summarizes the liquidity measures employed in this analysis.

Figures 3-6 document that liquidity conditions changed markedly over the period from early 2015 to early 2019.[7] In the period before the announcement of CSPP from the second half of 2015 to early 2016, financing and liquidity conditions deteriorated significantly owing to concerns on the growth prospects of China and other large emerging countries, and weaker than expected US economic data. HY bonds reacted stronger to the increased volatility, as e.g. indicated by the sharp increase of the Roll measure for HY bonds in early 2016.

[6]Notice that we have winsorised liquidity measures at 1% and 99% to reduce the impact of extreme outliers.

[7]Notice that some regulatory changes during this period could have affected liquidity of corporate bonds. Regulatory reforms such as Basel III make highly liquid bonds more popular than bonds considered as less liquid. The liquidity coverage ratio, for example, requires banks to hold a certain ratio of high-quality assets such as highly rated government and corporate bonds. However, at the same time other investors have compensated at least partially the declining demand of the banks for other than high-quality bonds. Moreover, since only a small part of German non-financial corporate bonds exhibits a high credit quality (i.e. a AA rating or better), the impact of regulatory reforms on the German market should be rather moderate.

The CSPP was announced against the backdrop of receding uncertainty in financial markets as growth prospects started to improve in early 2016. At this time, the Eurosystem announced the CSPP, thereby leading to an immediate significant decrease in spreads of eligible corporate bonds as evidenced by De Santis, Geis, Juskaite, and Vaz Cruz (2018). And Todorov (2018) finds that liquidity of CSPP-eligible bonds increased at the announcement of the scheme. Over most of the CSPP purchase period from March 2016 to mid-2018, liquidity measures like bid-ask spread, Roll, daily range, Amihud, average ticket size, the number of dealers, and the number of quotes continued to improve. A striking feature is that the number of quotes per bond increased extraordinary strong in 2018. A reason for this observation could be the strong issuance activity on the European corporate market during the CSPP purchase period (De Santis, Geis, Juskaite, and Vaz Cruz (2018)). The other liquidity measures (time to unwind and trading volume) suggest a slight deterioration or do not allow for a clear conclusion. In the second half of 2018, concerns around a further escalation in the trade dispute between the US and China caused an increase of risk aversion and thus a deterioration of market liquidity. Moreover, market liquidity usually declines at the end of the year. The end of net purchases in December 2018 was widely expected by the market participants and did not trigger a strong market reaction.

Overall, despite deteriorating conditions in the second half of 2018, liquidity conditions improved in general after the CSPP announcement as suggested by the comparison of the liquidity measures' mean values before and after the announcement of the CSPP (Tables 4-8). However, as discussed above, the CSPP purchases took place at the same time as a wide range of other events with potentially sizable effects on the German corporate bond market including the UK's vote to leave the EU, the Bank of England's corporate bond purchases and the US-China trade dispute, among many others. Therefore, we now carry out an econometric analysis to control for these confounding events and hence to isolate the impact of CSPP purchases on market liquidity.

4 Flow effects of Bundesbank's CSPP purchases on liquidity

We start by estimating the contemporaneous effect of the Bundesbank's corporate bond purchases on liquidity. This so-called flow effect of the CSPP offers insights into how individual purchases affected market functioning in the German corporate bond market immediately after the purchases are carried out. But estimating these effects is plagued by reversed causality and the next section explains how we tackle this problem.

4.1 Identification

Identifying the impact of purchases on liquidity or prices is difficult because of reverse causality: in general, dealers take into account liquidity indicators when deciding about whether or not to sell a bond to an NCB, and NCBs' purchasing decisions are likely to depend on liquidity, too.[8] To reduce this reverse causality issues, we explore design features of the Bundesbank's purchase mechanism, together with detailed data about the purchases.

As described in Section 2.2 above, the Bundesbank's purchase decision depends on market neutrality, dealers' inventories and the purchase target. While the latter does not depend on liquidity, liquidity conditions can have an impact on dealers' inventories if, for example, dealers are more willing to hold liquid bonds. Liquidity conditions can also affect by how much the Bundesbank's holdings deviate from market neutrality if past purchases depend on liquidity, which is likely to be the case. However, according to Bundesbank's trading desk, liquidity considerations don't play a direct role in their trading approach, but affect the RFQ process only indirectly. If the Bundesbank sends many requests to dealers for a specific bond, this is only a consequence of a large number of offers the Bundesbank portfolio managers receive previously. The more liquid a bond, the more dealers usually hold the bond and the more offers the Bundesbank should receive.

Concerning the dealer's decision to sell a bond, there are at least two potential mechanisms through which liquidity can affect that decision. First, dealers are more likely to hold more liquid bonds in their inventory. Indeed, the Bundesbank receives more offers for liquid compared to illiquid bonds. This can be controlled for by the number of offers received for a specific bond. Second, liquidity can affect dealers' decision whether or not to respond to the RFQ. On the one hand, pricing illiquid bonds could be difficult so dealers may not be able to provide a price quote within the time frame provided by the RFQ. On the other hand, dealers may be more willing to sell less liquid bonds to the Bundesbank as these bonds are more difficult and costly to sell in the secondary market.

To sum up, liquidity can affect purchases both via the Bundesbank's purchase decision and via dealer's inventory and RFQ decisions. This can be controlled for by the number of RFQ sent (which corresponds to the number of dealers holding that bond), the corresponding volumes and the number of trades taking place. Differently put, the variables

[8]For example, ECB confirmed publicly to take market conditions into account when selecting bonds to be purchased: "When implementing the CSPP, the Eurosystem is mindful of the potential impact of its purchases on market liquidity. Its participation in primary market purchases aims at striking a balance between the objective of the programme and the need to ensure continued market functioning. Similarly, when buying in the secondary market, it considers, inter alia, the scarcity of specific debt instruments and general market conditions, i.e. with a certain degree of flexibility to also take into account seasonal differences." See: https://www.ecb.europa.eu/mopo/implement/omt/html/cspp-qa.en.html

obtained from the RFQ process are observed factors that are correlated with both liquidity and the purchase decision. So controlling for these factors reduces the endogeneity problem. A formal argument why this approach works based on econometric theory is presented in Boneva, Elliott, Kaminska, Linton, McLaren, and Morley (2018).

4.2 Econometric model

To estimate the flow effect of CSPP purchases on purchased bonds we use a difference-in-difference design with a continuous treatment variable:

$$\text{Liquidity}_{bt} = \alpha_b + \mu_t + \beta \text{Purchases}_{bt} + \kappa' X_{bt} + \epsilon_{bt} \tag{1}$$

where Liquidity_{bt} is liquidity for bond b and day t, Purchases_{bt} is the amount purchased, X_{bt} are control variables for reverse causality. Specifically, we use the number of RFQs sent, number of trades and the volume offered from dealers that proxy for supply and demand factors. Because purchases usually take place during the morning hours, we can measure liquidity of the purchase day itself (assuming there is enough trading volume).

The treatment group are thus bond purchased on day t, containing an overall number of 218 bonds.[9] The treatment is "staggered" in the sense that the group of purchased (or treated) bonds differs across days. In contrast to the treatment group, the set of bonds in the control group is constant. We consider three different control groups:

1. **Eligible bonds that were not purchased**. These bonds account for only 11 percent of our sample of 274 bonds from German issuers in total. As discussed in section 2 above, there are a wide range of reasons for why eligible bonds were not purchased such as the binding criterion of market neutrality.

2. **Non-eligible investment-grade bonds**. In this control group, we use data on bonds issued by non-financial corporations (excl. real estate companies) from non-euro area EU countries and from the UK. There are a total of 204 bonds in this control group.

3. **Non-eligible high-yield bonds**. As above, this control group is not limited to German corporate bonds, and includes a total of 144 bonds issued by corporations from the EU (incl. Germany) and from the UK exhibiting a first-best rating of less than BBB-.

An important assumption when using a difference-in-difference design is that absent the Bundesbank's purchases, the difference in liquidity between purchased bonds on the one

[9]This number is lower compared to the total number of bonds purchased because of limited availability of our liquidity measures.

hand and the different control groups on the other is constant over time. Inspecting Figures 3-6, the liquidity trends before the announcement of the CSPP are indeed parallel with exception of HY ineligible bonds for some liquidity measures.

For our baseline results, we use the first control group, that is eligible but not purchased bonds. Unlike the other control groups, this control group allows us to construct proxies for demand and supply, hence tackling reverse causality issues.

Because of portfolio rebalancing, our analysis could underestimate the effect of CSPP purchases on liquidity if there are significant spill-overs between liquidity conditions of purchased bonds and those prevailing for our control groups. We expect this to be less of an issue for the non-eligible IG and HY control groups as they also include non-German bonds.

4.3 Baseline results

We find that liquidity conditions for purchased bonds improved in the immediate aftermath following the purchases, covering different dimensions of liquidity (Table 9). But albeit statistically significant, the estimated flow effects are economically small: for our baseline control group of bonds that are eligible but have not been purchased, we find that for an average purchase size of €7m, bid-ask spreads of purchased bonds tightened by about 0.7bps on the day of the purchase compared to an average bid-ask spread of 35bps for purchased bonds. Concerning our measures of market resilience, there is an additional 1/5 dealer quoting the bond for an average purchase size and the average ticket size is up by €0.04m, compared to an average of 12 and €0.8m, respectively. Our trading volume measure[10] of market depth indicates an improvement, too: for an average purchase size, trading volume is up by €0.6m compared to an average of €2.5m for purchased bonds.[11]

The flow effects estimated for the other control groups are similar or even perhaps a bit larger (Tables 10-11), but our proxy variables controlling for reverse causality are not available for ineligible bonds which complicates inference. Another interpretation of the somewhat larger results for the other control groups is that those are less affected by portfolio rebalancing, indicating that our baseline results should be interpreted as a lower bound.

[10]Notice that the volume traded by the Bundesbank is not included in the trading volume. The latter includes only the volume traded by the dealers.

[11]Our regression results show that the effect of the purchases decreases within the next five trading days for most liquidity measures. However, the results are not reported but can be provided upon request.

4.4 Heterogeneity across bonds and time

As a consequence of the broad eligibility criteria specified by the ECB for CSPP purchases, the bonds included in our analysis are quite different. In addition, CSPP purchases took place between mid-2016 and end of 2018, covering both calm periods and periods of increased financial market stress such as the UK vote to leave the EU, the Italian elections in spring 2018 and the US-Chinese trade war starting in early 2018 as well as raising fears about trade and economic growth starting to weigh on markets in the end of 2018. To assess whether the estimated effects differ across time and bond characteristics, we add an interaction term to our baseline specification:

$$\text{Liquidity}_{bt} = \alpha_b + \mu_t + \beta \text{Purchases}_{bt} + \phi \text{Purchases}_{bt} \times Z_{it} + \psi Z_{it} + \kappa' X_{bt} + \epsilon_{bt} \qquad (2)$$

where all variables are defined as above with exception of Z that is an indicator of bond characteristics or market conditions.

Specifically, we consider how the flow effect vary across age, bond size, residual maturity, the term spread, ifo business climate indicator and the MOVE index that tracks volatility in US Treasuries. For this purpose, we use data from Bloomberg, and ICE Data. Age (defined as the time elapsed since issuance) and amount issued are bond-specific characteristics that might be closely linked to liquidity. Since according to the ECB statistics, the Eurosystem buys a higher share of recently issued bonds than their market weight, the impact of purchases on liquidity could depend on the age of a bond. Moreover, newly issued ("on-the-run") bonds are usually more liquid than old ("off-the-run") bonds. One reason could be that in the course of time, a significant portion of corporate bonds are purchased more and more by long-term (buy-and-hold) investors who reduce their free float. Purchases of old (and thus already illiquid) bonds by central banks may additionally reduce their free float and, thus, their liquidity. This could imply that due to the CSPP liquidity has mainly improved in the already more liquid bonds, which is known as "bifurcation" of liquidity (Dudley (2016), Boneva, Elliott, Kaminska, Linton, McLaren, and Morley (2018)). We would like to analyze whether the CSPP has supported or leaned against this effect.

Also, residual maturity might play a role in the impact of purchases as bonds with long remaining maturities should be more liquid than those with short remaining maturities. Finally, we consider bond size, which is defined as the amount issued in the specific bond. Size is also linked to liquidity in the sense that bonds that were issued at higher volumes are usually the more demanded and hence the more liquid ones. For example, low volume bonds are not eligible for inclusion into benchmark bond indices. The term spread is defined as the difference between the 10-year and the 2-year yield of a German government bond. It is often considered as a predictor of recessions and closely linked

to the business cycle. The ifo index is a business climate index based on surveys among managers in Germany. So both measures capture the economic constitution of Germany. The MOVE index is a measure of bond market volatility based on options of the US Treasury yield curve and closely correlated to bond market volatility in the Euro area. We expect that both the economic environment and the market volatility play a role for the effect of the CSPP purchases. It is likely that the impact was larger in times of heightened market stress and insufficient demand by market participants.

Perhaps not surprisingly, we find that the estimated flow effects vary both across bonds and time (Figure 7, Table 13). Figure 7 illustrates these differences in the impact of CSPP purchases across bonds and time graphically for selected liquidity indicators, bond characteristics and economic time series. For example, we find that at the average (median) age of 2.7 years for bonds included in our baseline sample, CSPP purchases tighten bid-ask spreads of purchased bonds compared to eligible but not purchased bonds. However, for bonds with an age of 4.7 years or higher, we observe a widening in bid-ask spreads instead, which could be interpreted as evidence for the bifurcation hypothesis. Running the analysis only for old bonds (i.e. for bonds aged more than the median) confirms the result that for older bonds the bid-ask spreads widen (albeit not significantly different from zero, see Table 12.) Similarly, we find that for high levels of the term spread (indicating that markets expect short-term rates to increase in the future), CSPP purchases reduce the number of dealers, while the opposite effect is observed if the term spread is low. Some interpret a low term spread as a sign of an impeding recession,[12] similar to a low reading of the business climate index. So perhaps not surprisingly, the marginal effect of CSPP purchases on the number of dealers is declining in the business climate index too. Finally, we find that CSPP purchases reduced the time to unwind in times of low volatility, but had opposite effects when volatility was high.

4.5 Robustness

One concern with our liquidity measures is that some German corporate bonds are relatively illiquid and these bonds are often not traded on a specific day. So because we cannot measure liquidity for some of the most illiquid bonds in our daily dataset, our results may be biased. Also, computing some liquidity measures in general on the basis of very few underlying trades may render them unreliable. To assess if that is the case, we construct a weekly version of our dataset where we observe more trades per bond to construct our liquidity measures. Results are reported in Table 14 and confirm our results based on the daily dataset: the flow effects on liquidity of purchased bonds from

[12]But others disagree, documenting that the term spread has lost some of its predictive power for GDP growth over the ZLB period (Fendel, Mai, and Mohr (2019))

the Bundesbank's CSPP purchases are significant but relatively small.

5 Stock effects

In addition to flow effects, it is interesting to assess the impact of the Bundesbank's corporate bond purchases on liquidity in the long run, that is, extending beyond the purchase phase. In contrast to flow effects, these so-called stock effects assess the cumulative impact of the purchases on market functioning by comparing liquidity conditions before the announcement of the purchases with those prevailing in the market after the purchases came to an end.

5.1 Econometric model

To empirically quantify the stock effects of the Bundesbank's CSPP purchases, we estimate a cross-sectional regression relating the difference in market liquidity over the lifetime of the scheme to the cumulative amount purchased in addition to other bond characteristics. Importantly, we also control for the Eurosystem's sovereign bond purchases that were carried out at the same time:

$$\Delta\text{Liquidity}_b = \mu + \beta\text{Total purchased amount}_b + \kappa' X_{1b} + \phi' \Delta X_{2b} + \epsilon_b \tag{3}$$

where $\Delta\text{Liquidity}_b$ denotes the change in liquidity of bond b in the week after purchases were completed minus the liquidity in the week before the CSPP was announced. The primary variable of interest is the total purchased amount, which is defined as the total quantity of bond b purchased over the entire purchase period. X_1 consists of variables measured just prior to the announcement of the CSPP: amount issued[13], age of the bond, credit rating, residual maturity, industry fixed effects, yield spread to reference bund, and amount outstanding of bunds with a similar residual maturity. ΔX_2 consists of variables computed over the duration of the scheme: change in credit rating, change in amount outstanding of bunds with a similar residual maturity, and PSPP purchases of bunds with a similar maturity. As for the flow effect, to account for influences like portfolio rebalancing within the group of eligible bonds, we consider different samples of bonds to which we compare the purchased bonds to. As above, these are: eligible but not purchased bonds; ineligible IG bonds and ineligible HY bonds.

[13]We use amount issued instead of amount outstanding due to better data availability. The correlation of amount outstanding and amount issued is very high with a correlation coefficient of around 0.75.

5.2 Baseline results

We find in the long run, some liquidity measures point to a sizable deterioration in liquidity conditions for purchased bonds in the German corporate bond market when compared to counterparts that were not purchased. When using eligible bot not purchased bonds as a control group (Table 15), most measures from the category of market resilience are significant, suggesting that this dimension of liquidity is particularly affected. For an average purchase amount of around €29m per bond over the lifetime of the scheme, the number of quotes received for a purchased bond compared to an eligible but not purchased bond fell by around 2.2 and the number of dealers quoting the bond fell by around 0.3, compared to their averages (for purchased bonds) of 137 and 12, respectively. Also, both measures of tightness are significant and show a slight deterioration in liquidity. The bid-ask spread increased by around 1 bps and the Roll measure also points to an increase in effective spreads by 0.8 bps, compared to their averages for purchased bonds of 35 bps and 7 bps, respectively. Finally, the range increased slightly, too, by 1.7 bps compared to an average of 60 bps.

Turning to the results when using ineligible IG bonds as a control group (Table 16) confirms the deteriorating liquidity figures of the first control group, but the results are less significant, in part explained by the lower number of observations. Specifically, the range widens by 2.5 bps for an average purchase amount of €29m compared to an average (for purchased bonds) of 60 bps, while the Roll measure indicates an increase in effective spreads by 1 bps, compared to its average of 7 bps for purchased bonds.

Finally, when comparing liquidity conditions for purchased bonds to ineligible HY bonds, there is also evidence for a slight deterioration (Table 17). In this setup also the dimension of depth is affected. The Amihud measure is 5 bps higher after CSPP net purchases ended which is sizable given its average of 14 bps of bonds purchased by Bundesbank. Among the spread measures, the Roll measure increases by 3.6 bps given an average of 7 bp. Using this control group, the differences in liquidity measures of the two bond groups from before to after the CSPP are very pronounced despite their low significance. The reason could be that liquidity measures of HY bonds display strong variation that can cause strong divergences in liquidity measures in specific market periods. This is also suggested by the large standard errors in Table 17. Moreover, as for the IG control group, the number of observations is much lower than for the first control group in the regression.[14]

[14]Despite the number of bonds in the IG and HY control groups are similar to the first one, many of these bonds have a shorter maturity and expire during the length of the CSPP which is why many of them don't serve as comparison to the treatment group of purchased bonds. Hence, we cannot compare their liquidity before the start to after the end of the CSPP.

5.3 Heterogeneity across bonds

We also assess if the estimated stock effects differ across bonds with different characteristics. To do so, we add an interaction term to our regression specification above:

$$\begin{aligned}\Delta\text{Liquidity}_b =& \mu + \beta\text{Total purchased amount}_b + \kappa' X_{1b} \\ &+ \phi'\Delta X_{2b} + \psi\text{Total purchased amount}_b \times \text{Z}_b + \phi'\text{Z}_b + \epsilon_b \end{aligned} \tag{4}$$

where Z_b are selected bond characteristics such as age, residual maturity and amount issued. We find evidence for such heterogeneity to matter for age and for size (Tables 18 and 19). There is no evidence of heterogeneity in the purchase effects for residual maturity (Table 20). Specifically, the effect of the CSPP on the number of dealers and the number of quotes declines, while the effect on the Amihud measure increases in the age of a bond. All three measures suggest that liquidity has mainly declined for older bonds over the course of the CSPP. This result could be related to the increased search frictions since the CSPP reduced the free float of corporate bonds which might increase trading costs and reduce the dealer's willingness to trade. Apparently, bonds that were issued already some years ago and are therefore usually less liquid are especially affected compared to recently issued bonds. This implies that resilience falls for less liquid bonds which supports the "bifurcation" hypothesis mentioned earlier. When interacting purchases with a measure of size, the interaction term is only significant for our baseline control group. While CSPP purchases increase the number of quotes and dealers for large issuance sizes in a particular bond, trading volume declines and the range widens over the course of the programme. So for these measures we find again a worsening for less liquid bonds.

Figure 8 illustrates some of these effects graphically. Panels a) and b) display the effect of CSPP purchases depending on age. As already described above, the effect of the CSPP purchases on the Amihud measure increases in age. This implies that for bonds older than 2 years, CSPP purchases lead to a worsening of depth over the period of the programme. The same is true for the number of quotes; the older a bond, the stronger is the decline in the number of quotes, representing poor resilience.

Panels c) and d) show how the effect of CSPP purchases depends on size for selected liquidity measures. For bonds with large issue sizes, CSPP purchases lead to a decline in trading volumes, while for smaller-sized bonds the impact is positive. The opposite findings can be observed for the range measure. The higher the issued amount of a bond, the wider is the range measure, indicating poor immediacy. So if the issue size of a bond is higher than the average amount of 0.75 billion euro, immediacy deteriorates throughout the CSPP and trading volume declines. Both of these effects might be indicative of the back-stop buyer channel. This channel suggests that with the Central Bank serving as predictable source of bond purchases, overall volatility is muted and huge intraday price

swings are less likely as intermediation is facilitated. Hence, according to the back-stop-buyer channel, even less liquid bonds with small issuance size can be traded easily without a strong market impact. Despite CSPP purchases ended at the end of 2018, which is our reference point, market participants have learned that the Central Bank can intervene into the bond market by implementing a large-scale asset purchasing programme when necessary. This strengthens their confidence that the Central Bank will continue to use QE as a monetary policy instrument when economic conditions worsen.

5.4 Robustness

Our baseline specification compared the change in liquidity between the week before announcement to the week after the purchases ended. To assess the robustness of our estimated stock effects, we compare liquidity in 2 or 4 weeks before announcement to liquidity in 2 or 4 weeks after the end of net purchases. One reason for doing that is that the CSPP purchases ended in December which is also a period of low liquidity. Using averages over several weeks should dampen this effect. Tables 21 and 22 report the results for 2 and 4 week windows, respectively. Overall, changing the length of the window over which liquidity measures are computed produces results that are very similar in significance and magnitude to our baseline results reported in Tables 15-17, strengthening our findings that the Bundesbank's CSPP purchases might have worsened liquidity in the German corporate bond market over the long-run.

6 Conclusions

The Eurosystem purchased a significant share of the eligible corporate bond market in the euro area between June 2016 and December 2018 under the Corporate Sector Purchase Programme (CSPP). This paper has assessed whether the Bundesbank's CSPP purchases lead to a deterioration of liquidity conditions in the corporate bond market. To answer this question, we combined the Bundesbank's detailed CSPP purchase records with a range of liquidity indicators for both purchased and non-purchased bonds. Our findings suggest that the contemporaneous or flow effect of the purchases is positive albeit small. But in the long run, we found some evidence of a deterioration in liquidity conditions as the Bundesbank reduced the stock of corporate bonds available for trading in the secondary market, thus raising concerns about unintended consequences of large-scale asset purchases.

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TABLE 1: Descriptive statistics of daily RFQ and CSPP data at the bond-dealer level

	Median	Mean	Std.dev	Minimum	Maximum
Purchase size by bond and day (€m)	5	6.954	6.252	0	262.494
Purchase size by bond, day and dealer	2.5	3.238	2.811	0.09	87.498
No. purchases by bond and day	2	2.456	1.456	0	13
No. RFQs sent by bond and day	20	21.722	9.334	1	82
No. bonds requested by day	8	8.064	3.413	1	24
Volume offered by bond and day (€m)	70	75.560	44.561	0.1	544.105
Coverage ratio	0.085	0.101	0.078	0	1

TABLE 2: Further details on the CSPP data

No trade	4.23%
1 trade	28.55%
2 trades	25.83%
3 trades	21.75%
4 trades	10.57%
> 6 trades	0.76%
Number of different bonds purchased	362

TABLE 3: Liquidity measures

Liquidity measure	**description**	**facet of liquidity**	**meaning of the measure**
Bid-ask spread (BAS)	difference between ask price and bid price (in bps)	tightness	the lower the BAS (i.e. the lower the transaction costs) the better are liquidity conditions
Roll	effective bid-ask price	tightness	see bid-ask spread
Daily range	absolute difference between high and low prices (in bps) for each day	immediacy	a wide range indicates that the market is less able to absorb new orders (i.e. liquidity deteriorates)
Time to unwind	The no. of days to exit a €5m position	immediacy	lower values indicate higher liquidity
Traded volume	daily transactions (30 day avg trading volume) in €m	depth	high volume means high liquidity
Amihud	absolute 1 day price return (in bps) divided by trading volume	depth	higher values mean a high price impact and, thus, poor liquidity
Ticket size	in €m	resilience	higher values indicate higher liquidity
No. dealers	No. of dealers quoting the bond over one day	resilience	higher values indicate higher liquidity
No. quotes	No. of unique quotes received for an instrument over one day	resilience	higher values indicate higher liquidity

TABLE 4: Mean values of the liquidity measures: bonds purchased by Bundesbank

Liquidity measure	**before** 10 March 2016	**after** 10 March 2016
bid-ask spread (in bps)	47.18	35.22
Roll (in bps)	10.78	6.79
Daily range (in bps)	79.61	59.44
Time to unwind (in days)	10.21	10.96
Traded volume (in €m)	2.29	2.50
Amihud (in bps)	23.51	13.82
Ticket size (in €m)	0.58	0.76
No. dealers	9.39	12.22
No. quotes	38.25	136.67

Source: Markit, Euroclear.

bps: basis points

TABLE 5: Mean values of the liquidity measures: German eligible bonds not purchased

Liquidity measure	**before**	**after**
	10 March 2016	10 March 2016
bid-ask spread (in bps)	59.10	52.16
Roll (in bps)	15.15	8.78
Daily range (in bps)	110.13	90.94
Time to unwind (in days)	10.60	11.35
Traded volume (in €m)	3.57	2.81
Amihud (in bps)	21.11	13.16
Ticket size (in €m)	0.60	0.59
No. dealers	7.89	11.87
No. quotes	32.42	121.38

Source: Markit, Euroclear.

bps: basis points

TABLE 6: Mean values of the liquidity measures: eligible bonds not purchased

Liquidity measure	**before**	**after**
	10 March 2016	10 March 2016
bid-ask spread (in bps)	49.33	37.78
Roll (in bps)	12.75	7.22
Daily range (in bps)	84.59	66.00
Time to unwind (in days)	10.02	9.00
Traded volume (in €m)	2.70	2.23
Amihud (in bps)	19.58	10.62
Ticket size (in €m)	0.77	0.84
No. dealers	8.38	11.42
No. quotes	33.29	135.88

Source: Markit, Euroclear.

bps: basis points

TABLE 7: Mean values of the liquidity measures: non-eligible investment grade bonds

Liquidity measure	**before**	**after**
	10 March 2016	10 March 2016
bid-ask spread (in bps)	51.32	39.92
Roll (in bps)	13.80	7.97
Daily range (in bps)	88.73	65.02
Time to unwind (in days)	7.09	7.85
Traded volume (in €m)	3.25	2.43
Amihud (in bps)	18.44	11.05
Ticket size (in €m)	0.94	0.96
No. dealers	8.87	11.06
No. quotes	37.25	126.01

Source: Markit, Euroclear.

bps: basis points

TABLE 8: Mean values of the liquidity measures: non-eligible high yield bonds

Liquidity measure	**before**	**after**
	10 March 2016	10 March 2016
bid-ask spread (in bps)	86.06	80.80
Roll (in bps)	19.04	21.50
Daily range (in bps)	149.30	128.97
Time to unwind (in days)	6.88	7.50
Traded volume (in €m)	3.97	3.34
Amihud (in bps)	23.20	11.66
Ticket size (in €m)	0.67	0.64
No. dealers	8.10	9.75
No. quotes	30.14	82.95

Source: Markit, Euroclear.

bps: basis points

TABLE 9: Flow effects using eligible but not purchased bonds as a control group

	(1) Amihud	(2) Bid-ask	(3) Time to unwind	(4) No. dealers	(5) No. quotes	(6) Ticket size	(7) Traded volume	(8) Range	(9) Roll
Volume purchased in €m	0.0131	-0.0942***	-0.0987	0.0286**	-0.00438	0.00588**	0.0848**	-0.134	-0.0170
	(0.153)	(0.0331)	(0.0714)	(0.0122)	(0.284)	(0.00294)	(0.0390)	(0.175)	(0.0396)
No. RFQs sent	0.0859	0.0591**	-0.0339	0.0210**	-0.194	-0.00255	-0.0281	0.122	0.0294
	(0.0966)	(0.0250)	(0.0462)	(0.00904)	(0.271)	(0.00217)	(0.0285)	(0.137)	(0.0254)
No. purchases	-0.0962	-0.258**	0.503*	0.0175	-0.457	-0.00920	-0.0898	-0.749	-0.0608
	(0.551)	(0.104)	(0.278)	(0.0512)	(1.193)	(0.00851)	(0.0913)	(0.570)	(0.105)
Volume offered in €m	-0.0205	-0.00873	-0.00524	0.00306	0.172***	0.00125*	0.0157	0.0138	0.00128
	(0.0186)	(0.00532)	(0.0102)	(0.00198)	(0.0555)	(0.000735)	(0.0107)	(0.0341)	(0.00641)
N	3714	3727	3714	3724	3724	3714	3714	3681	3727
R^2	0.460	0.905	0.456	0.797	0.727	0.498	0.469	0.541	0.651
adj. R^2	0.309	0.878	0.303	0.740	0.650	0.357	0.320	0.412	0.554

Clustered standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The Table reports estimation results from equation (1). Amihud, bid-ask spread, range and Roll are measured in bps, time to unwind is in days, ticket size and traded volume in €m. Standard errors are clustered by bond.

TABLE 10: Flow effects using ineligible IG as a control group

	(1) Amihud	(2) Bid-ask	(3) Time to unwind	(4) No. dealers	(5) No. quotes	(6) Ticket size	(7) Traded volume	(8) Range	(9) Roll
Volume purchased in €m	-0.180**	-0.190***	-0.125***	0.0561***	0.0862	0.0130***	0.142***	-0.0681	0.0173
	(0.0778)	(0.0306)	(0.0460)	(0.0119)	(0.262)	(0.00317)	(0.0318)	(0.136)	(0.0239)
N	153941	157811	153941	157664	157664	153941	153941	153024	157811
R^2	0.297	0.794	0.310	0.730	0.652	0.171	0.140	0.449	0.401
adj. R^2	0.290	0.792	0.303	0.727	0.648	0.163	0.132	0.444	0.395

Clustered standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The Table reports estimation results from equation (1). Amihud, bid-ask spread, range and Roll are measured in bps, time to unwind is in days, ticket size and traded volume in €m. Standard errors are clustered by bond.

TABLE 11: Flow effects using ineligible HY as a control group

	(1) Amihud	(2) Bid-ask	(3) Time to unwind	(4) No. dealers	(5) No. quotes	(6) Ticket size	(7) Traded volume	(8) Range	(9) Roll
Volume purchased in €m	-0.0727	-0.175**	-0.101**	0.0569***	-0.334	0.0109***	0.131***	-0.181	0.00180
	(0.0823)	(0.0677)	(0.0473)	(0.0125)	(0.274)	(0.00311)	(0.0329)	(0.177)	(0.0530)
N	71012	72716	71012	72661	72661	71012	71012	69595	72716
R^2	0.234	0.720	0.563	0.665	0.627	0.448	0.363	0.571	0.361
adj. R^2	0.219	0.714	0.554	0.658	0.620	0.438	0.351	0.562	0.349

Clustered standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The Table reports estimation results from equation (1). Amihud, bid-ask spread, range and Roll are measured in bps, time to unwind is in days, ticket size and traded volume in €m. Standard errors are clustered by bond.

TABLE 12: Flow effects for old bonds using eligible but not purchased bonds as a control group

	(1) Amihud	(2) Bid-ask	(3) ttu	(4) no_dealer	(5) no_quotes	(6) ticketsize	(7) tradevol	(8) range	(9) Roll
volume purchased in €mn	0.119	0.0117	-0.197	0.0180	-0.664	0.00546	0.0125	-0.194	0.00479
	(0.460)	(0.0569)	(0.247)	(0.0241)	(0.630)	(0.00525)	(0.0125)	(0.241)	(0.0407)
total_rfq	-0.0920	0.00327	-0.153	0.0262	-0.830*	-0.00166	-0.00734	-0.191	0.0496*
	(0.270)	(0.0379)	(0.107)	(0.0163)	(0.491)	(0.00354)	(0.00847)	(0.193)	(0.0284)
no. of trades	0.114	-0.271	1.334**	0.0482	4.111**	-0.0246	-0.0314	-0.214	-0.145
	(1.287)	(0.192)	(0.665)	(0.0840)	(1.910)	(0.0158)	(0.0332)	(0.934)	(0.123)
volume offered in €mn	-0.0444	-0.00167	-0.0184	0.00285	0.140	0.00204*	0.00683***	0.0812	-0.00825
	(0.0626)	(0.00872)	(0.0286)	(0.00376)	(0.136)	(0.00121)	(0.00234)	(0.0837)	(0.00916)
N	1176	1190	1176	1188	1188	1176	1176	1172	1190
R^2	0.568	0.949	0.517	0.841	0.809	0.601	0.682	0.744	0.778
adj. R^2	0.277	0.914	0.191	0.734	0.682	0.333	0.467	0.572	0.629

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The Table reports estimation results from equation (1). Amihud, bid-ask spread, range and Roll are measured in bps, time to unwind is in days, ticket size and traded volume in €m. Standard errors are clustered by bond.

TABLE 13: Flow effects using eligible but not purchased bonds as a control group: heterogeneity across bonds and time

	Move	Term spread	Business climate	Age	Size	Residual maturity
Amihud	0.0134	0.228	0.00218	-0.0894**	0.000129	0.0517
	(0.0111)	(0.453)	(0.0620)	(0.0422)	(0.000119)	(0.0500)
Bid-ask spread	-0.00528*	0.108	0.0255	0.0448***	-0.0000287	-0.0349***
	(0.00270)	(0.110)	(0.0188)	(0.0113)	(0.0000456)	(0.0124)
Time to unwind	0.0162***	-0.0703	-0.0580*	-0.0679***	0.000180**	0.0269
	(0.00517)	(0.247)	(0.0330)	(0.0236)	(0.0000762)	(0.0203)
No. dealers	0.00131	-0.178***	-0.0177***	-0.000472	-0.00000860	0.00628
	(0.000925)	(0.0482)	(0.00660)	(0.00378)	(0.0000216)	(0.00404)
No. quotes	-0.0353*	-0.358	0.108	-0.168	-0.000297	0.419***
	(0.0209)	(0.669)	(0.158)	(0.121)	(0.000542)	(0.116)
Ticket size	0.0000450	0.00167	-0.000410	-0.000401	0.00000268	0.000184
	(0.000249)	(0.00955)	(0.00151)	(0.00139)	(0.00000573)	(0.00146)
Traded volume	0.00212	0.0668	-0.0242	-0.0471***	0.0000862	0.0244*
	(0.00292)	(0.0852)	(0.0167)	(0.0131)	(0.0000679)	(0.0129)
Range	-0.0152	-0.0108	0.0937	-0.0171	0.000117	0.0536
	(0.0165)	(0.495)	(0.0831)	(0.0589)	(0.000335)	(0.0598)
Roll	-0.00151	0.201*	0.0237	0.000531	0.0000853	-0.0120
	(0.00255)	(0.108)	(0.0168)	(0.00993)	(0.0000724)	(0.0110)

Notes: The Table reports the estimates of the interaction coefficient ϕ from equation (2). Amihud, bid-ask spread, range and Roll are measured in bps, time to unwind is in days, ticket size and traded volume in €m. Standard errors are clustered by bond.

TABLE 14: Robustness: flow effects using weekly data and eligible but not purchased bonds as a control group

	(1) Amihud	(2) Bid-ask	(3) Time to unwind	(4) No. dealers	(5) No. quotes	(6) Ticket size	(7) Traded volume	(8) Range	(9) Roll
Volume purchased in €m	-0.0937	-0.108***	-0.0855	0.0157	-0.283	0.0107***	0.0912**	-0.315**	-0.0152
	(0.130)	(0.0336)	(0.0574)	(0.0109)	(0.295)	(0.00320)	(0.0387)	(0.153)	(0.0342)
No. RFQs sent	0.129	0.0560**	0.0281	0.00958	-0.242	-0.00275	-0.0314	-0.0322	0.00713
	(0.0977)	(0.0262)	(0.0326)	(0.00879)	(0.229)	(0.00216)	(0.0218)	(0.103)	(0.0222)
No. purchases	-0.390	-0.215**	0.0876	-0.0391	-0.0248	-0.00959	0.00950	-0.285	0.000317
	(0.507)	(0.108)	(0.216)	(0.0467)	(1.106)	(0.00890)	(0.123)	(0.523)	(0.111)
Volume offered in €m	-0.0124	-0.00449	-0.00380	0.000549	0.133**	0.000332	0.00308	0.0491*	-0.00162
	(0.0175)	(0.00546)	(0.00752)	(0.00182)	(0.0601)	(0.000634)	(0.00573)	(0.0263)	(0.00546)
N	3291	3297	3291	3282	3282	3291	3291	3292	3297
R^2	0.417	0.903	0.472	0.785	0.728	0.517	0.476	0.537	0.664
adj. R^2	0.228	0.872	0.301	0.715	0.640	0.360	0.307	0.386	0.555

Clustered standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The Table reports estimation results from equation (1) at a weakly frequency (weekly averages). Amihud, bid-ask spread, range and Roll are measured in bps, time to unwind is in days, ticket size and traded volume in €m. Standard errors are clustered by bond.

TABLE 15: Stock effects using eligible but not purchased bonds as a control group

	(1) Amihud	(2) Bid-ask	(3) Time to unwind	(4) No. dealers	(5) No. quotes	(6) Ticket size	(7) Traded volume	(8) Range	(9) Roll
CSPP total purchases (in b euro)	78.84	33.13*	0.839	-11.67***	-76.72**	0.799	-0.445	58.20*	26.98**
	(54.63)	(19.22)	(16.94)	(3.668)	(35.17)	(0.800)	(3.393)	(34.48)	(12.01)
Amount issued (in b euro)	0.850	1.684	-2.761	-1.607***	-22.19***	0.197	-2.009***	-7.943	-0.292
	(6.501)	(3.494)	(3.108)	(0.566)	(5.726)	(0.157)	(0.653)	(8.964)	(2.512)
Age	-2.408**	0.757*	-0.781*	0.110	0.634	0.0430	0.471***	2.544**	1.103**
	(1.094)	(0.429)	(0.422)	(0.0793)	(0.851)	(0.0284)	(0.100)	(1.152)	(0.500)
Rating	0.373	0.651	-0.809	-0.428**	-3.632**	-0.0480	0.237**	1.619	1.299
	(1.961)	(0.889)	(1.061)	(0.176)	(1.599)	(0.0659)	(0.118)	(2.729)	(0.795)
Residual maturity	-1.424	1.639*	1.830	0.399**	1.318	-0.203***	-0.0545	4.144	-0.243
	(2.036)	(0.968)	(1.236)	(0.201)	(1.702)	(0.0677)	(0.202)	(2.653)	(0.986)
Yield spread to matched Bund (in %)	7.415*	-4.981	2.952	-0.425	2.385	0.0497	-1.047**	-11.02	-1.999
	(3.937)	(3.135)	(1.923)	(0.435)	(3.819)	(0.120)	(0.442)	(8.604)	(3.363)
Amount outst. matched Bund (in b euro)	0.233	-0.335	0.792	0.198*	1.828**	-0.0537*	0.0785	1.539	0.175
	(1.025)	(0.579)	(0.635)	(0.109)	(0.896)	(0.0272)	(0.0920)	(1.343)	(0.518)
Δ Rating	1.476	1.595	-1.000	-0.264	-3.140	-0.0844	0.366*	9.347	2.539
	(3.301)	(2.124)	(1.671)	(0.369)	(3.051)	(0.0938)	(0.221)	(6.930)	(1.615)
Δ Amount outst. matched Bund (in b euro)	0.000326	-0.00150**	0.000116	0.000157	0.000354	-0.0000568	0.0000435	0.00147	-0.00102
	(0.00116)	(0.000757)	(0.000690)	(0.000157)	(0.00134)	(0.0000344)	(0.000172)	(0.00191)	(0.000703)
PSPP total purchases (in b euro)	-1.283	0.692	-3.594	-0.573	-3.098	0.324***	0.264	-5.753	-0.742
	(3.870)	(1.882)	(2.289)	(0.419)	(3.500)	(0.112)	(0.320)	(4.828)	(1.602)
Constant	-5.305	-29.05**	-9.756	-6.719***	-25.38	2.227**	-1.749	-79.60**	-23.91*
	(23.85)	(13.97)	(17.41)	(2.510)	(22.14)	(0.920)	(2.415)	(37.18)	(13.52)
Industry indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	206	210	206	210	210	206	206	199	210
R^2	0.174	0.255	0.084	0.357	0.421	0.147	0.335	0.123	0.275
adj. R^2	0.095	0.185	-0.004	0.296	0.366	0.065	0.271	0.035	0.206

p-values in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The Table reports estimation results from equation (3). Amihud, bid-ask spread, range and Roll are measured in bps, time to unwind is in days, ticket size and traded volume in €m. Standard errors are robust to heteroscedasticity.

TABLE 16: Stock effects using ineligible IG bonds as a control group

	(1) Amihud	(2) Bid-ask	(3) Time to unwind	(4) No. dealers	(5) No. quotes	(6) Ticket size	(7) Traded volume	(8) Range	(9) Roll
CSPP total purchases (in b euro)	52.47	28.46	18.23	0.585	-23.17	0.157	2.779	86.47**	32.86**
	(46.34)	(21.25)	(22.74)	(5.287)	(55.13)	(1.291)	(9.430)	(41.57)	(13.06)
Amount issued (in b euro)	23.77	6.048	-5.582	-3.255	-11.57	0.117	2.487	-12.75	-8.357
	(15.29)	(9.698)	(10.73)	(2.073)	(22.34)	(0.779)	(5.633)	(27.81)	(6.550)
Age	-0.154	0.337	-1.450	0.185	5.806**	0.0509	1.175	-2.877	1.289**
	(2.131)	(0.973)	(1.170)	(0.277)	(2.730)	(0.0735)	(0.759)	(2.855)	(0.624)
Rating	6.417*	4.112**	0.462	0.854**	5.253*	-0.0933	-1.809	1.812	5.007***
	(3.723)	(1.830)	(2.259)	(0.323)	(3.125)	(0.159)	(1.759)	(7.941)	(1.111)
Residual maturity	5.272	2.190	4.925	0.118	6.235*	-0.419*	-1.285	8.315	-0.224
	(5.996)	(1.761)	(4.590)	(0.358)	(3.251)	(0.214)	(2.112)	(5.919)	(1.424)
Yield spread to matched Bund (in %)	-9.044**	-9.630***	-1.258	-2.005***	-16.90***	0.132	0.983	-19.35***	-9.406***
	(4.043)	(1.786)	(2.690)	(0.319)	(2.840)	(0.174)	(1.718)	(5.002)	(1.612)
Amount outst. matched Bund (in b euro)	2.144	-0.425	1.586	0.154	2.092	-0.150	-0.679	2.011	0.0801
	(2.668)	(1.155)	(1.983)	(0.223)	(1.706)	(0.100)	(1.182)	(3.369)	(0.878)
Δ Rating	-2.407	-0.0940	-0.636	0.831	-0.847	-0.0957	-1.716	-16.37	4.395
	(3.935)	(3.340)	(2.092)	(0.701)	(5.733)	(0.236)	(2.504)	(18.05)	(2.776)
Δ Amount outst. matched Bund (in b euro)	0.00212	-0.00155	0.000744	0.0000683	0.000508	-0.000148	-0.000578	-0.00162	-0.000633
	(0.00254)	(0.00160)	(0.00192)	(0.000329)	(0.00220)	(0.000121)	(0.00134)	(0.00392)	(0.00119)
PSPP total purchases (in b euro)	-7.909	2.905	-5.772	0.00311	-5.575	0.539	2.621	-5.006	0.474
	(9.409)	(3.721)	(7.367)	(0.734)	(5.451)	(0.376)	(4.196)	(10.82)	(2.901)
Constant	-114.3	-55.76*	-42.28	-11.82**	-108.0*	4.947*	18.90	-86.06	-35.38*
	(82.04)	(28.38)	(53.94)	(5.429)	(59.27)	(2.729)	(21.97)	(86.70)	(18.51)
Industry indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	67	67	67	67	67	67	67	66	67
R^2	0.296	0.477	0.192	0.544	0.555	0.330	0.183	0.257	0.632
adj. R^2	0.052	0.296	-0.088	0.385	0.400	0.098	-0.101	-0.005	0.504

p-values in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The Table reports estimation results from equation (3). Amihud, bid-ask spread, range and Roll are measured in bps, time to unwind is in days, ticket size and traded volume in €m. Standard errors are robust to heteroscedasticity.

TABLE 17: Stock effects using ineligible HY bonds as a control group

	(1) Amihud	(2) Bid-ask	(3) Time to unwind	(4) No. dealers	(5) No. quotes	(6) Ticket size	(7) Traded volume	(8) Range	(9) Roll
CSPP total purchases (in b euro)	186.1**	17.62	71.47	7.021	-31.33	-2.376	-7.771	64.88	123.8*
	(79.41)	(46.22)	(52.14)	(6.098)	(47.45)	(2.264)	(4.605)	(83.90)	(71.16)
Amount issued (in b euro)	-37.33	34.45	-43.25	-5.421*	-17.42	1.987	-2.167	83.73*	6.203
	(38.08)	(22.65)	(30.05)	(2.964)	(17.52)	(1.365)	(2.240)	(44.13)	(29.94)
Age	0.321	4.017***	-1.412	0.0190	0.330	0.121*	0.514***	-0.984	2.209
	(2.100)	(1.436)	(1.196)	(0.201)	(1.044)	(0.0623)	(0.127)	(2.420)	(2.239)
Rating	2.379	-0.482	-1.104	0.0834	-1.462	-0.106	-0.674***	6.463	11.22***
	(3.179)	(2.296)	(2.095)	(0.367)	(1.592)	(0.119)	(0.243)	(4.380)	(2.994)
Residual maturity	2.385	2.147	2.599	-0.257	-0.887	-0.0930	0.111	5.148**	2.967*
	(2.918)	(1.289)	(2.453)	(0.168)	(0.938)	(0.115)	(0.149)	(2.274)	(1.673)
Yield spread to matched Bund (in %)	-0.0325	1.896	1.363	-0.352	2.594	0.0746	0.593**	-11.70**	-2.388
	(4.000)	(3.063)	(2.875)	(0.445)	(1.854)	(0.151)	(0.262)	(5.225)	(5.191)
Amount outst. matched Bund (in b euro)	1.364	-0.702	0.409	-0.0613	0.151	0.0441	0.418***	-1.451	-0.982
	(1.716)	(1.323)	(1.205)	(0.186)	(0.910)	(0.0588)	(0.121)	(2.092)	(1.689)
Δ Rating	11.12*	10.79*	1.766	-1.530**	-19.93***	-0.0653	0.737*	13.22	70.66***
	(5.691)	(6.327)	(4.111)	(0.747)	(3.959)	(0.209)	(0.375)	(8.569)	(10.58)
Δ Amount outst. matched Bund (in b euro)	-0.00525	-0.00166	-0.00446	0.0000939	0.000743	0.000240*	0.000403**	-0.000333	-0.00127
	(0.00372)	(0.00130)	(0.00289)	(0.000272)	(0.00124)	(0.000132)	(0.000153)	(0.00318)	(0.00217)
PSPP total purchases (in b euro)	-2.482	6.251	-1.155	0.149	-3.353	-0.0821	-1.472***	4.303	1.397
	(6.611)	(4.608)	(5.145)	(0.530)	(3.169)	(0.253)	(0.445)	(6.543)	(5.507)
Constant	-51.13	-60.89***	11.42	-3.437	5.540	-0.310	0.491	-135.1***	-129.2***
	(38.46)	(21.39)	(17.75)	(2.777)	(22.29)	(1.038)	(2.643)	(41.72)	(42.84)
Industry indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	52	52	52	52	52	52	52	52	52
R^2	0.385	0.732	0.243	0.650	0.739	0.318	0.617	0.658	0.869
adj. R^2	0.078	0.599	-0.135	0.475	0.609	-0.024	0.425	0.487	0.803

p-values in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The Table reports estimation results from equation (3). Amihud, bid-ask spread, range and Roll are measured in bps, time to unwind is in days, ticket size and traded volume in €m. Standard errors are robust to heteroscedasticity.

TABLE 18: Stock effects by age: interaction coefficient for all control groups

	Eligible but not purchased	Ineligible IG	Ineligible HY
Amihud	47.65***	38.65***	45.78***
	(14.97)	(13.71)	(9.694)
Bid-ask spread	9.700	17.89***	5.563
	(5.913)	(4.516)	(13.15)
Time to unwind	-0.449	1.566	-0.821
	(7.455)	(7.005)	(8.430)
No. dealers	-2.102**	-3.190**	-1.952
	(0.924)	(1.332)	(1.346)
No. quotes	-25.05***	-49.24***	-25.54**
	(6.099)	(10.73)	(10.37)
Ticket size	0.286	0.236	-0.0872
	(0.444)	(0.360)	(0.355)
Traded volume	1.518	-2.078	0.630
	(1.453)	(4.851)	(1.446)
Range	-6.361	20.16	22.51
	(13.65)	(19.70)	(19.45)
Roll	3.983	5.635	39.09
	(4.478)	(4.101)	(27.48)

robust standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The Table reports estimates of the interaction coefficient ψ from equation (4). Amihud, bid-ask spread, range and Roll are measured in bps, time to unwind is in days, ticket size and traded volume in €m. Standard errors are robust to heteroscedasticity.

TABLE 19: Stock effects by amount issued: interaction coefficient for all control groups

	Eligible but not purchased	Ineligible IG	Ineligible HY
Amihud	-74.70	-42.97	-180.8
	(152.5)	(116.0)	(194.8)
Bid-ask spread	12.24	-30.14	-77.82
	(58.72)	(72.32)	(134.7)
Time to unwind	-80.68	-138.1	-212.8
	(91.34)	(117.5)	(185.8)
No. dealers	31.93***	13.56	24.70
	(9.651)	(15.72)	(15.02)
No. quotes	246.5***	165.3	174.6
	(81.99)	(153.6)	(130.6)
Ticket size	-0.841	2.657	7.593
	(3.514)	(5.569)	(7.637)
Traded volume	-27.86***	-56.88	-26.14
	(10.56)	(41.13)	(15.88)
Range	236.8**	94.14	-184.3
	(117.4)	(184.1)	(285.7)
Roll	-32.47	-32.32	-182.9
	(50.90)	(52.02)	(254.9)

robust standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The Table reports estimates of the interaction coefficient ψ from equation (4). Amihud, bid-ask spread, range and Roll are measured in bps, time to unwind is in days, ticket size and traded volume in €m. Standard errors are robust to heteroscedasticity.

TABLE 20: Stock effects by residual maturity: interaction coefficient for all control groups

	Eligible but not purchased	Ineligible IG	Ineligible HY
Amihud	12.73	-10.52	30.15
	(22.67)	(25.78)	(28.38)
Bid-ask spread	4.270	0.300	19.10
	(8.148)	(14.43)	(18.57)
Time to unwind	18.76	17.62	35.50
	(12.46)	(17.67)	(26.20)
No. dealers	-2.283	2.685	-2.245
	(1.720)	(2.874)	(2.179)
No. quotes	0.537	3.419	1.688
	(16.94)	(27.76)	(16.85)
Ticket size	-0.460	-0.606	-1.523
	(0.575)	(1.029)	(1.327)
Traded volume	0.865	4.531	1.492
	(1.920)	(8.342)	(2.042)
Range	14.74	-1.309	0.0974
	(23.49)	(33.61)	(38.92)
Roll	2.077	-0.493	-31.43
	(7.504)	(10.12)	(23.82)

robust standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The Table reports estimates of the interaction coefficient ψ from equation (4). Amihud, bid-ask spread, range and Roll are measured in bps, time to unwind is in days, ticket size and traded volume in €m. Standard errors are robust to heteroscedasticity.

TABLE 21: Robustness: stock effects for all control groups: using a window of 2 weeks

	Eligible but not purchased	Ineligible IG	Ineligible HY
Amihud	47.65***	38.65***	45.78***
	(14.97)	(13.71)	(9.694)
Bid-ask spread	9.700	17.89***	5.563
	(5.913)	(4.516)	(13.15)
Time to unwind	-0.449	1.566	-0.821
	(7.455)	(7.005)	(8.430)
No. dealers	-2.102**	-3.190**	-1.952
	(0.924)	(1.332)	(1.346)
No. quotes	-25.05***	-49.24***	-25.54**
	(6.099)	(10.73)	(10.37)
Ticket size	0.286	0.236	-0.0872
	(0.444)	(0.360)	(0.355)
Traded volume	1.518	-2.078	0.630
	(1.453)	(4.851)	(1.446)
Range	-6.361	20.16	22.51
	(13.65)	(19.70)	(19.45)
Roll	3.983	5.635	39.09
	(4.478)	(4.101)	(27.48)

robust standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The Table reports estimates of β from equation (3). Amihud, bid-ask spread, range and Roll are measured in bps, time to unwind is in days, ticket size and traded volume in €m. Standard errors are robust to heteroscedasticity.

TABLE 22: Robustness: stock effects for all control groups: using a window of 4 weeks

	Eligible but not purchased	Ineligible IG	Ineligible HY
Amihud	55.37	41.36	7.834
	(37.59)	(37.24)	(64.42)
Bid-ask spread	0.0544	25.23*	53.54*
	(10.58)	(14.68)	(29.02)
Time to unwind	31.63	41.55	66.15
	(25.42)	(25.56)	(56.30)
No. dealers	-11.40***	0.937	-3.470
	(3.426)	(3.171)	(6.230)
No. quotes	-189.1**	-115.7	3.045
	(88.16)	(80.43)	(54.21)
Ticket size	-2.030**	-0.488	-1.370
	(0.889)	(1.017)	(1.257)
Traded volume	-5.143	13.73	-10.80**
	(3.189)	(12.79)	(4.889)
Range	9.089	71.42	144.9*
	(43.84)	(49.22)	(73.89)
Roll	24.89**	27.48***	63.65
	(10.69)	(9.251)	(79.42)

robust standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The Table reports estimates of β from equation (3). Amihud, bid-ask spread, range and Roll are measured in bps, time to unwind is in days, ticket size and traded volume in €m. Standard errors are robust to heteroscedasticity.

FIGURE 1: Bundesbank CSPP Purchases by month and sector

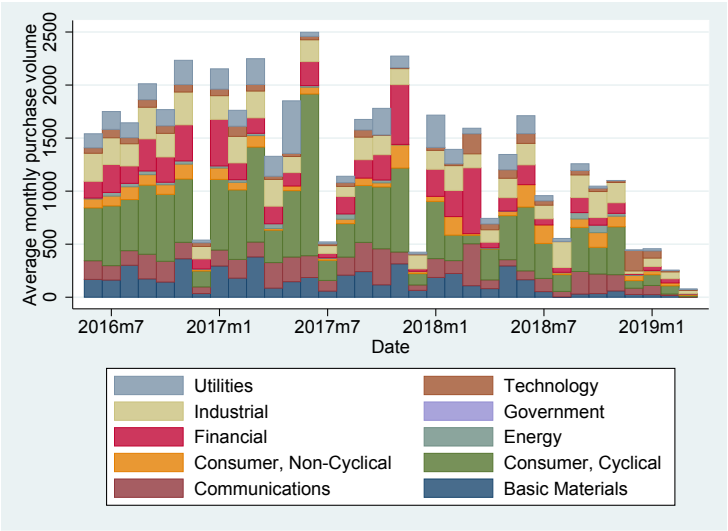
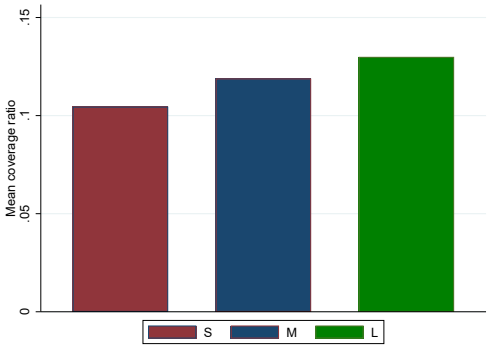
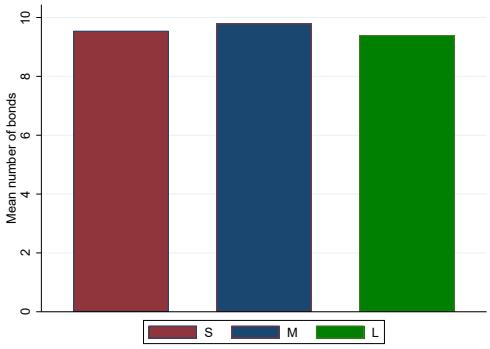


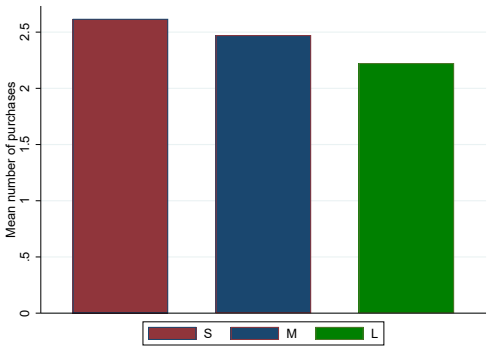
FIGURE 2: CSPP purchase data



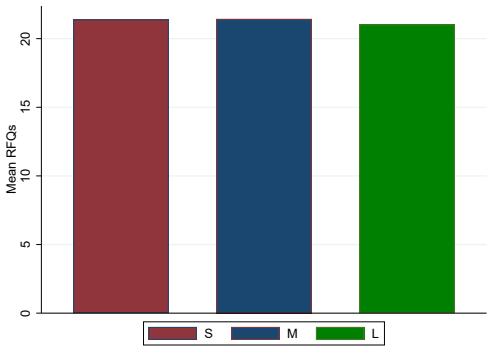
(A) Coverage ratio



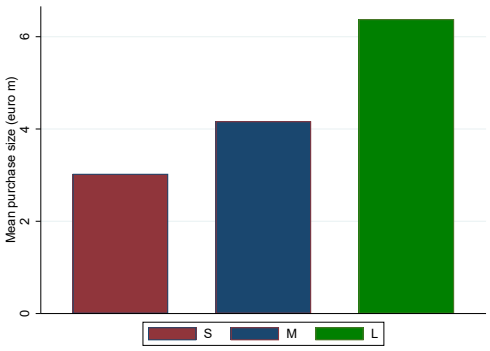
(B) Number of bonds



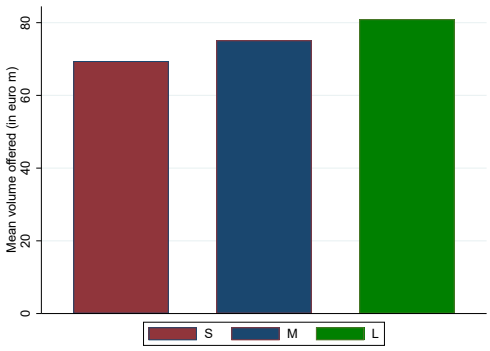
(C) Number of trades



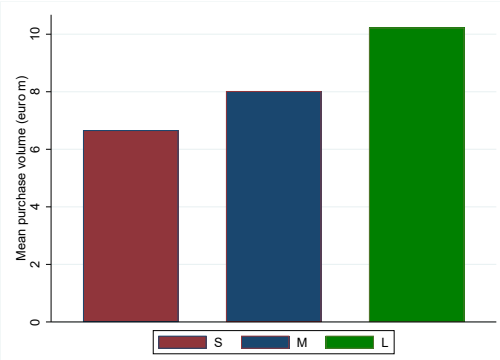
(D) RFQS



(E) Ticket size



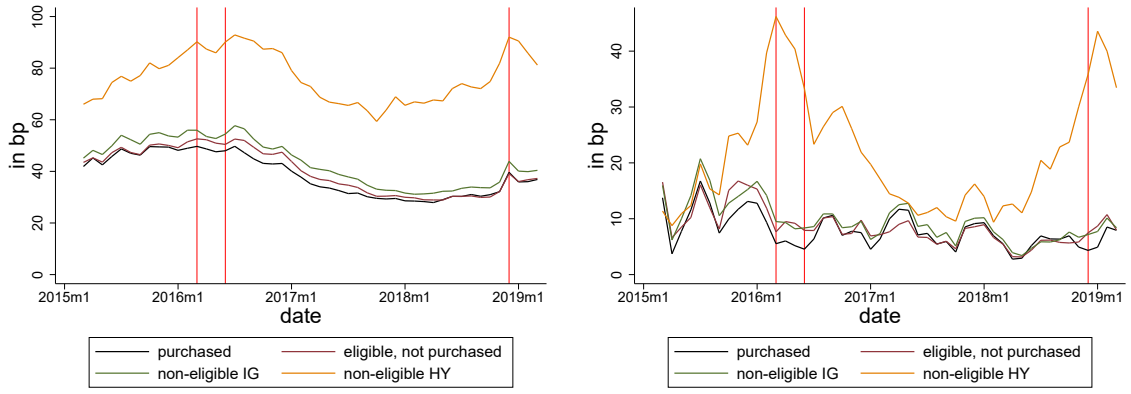
(F) Volume offered



(G) Volume purchased

Notes: S, M, L define small (maturity bucket of 0-3 years), medium (maturity bucket of 3-7 years) and large (maturity bucket of more than 7 years).

FIGURE 3: Evolution of liquidity measures (facet of tightness)



(A) Bid-ask spread (B) Roll

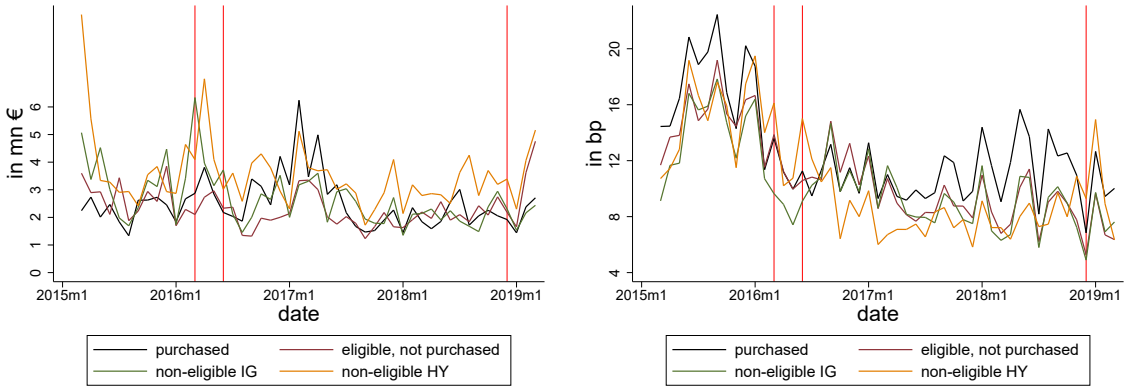
Notes: The vertical red lines point to the announcement of the CSPP on 10 March 2016, the start of the CSPP on 8 June 2018, and to the end of the net purchases on 31 December 2018, respectively.

FIGURE 4: Evolution of liquidity measures (facet of immediacy)

(A) Daily range (B) Time to unwind

Notes: The vertical red lines point to the announcement of the CSPP on 10 March 2016, the start of the CSPP on 8 June 2018, and to the end of the net purchases on 31 December 2018, respectively.

FIGURE 5: Evolution of liquidity measures (facet of depth)

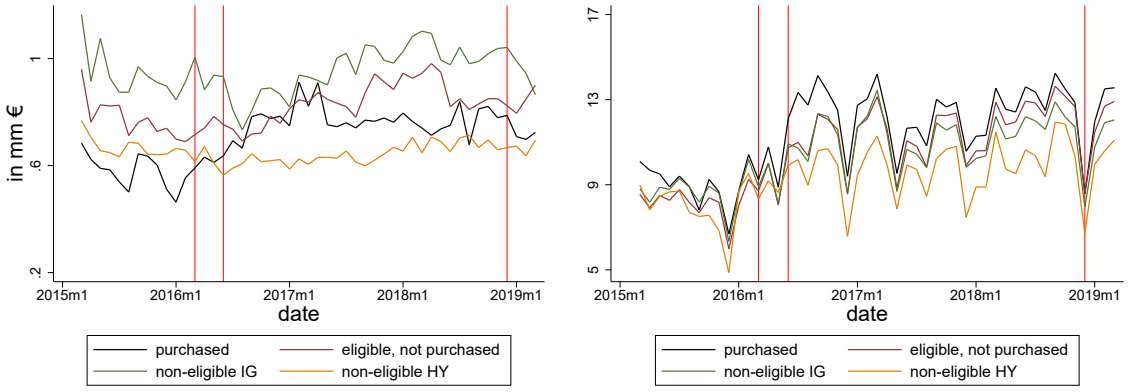


(A) Traded volume

(B) Amihud

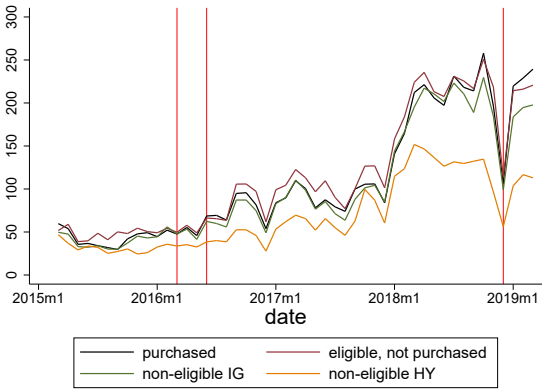
Notes: The vertical red lines point to the announcement of the CSPP on 10 March 2016, the start of the CSPP on 8 June 2018, and to the end of the net purchases on 31 December 2018, respectively.

FIGURE 6: Evolution of liquidity measures (facet of resilience)



(A) Ticket size

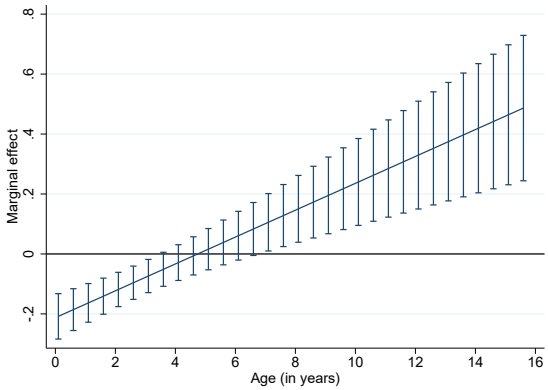
(B) No. dealers



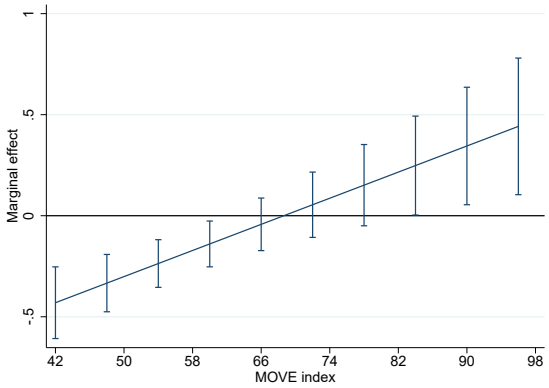
(C) No. quotes

Notes: The vertical red lines point to the announcement of the CSPP on 10 March 2016, the start of the CSPP on 8 June 2018, and to the end of the net purchases on 31 December 2018, respectively.

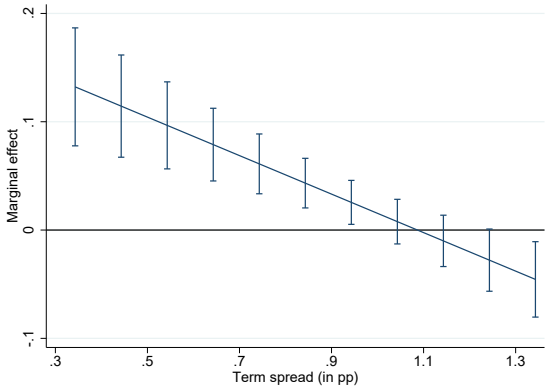
FIGURE 7: Marginal effects for the flow regressions for selected liquidity indicators, bond characteristics and economic time series



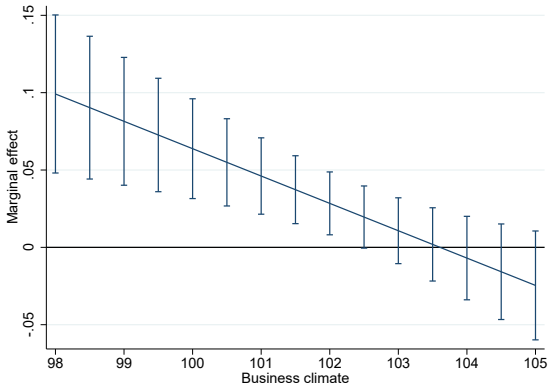
(A) Marginal effect of CSPP purchases on bid-ask spreads depending on bond age



(B) Marginal effect of CSPP purchases on time to unwind depending on the MOVE index



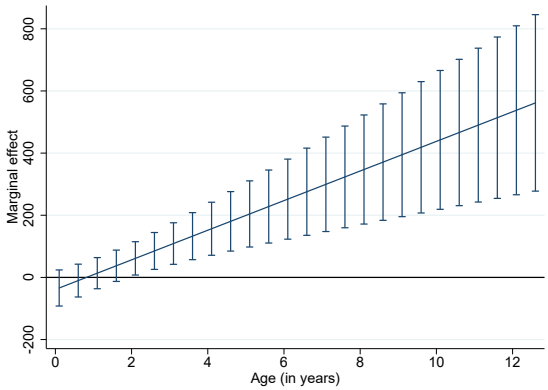
(C) Marginal effect of CSPP purchases on no. dealers depending on the term spread



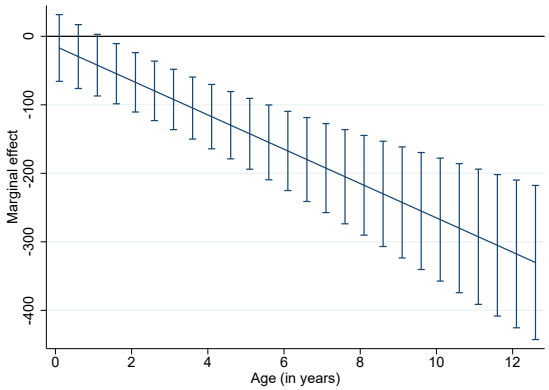
(D) Marginal effect of CSPP purchases on no. dealers depending on the business climate

Notes: The Figures use eligible but not purchased bonds as a control group. Marginal effects are shown together with 95% confidence intervals.

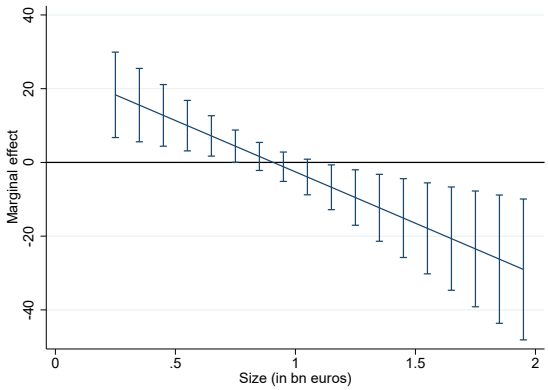
FIGURE 8: Marginal effects for the stock regressions for selected liquidity indicators and bond characteristics



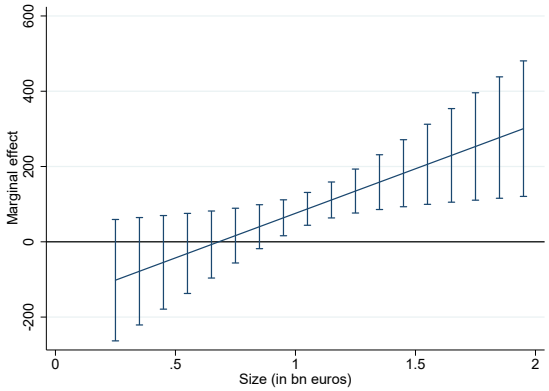
(A) Marginal effect of CSPP purchases on the Amihud measure depending on age



(B) Marginal effect of CSPP purchases on number of quotes depending on age



(C) Marginal effect of CSPP purchases on trading volume depending on size



(D) Marginal effect of CSPP purchases on the range depending on size

Notes: The Figures use eligible but not purchased bonds as a control group. Marginal effects are shown together with 95% confidence intervals.