Securities lender of last resort: On the causal effects of central banks' securities lending facilities*

Stefan Greppmair** Stephan Jank***

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Abstract

We quantify the causal effects of central banks' securities lending facilities on financial markets, using the Eurosystem's change in pricing conditions of November 2020 as a natural experiment. After reducing fees in their securities lending arrangements, utilization of securities lending facilities surged, in particular for bonds with otherwise inelastic supply to the repo market. There are no substitution effects, but rather total securities borrowing and lending in the repo market increased via the collateral multiplier. The improved pricing conditions alleviate scarcity in the repo market and enhance cash market liquidity.

Keywords: securities lending facilities, repo, central banks, monetary policy, liquidity

JEL: G10, G21, E50, E58

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**Deutsche Bundesbank, DG Markets, Wilhelm-Epstein-Str. 14, 60431 Frankfurt am Main, Germany. Email: stefan.greppmair@bundesbank.de.

***Deutsche Bundesbank, Research Centre, Wilhelm-Epstein-Str. 14, 60431 Frankfurt am Main, Germany. Email: stephan.jank@bundesbank.de.

1 Introduction

Quantitative easing has expanded central banks' balance sheets, making central banks one of, if not the largest single owner of sovereign and public-sector bonds. By withdrawing high-quality liquid assets from the market, central banks' asset purchases may negatively impact the functioning of the repo market. Given the important role of the repo market for allowing arbitrage of government bonds (Adrian, Begalle, Copeland and Martin, 2013), decreasing market quality in the repo market may also impair liquidity and price discovery in the secondary market for government bonds. To counteract such negative side effects, central banks have chosen to make their purchased bonds available for securities lending. Securities lending facilities (SLFs) are supposed to act as a backstop, providing market participants, in particular primary dealers, with collateral when specific securities become scarce, thereby safeguarding market liquidity. As a result, with the establishment of securities lending facilities in most developed financial markets,[1] central banks effectively have become the "securities lender of last resort". However, securities lending facilities are a relatively novel policy tool to central bankers. While the transmission of conventional and even unconventional monetary policies has been extensively studied,[2] the transmission of policy changes in the securities lending facilities is less understood. This paper aims to fill this gap.

To quantify the causal effect of the securities lending facilities on financial markets, we exploit a policy change using a difference-in-difference estimation approach. As of November 2, 2020, the Eurosystem changed the pricing conditions of their securities lending facilities, making securities borrowing from central banks in the euro area considerably cheaper. The pricing change reduced the minimum costs for securities borrowing against cash collateral by a third and against securities collateral by half. Our identification strategy builds on this policy change in combination with the fact that securities are

[1] The Bank of Japan, the U.S. Federal Reserve, Eurosystem central banks, and the Bank of Canada have implemented securities leaning facilities in connection with their asset purchase programs.

[2] For the transmission of conventional monetary policy, see for example Kashyap and Stein (2000), Jiménez, Ongena, Peydró and Saurina (2012), Jiménez, Ongena, Peydró and Saurina (2014), Heider, Saidi and Schepens (2019), Acharya, Imbierowicz, Steffen and Teichmann (2020); For unconventional monetary policy, see for example Acharya, Eisert, Eufinger and Hirsch (2019), Grosse-Rueschkamp, Steffen and Streitz (2019), and Di Maggio, Kermani and Palmer (2020).

heterogeneously affected by the central-bank induced collateral supply shock. In particular, we argue that the utilization of the securities lending facilities is more sensitive to the pricing change for securities with inelastic supply compared to securities with elastic supply. Securities with inelastic supply are typically held by investors which are unlikely to make their holdings available for securities lending. Market participants in need of these scarce securities are more likely to borrow them from central banks after securities lending arrangements have become cheaper. For our continuous treatment variable we therefore measure the share of inelastic investors in each bond using detailed information on its sectoral ownership structure provided by the Securities Holdings Statistics (Duffie, 1996; Arrata, Nguyen, Rahmouni-Rousseau and Vari, 2020; Koijen, Koulischer, Nguyen and Yogo, 2021).

After the Eurosystem improved its pricing conditions securities lending facilities' utilization surged, in particular for bonds with inelastic supply to the repo market. Our estimates suggests that after the lending fee reduction, a one standard deviation higher share of inelastic investors leads an increase in securities borrowing from the Eurosystem of 115% compared with pre-period levels. The increase in borrowing securities was of comparable magnitude across cash and securities collateral and it took mainly place at longer tenors, up to one week and above. We find no evidence that market participants substituted securities borrowing from other market participants with borrowing from central banks. On the contrary, securities borrowing and lending increased among market participants, consistent with the theory of a collateral multiplier. This means that a security borrowed from the central bank by one market participant is re-used in another independent repo transaction with another market participant. The receiving market participant, in turn, reuses the security in yet another transaction, and so forth. Hence, through multiple re-use the collateral lend out by the central bank results in an even further increase in collateral available for the market (Bottazzi, Luque and Pascoa, 2012; Gorton, Laarits and Metrick, 2020; Infante, Press and Strauss, 2018; Infante, Press and Saravay, 2020). In our setting, the collateral multiplier is the ratio of the total amount of collateral available to the initial amount of bonds lend out by the central bank. Our estimates suggest that the policy-induced increase in securities borrowing from the central bank by one unit, increased total available collateral in the repo market by 3.19 units.

The increase in collateral availability affected both repo and cash markets. After the pricing change, securities with otherwise inelastic supply become less scarce in the less-liquid overnight and tom-next market segments of the repo market but not in the more liquid spot-next segment. For overnight transactions, for example, a one standard deviation higher share of inelastic investors leads to a reduction in the specialness premium in the post period by 1 basis point, which corresponds to decrease of 22% relative to the average specialness premium in our sample. The greater collateral availability appears to also have improved market making in the cash market, as evidenced by an increase in secondary market liquidity after the pricing change. A one standard deviation higher share of inelastic investors leads to an decrease in the bid-ask spread in the post period by 0.6 basis points , which corresponds to a decrease of approximately 5% relative to the average bid-ask spread prior to the pricing change.

Overall, our evidence is consistent with an effective transmission mechanism of policy changes in securities lending facilities. Our main results suggest that making securities available for lending helps to alleviate QE-induced scarcity effects in financial markets. Additional collateral supply, resulting from a reduction of the Eurosystem's lending fees, enhances market conditions in both repo and cash markets without curtailing private market activity. Hence, SLFs appear to be an effective tool through which central banks can support bond market functioning.

1.1 Related Literature

We contribute to different strands of literature. Several studies investigate the transmission channels of quantitative easing. D'Amico and King (2013) study QE in the U.S., Joyce and Tong (2012) in the UK, Schlepper, Hofer, Riordan and Schrimpf (2020) study the microstructure of central bank purchases and their impact on liquidity and market functioning. Other studies highlight the side effects of central bank asset purchase programs on repo markets. Asset purchases increase scarcity in the repo market, measured by the specialness premium, and also increase delivery failures, as shown by D'Amico, Fan and Kitsul (2018), Arrata et al. (2020), and Corradin and Maddaloni (2020). Moreover, QE-induced collateral scarcity feeds back into treasury markets by increasing limits to arbitrage (Pelizzon, Subrahmanyam and Tomio, 2022).

Only very few studies look at the effectiveness of central banks' securities lending facilities. For the U.S., Fleming, Hrung and Keane (2010) document that higher usage of the Fed's Term Securities Lending Facility (TSLF) is associated with higher repo rates, suggesting that the TSLF mitigates shortages in collateral. Baltzer, Schlepper and Speck (2022) show that for German Bunds securities lending operations help to alleviate scarcity in the repo market, but that these operations are not offsetting the scarcity effects of asset purchases. Carrera de Souza and Hudepohl (2022) examine a broader set of sovereign collateral from several European countries and reach a similar conclusion. Furthermore, Pelizzon et al. (2022) highlight that SLFs help to reduce arbitrageurs' funding costs, thereby reversing some of the QE-induced treasury market mispricing dynamics. A common challenge in estimating the effects of securities lending facilities on collateral markets, is that their usage is endogenously determined. Collateral that becomes scarce is also increasingly borrowed from central banks, resulting in a reverse causality problem. To overcome this endogeneity problem, we use the Eurosystem's change in pricing conditions as a natural experiment. Moreover, we make use of the richness of MMSR data, covering banks' entire repo operations. This feature allows us to study in detail the transmission of the policy change in the securities lending facilities, in particular with regard to possible substitution or collateral multiplier effects in the repo market.

Finally, our study provides insights into the connection between securities lending markets and secondary bond markets. Although a link between these two markets seems obvious – dealers routinely use repo markets to source assets for secondary market-making activities – analyzing how frictions in the lending market affect outcomes in the cash market is not straightforward as such an analysis is typically plagued with endogeneity concerns. A few studies try to address these issues by using exogenous variation in dealer funding conditions (Macchiavelli and Zhou, 2022) or the shutdown of an institution's securities lending program (Foley-Fisher, Gissler and Verani, 2019). We add to this literature and exploit an exogenous shock to securities lending that resulted from the pricing change in the Eurosystem's SLFs to show that securities lending, through its effect on repo specialness, has a direct impact on market liquidity. The link between securities lending activities and market liquidity that we establish in this paper is related to the impact of quantitative easing on market liquidity. However, while both QE and SLFs have an impact on specialness, quantitative easing also affects market liquidity through a reduction in free float. The exogenous shock to securities lending that we observe allows us to tie specialness to market liquidity without this confounding effect and gives us the opportunity to establish an undistorted connection between securities lending markets and secondary bond markets.

2 Institutional background

Quantitative easing in the euro area comprises various asset purchases programs, including purchases of the public and private sector. Our paper focuses on sovereign bonds purchased under public sector purchase programme (PSPP) and the pandemic emergency purchase programme (PEPP) and their securities lending. In general, national central banks (NCBs) of the Eurosystem purchase their respective sovereign bonds and not those of other jurisdictions. Additionally the ECB conducts purchases of sovereign bonds from all jurisdictions, which account for 10% of the total sovereign bonds purchased and which are subject to risk sharing within the Eurosystem. Eurosystem central banks make the securities purchased under their asset purchase programs available for securities lending. The operations aim at primary dealers of sovereign bonds and at other market makers. Securities lending is organized in a decentralized manner, i.e. national central banks and the ECB are operating their own securities lending facilities. The purchases allocation described above means that sovereign bonds of a specific jurisdiction (for example, France) can be borrowed from the respective national central bank (in the example's case, from Banque de France) or from the ECB. Modalities of the different securities lending facilities vary in terms of counterparty eligibility, haircuts or tenor to take account of domestic market practices. Apart from these organizational differences, there is an overarching framework for all Eurosystem central banks, in particular in terms of pricing.

The Eurosystem's SLFs are implemented through repo and reverse repo transactions, where securities can be borrowed either against securities collateral or against cash collateral. Borrowing against securities collateral means that the repo transactions are accompanied by fully offsetting reverse repo transactions of the same value and term. Essentially, the transactions are cash neutral since one collateral is swapped with another collateral. For cash collateral transactions, which are possible since December 8, 2016, there is no offsetting reverse repo transaction. However, there is an overall limit on cash collateral transactions, which amounts to 150 bn EUR in our sample period. Apart from this global limit, the Eurosystem's SLFs are also subject to individual counterparty limits. Moreover, securities lending operations of the Eurosystem are different from private repo market contracts along several lines: transaction terms are more restrictive meaning that pricing is done with a minimum spread, some NCBs impose restrictions on the maximum maturity of a contract, netting of individual transactions is not possible, and there is a rather high charge for delivery failures. On the other hand, settlement of transactions vis-á-vis the Eurosystem is practically guaranteed since NCBs do not need to locate the securities they agree to lent out but rather have these in stock.

Pricing is done at market rates, but there is minimum securities lending fee that is charged. This policy parameter was changed in November 2020, making securities borrowing from central banks considerably cheaper. Specifically, the pricing conditions for cash and securities collateral before November 02, 2020 and after (shown in parentheses) were as follows:

> "[...] The ECB's securities lending arrangements allow eligible counterparties, at any time, to borrow securities against securities as collateral at a fixed minimum fee of 10 (5) basis points, or a fee based on prevailing market rates, whichever is higher. The fee is the difference between the repo and reverse repo rates.

> [...] The ECB also allows eligible counterparties to borrow securities against cash as collateral at a rate equal to the rate of the deposit facility minus 30 (20) basis points or the prevailing market repo rate [...], whichever is lower."[3]

In other words, the minimum rate for borrowing against securities collateral was reduced half. For cash collateral, the spread between the deposit facility and repo rate, representing the securities lending fee, was reduced by a third.

This policy change led a sizable increase on the utilization of the securities lending facilities, which can be seen from Figure 1. The upper graph, Figure 1a, shows the developments since the start of the Eurosystem's securities lending facilities until the end of our sample period. In the past, the usage of the securities lending facilities was elevated in particular during times of heightened scarcity in the repo market (2017 and 2018). During this period of time there is also heightened usage of borrowing against cash collateral. Looking at the change in pricing conditions in November 2020, we observe a sharp increase in the usage of the securities lending facilities, reaching a new record level. The bottom graph, Figure 1b, zooms into this episode, showing the usage of the securities lending facilities at daily frequency for the twelve months before and after the change in pricing conditions (November 1, 2019 - October 31, 2021). The daily frequency reveals further details that are masked by monthly averaging. We observe that the securities lending facilities are increasingly used and year ends and also at quarter ends, which generally represent periods where supply in the repo market is low due regulatory window dressing (see, for example, Corradin, Eisenschmidt, Hoerova, Linzert, Schepens and Sigaux, 2020; Schaffner, Ranaldo and Tsatsaronis, 2019). Regarding the change in pricing conditions, the increase in borrowing from the Eurosystem follows promptly after the policy change and is economically sizable. The "on-loan" market value of borrowed securities almost doubled from a daily average of 35 bn EUR in the pre period to 69 bn EUR in the post period.

[3]Source: https://www.ecb.europa.eu/mopo/implemenUapp/lending/html/pspp-lending-ecb.en.html (retrieved 2020-10-10). Basis points in parentheses, representing the pricing conditions in the post period, were added.

3 Hypotheses development

We exploit the Eurosystem's change in pricing conditions, which represents a sizable supply shock to the repo market, in a difference-in-difference estimation approach. In the following section we develop our main testable hypotheses.

We utilize the fact that securities are heterogeneously affected by the central bank supply shock originating from the change in pricing conditions. Specifically, we follow Arrata et al. (2020) and argue that the collateral supply of a given security is related to its investor base. The supply of securities held by a large fraction of buy-and-hold investors (e.g. insurance companies or pension funds) is usually inelastic to changes in repo market conditions, because of legal or institutional frictions on the side of security lenders. Lending supply of these securities should be less likely to match high levels of demand so we expect higher securities borrowing from the Eurosystem particularly in these securities after the pricing change. Our identification strategy thus relies on the argument that the utilization of the securities lending facilities is more sensitive to the pricing change for securities with inelastic supply compared to securities with elastic supply.

It is unclear how securities borrowing from other market participants is affected by the positive central bank supply shock. There are two competing views on this: On the one hand, the increased supply by central banks could crowd out supply from other market participants. If market participants substitute securities borrowing from other market participants with borrowing from the central bank, then the overall volume in the repo market should stay constant, but the repo market would end up to be more dependent on the central bank. We will refer to this as the *substitution hypothesis*. On the other hand, collateral borrowed from the central bank by one market participant could be re-used in another independent repo or securities lending transactions with another market participant. The receiving market participant, in turn, can reuse the security in yet another transaction, and so forth. As collateral can be reused multiple times, an increase in supply of collateral by the central bank can result in an even further increase in collateral available for market transactions (Bottazzi et al., 2012; Gottardi, Maurin and Monnet, 2019; Gorton et al., 2020). We will refer to this mechanism as the *collateral multiplier hypothesis*.

The effects on the repo and cash market much depend on what mechanism mentioned above is at play. Under the substitution hypothesis, the overall volume in the repo market does not change and consequently its liquidity does not change. Under the collateral multiplier hypotheses, on the contrary, overall trading volume and consequently liquidity increases in the repo market. Since the repo market is crucial for market makers in the cash market, improvements of repo market liquidity may spill over to the cash market.

4 Data and descriptive statistics

4.1 Data sources and sample construction

We utilize different data sources to construct the main dataset for our analysis. We use data on money market activity from the money market statistical reporting dataset (MMSR). The MMSR is a proprietary dataset collected by the European System of Central Banks (ESCB) and contains transaction-level information on secured and unsecured money market activity of the 47 largest euro area banks. For the secured segment, which is the focus of this paper, the MMSR provides information on the counterparties, the collateral, and the terms of each transaction. Specifically, we have information on the transaction volume, deal rate, tenor and direction of each trade, that is, whether the reporting agent borrows or lends a security. With regard to the counterparties involved in a trade, we distinguish two cases: (1) centrally cleared trades, for which the reporting agent's LEI is reported while the counterparty is being reported as "CCP"; (2) bilateral trades, for which both the reporting agent's LEI and the counterparty's LEI is reported. We use both types of trades in our analysis. With regard to the securities that act as collateral, the MMSR provides a broad range of information, including ISIN, issuer sector, issuer country, issuance date and maturity date of the asset. We restrict our attention to securities issued by central governments, as these make up for most of the deals in terms of transaction volume. Moreover, we only consider trades with a fixed deal rate that are backed by a single instrument.

Repo transactions involve different tenors. The most frequently observed tenors are O/N, S/N and T/N. Such transactions are settled on day t, t+1 and t+2, respectively, and have a maturity of one day. Transactions involving other tenors are term loans with a maturity of one week or longer. Regardless of the tenor, however, the MMSR contains each loan only once, namely at the time of the trade.[4] Without any further adjustments to the data, this implies that a 30-day term loan for 1,000 EUR (one transaction in MMSR) and 30 consecutive O/N loans for 1,000 EUR each (30 transactions in MMSR) would lead to different "on-loan" amounts for a particular security on a given day, although the "on-loan" values for the 30 days considered should be the same. In order to correctly calculate the amount of a particular security that is on loan, we thus construct an ISIN-level panel from the transaction-level data taking into account the tenor of each transaction. That is, for each trade, we consider the time between settlement date and maturity date and carry forward the transaction volume over the lifetime of the loan. This transformation ensures that the amount of securities borrowed through term loans is reflected equivalent to the amount borrowed trough consecutive one day loans.

We augment the money market data with information on the ownership composition of the securities. This information comes from the securities holding statistics (SHS-S), another proprietary dataset collected by the ESCB. The SHS-S reports quarterly security holdings of different investor sectors. We follow Koijen et al. (2021) and define six sectors: households, insurance companies and pension funds, non-financial corporations, investment funds, monetary financial institutions, and general government. We then exploit sector-level heterogeneity in lending supply elasticity to calculate a proxy for the lending supply provided by investors other than the Eurosystem. Analogous to Arrata et al. (2020), we label monetary financial institutions and investment funds *elastic investors*. They routinely provide collateral to the repo market as part of their business model and their lending supply is elastic to changes in repo market conditions. Households, insurance companies

[4]The only exception are repos with open term. According to the reporting guidelines, these should be reported as new O/N transactions on an ongoing daily basis until the loan is recalled. To identify such cases, we screen the data for consecutive O/N transactions with recurring patterns in their proprietary transaction identifiers (PTI) and label them as "open repos". Furthermore, we carefully screen all other tenors accordingly and re-label consecutive term loans with recurring patterns in their PTIs as "open repos" as well to avoid double-counting issues.

and pension funds, non-financial corporations and governments, on the other hand, are inelastic to changes in repo market conditions due to legal and other institutional barriers (Duffie, 1996). As a consequence, we expect available lending supply to be lower when the fraction of *inelastic investors* is high. Figure 2 provides some empirical validation for the chosen classification of sectors into elastic and inelastic investors. In particular, we plot average outstanding security lending volumes from bilateral repo market activity for different sectors. We scale the volume by a sector's total holding of a given security in order to capture the degree to which different investors make their holdings available for lending in the repo market. In line with our classification, we observe that monetary financial institutions, investment funds, and other financial intermediaries (mostly security dealers) lend out 8% to 10% of their holdings in bilateral repo transactions. In contrast, insurance companies, pension funds, governments, non-financial corporations, and households are far less active in the repo market and typically lent out only 2% of their bond holdings.

We add further security-level information from other data sources. Data on the bonds' amount outstanding, bid-ask spreads and re-issuance dates comes from Thomson Reuters Eikon. We use repo rate data from BrokerTec as an alternative to repo rates reported in the MMSR. BrokerTec and MMSR differ along two dimensions: (1) MMSR provides granular data on the transaction-level while BrokerTec data is reported on the ISIN-level; (2) BrokerTec covers a larger segment of the secured money market while MMSR only covers the money market activity of the largest euro area banks. The BrokerTec data thus complements the MMSR data for the analysis on repo rates.

For our final dataset, we limit the sample period to twelve months before and after the change in pricing conditions. Specifically, our sample period ranges from November 1, 2019 to October 31, 2021. For each bond, we consider all tradings days from the issuance date to the maturity date of the instrument. That is, days within the sample period for which the amount borrowed is zero for a particular bond are also included in the panel. Moreover, we apply a number of additional data filters: First, we only include EUR-denominated government bonds of euro area countries with a developed financial market.[5] Second, we

[5] The list of euro area countries with a developed financial market includes Austria, Belgium, Germany, Spain, Finland, France, Ireland, Italy, Luxembourg, Netherlands, and Portugal.

exclude strips, certificates and convertible bonds. Third, we exclude bonds for which the sum of holdings reported in the SHS exceeds the bond's amount outstanding by more than 25%. Finally, we only include bonds for which we observe at least one transaction per week in 95% of all weeks during the sample period.

4.2 Descriptive statistics

The cleaned sample consists of 240,823 observations for 779 individual securities. Table 1 reports descriptive statistics for the variables used in the subsequent analysis. Reporting banks engage in repo transactions with the Eurosystem on 13% of all bond-day observations. When banks use the securities lending facilities, the average borrowing amount of a given bond is 116 milion EUR. This is about 10% of the average borrowing amount from other repo market participants. These observations highlight the backstop character of the Eurosystem's securities lending facilities and suggest that in the aggregate, the Eurosystem's footprint in the repo market tends to be rather small. However, as documented in Figure 1, borrowing from the Eurosystem grows significantly after the pricing change. This indicates that the usage of the Eurosystem's securities lending facilities increases once pricing conditions are closer to market prices. We examine the pricing change in more depth in the following sections.

For the main analysis, we scale the nominal amount borrowed with a bond's outstanding nominal amount and also include days for which the borrowed amount is zero for a particular bond. This results in average borrowing from the Eurosystem of less than 0.08% of a bond's amount outstanding on any given day. When compared to the scaled borrowing amount from the market (5.82%), this means that the Eurosystem's market share of total borrowing is less than 1.4% on average ($0.08/(0.08 + 5.82) = 1.4\%$). When we further split the amount borrowed from the market into centrally cleared and bilateral trades, we see that a larger amount of repo transactions is centrally cleared. On average, reporting agents borrow securities amounting to 3.59% of a bond's amount outstanding from central counterparties and securities amounting to 2.23% bilaterally. Finally, reporting agents also actively lend securities through repo transactions. In fact, securities lending by reporting agents is on average larger than securities borrowing in our sample period, both in absolute and scaled terms. This indicates that reporting banks are important market participants on both sides of the repo market.

Specialness spreads are computed by deducting the GC pooling rate from volume-weighted average repo rates for a particular bond on a given day. We can observe that spreads in the MMSR sample are very similar to spreads in BrokerTec with the exception of the overnight segment, for which the spread is larger in BrokerTec.[6] Moreover, bonds trade on special during the sample period as spreads across all tenors are positive on average. A positive specialness spread indicates that market participants actively seek to borrow a specific bonds and are willing to accept a rate below the GC rate for lending out their cash.[7] As (Arrata et al., 2020; D'Amico et al., 2018; Baltzer et al., 2022). We return to this issue in Section 7.1 where we examine how the increase in collateral availability affected repo rates.

Our main treatment variable, the share of inelastic investors, is 32% on average. There is, however, considerable variation in the inelastic share across individual bonds with a standard deviation of 15%. We will exploit this variation in the following difference-in-difference estimation to quantify the causal effect of the Eurosystem's securities lending facilities on repo market activities.

5 Effects on the utilization of securities lending facilities

We start with a graphical analysis of securities borrowing from the Eurosystem across different degrees of supply elasticity. Figure 3 plots the aggregate securities borrowing from the Eurosystem for securities with low and high shares of inelastic investors, with the median as cutoff. We report the average daily market value of securities borrowed[8] during periods of three months, which are chosen due to data disclosure rules. Before the pricing

[6] The difference in mean values is mostly due to the different coverage of MMSR and BrokerTec. If we limit the sample to bond-days for which both MMSR and BrokerTec rates are available, average spreads are very close to each other.

[7] Euro area repo markets are mostly collateral-driven in recent years with 90 percent of all secured money market transactions being backed by specific collateral (ECB, 2021).

[8] We calculate the market value of securities borrowed according to the following formula, which we take from the MMSR reporting instructions: $MV_{SecBorr} = \frac{TrnsNomAmt}{1-(HairCut/100)}$, where $TrnsNomAmt$ is the cash lent and $HairCut$ is the haircut applied to the collateral.

change, securities with an inelastic investor structure are slightly more borrowed from the Eurosystem than securities with an elastic investor structure. After the Eurosystem changed its pricing policy we see a sharp increase in securities borrowing only for bonds with otherwise inelastic supply to the repo market. Securities borrowing of bonds with low supply more than doubled from 3 billion EUR in the months August to October 2020 to 8 billion EUR in the months November 2020 to January 2021. Securities borrowing of bonds with high supply, on the contrary, remains unaffected by the change in pricing conditions. To substantiate this finding, we formalize the analysis in a regression framework in the following section.

5.1 Baseline

For our difference-in-difference model, we rely the following general regression:

$$\begin{aligned} Y_{i,t} &= \beta_1 Post_t \times InelasticSupply_{i,t} + \beta_2 Post + \beta_3 \times InelasticSupply_{i,t} + \\ &\quad \mathbf{X}'_{i,t}\gamma + \alpha_0 + \alpha_i + \alpha_t + \epsilon_{i,j,t}, \end{aligned} \tag{1}$$

where $Y_{i,t}$ is the outcome variable of interest. In case of our baseline model, it is the nominal amount of bond i borrowed from the EuroSystem at day t scaled by the bond's nominal amount outstanding. $Post_t$ is a dummy variable that equals 1 for the time period after the pricing change of 02 November 2020 and zero otherwise. *InelasticSupply* is the ownership share of investor sectors with inelastic supply to the repo market in bond i measured at the previous quarter end. We de-mean the continuous treatment variable (and also other continuous variables) for an easier interpretation of the interaction term. All control variables are collected in vector $\mathbf{X}_{i,t}$; α_0 is the constant, α_i and α_t denote bond and time (day) fixed effects. We cluster standard errors at the bond and time level.

We control for bonds' maturity remaining, age, log amount outstanding and several demand factors in the repo market, which we describe in the following. Following Corradin and Maddaloni (2020), we use repo imbalance, defined as the difference between lending and borrowing volumes scaled by a bond's amount outstanding, as a proxy for demand-supply imbalances in the repo market. Moreover, bonds show other predictable patterns of high demand or low supply. On-the-run bonds, which are the the most recently issued bond of a specific maturity, are generally is generally more liquid than previously issued bonds ("off-the-run") (Krishnamurthy, 2002). Due to their higher liquidity, on-the-run bonds are the preferred hedging vehicle and therefore also in high demand on the repo market (Jordan and Jordan, 1997). Even though the on-the-run phenomenon seem less pronounced in Europe compared with the U.S. (Ejsing and Sihvonen, 2009; Brand, Ferrante and Hubert, 2019), we control for the on-the-run status using a dummy variable. Bonds are typically in high demand in the repo market around re-issuance dates and become special during this period of time (D'Amico et al., 2018; Arrata et al., 2020). We control for the re-issuance period using a dummy variable that is one for the day of re-issuance and the previous day (and zero otherwise). Another important reason for a bond to be in high demand in the European repo market is when it becomes the cheapest to deliver in the futures market (Buraschi and Menini, 2002; Brand et al., 2019). We control for this using a dummy variable that is one for the bond that is the cheapest to deliver on the five days until Futures delivery date, and zero otherwise. Lastly, in our specification without time fixed effects, we also include dummies for quarter and year ends, since repo activity is typically reduced due to regulatory window dressing at these dates (Corradin et al., 2020; Schaffner et al., 2019).

Table 2 shows the estimation results of equation (1). First we discuss the results of Column (1), which shows a specification without time and bond fixed effect. Before the pricing change there is a weak positive association between supply inelasticity and the utilization of the Eurosystem securities lending facilities as the positive *InelasticSupply* coefficient of 0.13 suggests. After the Eurosystem changed its pricing conditions, we observe an increase of 0.06 in the scaled amount of securities borrowed from the Eurosystem, as can be seen from the *Post* coefficient. Since we de-mean all continuous variables, this effect represents the increase in the borrowing amount of an average bond in the sample. Relating this estimate to the unconditional pre-period average of 0.055, borrowing of securities from the Eurosystem more than doubled on average. This finding is in line with the aggregate growth documented in Figure 1.

Looking at the interaction term $Post \times InelasticSupply$ of 0.52, we see that the increase in borrowing took place in particular in bonds that have a investor base with an inelastic supply to the repo market. The interaction term yields the same coefficient when including time fixed effects in Column (2). When we additionally control for bond fixed effects in Column (3), the interaction coefficient is slightly reduced to 0.41, but still highly statistically significant. The coefficient estimate suggests, that after the pricing change, a one standard deviation increase in the share of inelastic investors (0.154) leads to an increase of $0.154 \times 0.41 = 0.063$ in the scaled securities borrowing amount. Relating this to the pre-change level of 0.055 yields a relative increase by 115% for a one standard deviation increase in the share of inelastic investors.

The results on the control variables provide further insights as to when market participants use the securities lending facilities. There is elevated usage at year ends, during re-issuance periods and in particular during Futures delivery dates for the cheapest-to-deliver bond. Note that even though coefficients of quarter and year end are relatively small compared to the cheapest-to-deliver dummy, the former is only related to few bond, whereas the latter represents low supply concerning the entire cross-section of bonds. For specification (3), there is also increased usage of the securities lending facilities, when demand in the repo market is high, as measured by repo imbalance.

In Columns (4)-(6) of Table 2, we re-run the regression for the small time window covering 4 weeks before and 4 weeks after change in pricing conditions. This small time window measures the immediate effect of the pricing change and also accounts for possible confounding effects that may arise at a longer horizon. Even in this small time window we estimate a statistically significant interaction term that is very close to the fixed effects model of column (3).

To asses the validity of the common trends assumption we follow Autor (2003). We interact our continuous treatment variable *InelasticSupply* with dummies for periods of three months and include them in equation (1) instead of a post-period dummy. Figure 4 plots the interaction coefficient of $Period \times Inelastic\ Supply$ with 90% confidence intervals over time. The time period August - October 2020 serves as a reference period and is by construction zero. The tendency of borrowing securities with inelastic supply increases in the first three months after the policy change relatively to the reference period. Moreover, the difference is statistically significant and sizable for all sub-periods after the pricing change. In the period before the pricing change, interaction terms are virtually zero and statistically insignificant from the reference period.

5.2 Exploring the cross sections of repo and bond characteristics

In this section we explore the continuous treatment effect across different repo and bond characteristics. We start by investigating how the policy change affected different features of securities borrowing offered by the Eurosystem. Key differences in this context are: Securities can be borrowed against cash or securities collateral. Moreover, securities can be borrowed at different tenors ranging from short-term (daily) up to long-term (3 months) or open term.

We investigate this in the generalized diff-in-diff regression framework outlined in equation (1). In our first analysis the new dependent variables are the daily aggregate borrowing amounts per security against cash and securities collateral. Again, we scale these aggregates by the total amount outstanding in a given bond. To measure borrowing against securities collateral we identify repo transactions that are accompanied by fully offsetting reverse repo transactions of the same value and term using different algorithms. Such an approach is necessary, since there are no identifiers for related offsetting trades in the MMSR. For the analysis on repo tenor we also aggregate daily borrowing per security for different tenor buckets and scale it by the total amount outstanding in a given security.

Table 3 provides the results for the different repo characteristics. Panel A shows that the relevant interaction coefficients for securities borrowing against securities or cash collateral are very similar, amounting to 0.22 and 0.19 respectively. Note that the sub-aggregates of borrowing against cash and securities collateral sum up to total securities borrowing. For this reason coefficients add up to the overall effect shown in Table 2, Column (3) of 0.41, subject to rounding. Overall, this suggests that the pricing changes in both cash and securities collateral transactions increased securities borrowing of bonds with inelastic supply. Panel B shows the dis-aggregated effects for different repo terms. The strongest increases in borrowing securities with inelastic supply can be seen at longer tenors in particular for repos with a term of up to one week, where the interaction coefficient is 0.30. Above one week the effects are less pronounced with an interaction coefficient of 0.07. However, not all Eurosystem central banks are offering tenors in this segment. The increase in borrowing with daily maturity, covering overnight, tom-next, and spot next transactions is much lower, with a coefficient of 0.01 in all three segments. For the tom-next market, the interaction coefficients is also statistically significant. Overall, these results suggest that banks mainly use the securities lending facilities of the Eurosystem to borrow securities at longer tenors. This stands in contrast to general money market trading activity where the majority of repo transactions has a one day maturity.

We next explore, how the treatment effect of the policy change differs across security characteristics. For this analysis we perform sample splits along maturity remaining and issuer rating in Table 4. In Panel A we differentiate between bonds with shorter remaining maturity (< 10 years) and bonds with longer remaining maturity (≥ 10 years). For bonds with longer maturities, collateral scarcity is more likely to be supply-drive because these bonds are typically held by more buy-and-hold investors that are less inclined to provide their assets to the repo market. For bonds with shorter maturities, on the other hand, collateral scarcity is more likely to be demand-driven as repo volumes for these bonds are typically much higher. Consistent with the pricing change addressing both types of constraints, we find comparable effects across the two subsamples. The difference-in-difference coefficient is 0.47 for short-term bonds (Column 1) and 0.49 for long-term bonds (Column 2).

In Panel B we split the sample into issuers with prime and high-grade ratings (AAA and AA) and issuers with medium-grade ratings (A and BBB). In line with the idea that demand for high-grade collateral is higher, we find that the treatment effect for this issuer group is considerably higher than for medium-grade collateral. In fact, the interaction term $Post \times InelasticSupply$ is only significant in the subsample of high-grade issuers (Column 1).

In sum, after the Eurosystem changed the pricing conditions for its securities lending facilities, bonds with otherwise inelastic supply were increasingly borrowed at longer tenors. The increase in borrowing these securities was quite comparable across cash and securities collateral. Moreover, the pricing change had stronger effects on borrowing inelastic bonds of issuers with a better credit rating.

6 Effects on repo activity in general

So far, we have shown that the pricing change has led to significantly higher usage of the Eurosystem's securities lending facilities. A natural follow-up question is whether the increase in borrowing from the Eurosystem affects securities borrowing and lending among other market participants. In Section 3, we argue that, one the one hand, the positive supply shock from the Eurosystem can potentially crowd out lending supply coming from the market *(substitution hypothesis)*. On the other hand, the additional supply can also lead to more market activity through the re-use of the newly available collateral *(collateral multiplier hypothesis)*.

In order to answer which of the two scenarios prevails, we re-run our baseline model as specified in equation (1) with different outcome variables. Instead of looking at the nominal amount of bond i borrowed from the Eurosystem, we now consider the nominal amount of bond i borrowed from counterparties *other than the Eurosystem*. We define all other counterparties as "the market" from here on. Moreover, we analyze total borrowing which is defined as the sum of borrowing from the market and the Eurosystem. Last, we also consider the amount borrowed from the Eurosystem as a fraction of total borrowing, which corresponds to the market share of the Eurosystem. In order to minimize the impact of confounding factors that might influence repo market activity in general but are unrelated to the change in pricing conditions, we limit our sample to four weeks before and after the event. Standard errors are clustered at the bond level.

The results are given in Table 5. In Panel A, our dependent variable is the scaled amount of securities borrowed from the market. The difference-in-difference coefficient suggests that reporting banks do not only borrow more bonds from the Eurosystem, but they also borrow more bonds from security lenders *other than* the Eurosystem after the pricing change. While the effect is marginally insignificant for all tenors combined (Column 1), banks significantly increase their borrowing of bonds with an inelastic investor base from the market in the overnight segment (Column 2). For a one standard deviation higher share of inelastic investors, the scaled amount of securities borrowed in the overnight segment increases by $0.154 \times 0.3495 = 0.054$, which corresponds to an increase of 32% relative to the period prior to the change in pricing conditions (average scaled amount borrowed: 0.167). Thus, the effect is not only strongly statistically significant but also economically sizable. Borrowing in the remaining tenors does not increase significantly in the four weeks following the pricing change, although the coefficient for the one week segment is, again, only marginally insignificant. The increase in overnight repos vis-à-vis the market is particularly interesting given that banks use the Eurosystem's securities lending facilities to mainly borrow securities at longer tenors. Hence, a certain degree of maturity transformation seems to take place through the securities lending program of the Eurosystem: banks resort to term loans when they borrow securities from the Eurosystem, whereas a large share of ensuing transactions in the repo market are set up as one day loans.[9]

When we replace the dependent variable with total borrowing in Panel B, we find that the additional lending supply from the Eurosystem leads to higher total repo market borrowing of bonds with inelastic supply both in general (Column 1) and in particular for the overnight segment (Column 2) and the one week segment (Column 5). Combined, the evidence presented thus far shows that the increased usage of the Eurosystem's lending facilities does not crowd out other market activity but rather leads to an overall increase in repo market borrowing volumes. This is consistent with the *collateral multiplier hypothesis* and suggests that market participants seem to reuse the collateral they acquire from the Eurosystem in further repo transactions.

Since borrowing from the Eurosystem and total borrowing have likewise increased after the Eurosystem reduced its lending fees, it remains unclear how the market share of the Eurosystem evolves in response to the pricing change. Therefore, we continue our analysis with the market share of the Eurosystem as our dependent variable in Panel C of Table 5. The significant interaction term *Post* $\times$ *Inelastic Supply* indicates that the market share

[9] Infante et al. (2020) show that a similar maturity transformation takes place in dealers' securities financing activities involving US Treasuries as collateral.

across all tenors indeed increases in the post period for bonds with inelastic investors. When we split up the transactions into the different repo tenors, we can further see that the effect is largely driven by tenors up to one week. Here, for a one standard deviation higher share of inelastic investors, the Eurosystem gains an additional $0.154 \times 0.1289 = 1.99\%$ in terms of market share. This increase is sizeable in relative terms, given that the average market share of the Eurosystem is only 1.4%. In absolute terms, however, the Eurosystem's market share still remains at rather low levels. In isolation, this result would point towards a certain shift of activity away from the market towards the Eurosystem's securities lending facilities once its lending fees are reduced. It is nevertheless inconsistent with the *substitution hypothesis* because overall repo market activity does not stay constant but rather picks up.

In a back of the envelope calculation, we can compute the inherent collateral multiplier. The estimates of Table 2, Column (6) imply that a one standard deviation higher share of inelastic investors leads to an increase of $0.154 \times 0.37 = 0.057$ in the scaled securities borrowing amount from the Eurosystem. The estimates of Table 5, Panel B, Column (1) imply that the same increases in the share of inelastic investors leads to a rise of $0.154 \times 1.1754 = 0.181$ in the total scaled securities borrowing amount. Relating the increase in the total amount of securities borrowed (0.181) to increase in the amount borrowed from the Eurosystem (0.057), yields a collateral multiplier of 3.18.[10] In other words, for each unit of additional collateral sourced from the Eurosystem increases total available collateral in the repo market by approximately three units. This estimate of the collateral multiplier is somewhat lower than that of Infante et al. (2020), which report a collateral multiplier ranging between six an seven for U.S. Treasuries. The difference arises most likely due to the fact that our data merely covers collateral activity in the repo market, and not other securities financing transactions.

We next present further tests related to the collateral multiplier hypothesis. According to our working hypothesis, the additional collateral supply provided by the Eurosystem leads to an even further increase in available collateral for market transactions through

[10]Note: Since we scale all quantities by a bond's amount outstanding, the magnitude of both coefficients is actually directly comparable. Their ratio gives us directly the implied collateral multiplier.

repeated re-use of the collateral in the repo market.[11] For this mechanism, we need to test whether reporting agents increase their *securities lending* of bonds with a large share of inelastic investors following the pricing change. Since the MMSR data includes both securities lending and borrowing activities of reporting banks, we can directly test this conjecture. We replace the dependent variable in equation (1) with the total amount of securities lent by the reporting agents (scaled by the bond's amount outstanding) and re-run our baseline model. In order to get a better understanding of the use of the borrowed collateral, we conduct the analysis separately for centrally cleared and bilateral repo transactions. Moreover, we quantify collateral re-use in repos directly. To do so, we measure collateral re-use as the minimum of collateral received and collateral posted through repos at the bank-security level. We distinguish between re-use channeled to CCPs and to bilateral repo transactions, using the respective share of the two types of securities lending transactions. We then aggregate the amount of collateral re-used to the security level. In our regressions we use the collateral re-use amount scaled by the total amount outstanding and the re-use rate, which is defined as the collateral re-use amount divided by collateral borrowed. Computing collateral re-use this way hinges on the assumption that when posting collateral, banks first use all incoming collateral before resorting to their outright owned shares. Jank, Moench and Schneider (2021), however, show that this measure is highly correlated with alternative re-use measures, which assume a different ordering of sourced collateral. This is in particular so for bonds where outright ownership of banks is rather low, as in our case. Another data limitation to the re-use measure is the fact that MMSR data only covers repurchase transactions. Hence, collateral re-use from other securities financing transactions, such as securities lending transactions as important source for high-grade collateral (Aggarwal, Bai and Laeven, 2021), are not covered by our measure. Keeping these limitations in mind, our measure nevertheless captures how banks channel collateral through the repo market.

The results are presented in Table 8. Consistent with the idea that the collateral borrowed from the Eurosystem is being re-used in further repo transactions, we document

[11] In principle, the additional supply could also be fed into re-use chains when the reporting banks sells the borrowed security short to an investor who subsequently uses the purchased security in a repo transaction.

that securities lending of reporting banks significantly increased after the pricing change in bonds with inelastic supply. This is, however, only the case for centrally cleared repos as can be seen in Panel A, Column 2 of Table 8. In Panel B of Table 8, we directly study collateral re-use in repurchase agreements. Re-use of collateral increased after the pricing change in bonds with inelastic supply. Re-used collateral was in particular channeled towards transactions with CCPs. This channel is also evident from our analysis of the re-use rate in Panel C. The results show that banks did not only route the additional collateral available to the repo market at the prevailing collateral re-use, but also increased the intensity of collateral re-use for bonds in low supply.

All in all, our results suggest that the positive supply shock coming from the improved pricing conditions of the Eurosystem's lending program does not curtail repo market activity by other market participants. On the contrary, we conclude that the newly available collateral fosters repo market activity through re-use of the collateral.

7 Effects on the repo and cash market

7.1 Repo market

In this section, we study the effect of the securities lending facilities on repo market rates. In particular, we analyze whether the change in pricing conditions in November 2020 has a meaningful impact on the specialness premium of borrowed bonds. The specialness premium in the euro area money market is strongly driven by scarcity effects of the ECB's purchase programs (Arrata et al., 2020; Baltzer et al., 2022). A higher usage of the securities lending facilities and the overall increase in available collateral that we have documented so far should alleviate these scarcity effects. We therefore expect the pricing change in the Eurosystem's securities lending facilities to lead to a tightening of specialness spreads. To measure the causal effect of the lending program on specialness premia, we again exploit the fact that bonds are heterogeneously affected by the central bank induced supply shock, depending on their supply elasticity.

We therefore re-run our baseline model with the specialness spread as our dependent variable. As before, we limit the sample to four weeks before and after the event to minimize the impact of confounding factors. Furthermore, we only consider repos with O/N, S/N, and T/N tenor. The reason for doing so is two-fold: First, these segments are the most liquid ones in the money market. Second, we have data on these three segments from both MMSR and BrokerTec, which allows us to gauge the robustness of our findings with respect to different data sources.[12] Standard errors are clustered at the bond level.

The results are reported in Table 7. In Columns (1) to (3), we use repo rates reported in MMSR to compute the spread. In Columns (4) to (6), we use repo rates from BrokerTec to compute the spread. We sort the different tenors from least (O/N) to most liquid (S/N). Columns (1) and (4) report O/N rates, Columns (2) and (5) report T/N rates, Columns (3) and (6) report S/N rates. Panel A contains the result for the full set of bonds. The interaction term $Post \times InelasticSupply$ indicates that spreads across all segments decline with the effect being statistically significant in the O/N segment for both MMSR and BrokerTec rates. Economically, the MMSR (BrokerTec) specialness premium goes down by about 1 (1.2) basis point(s) for a one standard deviation increase in the share of inelastic investors, which translates into a 22% (10%) decline relative to its pre-period mean value. Hence, we observe both a statistically and economically significant reduction in the spread after the alteration of the Eurosystem's lending pricing scheme for the less liquid O/N segment. The O/N segement is, at the same time, the segment for which we observe a significantly higher amount of securities borrowing activity vis-à-vis the market. Combining both results, we conclude that the securities lending facilities of the Eurosystem helps to alleviate the scarcity of available collateral. As a consequence, securities borrowing costs in the repo market decline.

Similar to before, we conduct two additional sample splits to corroborate our main result. First, we perform a sample split into bonds with shorter remaining maturity (Panel B) and longer remaining maturity (Panel C). In terms of economic magnitudes, we find comparable spread reductions in the post-period for overnight transactions involving either type of bonds. For bonds with shorter residual maturity, the effect is statistically significant in the MMSR and the BrokerTec sample. For bonds with longer residual maturity, on the

[12] We also conduct the analysis for the other tenors (one week, above one week, open repo) and report the results in the Internet Appendix.

other hand, the coefficient estimates are somewhat larger but also estimated less precisely, which is possibly due to the fact that we observe fewer transactions in these bonds. The second sample split we conduct is based on the credit rating of the issuer. We split our data into high-quality issuers (Panel D) and medium-quality issuers (Panel E). We find that lower levels of specialness after the pricing change are only observable for bonds of highly rated issuers. For these bonds, we observe a significant reduction in specialness not only for the overnight, but also for the tomorrow-next segment. For medium-rated issuers, in turn, there is no statistically significant effect. This reflects the idea that the additional lending supply was especially helpful to address and to alleviate the scarcity of high-quality collateral.

7.2 Cash market

In a final step, we examine whether the pricing change in the Eurosystem's securities lending operations also had an effect on the underlying cash market of the bonds. So far, we have documented that the pricing change helped to increase available collateral in the repo market, both through a higher usage of the securities lending facilities itself and through the re-use of collateral in further money market transactions. This overall increase in collateral led to a tightening of specialness spreads. As Huh and Infante (2021) show in a theoretical model, the specialness of a bond can be regarded as a cost for dealers who intermediate cash market transactions in the same bond. Lower levels of specialness are passed on to customers through lower bid-ask spreads. Consequently, we hypothesize that the pricing change should increase the cash market liquidity of borrowed bonds, as proxied by their bid-ask spreads.

We test this hypothesis by running our baseline model specified in equation (1). This time, our dependent variable is the bid-ask spread of the bond in the cash market. Our analysis again focuses on the four week window around the pricing change. To mitigate the influence of outliers, we winsorize the bid-ask spread at the 1% level. Again as before, we first report the results for the full sample. In a second step, we split the sample into bonds with shorter and longer remaining maturity. Finally, we split the sample into bonds with high- and medium-quality ratings. For the full sample, we document a significant decline in the bid-ask spread after the implementation of the pricing change (Column 1). This is consistent with the theoretical results of Huh and Infante (2021) and suggests that lower specialness indeed translates into higher cash market liquidity because dealers now face lower intermediation costs in case they have to source the bond from the repo market. Compared to a bond's average bid-ask spread in the sample, the effect we document amounts to a close to 5% decline in the bond's bid-ask spread relative to its pre-period sample mean for a one standard deviation increase in the share of inelastic investors $((0.154 \times 3.7861) \div 12.63 = 4.63\%)$. When splitting up the sample according to a bond's residual maturity, we find that the effect on the bid-ask spread is present for both types of bonds but stronger for bonds with a shorter maturity (Column 2). For the sample split based on the issuer credit rating of the bond, the results are less conclusive. While the economic magnitude of the interaction term remains comparable to the full sample, the effect is statistically insignificant in both subsamples, which is possibly a consequence of the smaller sample size. All in all, the analysis shows that the pricing change in the Eurosystem's securities lending operations does not only influence conditions in the repo market itself but it also positively affects the liquidity in the cash market as the additional collateral supply reduces the costs for bond market intermediaries.

8 Conclusion

Using the 2020 policy change in the Eurosystem's securities lending facilities, we study the causal effects of securities lending facilities on repo and cash markets. After the reduction in securities lending fees, market participants increased their securities borrowing form central banks. We do not observe any substitution effects, but rather an increase in total securities borrowing and lending in the repo market via the collateral multiplier. That is, securities borrowed from the central bank are channeled though the repo market and repeatedly used as collateral. Our estimates suggest, that for each unit of collateral borrowed form euro area central banks, total available collateral increases by 3.44 units. The improved collateral availability alleviated scarcity in the repo market and enhanced cash market liquidity.

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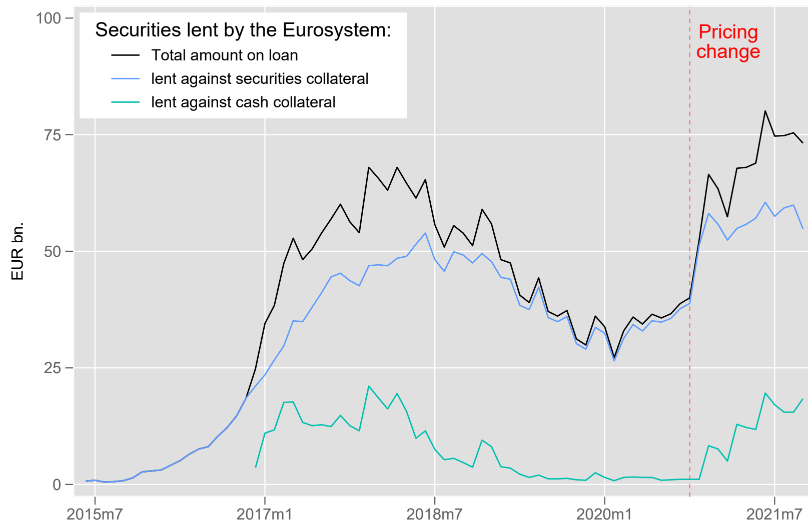
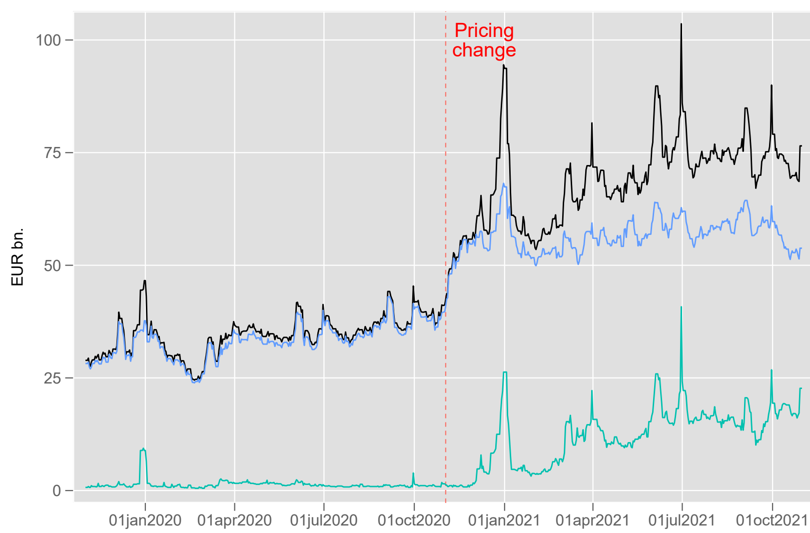
9 Figures and Tables



(a) Since inception of securities lending facilities (monthly)



(b) Sample period of pricing change (daily)

Figure 1: Eurosystem's public sector securities lending balances
This figure shows Eurosystem PSPP and public sector PEPP securities lending balances over time. Figure 1a reports the total average balance at market value during the month since the start of the securities lending facilities. Figure 1b reports the on-loan balance at market value at daily frequency for the two years of our sample period (November 1, 2019 - October 31, 2021). The figures show the total on-loan amount as well as the breakdown by securities lent against securities collateral and securities lent against cash collateral, the latter being possible as of December 8, 2016. The red dashed line marks the Eurosytem's change in pricing conditions effective since November 2, 2020. Data source: ECB.

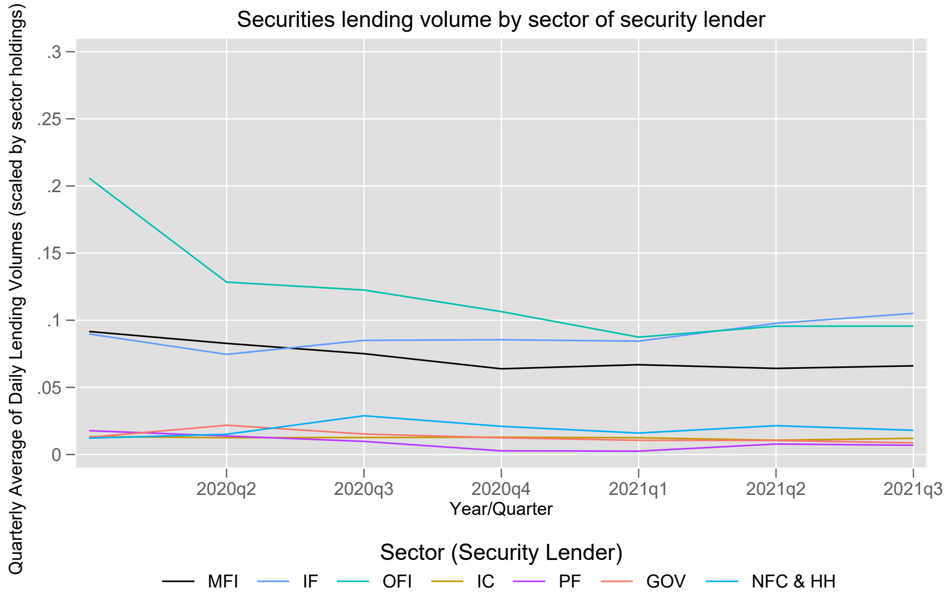


Figure 2: Securities lending volume by sector

This figure shows quarterly averages of daily securities lending volumes for different security lenders. We categorize security lenders according to their sector classification: monetary financial institutions (MFI), investment funds (IF), other financial intermediaries (OFI), insurance companies (IC), pension funds (PF), general government (GOV), non-financial corporations (NFC), and households (HH). Securities lending volume is calculated as the sum of outstanding bilateral repos for a given security on a given day. We scale the volume by the sector's total holdings of a given security. The sample period is Q1:2014 to Q3:2021.

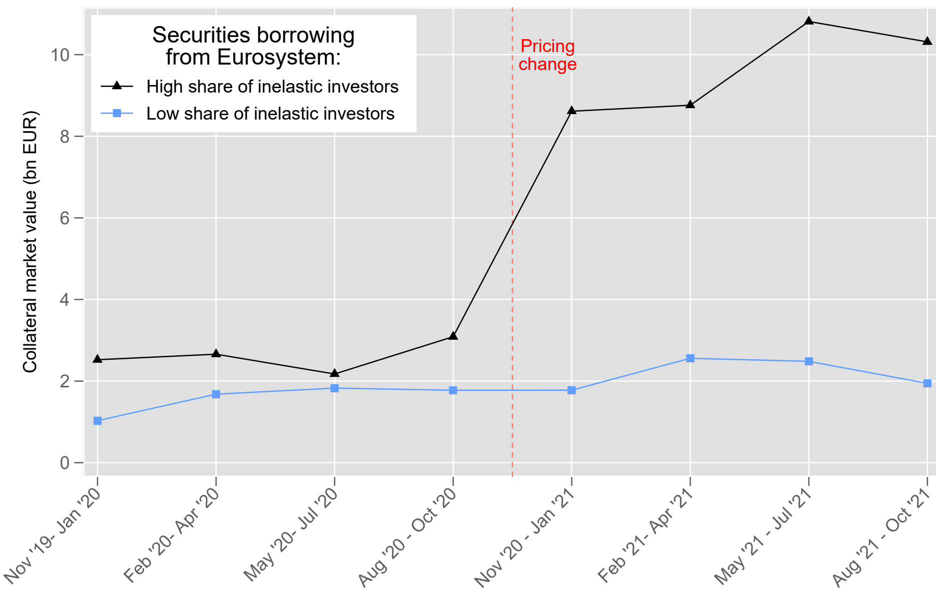


Figure 3:
Securities borrowing from the Eurosystem across securities with otherwise elastic and inelastic supply to the repo market

This figure shows aggregate securities borrowing from the Eurosystem for securities with an otherwise low and high share of inelastic investors, with the median as cutoff. We report the average daily market value of securities borrowed during periods of three months. The sample consists of MMSR reporting agents and their repo activity in government bonds of financially developed markets; the sample period is November 1, 2019 to October 31, 2021. The red dashed line marks the Eurosystem's change in pricing conditions effective as of November 2, 2020.

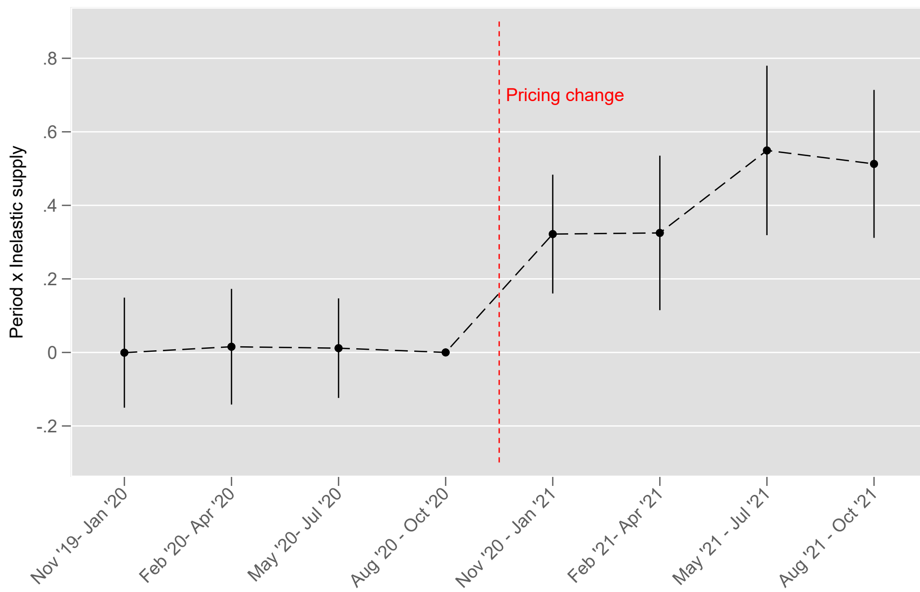


Figure 4: Treatment effect over time
This figure is based on a sub-period estimation of the fixed effects panel regression described in equation (1) that includes control variables as in Table 2 and bond and time fixed effects. The graph displays the interaction coefficient of *Period* $\times$ *Inelastic supply* with 90% confidence intervals over the sample period. Standard errors are clustered at the bond and time level. The red dashed line marks the change in Eurosystem's pricing conditions effective since November 2020. The reference period is August - October 2020, the three month before the pricing change, which is zero by construction.

Table 1: Descriptive Statistics

Table 1 reports summary statistics for the variables used in the analyses. Statistics include the number of bond-day observations (N), mean, standard deviation (SD), and the 25th, 50th, and 75th percentiles. The first group of variables are the amount of securities borrowed and lent by MMSR reporting agents. Amounts are reported at market value (EUR) or scaled by the bonds' total amount outstanding. The second group of variables comprises repo specialness spreads for the terms overnight (O/N), tom-next (T/N), and spot-next (S/N) computed for the MMSR and BrokerTec sample. Specialness spreads are computed as the difference between the GC Pooling rate and the repo rate of the specific bond. The relative bid-ask spread is based on closing prices in the cash market. The last group of variables collect all relevant explanatory variables. The sample period is 01 November 2019 to 31 October 2021.

				Percentiles		
Variable	N	Mean	SD	25th	50th	75th
Amount of securities borrowed & lent						
Dummy: Borrowed from Eurosystem	241,825	0.13				
Amount Borrowed from Eurosystem (in mn EUR)	30,587	117	199		52	
Amount Borrowed from Eurosystem (scaled, in%)	241,825	0.08	0.47		0.00	
Amount Borrowed from Market (in mn EUR)	241,825	1,016	1,294	213	618	1,335
Amount Borrowed from Market (scaled, in%)	241,825	5.83	5.58	2.11	4.24	7.64
Amount Borrowed from Market - CCP (scaled, in%)	241,825	3.60	3.90	1.08	2.36	4.70
Amount Borrowed from Market - Bilateral (scaled, in%)	241,825	2.23	2.74	0.38	1.37	3.07
Amount Lent to Market (in mn EUR)	241,825	1,465	2,930	224	681	1,600
Amount Lent to Market (scaled, in %)	241,825	7.69	12.64	2.22	4.83	9.01
Amount Lent to Market - CCP (scaled, in %)	241,825	3.95	3.60	1.42	2.98	5.34
Amount Lent to Market - Bilateral (scaled, in %)	241,825	3.74	11.63	0.17	1.22	3.28
Repo & Cash Market						
Specialness Spread O/N (MMSR, in bps)	89,485	7.23	11.66	0.00	4.00	11.00
Specialness Spread T/N (MMSR, in bps)	197,071	5.89	8.41	0.49	4.50	9.90
Specialness Spread S/N (MMSR, in bps)	238,143	5.85	6.96	1.48	4.86	9.24
Specialness Spread O/N (BrokerTec, in bps)	45,014	15.11	13.17	5.50	12.00	22.00
Specialness Spread T/N (BrokerTec, in bps)	150,193	8.04	8.43	2.50	6.70	12.00
Specialness Spread S/N (BrokerTec, in bps)	206,702	6.42	6.97	2.00	5.34	10.00
Relative Bid-Ask Spread (in bps)	165,935	13.36	12.64	4.78	8.90	17.57
Explanatory Variables						
Inelastic Share (in %)	241,825	32.48	15.36	20.07	30.77	43.21
Amount Outstanding (in mn EUR)	241,825	15,794	9,192	8,404	15,015	20,636
Age (in years)	241,825	5.56	5.74	1.19	3.97	7.66
Maturity Remaining (in years)	241,825	7.04	7.41	1.43	4.58	9.48
Repo Imbalance (in %)	241,825	-0.70	2.16	-1.80	-0.53	0.41
Dummy: Re-Issuance	241,825	0.0043				
Dummy: Cheapest to Deliver	241,825	0.0011				
Dummy: On-the-run	241,825	0.2292				

Table 2: Effects on the utilization of securities lending facilities

Table 2 shows the result for the fixed-effects panel regression described in equation (1). The dependent variable is the nominal amount of security i borrowed from the EuroSystem at day t scaled by the security i's amount outstanding. The main explanatory variables are: *Post*, which is a dummy variable that equals 1 for the time period after the pricing change of 02 November 2020 and zero otherwise and the *Inelastic suply*, which is the ownership share of investor sectors with inelastic supply to the repo market in bond i measured at the previous quarter end. Control variables are the bond's maturity remaining, age, log amount outstanding, repo imbalance and dummy variables for auction periods and the cheapest-to-deliver (CTD) in Futures contracts. For the ease of interpretation, all continuous variables are de-meaned. The sample period is 01 November 2019 to 31 October 2021 for the full sample (Columns 1 - 3), and 05 October 2020 to 29 November 2020 for the small sample, covering eight weeks around the pricing change (Columns 4 - 6). We report t-statistics based on standard errors, clustered at the bond and time level, in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	$\frac{\text{Amount of securities borrowed from Eurosystem}}{\text{Amount outstanding}} \times 100$					
	Full sample			Short sample: eight weeks around pricing change		
Post × Inelastic supply	0.52***	0.52***	0.41***	0.38***	0.38***	0.37**
	(5.42)	(5.44)	(4.14)	(2.59)	(2.59)	(2.55)
Inelastic supply	0.13***	0.13***	-0.20	0.20**	0.20**	
	(2.65)	(2.68)	(-1.38)	(2.42)	(2.43)	
Post	0.06***			0.04**		
	(5.69)			(2.13)		
Maturity remaining	-0.00**	-0.00**		-0.01*	-0.01*	
	(-2.42)	(-2.42)		(-1.83)	(-1.83)	
Age	-0.00*	-0.00*		-0.00	-0.00	
	(-1.82)	(-1.82)		(-0.85)	(-0.85)	
Log amount outstanding	0.01	0.01	-0.22***	0.01	0.01	-0.41*
	(0.66)	(0.65)	(-4.30)	(0.59)	(0.59)	(-1.92)
Repo imbalance	0.00	0.00	0.01***	0.00	0.00	-0.00
	(0.49)	(0.52)	(3.67)	(0.46)	(0.45)	(-0.66)
On the run	-0.00	-0.00	-0.05**	-0.04	-0.04	-0.00
	(-0.21)	(-0.24)	(-2.01)	(-1.12)	(-1.12)	(-0.23)
Re-issuance	0.09***	0.09***	0.07***	0.08	0.08	0.04
	(3.92)	(3.88)	(3.76)	(0.99)	(0.99)	(0.61)
Cheapest to deliver	1.15***	1.14***	1.05***			
	(4.48)	(4.45)	(4.36)			
Quarter end	0.01					
	(0.54)					
Year end	0.01					
	(1.30)					
R^2	3.5	3.4	28.3	1.5	1.6	73.3
Within R^2	3.5	3.1	1.7	1.5	1.4	1.1
N	241,825	241,825	241,825	19,712	19,712	19,712
Time fixed effects	No	Yes	Yes	No	Yes	Yes
Bond fixed effects	No	No	Yes	No	No	Yes

Table 3: Effects on securities lending facilities' utilization across repo characteristics
Table 3 shows the result for the fixed-effects panel regression described in equation (1) across different repo characteristics. Panel A distinguishes between cash and securities collateral. Panel B distinguishes between different repo tenors, which are: overnight (O/N), tom-next (T/N), spot-next (S/N), 1 day $<$ tenor $\leq$ 7 days (up to one week), 7 days $<$ tenor $\leq$ 90 days (above one week), and open repo. The dependent variable is the nominal amount of security i borrowed from the Eurosystem at day t for the given repo characteristic c scaled by the nominal amount outstanding of bond i. The table reports the interaction term *Post* $\times$ *Inelastic supply* across the different repo tenors, where *Post* is an indicator variable for the period after the pricing change and *Inelastic supply* is the ownership share of investor sectors with inelastic supply to the repo market in bond i measured at the previous quarter end. All regressions include control variables as in Table 2 and time and bond fixed effects. The sample period is 01 November 2019 to 31 October 2021. We report t-statistics based on standard errors, clustered at the bond and time level, in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively.

Dependent variable: $\frac{\text{Amount of securities borrowed from Eurosystem}}{\text{Amount outstanding}} \times 100$

Panel A:	Collateral type	
	securities	cash
Post × Inelastic supply	0.22***	0.19***
	(3.43)	(3.78)
R^2 (%)	22.8	13.1
Within R^2 (%)	1.0	0.9
N	241,825	241,825
Controls	Yes	Yes
Time fixed effects	Yes	Yes
Bond fixed effects	Yes	Yes

Panel B:	Repo tenor					
	O/N	T/N	S/N	up to one week	above one week	open repo
Post × Inelastic supply	0.01	0.01***	0.01*	0.30***	0.07**	0.02
	(1.61)	(3.20)	(1.76)	(3.58)	(2.13)	(0.66)
R^2 (%)	13.4	3.7	7.9	22.8	28.7	17.2
Within R^2 (%)	0.2	0.1	0.1	3.1	0.1	0.2
N	241,825	241,825	241,825	241,825	241,825	241,825
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Bond fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Table 4: Effects on securities lending facilities' utilization across bond characteristics

Table 4 shows the result for the fixed-effects panel regression described in equation (1) across different bond characteristics. Panel A provides a breakdown into buckets of different remaining maturity, Panel B provides a breakdown into different rating groups. The dependent variable is the nominal amount of security i borrowed from the Eurosystem at day t for the given repo characteristic c scaled by the nominal amount outstanding of bond i. The table reports the interaction term *Post* × *Inelastic supply* across the different repo tenors, where *Post* is an indicator variable for the period after the pricing change and *Inelastic supply* is the ownership share of investor sectors with inelastic supply to the repo market in bond i measured at the previous quarter end. All regressions include control variables as in Table 2 and time and bond fixed effects. The sample period is 01 November 2019 to 31 October 2021. We report t-statistics based on standard errors, clustered at the bond and time level, in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively.

Dependent variable: $\frac{\text{Amount of securities borrowed from Eurosystem}}{\text{Amount outstanding}} \times 100$

Panel A:	Remaining maturity (yrs.)	
	<10	≥10
Post × Inelastic supply	0.47***	0.49**
	(3.45)	(2.55)
R^2 (%)	29.7	24.1
Within R^2 (%)	1.6	3.2
N	186,866	54,958
Controls	Yes	Yes
Time fixed effects	Yes	Yes
Bond fixed effects	Yes	Yes

Panel B:	Issuer rating	
	AAA, AA	A, BBB
Post × Inelastic supply	0.55***	0.12
	(3.97)	(1.56)
R^2 (%)	28.4	25.0
Within R^2 (%)	2.2	1.0
N	138,179	103,646
Controls	Yes	Yes
Time fixed effects	Yes	Yes
Bond fixed effects	Yes	Yes

Table 5: Effects on overall repo market activity across tenors

Table 5 shows the result for the fixed-effects panel regression described in equation (1) for different outcome variables across different repo tenors. The dependent variable in Panel A is the scaled amount of securities borrowed from other market participants other than the Eurosystem, in Panel B it is the total amount of securities borrowed from Eurosystem central banks and other market participants, in Panel C it is the market share of Eurosystem central banks. The table reports the interaction term *Post* × *Inelastic supply* across the different repo tenors, where *Post* is an indicator variable for the period after the pricing change and *Inelastic supply* is the ownership share of investor sectors with inelastic supply to the repo market in bond i measured at the previous quarter end. All regressions include control variables as in Table 2 and time and bond fixed effects. The sample period is October 5 to November 29, 2020, covering eight weeks around the pricing change. We report t-statistics based on standard errors, clustered at the bond and time level, in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively.

	(1) All	(2) O/N	(3) T/N	(4) S/N	(5) up to one week	(6) above one week	(7) open repo
Panel A: Amount borrowed from the market (Non-Eurosystem)							
Dependent variable:	$\frac{\text{Amount of securities borrowed from Non-Eurosystem}}{\text{Amount outstanding}} \times 100$						
Post x Inelastic Supply	0.8058	0.3495***	-0.0337	0.1097	0.2370	0.2740	0.0479
	(1.48)	(3.33)	(-0.13)	(0.62)	(1.39)	(0.75)	(0.37)
R^2	90.98	29.13	69.12	52.86	44.35	91.92	80.31
Within R^2	3.39	2.82	4.75	1.14	0.31	1.23	0.39
N	19,712	19,712	19,712	19,712	19,712	19,712	19,712
Panel B: Total amount borrowed							
Dependent variable:	$\frac{\text{Total amount of securities borrowed}}{\text{Amount outstanding}} \times 100$						
Post x Inelastic Supply	1.1754**	0.3872***	0.0206	0.1167	0.4639**	0.3322	0.0334
	(2.06)	(3.57)	(0.08)	(0.66)	(2.12)	(0.89)	(0.25)
R^2	90.87	29.25	69.16	52.82	43.96	91.53	79.21
Within R^2	3.50	3.03	4.73	1.13	0.88	1.30	0.26
N	19,712	19,712	19,712	19,712	19,712	19,712	19,712
Panel C: Market Share of Eurosystem							
Dependent variable:	$\frac{\text{Amount of securities borrowed from Eurosystem}}{\text{Total amount of securities borrowed}} \times 100$						
Post x Inelastic Supply	0.0349**	0.0165	0.0175**	0.0111**	0.1289***	0.0089	-0.0143
	(2.20)	(0.83)	(2.54)	(2.42)	(2.88)	(0.53)	(-0.57)
R^2	54.87	29.30	19.27	2.61	31.18	77.75	42.42
Within R^2	0.35	0.13	0.59	0.70	0.75	0.01	0.12
N	19,712	19,712	19,712	19,712	19,712	19,712	19,712
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bond Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 6: Effects on repo re-use activity

Table 8 shows the result for the fixed-effects panel regression described in equation (1) for different outcome variables. The dependent variable in Panel A is the scaled amount of securities lent to market participants other than the Eurosystem, in Panel B it is a measure of collateral re-use in repurchase agreements scaled by the bond's amount outstanding, in Panel C it is the re-use rate. Additionally, the table distinguished between repos with a central clearing counterparty (CCP) and bilateral repos. The table reports the interaction term *Post* × *Inelastic Supply*, where *Post* is an indicator variable for the period after the pricing change and *Inelastic Supply* is the ownership share of investor sectors with inelastic supply to the repo market in bond i measured at the previous quarter end. All regressions include control variables as in Table 2 and time and bond fixed effects. The sample period is October 5 to November 29, 2020, covering eight weeks around the pricing change. We report t-statistics based on standard errors, clustered at the bond and time level, in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively.

	(1) All	(2) CCP	(3) Bilateral
Panel A: Amount lent to market participants			
Dependent variable:	$\frac{\text{Amount of securities lent}}{\text{Amount outstanding}} \times 100$		
Post x Inelastic Supply	0.9949	1.0025***	-0.0076
	(1.08)	(3.21)	(-0.01)
R^2	94.32	88.85	94.21
Within R^2	2.49	6.50	0.25
N	19,712	19,712	19,712
Panel B: Collateral re-use			
Dependent variable:	$\frac{\text{Collateral re-use}}{\text{Amount outstanding}} \times 100$		
Post x Inelastic Supply	0.5469*	0.7453***	-0.1983
	(1.73)	(3.10)	(-0.85)
R^2	91.35	86.91	88.55
Within R^2	1.33	1.05	1.27
N	19,672	19,672	19,672
Panel C: Re-use rate			
Dependent variable:	Re-use rate × 100		
Post x Inelastic Supply	3.3593	7.8576***	-4.4983*
	(1.07)	(2.90)	(-1.79)
R^2	73.87	64.08	72.90
Within R^2	2.04	2.05	0.50
N	19,507	19,507	19,507
Controls	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
Bond Fixed Effects	Yes	Yes	Yes

Table 7: Effects on repo specialness spreads

Table 7 shows the result for the fixed-effects panel regression described in equation (1) with a bond's specialness spread as the dependent variable. The specialness spread is computed as the difference of the reported repo rate and the GC pooling rate on day t. In Panel A, we include all bonds in our sample. Panel B and Panel C provides a breakdown into buckets of different remaining maturity. Panel D and Panel E provide a breakdown into different rating groups. The table reports the interaction term *Post* × *Inelastic supply*, where *Post* is an indicator variable for the period after the pricing change and *Inelastic supply* is the ownership share of investor sectors with inelastic supply to the repo market in bond i measured at the previous quarter end. All regressions include control variables as in Table 2 and time and bond fixed effects. The sample period is October 5 to November 29, 2020, covering eight weeks around the pricing change. We report t-statistics based on standard errors, clustered at the bond level, in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively.

	(1) O/N	(2) T/N	(3) S/N	(4) O/N	(5) T/N	(6) S/N
Panel A: All Bonds						
	MMSR			BrokerTec		
Post x Inelastic Supply	-6.0560** (-2.55)	-1.1436* (-1.69)	-0.8678* (-1.76)	-7.0846** (-2.58)	-1.8282** (-2.39)	-0.7557 (-1.35)
R^2	42.51	64.32	85.59	36.56	65.23	84.81
Within R^2	0.71	0.42	2.17	0.90	0.96	2.38
N	4,376	10,226	12,863	2,427	7,844	11,297
Panel B: Bonds - Remaining Maturity < 10 Years						
	MMSR			BrokerTec		
Post x Inelastic Supply	-6.4014** (-2.30)	-1.7540** (-2.32)	-0.8678* (-1.76)	-6.6483* (-1.82)	-1.6179** (-2.05)	-0.4103 (-0.78)
R^2	40.86	64.74	86.95	35.02	65.93	85.94
Within R^2	0.93	0.46	2.20	0.63	0.65	2.39
N	3,259	7,346	9,149	1,685	5,443	8,014
Panel C: Bonds - Remaining Maturity > 10 Years						
	MMSR			BrokerTec		
Post x Inelastic Supply	-8.7002 (-1.62)	-0.7375 (-0.48)	-1.5828 (-1.33)	-11.7477** (-2.14)	-3.0423* (-1.92)	-1.8320 (-1.41)
R^2	47.00	63.85	83.08	43.27	64.48	82.89
Within R^2	1.35	1.09	3.14	2.10	2.27	3.23
N	1,117	2,880	3,714	742	2,401	3,283
Panel D: Bonds - Rating AAA, AA						
	MMSR			BrokerTec		
Post x Inelastic Supply	-9.7672*** (-3.12)	-1.7424* (-1.92)	-0.2696 (-0.38)	-7.8214** (-2.44)	-1.9073** (-2.17)	-0.2084 (-0.28)
R^2	38.68	62.37	85.66	34.28	64.84	85.76
Within R^2	2.01	1.13	3.26	0.99	1.59	3.35
N	2,271	4,874	7,170	1,957	5,485	7,176
Panel E: Bonds - Rating A, BBB						
	MMSR			BrokerTec		
Post x Inelastic Supply	-2.0133 (-0.50)	0.3931 (0.25)	0.4094 (0.37)	-4.7416 (-0.63)	0.0728 (0.02)	1.0634 (0.73)
R^2	34.86	60.93	85.12	35.93	60.84	82.33
Within R^2	0.33	1.10	1.06	0.99	0.17	0.92
N	2,105	5,352	5,693	470	2,359	4,121
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Bond Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Table 8: Effects on cash market liquidity

Table 8 shows the result for the fixed-effects panel regression described in equation (1) using the relative bid-ask spread as outcome variable. The table shows effect for all bonds in Column (1) and for two sample splits across remaining maturity in Columns (2)-(3) and issuer rating in Columns (4)-(5). The table reports the interaction term *Post* × *Inelastic supply*, where *Post* is an indicator variable for the period after the pricing change and *Inelastic supply* is the ownership share of investor sectors with inelastic supply to the repo market in bond i measured at the previous quarter end. All regressions include control variables as in Table 2 and time and bond fixed effects. The sample period is October 5 to November 29, 2020, covering eight weeks around the pricing change. We report t-statistics based on standard errors, clustered at the bond and time level, in parentheses. *, **, and *** indicate significance at the 10%, 5%

	(1)	(2)	(3)	(4)	(5)
	All Bonds	< 10 yrs.	>= 10 yrs.	AAA, AA	A, BBB
Dependent Variable: Relative Bid-Ask Spread (in bps)					
Post x Inelastic Supply	-3.7861***	-4.6590***	-2.7955*	-2.8267	-3.9085
	(-2.97)	(-3.06)	(-1.72)	(-1.43)	(-1.55)
R^2	75.81	69.44	72.52	74.17	78.64
Within R^2	0.31	0.55	0.04	0.14	0.25
N	13,111	9,356	3,755	7,338	5,773
Controls	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes
Bond Fixed Effects	Yes	Yes	Yes	Yes	Yes