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Collateral scarcity and market functioning: Insights from the Eurosystem securities lending facilities

Stefan Greppmair
Stephan Jank

Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main,
Postfach 10 06 02, 60006 Frankfurt am Main

Tel +49 69 9566-0

Please address all orders in writing to: Deutsche Bundesbank,
Press and Public Relations Division, at the above address or via fax +49 69 9566-3077

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Non-technical summary

Research Question

Safe assets play a pivotal role as collateral within the financial system. A withdrawal of these assets from the market through large-scale asset purchase programs can impair the functioning of the repo market. To counteract such negative side effects central banks have chosen to make their purchased bonds available for securities lending. We utilize the securities lending facilities as a laboratory to understand the effects of collateral scarcity on market functioning. Specifically, we capitalize on a natural experiment that took place in November 2020, where the Eurosystem modified the pricing conditions of its securities lending facilities, resulting in a significant reduction in the cost of borrowing securities.

Contribution

We exploit the reduction of the Eurosystem's security lending fees as a natural experiment. It represents a rule-based pricing change in the supply of collateral enacted by one of the largest owners in the market. Such a shock allows us to quantify in a causal manner how securities lending programs are used by market participants and how they affect both the repo market and the underlying cash market. Our study provides valuable insights to improve our understanding of how modern monetary policy tools affect market functioning.

Results

We show that the utilization of securities lending facilities surges after the pricing change, in particular for bonds with relatively inelastic lending supply from market participants. We find no evidence that market participants substitute securities borrowing from other market participants with borrowing from the Eurosystem. Rather, total securities borrowing and lending activities increase after the pricing change, in line with the idea that collateral sourced from the central bank is re-used in other independent repo transactions. The availability of additional collateral alleviates scarcity effects and rate dispersion in the repo market and enhances cash market conditions.

Nichttechnische Zusammenfassung

Fragestellung

Hochwertige Sicherheiten spielen eine zentrale Rolle im Finanzsystem. Entzieht man dem Markt diese Vermögensgegenstände durch große Ankaufprogramme, kann das negative Auswirkungen auf die Funktionsweise der Repo-Märkte haben. Um solch negativen Effekten entgegenzuwirken, haben sich Zentralbanken dazu entschieden, die im Rahmen dieser Programme erworbenen Bestände für die Wertpapierleihe zur Verfügung zu stellen. Wir nutzen diese Wertpapierleihefazilitäten des Eurosystems, um die Auswirkungen der Sicherheitenknappheit auf die Marktfunktionalität zu untersuchen. Unsere Analysen basieren auf einer Änderung der Preiskonditionen der Fazilitäten am 2. November 2020, wodurch die Wertpapierleihe beim Eurosystem erheblich günstiger wurde.

Beitrag

Die Senkung der Wertpapierleihgebühr des Eurosystems stellt ein natürliches Experiment dar. Es handelt sich um eine regelbasierte Preisänderung des Sicherheitenangebots, ausgehend von einem der größten Wertpapier-Eigentümer des Marktes. Ein Schock dieser Art ermöglicht es uns, auf kausale Weise zu quantifizieren, wie Wertpapierleihefazilitäten von Marktteilnehmern verwendet werden und wie sie sich sowohl auf den Repo-Markt, als auch auf den zugrunde liegenden Kassamarkt auswirken. Dahingehend liefert unsere Studie wertvolle Erkenntnisse, um besser zu verstehen, wie moderne geldpolitische Instrumente die Marktfunktionalität beeinflussen.

Ergebnisse

Wir zeigen, dass die Nutzung von Wertpapierleihgeschäften nach der Preisänderung stark zunimmt, insbesondere für Anleihen mit einem relativ unelastischen Angebot auf dem Repo-Markt. Wir finden keine Hinweise darauf, dass Marktteilnehmer Wertpapierleihen von anderen Marktteilnehmern durch Leihen beim Eurosystem ersetzen. Vielmehr steigt die Gesamtaktivität der Wertpapierleihe und -verleihe nach der Preisänderung an im Einklang mit der Idee, dass von der Zentralbank beschaffte Sicherheiten in anderen unabhängigen Repo-Geschäften wiederverwendet werden. Die Verfügbarkeit zusätzlicher Sicherheiten mildert Knappheitseffekte und Preisdispersion auf dem Repo-Markt und verbessert die Bedingungen auf dem Kassamarkt.

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Stefan Greppmair** Stephan Jank***

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Abstract

We utilize the Eurosystem securities lending facilities as a laboratory to investigate the impact of collateral scarcity on market functioning. The reduction of securities lending fees, implemented in November 2020, provides a natural experiment for our analyses. This policy change results in a surge in the utilization of securities lending facilities, particularly for bonds with limited supply elasticity in the repo market. We find no evidence of substitution effects; instead, the overall activity in the repo market expands through the collateral multiplier. The improved pricing conditions alleviate collateral scarcity and enhance market quality in both the repo and cash markets.

Keywords: safe assets, collateral scarcity, monetary policy, quantitative easing, securities lending facilities, repo, market functioning

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 them one of, if not the largest single owners of sovereign and public-sector bonds. This significant ownership has the potential to exacerbate existing demand and supply imbalances for safe assets (Caballero and Krishnamurthy, 2009; Krishnamurthy and Vissing-Jorgensen, 2012), leading to adverse effects on the functioning of financial markets. Specifically, safe assets play a pivotal role as collateral within the financial system. The withdrawal of these assets from the market can impair the functioning of the collateral market, i.e., the repo market. Considering the key role the repo market plays for allowing arbitrage of government bonds (Adrian, Begalle, Copeland and Martin, 2013), any deterioration in market quality within the repo market can adversely impact liquidity and price discovery in the cash market. Moreover, impaired market functioning could feed back into the efficacy of monetary policy as it relies on a smooth transmission of key policy rates through money and bond markets (Bindseil and Logan, 2019).

To counteract such negative side effects, central banks have chosen to make their purchased bonds available for securities lending. These 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 functioning. As a result, with the establishment of securities lending facilities in most developed financial markets,[1] central banks effectively have assumed the role of the "securities lender of last resort".

We utilize the securities lending facilities as a laboratory to understand the effects of collateral scarcity on market functioning. Specifically, we capitalize on a natural experiment that took place in November 2020, where the Eurosystem modified the pricing conditions of its securities lending facilities, resulting in a significant reduction in the cost of borrowing securities. The pricing change reduced the minimum rate for securities borrowing against cash collateral by a third, and against securities collateral by half. As a result, the utilization of SLFs within the Eurosystem nearly doubled, surging from 35 billion EUR

[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.

to 69 billion EUR. We utilize this sizable central bank-induced collateral supply shock to comprehend how collateral is channeled through the financial system and what impact it has on market functioning in both the repo and cash markets. Our identification strategy builds on the pricing change, combined with the fact that securities are differentially impacted by the new pricing conditions. In particular, we hypothesize – and subsequently validate in our analysis – that the utilization of securities lending facilities will be higher for securities with a lower elasticity in supply to the repo market. In our empirical analysis, we utilize the comprehensive ownership data available in the Securities Holdings Statistics (see e.g., Arrata, Nguyen, Rahmouni-Rousseau and Vari, 2020; Koijen, Koulischer, Nguyen and Yogo, 2021) to measure the supply elasticity of securities within the repo market.

The insights derived from this natural experiment are manifold. In the first instance, it significantly contributes to our understanding of the effectiveness of securities lending facilities, which has been relatively underexplored thus far. Moreover, and of even greater importance, our setting provides valuable insights to improve our understanding of how modern monetary policy tools impact market functioning. The impact of quantitative easing on financial markets is a subject of significant interest for policymakers and academics alike. However, quantifying the effects of quantitative easing on market functioning can be challenging due to the presence of reverse causality issues. This arises because asset purchase programs are designed to consider prevailing market conditions (Cœuré, 2015), creating potential difficulties in establishing causality. In a more general sense, our setting also sheds light on the interconnection between securities lending markets and the cash market. The relationship between these two markets may appear apparent as dealers frequently utilize repo markets to acquire assets for secondary market-making activities. However, analyzing how frictions in the lending market influence outcomes in the cash market is not a straightforward task, as such an analysis is typically complicated by endogeneity concerns as well. To overcome these issues, our identification strategy leverages a natural experiment, which represents a rule-based pricing change in the supply of collateral enacted by one of the largest owners in the market.

Our findings are summarized as follows: Following the enhancement of pricing conditions in securities lending facilities by the Eurosystem, there is a substantial surge in utilization, particularly for bonds with inelastic supply to the repo market. Our estimates suggest that after the reduction in lending fees, a one standard deviation higher share of inelastic investors leads to a 106% increase in securities borrowing from the Eurosystem compared to pre-period levels. The increase in borrowing securities is of comparable magnitude across cash and securities collateral and it mainly takes place at longer tenors, up to one week and above. We find no evidence that market participants substitute securities borrowing from other market participants with borrowing from central banks. On the contrary, securities borrowing and lending increases among market participants, consistent with the theory of a collateral multiplier (Bottazzi, Luque and Pascoa, 2012; Gorton, Laarits and Metrick, 2020; Infante, Press and Strauss, 2018; Infante and Saravay, 2020; Infante, Press and Saravay, 2020). This implies that a security borrowed from the central bank by one market participant is subsequently reused in another separate repo transaction with a different market participant. The recipient of the security then reuses it in yet another transaction, and so on. Consequently, through multiple reuses, the collateral provided by the central bank leads to a significant expansion in the overall collateral available within the market. Based on our estimates, we find that when the central bank lends out one unit of collateral, it effectively expands the total available collateral in the repo market by a factor of 3.13 units.

The increase in collateral availability has a notable impact on both the repo and cash markets. After the pricing change, securities with otherwise inelastic supply become less scarce, in particular in the overnight segment. For overnight transactions, 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. As complementary evidence for improved repo market functioning, we also observe a significantly lower level of rate dispersion for bonds with low supply elasticity. The greater collateral availability appears to also improve 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. When considering yield curve fitting errors as proxy for liquidity, as suggested by Hu, Pan and Wang (2013), we find a similar decline. The policy change leads to a 10% reduction in the root mean squared fitting error for more inelastic bonds (above the median).

Overall, our evidence suggests that making securities available for lending helps 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 diminishing 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) find 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. An inherent challenge when 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. Our contribution to this literature lies in providing causal estimates by exploiting exogenous variation originating from a natural experiment. Additionally, the extensive coverage of MMSR data, encompassing banks' complete repo operations, enables a detailed examination of the transmission of the policy change along the intermediation chain. In particular, it allows us to analyze possible substitution effects and to quantify collateral multiplier effects in the repo market.

Finally, our study provides insights into the connection between securities lending markets and secondary bond markets. As previously mentioned, 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 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 program (PSPP) and the pandemic emergency purchase program (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 allows for sovereign bonds of a specific jurisdiction (e.g., German Bunds) to be borrowed either from the respective national central bank (in this example, Deutsche Bundesbank) 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 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.

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, and netting of individual transactions is not possible. Furthermore, fails to deliver entail a rather high charge (both explicitly and in terms of reputational damages) and can, in principle, culminate in access restrictions if the charge is not covered swiftly enough. This stands in stark contrast to prevailing market practices, where delivery failures are frequent, strategically employed, and carry minimal to no reputational damage (Fleming and Garbade, 2005). On the other hand, settlement of transactions vis-á-vis the Eurosystem is practically guaranteed since NCBs do not need to locate the securities that they agree to lent out but rather have these in stock. Trading times of the Eurosystem SLFs are aligned with the market. Trading mostly takes place between 9:00am and 4:00pm (CET) but can be more flexible on a case-by-case basis.[2]

Pricing is based on market rates being quoted on electronic platforms, in particular for the more liquid S/N and T/N segments of the market.[3] However, 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.

[2]The only exception are O/N trades which need to be executed until 3:00pm in order to guarantee settlement.

[3]For less liquid term repos, S/N market rates are taken as an initial indication. Specific conditions are then often bilaterally negotiated between the respective counterparties. Pricing for O/N repos is based on a combination of S/N and T/N market 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."[4]

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 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 at 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.

[4] 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 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.

For our empirical strategy, we combine the natural experiment with the fact that securities are heterogeneously affected by the central bank supply shock originating from the change in pricing conditions. Following Duffie (1996) and Arrata et al. (2020), we 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 more 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 reused 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, repo and cash market should remain unaffected. Under the collateral multiplier hypotheses, on the contrary, overall collateral availability increases and, consequently, scarcity effects in the repo market should be alleviated. Since the repo market is crucial for market makers in the cash market, improvements in repo market quality can potentially spill over and positively impact the cash market.

4 Data and descriptive statistics

4.1 Data sources and sample construction

We utilize different data sources to construct the main data set for our analysis. We use data on money market activity from the money market statistical reporting data set (MMSR). The MMSR is a proprietary data set 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 flagged as a "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, T/N, and S/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.[5] 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 data set 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

[5]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.

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 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).[6] As a consequence, we expect available lending supply to be lower when the fraction of *inelastic investors* is high. We provide some empirical validation for the chosen classification of sectors into elastic and inelastic investors. Specifically, we compute 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. The analysis is provided in Figure OA.1 of the Online Appendix. In line with our classification, we observe that monetary financial institutions, investment funds, and other financial intermediaries (mostly security dealers or hedge funds) 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

[6] One reason for the limited participation of insurance companies and pension funds is discussed by Roh (2019): The repo market in the Euro Area heavily relies on CCP-based intermediation nowadays. For a transaction to be CCP-eligible, both counterparties need to have a CCP-membership. While this is often the case for banks, only few non-banks are members of CCPs because membership is costly and only beneficial if an institution has a two-way order flow, which enables a netting of transactions. Since the latter condition is rarely met by insurers and pension funds, they are typically not members of CCPs. This makes them less attractive counterparties for banks that rely on centrally cleared rather than bilateral repos in order to limit their balance sheet exposure. The absence of an active tri-party repo market further hinders repo market participation of insurance companies and pensions funds since interested entities would need to spend a considerable amount of their own resources to set up and run a proprietary repo desk.

thus complements the MMSR data for the analysis on repo rates. Lastly, we collect daily information on bond prices and yields from MTS for estimating zero-coupon yield curves for a subset of euro area countries.

For our final data set, 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.[7] Second, we 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% in order to reduce the influence of reporting issues in the SHS. 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 241,825 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 117 million EUR. This is about 10% of the average borrowing amount from other repo market participants. These observations highlight the backstop character of the Eurosystem 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 securities lending facilities increases once Eurosystem lending fees

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

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 around 0.09% of a bond's amount outstanding on any given day. When compared to the scaled borrowing amount from the market (5.83%), this means that the Eurosystem's market share of total borrowing is about 1.5% on average ($0.09/(0.09 + 5.83) = 1.52\%$). 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 3.60% 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 intermediaries on both sides of the repo market.

Specialness spreads are calculated by subtracting the volume-weighted average repo rate for a specific bond on a given day from the GC pooling rate. 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.[8] 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 (Arrata et al., 2020; D'Amico et al., 2018; Baltzer et al., 2022).[9] We return to this issue in Section 7.1 where we examine how the increase in collateral availability affects bond specialness.

[8]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.

[9]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).

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 securities lending facilities on repo and cash markets.

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 2 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[10] during periods of three months, which are chosen due to data disclosure rules. Before the pricing change, securities with an inelastic investor base are borrowed to a slightly greater extent 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 doubles 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 on the following general regression:

$$\begin{aligned} Y_{i,t} &= \beta_1 \times Post_t \times InelasticSupply_{i,t} + \beta_2 \times Post + \beta_3 \times InelasticSupply_{i,t} + \\ &\quad \gamma \times \mathbf{X}_{i,t} + \alpha_i + \alpha_t + \epsilon_{i,t}, \end{aligned} \tag{1}$$

[10]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.

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_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 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 very weak positive and statistically insignificant association between supply inelasticity and the utilization of the Eurosystem securities lending facilities. 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 doubles on average. This finding is in line with the aggregate growth documented in Figure 1.

Looking at the interaction term *Post* $\times$ *Inelastic supply* of 0.44, we see that the increase in borrowing takes 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 0.38, but still highly statistically significant. The coefficient estimate suggests, that after the policy change, a one standard deviation increase in the share of inelastic investors (0.154) is associated with an increase of $0.154 \times 0.38 = 0.058$ in the scaled securities borrowing amount. Relating this to the pre-change level of 0.055 yields a relative increase by 106%.

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.[11] Note that even though coefficients of quarter and year end are relatively small and insignificant compared to the cheapest-to-deliver dummy, the former is only

[11]In unreported results, we examine whether the observed borrowing behavior for inelastic bonds is different on quarter-end reporting dates. We find that our main coefficient of interest, *Post x Inelastic*, is remarkably stable across a subsample including only non-reporting dates and a subsample including only reporting dates.

related to few bond, whereas the latter represents low supply concerning the entire cross-section of bonds. 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).[12]

To assess the validity of the common trends assumption we follow Autor (2003). We interact our continuous treatment variable *Inelastic supply* with dummies for periods of three months and include them in equation (1) instead of a post-period dummy. Figure 3 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 very close to zero and statistically insignificant from the reference period.

5.2 Exploring different features of repo contracts

In this section we explore how the policy change affects different features of securities borrowing offered by the Eurosystem. We first take a closer look at securities borrowing against different types of collateral, namely cash and securities collateral. While borrowing against cash collateral quite clearly reflects demand for a specific security, borrowing against securities collateral could also be motivated by collateral upgrading, that is, swapping lower-quality against higher-quality collateral. We elaborate on the different motivations

[12]In the online appendix, we present Table OA.1, which distinguishes between the "extensive" and "intensive" margins of utilizing the Eurosystem securities lending facilities (SLFs). Our findings indicate that both the likelihood of using the SLFs and the amount borrowed increase after the policy change, particularly for bonds with inelastic supply. Notably, the increase is more pronounced at the extensive margin compared to the intensive margin in relative terms.

further below. The second feature we consider is securities borrowing at different tenors ranging from short-term (daily) repos to more strategic long-term (3 months) or open term repos.

We investigate possible sources of heterogeneity in our treatment effect 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 0.20 and 0.18 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 0.38. Overall, this suggests that the pricing changes in both cash and securities collateral transactions increase securities borrowing of bonds with inelastic supply.

The ability to observe borrowing against different types of collateral can further help to shed light on different motives for accessing the securities lending facilities offered by the Eurosystem. Borrowing against cash collateral quite clearly reflects the motive of the counterparty: demand for a specific security. The motive for borrowing against securities collateral, on the other hand, can be two-fold: besides demand for a specific security, the counterparty might also be interested in a "collateral upgrade", that is, swapping a low quality against a high quality bond. In the Online Appendix, we provide a more formal analysis of such a "collateral upgrading" incentive. In short, we do not find evidence for such an incentive to be particularly strong when primary dealers borrow securities from the Eurosystem.[13]

Panel B of Table 3 shows the disaggregated 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 0.29. For term repos above one week, the effects are less pronounced with an interaction coefficient of 0.05. 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, which are, however, not always statistically significant. Overall, these results suggest that banks mainly use the securities lending facilities of the Eurosystem to strategically 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.[14]

In sum, after the Eurosystem changed the pricing conditions for its securities lending facilities, bonds with otherwise inelastic supply are increasingly borrowed at longer tenors. The increase in borrowing these securities is quite comparable across cash and securities collateral.

6 Effects on overall repo activity

So far, we have shown that the pricing change has led to significantly higher usage of the Eurosystem 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

[13] We provide further details on the empirical setup and the results of this additional analysis in Section A.1 of the Online Appendix.

[14] We also explore how the treatment effect of the policy change differs across bond characteristics. Our findings reveal that the pricing change has more significant effects on borrowing inelastic bonds issued by issuers with better credit ratings, which are generally considered scarcer in the market. Additionally, we observe comparable effects in size for bonds with shorter remaining maturity ($<$ 10 years) and bonds with longer remaining maturity ($\geq$ 10 years). This robustness check is available in Table OA.2 of the Online Appendix.

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.

The results are given in Table 4. 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 $0.154 \times 0.32 = 0.049$, which corresponds to an increase of 30% 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 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.[15]

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 securities 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 likewise increase 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 4. The significant interaction term *Post* $\times$ *Inelastic supply* indicates that the market share 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 $0.154 \times 0.13 = 2.00\%$ 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

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

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 intuition is as follows: At the start of the collateral chain, the central bank lends its outright security holdings to Bank A. Bank A then reuses a portion of the received collateral in additional independent repo or securities lending transactions with Bank B. Bank B can further reuse the security in subsequent transactions with Bank C, and so on. By summing up the total collateral borrowed across all banks, we arrive at the overall amount of collateral accessible to market participants. To calculate the collateral multiplier, we compute the ratio of the total collateral amount to the outright holdings that back these transactions. Since the central bank is positioned at the start of the collateral chain, this corresponds to the total collateral amount divided by initial securities lending transaction with the central bank. It is important to note that the collateral multiplier is an inherent characteristic of the market and exists even in the absence of a securities lending facility. In fact, the aforementioned chain applies to any investor who offers their outright holdings in an initial securities financing transaction. Instead, the natural experiment we investigate provides us with an opportunity to observe a rule-based change in the quantity of outright holdings provided for securities lending at the beginning of a collateral chain.[16]

The estimates of Table 4, Panel B, Column (1) imply that a one standard deviation higher share of inelastic investors leads to an increase of $0.154 \times 1.10 = 0.169$ in the total scaled securities borrowing amount. We compare this effect to the initial increase in securities lending from the Eurosystem. The estimates of Table 2, Column (6) imply that a one standard deviation higher share of inelastic investors leads to an increase of $0.154 \times 0.35 = 0.054$ in the scaled securities borrowing amount from the Eurosystem.

[16] The concept of the collateral multiplier we employ is similar to the definition provided Infante and Saravay (2020). They define the collateral multiplier as the ratio of the amount of outgoing collateral (which equals to the amount of secured funding) to the amount of collateral that is outright owned. However, our approach differs in one aspect as we consider incoming collateral in the numerator instead of outgoing collateral. It is worth noting that since the majority of incoming collateral received by dealers usually flows out (Infante et al., 2020), this difference is expected to be negligible in practice. Notably, the denominator is the same in both cases as the initial securities lending transaction relies on securities that are outright owned by the central bank.

Relating the increase in the total amount of securities borrowed to initial increase in the amount borrowed from the Eurosystem yields a collateral multiplier of $0.169/0.054 = 3.13$.[17] 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 in the repo market is consistent with findings by Infante and Saravay (2020) in the United States. Their research indicates that the collateral multiplier, when solely focusing on repo contracts, ranges between four and five.[18]

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 repeated re-use of the collateral in the repo market.[19] To validate this mechanism, we need to examine whether reporting agents also 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

[17] 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.

[18] Infante and Saravay (2020) report an aggregate collateral multiplier ranging between six an eight for U.S. Treasuries.

[19] 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.

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 5. Consistent with the idea that the collateral borrowed from the Eurosystem is being re-used in further repo transactions, we document that securities lending of reporting banks significantly increases 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 5. In Panel B of Table 5, we directly study collateral re-use in repurchase agreements. Re-use of collateral increases after the pricing change in bonds with inelastic supply. Re-used collateral is 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 do not only route the additional collateral available to the repo market at the prevailing collateral re-use, but also increase 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 market quality

7.1 Repo market - Specialness Spreads

In this section, we study the impact of the securities lending facilities on repo market quality from two dimensions. In a first step, we analyze whether the change in pricing conditions has a meaningful impact on the specialness spreads in the repo market. In a second step, we examine whether more competitive SLF pricing also helps to reduce rate dispersion in different repo market segments.

The specialness spread 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. Thus, we expect a narrowing of specialness spreads following the reduction in SLF lending fees.

To test this hypothesis, we 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 events. Furthermore, we only consider repos with O/N, T/N, and S/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.

The results are reported in Table 6. 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). The interaction term *Post* $\times$ *Inelastic supply* 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 SLF's pricing scheme for the less liquid O/N segment. As documented in Table 4, the O/N segment 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 help to alleviate the scarcity of available collateral. As a consequence, securities borrowing costs in the repo market decline.

7.2 Repo market - Rate Dispersion

Collateral scarcity can not only impact the average specialness of a bond, it can also lead to higher levels of rate dispersion. For example, Corradin et al. (2020) document a larger dispersion of repo rates after 2015 and argue that part of the increase can be attributed to the large-scale asset purchases. Elevated rate dispersion poses two concerns: First, it affects market quality as it leads to lower pricing efficiency. Second, it impacts monetary policy by lowering pass-through efficiency (Cœuré, 2018; Eisenschmidt, Ma and Zhang, 2023). Therefore, to the extent that the pricing change in the Eurosystem SLFs increased overall collateral availability, we expect to observe a dampening effect on rate dispersion after the policy change.

For the empirical analysis, we adopt the approach of Duffie and Krishnamurthy (2016) and calculate rate dispersion as the value-weighted absolute deviation of rates from average rates on a given day for all bonds of a given country. We opt for such a higher level of aggregation in this analysis to obtain a meaningful measure of dispersion. Since our identification strategy relies on variation in the share of inelastic bond investors, we compute country-level dispersion separately for bonds with above and below median share of inelastic investors. Consequently, we adjust our main regression equation (1) as follows:

$$\begin{aligned} Y_{c,g,t} \quad = \quad & \beta_1 \times Post_t \times D(Inelastic)_{g,t} + \beta_2 \times Post_t + \beta_3 \times D(Inelastic)_{g,t} + \\ & \gamma \times \mathbf{X}_{c,g,t} + \alpha_c + \alpha_t + \epsilon_{c,g,t}, \end{aligned} \tag{2}$$

where $Y_{c,g,t}$ is our dispersion measure, c denotes the respective country, g the group of bonds based on repo supply elasticity (low or high), and t denotes the trading day. $\mathbf{X}_{c,g,t}$ is a vector of control variables measured at the issuer country-group-level, including the fraction of on-the-run bonds, the fraction of bonds with an auction period, and the average repo imbalance.

Table 7 summarizes the estimation results. Analogous to the last section, we present results for different repo tenors sorted from least (O/N) to most liquid (S/N). We observe a significant decline in rate dispersion for bonds with a high share of inelastic investors after the policy change in both the overnight and tom-next segment, by 1.34 and 0.49 bps respectively. To gauge the economic magnitude of our results, we compare this decline to the average pre-period level of dispersion in the respective market segment. For O/N (T/N) transactions, rate dispersion of inelastic bonds declines by a relative amount of 30% (12%).

In summary, our evidence suggests that central banks can effectively support repo market functioning. Securities lending programs increase collateral availability, which helps to reduce specialness and rate dispersion in the market. In a final step, we investigate whether the pricing policy change also influences the underlying cash market of the bonds.

7.3 Cash market - Bid-Ask Spreads

So far, we have documented that the pricing change helps 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 leads 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. The regression results are summarized in Table 8. We document a significant and robust decline in the bid-ask spread after the implementation of the pricing change. In the most stringent specification in Column (3), which focuses on within-bond variation, we find that the bid-ask spread declines by 0.6 basis points for a one standard deviation increase in the share of inelastic investors (0.154×3.78). This translates into a close to 5% decline in the bond's bid-ask spread relative to the pre-period sample mean of 12.63 basis points. The effect 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.

7.4 Cash market - Pricing Errors

An alternative to using bid-ask-spreads as a measure for market quality is to consider how bond yields compare to their model-implied yields. Systematic deviations between the two yields can serve as an indicator for market inefficiency due to a lack of arbitrage capital. This is the basic idea behind the noise measure introduced by Hu et al. (2013). In our context, lower levels of asset scarcity, resulting from the improved pricing conditions of the SLF, could be associated with lower limits to arbitrage and thus, a higher pricing efficiency of the underlying bonds. To test this hypothesis, we calculate the noise measure of Hu et al. (2013) by fitting a yield curve using the Svensson (1994) method which we then use to calculate model-implied yields for each bond on each day for the four largest sovereign bond markets, namely France, Germany, Italy and Spain. The noise measure is then given by the root mean squared error across all bonds of a particular country. Since our identification strategy relies on the heterogeneity across bonds with respect to their share of inelastic investors, we separately calculate for each country the measure for bonds with above and below median share of inelastic investors. The noise measure we use is thus given by:

$$Noise_{c,g,t} = \sqrt{\frac{1}{N_{c,g,t}} \Sigma_{i=1}^{N_{c,g,t}} [y_t^i - y^i(b_t)]^2}, \tag{3}$$

where c denotes the respective country, g the group of bonds based on repo supply elasticity (low or high), and t denotes the trading day. y_t^i is the observed yield of bond i and $y^i(b_t)$ is its model implied yield based on the the Svensson (1994) method. We then use $Noise_{c,g,t}$ as our dependent variable and re-run regression equation (2).

If the new pricing scheme of the Eurosystem's SLF indeed improves cash market quality, we would expect to see a lower level of noise after the change, in particular for bonds with a high share of inelastic investors. Table 9 confirms this conjecture. The main coefficient of interest, *Post x D(Inelastic)*, is negative and significant irrespective of whether we include country-level controls, issuer fixed effects or time fixed effects. Economically, the estimated effect is equivalent to a 10% decline in noise relative to the pre-period average. This result suggests that a higher usage of SLFs is associated with meaningfully smaller pricing errors. In sum, our analysis thus highlights that central banks' securities lending operations do not only help to support repo market functioning but that increased collateral availability also has a positive impact on cash market quality.

8 Conclusion

Using the 2020 policy change in the Eurosystem's securities lending facilities, we study the causal effects of collateral scarcity on repo and cash market functioning. After the reduction in securities lending fees, market participants increase their securities borrowing from 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 through the repo market as they are repeatedly used as collateral. Our estimates suggest, that for each unit of collateral borrowed from euro area central banks, total available collateral increases by more than three units. The improved collateral availability alleviates asset scarcity and rate dispersion in the repo market and enhances cash market quality.

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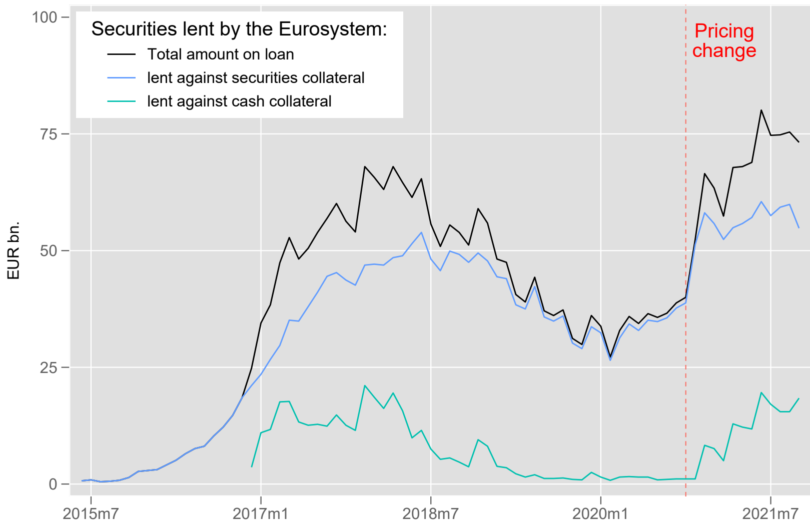
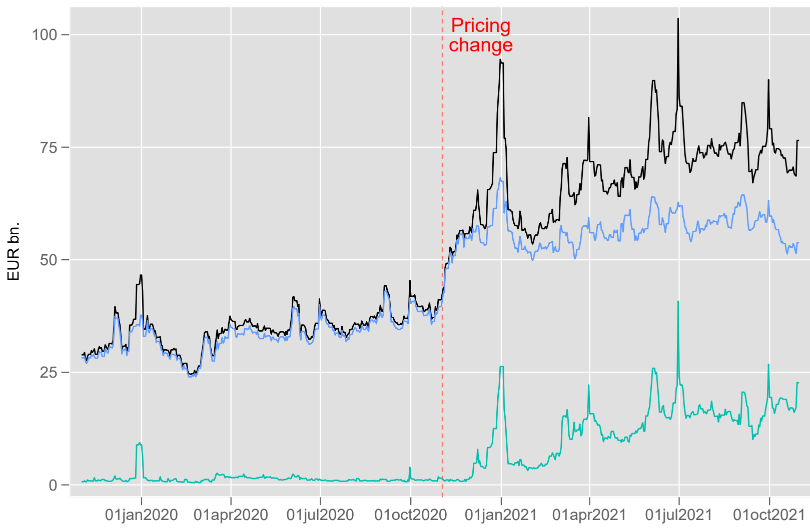
9 Figures and Tables



(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 Eurosystem's change in pricing conditions effective since November 2, 2020. Data source: ECB.

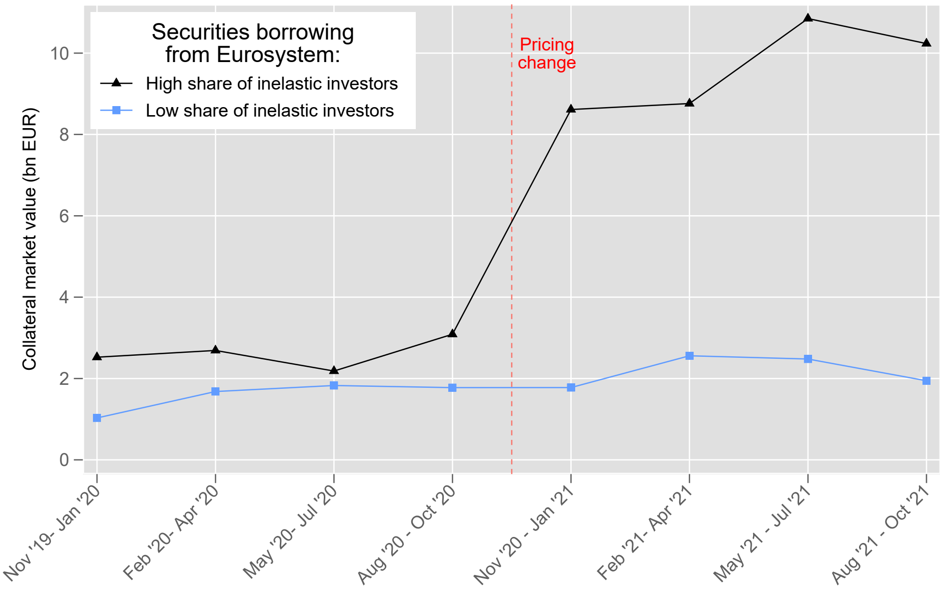


Figure 2:
Securities borrowing from the Eurosystem across securities with otherwise elastic and inelastic supply to the repo market

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.

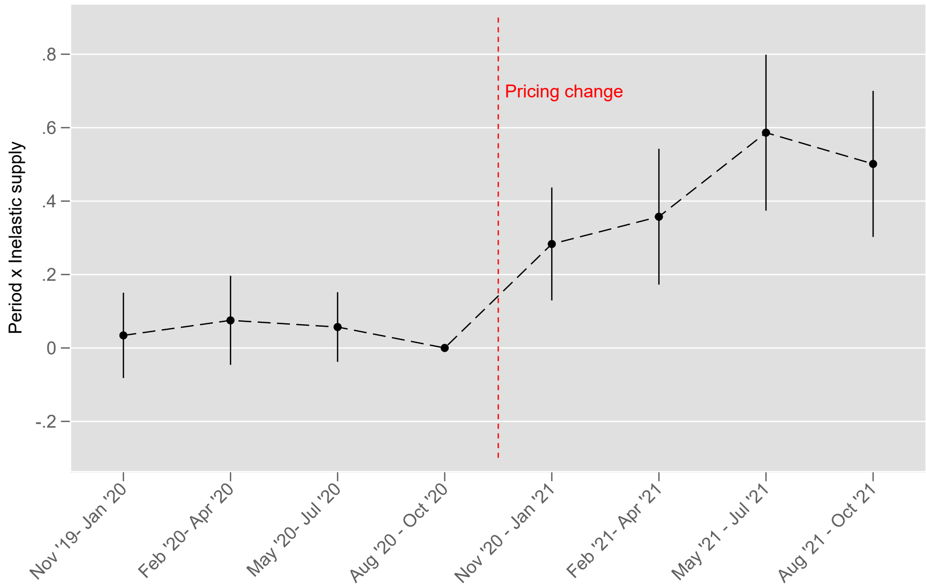


Figure 3: Treatment effect over time

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. In some cases, percentiles for continuous variables are not disclosed but set to missing due to data confidentiality rules. 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)	30,620	117.22	198.61		52.00	
Amount Borrowed from Eurosystem (scaled, in%)	241,825	0.09	0.47		0.00	
Amount Borrowed from Market (in mn EUR)	241,825	1,016	1,295	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
Rate Dispersion O/N (Country-Group Level, in bps)	573	3.10	3.35	0.69	1.87	4.38
Rate Dispersion T/N (Country-Group Level, in bps)	785	3.20	1.73	1.97	3.01	4.17
Rate Dispersion S/N (Country-Group Level, in bps)	800	2.46	0.92	1.86	2.35	3.01
Relative Bid-Ask Spread (in bps)	165,935	13.36	12.64	4.78	8.90	17.57
Noise (Country-Group Level, in bps)	320	2.18	0.83	1.63	1.91	3.04
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	-0.71	2.17	-1.82	-0.54	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 supply*, 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. Moreover, we indicate at the bottom of the table whether issuer, time or bond fixed effects are included. 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=1 x Inelastic supply	0.44***	0.44***	0.38***	0.35**	0.35**	0.35**
	(4.92)	(4.92)	(3.91)	(2.58)	(2.58)	(2.46)
Inelastic supply	0.04	0.04	-0.19	0.05	0.05	
	(0.67)	(0.72)	(-1.35)	(0.48)	(0.48)	
Post=1	0.06***			0.04**		
	(6.25)			(2.70)		
Maturity remaining	-0.00**	-0.00**	0.00	-0.01	-0.01	0.00
	(-1.97)	(-1.98)	(0.00)	(-1.56)	(-1.56)	(0.00)
Age	-0.00**	-0.00**	0.00	-0.00	-0.00	0.00
	(-2.08)	(-2.09)	(0.00)	(-0.64)	(-0.64)	(0.00)
Log amount outstanding	-0.02	-0.02	-0.19***	0.01	0.01	-0.34**
	(-0.88)	(-0.88)	(-4.40)	(0.22)	(0.21)	(-2.17)
Repo imbalance	0.01***	0.01***	0.01***	0.01**	0.01**	0.01
	(3.22)	(3.31)	(5.47)	(2.20)	(2.20)	(1.04)
On the run	-0.03	-0.03	-0.05**	-0.05	-0.05	-0.01
	(-1.13)	(-1.13)	(-2.12)	(-1.35)	(-1.35)	(-1.24)
Re-issuance	0.07***	0.07***	0.06***	0.06	0.06	0.04
	(3.59)	(3.51)	(4.01)	(0.71)	(0.70)	(0.63)
Cheapest to deliver	0.99***	0.98***	0.93***			
	(4.82)	(4.81)	(4.90)			
Quarter end	0.01					
	(1.42)					
Year end	0.01					
	(0.98)					
R^2	7.80	7.85	30.30	3.72	3.58	73.78
Within R^2	3.68	3.14	2.62	1.32	1.21	1.31
N	241,825	241,825	241,825	19,712	19,712	19,712
Issuer fixed effects	Yes	Yes	–	Yes	Yes	–
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. We winsorize the dependent variable at the 1%level. 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: $\dfrac{\text{Amount of securities borrowed from Eurosystem}}{\text{Amount outstanding}} \times 100$

Panel A:	Collateral type	
	securities	cash
Post $\times$ Inelastic supply	0.20***	0.18***
	(3.15)	(3.81)
R^2 (%)	26,57	16.22
Within R^2 (%)	1.62	1.57
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 $\times$ Inelastic supply	0.01	0.01***	0.01*	0.29***	0.05**	0.02
	(1.29)	(3.16)	(1.71)	(3.55)	(2.31)	(0.69)
R^2 (%)	14.03	3.71	8.02	24.04	34.74	18.64
Within R^2 (%)	0.06	0.01	0.16	2.99	0.27	0.21
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 overall repo market activity across tenors

Table 4 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. Dependent variables are winsorized at the 1%level. 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	0.73	0.32***	0.02	0.17	0.18	0.23	0.03
	(1.49)	(3.06)	(0.07)	(1.38)	(1.18)	(0.64)	(0.26)
R^2	92.08	31.31	71.52	55.73	49.84	91.66	80.75
Within R^2	3.63	3.25	5.27	1.22	0.30	1.32	0.34
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	1.10**	0.35***	0.07	0.18	0.36**	0.28	0.01
	(2.13)	(3.28)	(0.33)	(1.43)	(2.12)	(0.75)	(0.12)
R^2	91.96	31.79	71.56	55.67	48.89	91.66	79.55
Within R^2	3.96	3.99	5.28	1.22	0.80	1.34	0.12
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	0.04**	0.02	0.02**	0.01**	0.13***	0.01	-0.01
	(2.12)	(0.70)	(2.52)	(2.22)	(2.73)	(0.53)	(-0.59)
R^2	54.86	29.66	20.89	2.61	31.16	77.75	42.41
Within R^2	0.33	0.65	0.65	0.01	0.72	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 5: Effects on repo re-use activity

Table 5 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. Dependent variables are winsorized at the 1%level. 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	0.80	0.94***	-0.34
	(1.43)	(15)	(-0.64)
R^2	96.33	88.91	96.75
Within R^2	4.52	5.88	0.60
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	0.64**	0.70***	-0.11
	(2.09)	(2.86)	(-0.50)
R^2	91.26	86.56	87.49
Within R^2	1.47	1.00	1.28
N	19,672	19,672	19,672
Panel C: Re-use rate			
Dependent variable:	Re-use rate × 100		
Post x Inelastic supply	3.57	7.83***	-4.48*
	(1.07)	(2.80)	(-1.78)
R^2	73.94	65.50	73.31
Within R^2	1.96	2.04	0.53
N	19,507	19,507	19,507
Controls	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
Bond Fixed Effects	Yes	Yes	Yes

Table 6: Effects on repo specialness spreads

Table 6 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. We winsorize the dependent variables at the 1%level. The table reports the interaction term *Post* $\times$ *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)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Specialness Spread = GC Rate - Repo Rate					
	MMSR			BrokerTec		
	O/N	T/N	S/N	O/N	T/N	S/N
Post x Inelastic supply	-6.05**	-1.14	-0.98	-7.16**	-1.85**	-0.76
	(-2.46)	(-1.36)	(-1.65)	(-2.44)	(-2.16)	(-1.22)
R^2	42.50	64.31	85.59	32.98	57.85	78.82
Within R^2	0.71	0.40	2.20	0.91	0.98	2.36
N	4,376	10,226	12,863	2,427	7,844	11,297
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 7: Effects on repo rate dispersion

Table 7 shows the result for a fixed-effects panel regression based on equation (2) using *Dispersion*, value-weighted absolute deviations from the mean rate, as outcome variable at the issuer country-date level, calculated separately for bonds with a high versus low share of inelastic investors. The dispersion measure is winsorized at the 1% level. The table reports the interaction term $Post \times D_{Inelastic}$, where *Post* is an indicator variable for the period after the pricing change and $D_{Inelastic}$ is a dummy variable which is equal to one when a bond's ownership share of investor sectors with inelastic supply to the repo market is above the sample median (measured at the previous quarter end). All regressions include the following control variables measured at the issuer country-level: fraction of on-the-run bonds, fraction of bonds with an auction period, and average repo imbalance. Moreover, we indicate at the bottom of the table whether time and issuer fixed effects are included. The sample period is October 5 to November 29, 2020, covering eight weeks around the pricing change. We report t-statistics based on robust standard errors in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively

	(1) O/N	(2) T/N	(3) S/N
Dependent Variable:	Rate Dispersion (in bps)		
Post x D(Inelastic)	-1.34***	-0.49**	0.08
	(-2.77)	(-2.17)	(0.73)
R^2	25.89	17.50	36.22
Within R^2	9.87	9.79	9.12
N	573	785	800
Country-Level Controls	Yes	Yes	Yes
Issuer Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	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. We winsorize the dependent variable at the 1% level. 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. Moreover, we indicate at the bottom of the table whether issuer, time or bond fixed effects are included. 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)	(2)	(3)
Dependent Variable:	Relative Bid-Ask Spread (in bps)		
Post x Inelastic Supply	-4.03***	-4.03***	-3.78***
	(-3.64)	(-3.64)	(-2.81)
R^2	49.66	49.81	75.81
Within R^2	35.24	35.37	0.31
N	13,111	13,111	13,111
Controls	Yes	Yes	Yes
Issuer Fixed Effects	Yes	Yes	–
Time Fixed Effects	No	Yes	Yes
Bond Fixed Effects	No	No	Yes

Table 9: Effects on pricing errors

Table 9 shows the result for a fixed-effects panel regression based on equation (2) using the noise measure of Hu et al. (2013) as outcome variable at the issuer country-date level, calculated separately for bonds with a high versus low share of inelastic investors. The noise measure is winsorized at the 1% level. The table reports the interaction term $Post \times D_{Inelastic}$, where $Post$ is an indicator variable for the period after the pricing change and $D_{Inelastic}$ is a dummy variable which is equal to one when a bond's ownership share of investor sectors with inelastic supply to the repo market is above the sample median (measured at the previous quarter end). Some regressions include the following control variables measured at the issuer country-level: fraction of on-the-run bonds, fraction of bonds with an auction period, and average repo imbalance. Moreover, we indicate at the bottom of the table whether time and issuer fixed effects are included. The sample period is October 5 to November 29, 2020, covering eight weeks around the pricing change. The sample is limited to German, French, Italian and Spanish government bonds. We report t-statistics based on robust standard errors in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level respectively

	(1)	(2)	(3)
Dependent Variable:	Noise Measure (Hu et al., 2013)		
Post x D(Inelastic)	-0.20*	-0.21**	-0.21**
	(-1.84)	(-2.48)	(-2.50)
R^2	65.42	78.58	79.49
Within R^2	6.06	41.81	46.67
N	320	320	320
Country-Level Controls	No	Yes	Yes
Issuer Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	No	No	Yes

A Appendix

A.1 Collateral Upgrading

In order to analyze whether counterparties access SLFs to upgrade their collateral, we zoom in on the transactions secured by non-cash collateral and look at different features of the exchanged bonds: inelastic supply, specialness, liquidity, rating, and on-the-run-status. We compute the difference along each of these dimensions between the borrowed bond and the bond securing the transaction and take this difference as our dependent variable. We then regress this variable on a set of bond characteristics and our post dummy. The constant term in the regressions measures the average propensity of market participants to swap bonds of different quality. The coefficient for the post dummy shows us whether the incentive for "collateral upgrading" has increased with the pricing change.

Table OA.3 displays the results of our analysis. Our findings suggest that dealers swap bonds with lower inelastic supply for bonds with higher inelastic supply (Column 1). The same conclusion applies when we consider differences in the specialness of exchanged bonds (Column 2). Both of these observations mirror our main finding and confirm that dealers primarily access SLFs when bonds are otherwise hard to locate in the private market. For liquidity, we find that dealers seem to use more liquid bonds to receive less liquid bonds although this result is not robust to alternative specifications.[20] With regard to the rating of a bond, we do not find evidence that dealers use the Eurosystem's SLF to upgrade their portfolio, i.e. swapping low-rated for high-rated bonds. This result is not surprising given that most NCBs require collateral of the same credit-quality in transactions secured by non-cash collateral. Finally, we document that dealers are more likely to hand in a bond as collateral which is on-the-run (Column 5). This is consistent with dealers having larger inventories of these bonds (see, for example, Ballensiefen, 2022).

[20]In contrast, Fleming et al. (2010) find that dealers accessed the TSLF to swap less liquid with more liquid collateral. However, the TSLF was designed to address distress in funding markets which are more dependent on the availability of liquid collateral. The Eurosystem's SLF in turn were designed to address the broader phenomenon of asset scarcity which is not necessarily solely related to an asset's liquidity.

A.2 Additional Figures and Tables

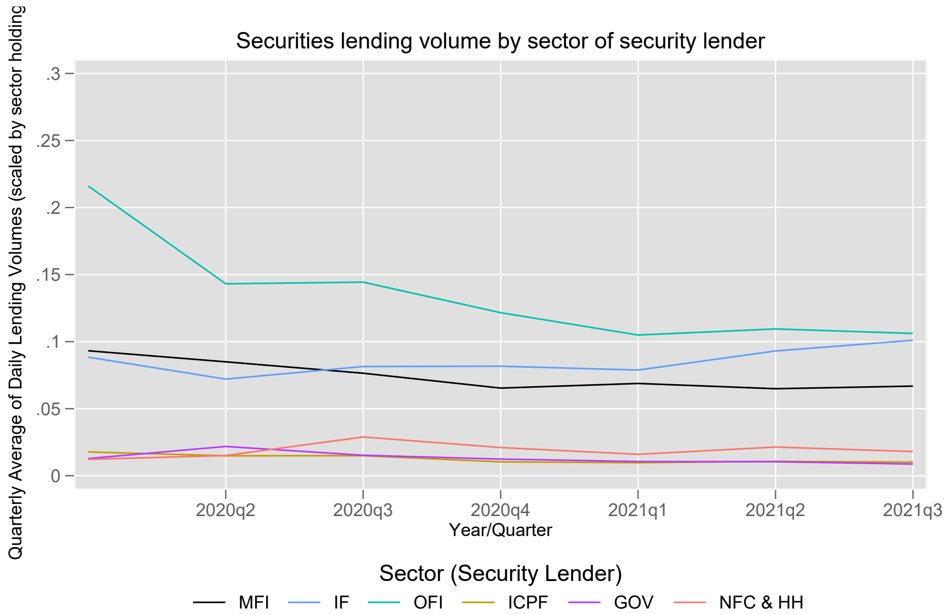


Figure OA.1: Securities lending volume by sector
This figure shows quarterly averages of daily securities lending volumes for different security lenders. We categorize security lenders according to their sector classification: monetary financial institutions (MFI), investment funds (IF), other financial intermediaries (OFI), insurance companies and pension funds (ICPF), 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 as reported in the securities holdings statistic (SHS-S). The sample period is Q4:2019 to Q3:2021.

Table OA.1: Effects on the utilization of securities lending facilities: "intensive" vs. "extensive" margin

Table OA.1 presents a distinction between the "extensive" and "intensive" margins of utilizing the Eurosystem securities lending facilities (SLFs). In Columns (1) to (3), we present the extensive margin using a dummy variable as the dependent variable, taking the value of one if the SLF is utilized for a specific bond on a given day and zero otherwise. In Columns (4) to (6), we present the intensive margin by using the scaled amount of securities borrowed from the SLFs, given the utilization of SLFs. Our specification is the same as in Table 2, including all control variables. We indicate at the bottom of the table whether issuer, time or bond fixed effects are included. 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. The economic magnitudes of the effects are as follows. In Column (3), a one standard deviation increase in inelastic supply is associated with a $0.15 \times 0.33 = 0.051$ increase in the likelihood of using the SLFs for a particular bond on a given day. This represents a relative increase of 58.2% compared to the pre-period frequency of usage (0.088) at the extensive margin. In Column (6), a one standard deviation increase in inelastic supply is associated with a $0.15 \times 0.82 = 0.126$ increase in the scaled utilization amount. This represents a relative increase of 21.1% compared to the pre-period scaled amount (0.596) at the intensive margin.

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable:					
	Dummy: Utilization of SLFs			Scaled amount, given utilization of SLFs		
Post=1 × Inelastic supply	0.41***	0.42***	0.33***	0.65**	0.61**	0.82***
	(7.14)	(7.22)	(5.35)	(2.53)	(2.44)	(3.69)
Inelastic supply	0.05	0.05	-0.15	-0.07	-0.04	-0.71*
	(0.95)	(0.92)	(-1.47)	(-0.26)	(-0.14)	(-1.81)
Post=1	0.08***			0.08*		
	(9.51)			(1.66)		
R^2	10.33	10.8	43.55	20.39	22.12	49.26
Within R^2	4.96	3.71	1.45	11.76	11.39	6.03
N	241,825	241,825	241,825	30,620	30,620	30,567
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Issuer fixed effects	Yes	Yes	–	Yes	Yes	–
Time fixed effects	No	Yes	Yes	No	Yes	Yes
Bond fixed effects	No	No	Yes	No	No	Yes

Table OA.2: Effects on securities lending facilities' utilization across bond characteristics

Table OA.2 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. We winsorize the dependent variable at the 1%level. 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: $\dfrac{\text{Amount of securities borrowed from Eurosystem}}{\text{Amount outstanding}} \times 100$

Panel A:	Remaining maturity (yrs.)	
	<10	≥10
Post × Inelastic supply	0.42***	0.49**
	(3.22)	(2.54)
R^2 (%)	32.16	23.66
Within R^2 (%)	2.68	3.29
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	0.53***	0.12
	(3.84)	(1.48)
R^2 (%)	30.82	25.22
Within R^2 (%)	3.71	0.97
N	138,179	103,646
Controls	Yes	Yes
Time fixed effects	Yes	Yes
Bond fixed effects	Yes	Yes

Table OA.3: Collateral Upgrading

Table OA.3 shows the result for a panel regression using differences between the bond received in the repo leg and the bond acting as collateral in the reverse repo leg of a securities-against-securities transaction with the Eurosystem as outcome variable. We select the following bond-level characteristics to compute the differences: Inelastic supply (Column 1), specialness spread (Column 2), bid-ask-spread (Column 3), bond rating (Column 4), on-the-run status (Column 5). The table reports the constant term of the regression, which gives the average propensity of market participants to swap one bond for another given a certain characteristic. *Post* is an indicator variable for the period after the pricing change and shows whether the propensity changes following to the event. All regressions include control variables as in Table 2 (excluding the respective characteristic chosen as dependent variable) for both the received and the collateralized bond. 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:	(1) Δ Inelastic	(2) Δ Special	(3) Δ BAS	(4) Δ Rating	(5) Δ On-the-Run
Constant	-0.1620***	0.0633***	-0.0163**	-0.0136	0.3546***
	(-3.10)	(9.47)	(-1.98)	(-0.19)	(8.16)
Post	-0.0577**	0.0077	0.0040	0.0273	-0.0210
	(-2.22)	(1.18)	(0.50)	(0.58)	(-0.36)
R^2	18.92	13.89	31.07	15.14	20.57
N	2,467	2,467	2,467	2,467	2,467
Controls - Received Bond	Yes	Yes	Yes	Yes	Yes
Controls - Collateral Bond	Yes	Yes	Yes	Yes	Yes