# Central Bank Haircut Policy and Repo Market Crowding-Out\*

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#### Abstract

Does expansionary central bank lending policy crowd out private wholesale markets? We show that a haircut reduction of EU-bonds in the Eurosystem collateral framework induces banks to substitute other high quality government bonds by EU-bonds. This substitution is particularly strong for large holders of EU-bonds: German banks. Using euro area repo market data, we document that the Eurosystem haircut reduction translates into a negative supply shock of EU-bonds into the repo market. Banks earn around 10 basis points larger repo fees on EU-bonds, while the amount of bonds supplied declines substantially. Consistent with the notion of collateral arbitrage, the negative bond supply effect into the repo market is particularly strong for riskier banks.

Keywords: Central Bank Haircut Policy, Repo Markets, Crowding Out, Market Microstructure

JEL Classification: E58, F33, G15, G20, H63

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## 1 Introduction

How does expansionary central bank lending policy affect the private wholesale funding market? Following a large body of theoretical and empirical research on the central banks role as lenderof-last-resort (LOLR), expansionary lending policy has benign effects on financial markets in times of high stress. However, maintaining such lenient lending policies in normal times might undermine banks' incentive to borrow on the private market since banks can refinance themselves at comparatively favorable conditions through central bank facilities. This is particularly appealing to weakly capitalized banks and to banks that hold a large share of risky assets, which has been associated with undesirable side effects such as risk-shifting.<sup>1</sup> Since the lenient lending policy stance of most central banks only reverted very slowly, if at all, to its pre-crisis level, these policies have a long-lasting impact on the private wholesale funding market, which is not yet fully understood.<sup>2</sup>

Using confidential data from the secured segment of the euro area wholesale funding market, also referred to as the repo market, we show empirically that expansionary central bank lending policy crowds out the repo market. A key empirical challenge to identifying crowding-out effects of central bank lending policy lies in the fact that policy changes usually occur in times of high stress: if the repo market is not a funding option to banks, it can also not be subject to crowdingout by central bank lending. In this paper, we address this empirical challenge by exploiting an haircut reduction of bonds issued by the European Commission (EU-bonds) relative to central government bonds in the Eurosystem collateral framework. After the haircut reduction, EUbonds can be pledged at Eurosystem facilities under the same conditions as central government bonds issued by Germany and France, for example, while they were previously receiving a larger haircut. The haircut reduction of EU-bonds was announced in December-20, 2022 and implemented in June-29, 2023.<sup>3</sup>

We argue that this haircut reduction is a plausibly *exogenous* event that allows us to isolate the effect of central bank lending policy on banks' incentive to supply bonds to the repo market. Since there has been no adverse market event that prompted the Eurosystem to reduce haircuts on EU-bonds in the second half of 2022, we can reasonably assume that all market participants had access to private sector funding. The effects of the haircut reduction can, therefore, be attributed to a change in banks' funding conditions with the Eurosystem relative to the repo market.

As a preliminary step, we demonstrate that the haircut reduction of EU-bonds was a *relevant* event for financial markets in general and for euro area banks in particular. First, using proprietary data on banks' pledging behavior at Eurosystem lending facilities, we document that the use of EU-bonds increased significantly relative to untreated central government bonds after the haircut reduction. This reflects the relative attractiveness of obtaining Eurosystem funding

<sup>&</sup>lt;sup>1</sup>The associated reduction in funding costs for such banks is sometimes referred to as stealth recapitalization. <sup>2</sup>Most major central banks undertook exceptionally large credit operations in response to the Great Financial

Crisis and the Covid-Pandemic. These policies include (temporary) relaxations of minimum rating requirements, haircut reductions, large-scale asset purchases and long-term refinancing operations.

 $<sup>^3 \</sup>mathrm{See}$  this link for the full ECB policy announcement from December-20, 2022.

by pledging bonds subject to a smaller collateral haircut and is consistent with the concept of *collateral arbitrage.*<sup>4</sup> The effect becomes statistically significant in June 2023, after the haircut reduction came into force and is economically large: at the bond level, each bank on average increases the amount of EU-bonds pledged by around EUR 7.5 millions. In the aggregate, euro area banks now pledge more EU-bonds than control bonds in *absolute* values. The effect is particularly strong for German banks, which are a major holder of EU-bonds. The rebalancing of collateral portfolios in response to a change in relative haircuts resembles the portfolio rebalancing effects of asset purchase programmes documented in Koijen et al. (2021). In addition, the Eurosystem haircut reduction was also a relevant event for the pricing of EU-bonds on the secondary market: EU-bond yields dropped by 11 to 24 basis points after the haircut reduction was announced, which reflects the improved eligibility premium of EU-bonds.

We then test whether the Eurosystem haircut reduction for EU-bonds bears implications for the supply of such bonds to the repo market. Throughout the analysis, we focus on repo borrowing transactions, in which banks obtain cash from a counterparty in exchange for supplying bonds. As far as our analysis is concerned, a repo is characterized by its rate, the amount of cash transferred and the amount of bonds pledged as collateral. From the banks' point of view, the benefit of supplying bonds to the repo market positively depends on the amount of cash obtained per unit of bonds - the *cash conversion rate* of a repo - and the spread between the repo rate and the Eurosystem's deposit facility rate which banks earn per unit of cash.<sup>5</sup> We refer to the income per unit of bond as the *repo fee*, which is conceptually similar to a securities lending fee.

How do central bank collateral haircuts affect the repo market? While they do not directly matter for bond demand by non-banks, they negatively affect their supply by locking up treated EU-bonds with the central bank. The supply shock should be largely driven by banks that intend to pledge bonds with the Eurosystem, or have a higher probability of doing so in the future and therefore prefer to hoard such bonds. In addition, repo market supply might also decline if banks that are active on the repo market sell EU-bonds to less active, smaller banks which in turn pledge these bonds with the Eurosystem. The repo market equilibrium can be characterized in terms of a repo fee and the quantity of bonds exchanged. Assuming that bond supply (demand) in the repo market increases (decreases) in the fee, this negative supply shock should decrease repo volumes and increase repo fees.

Using transaction level data from the euro area repo market, we first show that repo fees on EU-bonds increase significantly and substantially after the haircut-category upgrade, relative to a untreated high quality central government bonds. The effect size amounts to around 10bps. This effect is economically meaningful, compared to a full sample average repo fee of 25 bps. At the same time, the EU-bond repo transaction size declines by EUR 5 millions after the haircut

 $<sup>^{4}</sup>$ Related to the concept of collateral arbitrage, Crosignani et al. (2020) show that banks actively acquire government bonds in order to pledge them with central bank facilities due to the collateral eligibility of such bonds.

 $<sup>^{5}</sup>$ The notion of the *cash conversion rate* is similar to a *repo haircut* with the important difference that haircuts are computed based on the market value of pledged collateral. Since the Eurosystem haircut reduction also changes the market value of EU-bonds, the repo haircut is affected mechanically. Focusing on cash conversion rates allows us to abstract from such valuation effects.

reduction, which is a substantial decline relative to a full sample average of EUR 58 millions. In contrast, we do not find a robustly significant effect on cash conversion rates.

To justify the causal interpretation of our estimated effects, we need to address several concerns. Our sample period starts on April-01, 2022, after the last major collateral policy change by the Eurosystem. There was arguably no change in fundamentals and liquidity conditions for EU-bonds or Bunds between April and December 2022, such that it is reasonable to treat the haircut category upgrade as plausibly exogenous with respect to the haircut-category upgrade. This is supported by the absence of statistically significant pre-trends for repo fees. Our baseline specification includes a set of macroeconomic control variables that might affect repo market activity over time. We also include ISIN fixed effects to ensure that our results are not driven by specific bonds, which is particularly relevant for our control group that contains (scarce) German government bonds. We also absorb relationship-specific repo market outcomes by adding bank  $\times$  counterparty fixed effects.<sup>6</sup>

To inspect the driving forces behind these economically large effects, we exploit the granularity of our dataset and separately add counterparty  $\times$  date and bank  $\times$  date fixed effects. When controlling for bond demand by adding counterparty  $\times$  date fixed effects, we observe a similarly sized coefficient on the interaction between the Post- and treatment indicators when using the repo fee as outcome variable. However, the coefficient on repo volumes increases fourfold, pointing towards substantial heterogeneity in banks' bond supply. To further qualify the role of bank heterogeneity, we collect bank CDS to construct sub-samples of risky and safe banks. The volume effect is considerably stronger for the sub-sample of risky banks, while the fee income increases more for safe banks. Both observations are consistent with risky banks reducing their bond supply to the repo market.

Conversely, we study the role of bond demand by adding bank  $\times$  date fixed effects. Again, the effect on repo fees is quite similar to the baseline, but the volume effect vanishes. We then re-estimate our baseline specification on the sub-samples of bank and non-bank counterparties, respectively. The entire effect on volumes can be attributed to bank counterparties, which are typically more price sensitive than non-banks. Indeed non-banks experience an increase in the repo fee by 13 basis points, while volumes do not change significantly. We obtain similar results when sub-sampling repos into cash- and collateral-driven trades. Collateral-driven trades should generally be characterized by negative haircuts, i.e. banks receive more cash than the market value of pledged collateral. With a larger probability, such trades correspond to non-bank counterparties with a very inelastic demand for specific assets, although the distinction is less sharp than the sectoral decomposition. Nevertheless, we observe a stronger increase in fees and a smaller decrease in volume.

**Related Literature** Our paper relates to three strands of literature. First, a series of papers studies potentially unindented side effects of expansionary central bank lending policies.

<sup>&</sup>lt;sup>6</sup>Our results are robust to excluding all green sovereign bonds, bonds targeted in the German debt management office's securities lending facility, truncating the pre-event window to take out a previously announced collateral framework change unrelated to EU and central government bonds, and excluding all German bonds from the control group.

Crosignani et al. (2020) demonstrate that the ECB's long term refinancing operations induced banks to acquire short-term government bonds in order to pledge them with the central bank. Using euro area data, Drechsler et al. (2016) document that in particular riskier banks were borrowing more heavily against riskier collateral from central bank facilities during the European debt crisis. Our analysis suggests that these patterns are also present outside of crisis periods. Jasova et al. (2023) show that banks' pledging behavior is affected by central bank haircuts, in particular for bank bonds, which bears implications for the interconnectedness of large banks.

By using a change to the collateral framework as exogenous source of variation, our paper is also related to papers studying the implications of central banks' collateral framework. Pelizzon et al. (2023) finds that the inclusion of corporate bonds in the Eurosystem's list of eligible assets lowers their yields, eligible corporations expand their market presence in corporate bonds and reduce bank debt. Van Bekkum et al. (2018), Mésonnier et al. (2021), Chen et al. (2022) and Harpedanne de Belleville (2023) use relaxations in minimum rating requirements to establish effects on corporate bond or loan rates. Using the introduction of the ECB single collateral framework list, which allowed euro area banks to pledge cross-border bank loans as collateral Hüttl and Kaldorf (2023) show that collateral policy has an effect on increased loan supply and pricing of affected banks, even without affecting minimum rating requirements. The estimated effect of the haircut-category upgrade on secondary market yields is at the upper end, but still in the range of this literature. The effects of changes to central bank *haircuts* on the secondary and repo market are still largely unexplored, see Adler et al. (2023).

Furthermore, our paper contributes to the literature studying crowding-out effects of central bank policies in the context of asset purchase programmes. Using US data, D'Amico et al. (2018) study security-specific supply effects, largely driven by the Federal Reserve's asset purchases, on the repo market and find results consistent with a collateral scarcity channel of APPs. Corradin and Maddaloni (2020) and Arrata et al. (2020) link the APPs to safe asset scarcity on the repo market using data from the Eurosystem Public Sector Purchase Programme.

**Outline** The paper is structured as follows. We describe the institutional background and data in Section 2. In Section 3, we demonstrate that banks adjusted their pledging behavior with the Eurosystem after the policy change and that secondary market yields responded substantially to the haircut reduction. We present our main analysis of the repo market effects in Section 4. Section 5 discusses potential policy implications and concludes.

# 2 Institutional Background and Data

In this section, we provide an overview of the Eurosystem collateral framework in the context of government bonds and supranational debt and on the European Commission's debt issuance. We additionally provide information on the datasets employed in the analysis.

**Eurosystem Collateral Framework** The Eurosystem implements monetary policy by providing various types of loans to banks, spanning from very short-term loans, such as overnight and intra-day, to longer-term loans with maturities of up to four years. All central bank lending by the Eurosystem is against collateral, which in turn is subject to haircuts. Government bonds are still a major asset class that euro area banks use as collateral. Specifically, in 2023Q3, government bonds make up around 13% of all marketable assets pledged as collateral and 9% of total collateral.

Collateral haircuts depend on instrument and issuer characteristics, such as seniority, credit rating, remaining maturity and coupon structure, but are independent of the counterparty.<sup>7</sup> While they are revised irregularly, one important revision of haircut schedules was a 20% assetwide haircut reduction in April 2020, following the Covid19 pandemic. The haircut adjustment was subsequently revised in two stages. On March-20, 2022, the Eurosystem announced to cut the haircut reduction across all assets from 20% to 10% after July-8, 2022.<sup>8</sup> This announcement was the last modification of the Eurosystem collateral framework affecting central government bonds and EU-bonds before the haircut-category upgrade and, thereby, restricts our sample to start in April 2022. On December-20, 2022, the Eurosystem announced that the haircut schedules would resume to their pre-pandemic level in June 2023 and announced several additional modifications. It re-assigned debt instruments issued by the European Union from haircut category II to haircut category I, the same used for debt instruments issued by central governments.<sup>9</sup>

We provide a comparison of the change in valuation haircuts applied to EU-bonds before and after the policy change in Table 1. Note that the general increase in the haircut level affects all asset classes uniformly and has been announced already in March 2022 and can, thus, reasonably assumed to be priced by market participants. The surprise component in the policy change announced in December 2022 is the re-assignment of EU-bonds form haircut-category II to category I. Here, the *relative* reduction is fairly stable across maturities, at 50% for the shortest bonds, at 33% for maturities between one and three years, and at 40% for bonds with a maturity of more than 30 years.

Maturity	December 2022		July 2023	
(years)	Category I	Category II	Category I	Category II
[0,1)	0.5	0.9	0.5	1.0
[1,3)	0.9	1.4	1.0	1.5
[3, 5)	1.4	2.3	1.5	2.5
[5, 7)	1.8	3.2	2.0	3.5
[7, 10)	2.7	4.1	3.0	4.5
[10, 15)	4.5	7.2	4.0	6.5
[15, 30)	4.5	7.2	5.0	8.0
30+	4.5	7.2	6.0	10.0

Table 1: Haircuts on AAA-rated bonds in haircut-categories I and II

Notes: All values in percentage points. Source: ECB

<sup>7</sup>See Bindseil et al. (2017) for a comprehensive discussion.

<sup>&</sup>lt;sup>8</sup>See the ECB press release from March-24, 2022 here for more details.

<sup>&</sup>lt;sup>9</sup>See the ECB press release from December-20, 2022 here for more details.

**EU-bonds and Bond Market Data** The Covid-19 pandemic has induced the European Commission to increase bond market-based borrowing with the aim of supporting the European Union's effort to accelerate the recovery from the pandemic and the associated recession. Notably, this is in sharp contrast to earlier proposals aiming at manufacturing euro area safe assets by tranching sovereign bond portfolios (see for example Brunnermeier et al. (2016)). Bond issuances under the new "Support to Mitigate Unemployment Risk in an Emergency" (SURE) and "Next Generation EU" (NextGenEU) programmes have far exceeded historical issuances under the European Financial Stability Mechanism (EFSM) and Macro-financial Assistance programmes (MFA). The European Commission has announced to switch towards a "unified funding strategy" that aims at reducing fragmentation between different EU programmes. Therefore, throughout the paper, we refer to bonds issued under any European Commission programme as EU-bonds.<sup>10</sup>

Credit and liquidity risks are the most important characteristics of sovereign bonds, at least as far as wholesale funding markets are concerned. Due to technical differences in the order book system and the absence of a futures market, the secondary market for EU-bonds has structural differences to the secondary market for German bonds, which is the incumbent euro area safe asset. Bletzinger et al. (2022) provide a discussion of the EU-bond market in 2020 and 2021. Furthermore, EU-bonds are not included in benchmark sovereign bond indices. Bonfanti and Marcucci (2023) demonstrate empirically and theoretically that investment mandates can explain parts of the yield spread between EU-bonds and German bunds. Therefore, we also include slightly less liquid central government bonds into the control group.

Under the NextGenEU programme, the European Commission increased its issuance volumes from about EUR 0.4 billions in 2019 to almost EUR 120 billions in 2023, thus turning from a small-scale supranational agency into a sovereign-sized issuer of debt. With more than EUR 400 billions of outstanding debt in 2023, the EU-bonds already exceeded the nominal debt of sovereigns such as Austria and will soon approach Belgium. By the end of 2026, the European Commission debt is projected to reach about EUR 800 billions, thus becoming the third-largest single issuer of euro-denominated debt.<sup>11</sup>

Regarding credit risk, EU-bonds have received an AAA rating from all relevant credit rating agencies.<sup>12</sup> The AAA-rating of EU-bonds is a reflection of several layers of protections and guarantees for investors. Coupon and redemption payments are serviced by the member states's contributions to the European Commission, based on their Gross National Income. The annual contributions the EU can call from member states has been raised from 1.4% to 2.0% of Gross National Income specifically to finance repayment of NextGenEU bonds, while SURE, EFSM

<sup>&</sup>lt;sup>10</sup>SURE social bonds were issued to reduce financing costs of the Union's members temporary unemployment schemes. NextGenEU bonds are issued to finance the economic recovery of member states with an emphasis on the green and digital transitions. For details on the unified funding strategy of the EU-comission, we refer to this press release.

<sup>&</sup>lt;sup>11</sup>With the NextGenEU programme, the European Commission has committed to raise 30% (e.g. EUR 250 billions) of funds via green bonds, which we also exclude in a robustness check to ensure that our results are not driven by a secular shift towards green bonds.

<sup>&</sup>lt;sup>12</sup>As of December 2022, these rating agencies are Fitch, Moody's, Scope and DBRS. More details are provided by the European Commission here.





*Notes:* This figure displays the share of EU-bonds outstanding relative to all high-quality public debt, which is defined as the sum of EU-bonds and high-quality central government bonds (Germany, France, the Netherlands, Belgium). *Source:* Centralised Securities Database

and MFA bonds re-payments are covered from the initial 1.4%. Finally, the European Union can also reallocate funds of its budget to honor its obligations. As a result of these guarantees, the European Union currently receives a better credit rating than 22 out of 27 members states.

Both liquidity considerations (such as market size) and the absence of substantial credit risk affect the choice of our control group in our empirical analysis and we are essentially left with bonds issued by Germany, France, the Netherlands, and Belgium. We refer to those bonds as high-quality central government bonds. In Figure 1, we show that the share of EU-bonds in high-quality public debt increased steadily from around 5% to almost 10% by the end of 2023. Since this secular shift towards a larger share of EU-bonds might confound our empirical strategy, we use it is a control variable throughout the analysis.

We retrieve secondary market bond yields and prices from *LSEG Refinitv* and general information on the bonds such as maturity and issuance date, issuer ratings and nominal value outstanding from the *Centralised Securities Database*. We obtain a list all bonds issued by the European Commission and Germany, Belgium, France and the Netherlands - our control group together - since 1980 from *LSEG Refinitv*, accessed via *Eikon*. We focus on Euro-denominated bonds, since bonds in foreign currency are not eligible in the Europystem collateral framework. As customary in the literature, we focus on fixed coupon bonds, which account for the majority of outstanding public debt.

**Repo Market Data** Our main data source is the repo segment of the *Money Market Statistical Reporting (MMSR)*, a regulatory dataset introduced in July 2016 that contains all repo transactions with a maturity below one year, reported by banks to the Eurosystem. On the repo market, financial institutions trade securities against cash. A *borrowing* transaction refers to instances where banks obtain cash from counterparties, for example hedge funds, and deliver a security. Consequently, banks obtain the security and become creditors vis-a-vis counterparties, such as pension funds in a *lending* transaction. Since the financial crisis, the euro repo market is typically characterized as a securities-driven market, rather than a cash-driven market, which reflects a scarcity of certain asset classes, specifically safe bonds. We refer to Mancini et al. (2015) and Brand et al. (2019) for an overview.

We use the European MMSR, under which 53 euro area banks report all repo market transactions to the European Central Bank. All banks with a balance sheet size of 0.35% of the aggregate balance sheet of all euro area banks are included in this dataset. For every transaction, we observe tenor and repo rate, reporting agent (i.e. the bank), counterparty, nominal cash and collateral volume transacted, a flag if the repo counterparty is a central clearing counterparty (CCP), and the bond used as collateral. We restrict our focus to single collateral fixed-term repos and overnight transactions, with overnight, tomorrow-next and spot-next tenor contracts, which account for the vast majority of repo segment's transactions.<sup>13</sup> We align transactions on the *settlement date* to address potential biases due to a mismatch in the repo tenors.

To ensure that our results are not driven by outliers, we apply a simple trimming filter to deal rates, and cash and collateral volumes separately. Furthermore, we exclude transactions where the counterparty is missing or a central bank. We further drop reporting agents that are not active in the repo market by excluding all institutions that do not have any observation in more than 75% of all months in our sample. Finally, we exclude observation near quarter and year-end events, which might be driven by window-dressing behavior.

**Financial Market Data** We obtain daily time-series of overnight index swap rates (OIS) with a maturity of one year and ten years to compute the slope of the yield curve, which captures market participants' expectations on future monetary policy. The spread between OIS and Euribor is used as a control for the level of credit risk in the interbank market. We also retrieve the Standard and Poor's GSCI Commodity index to control for the periods of high demand of high quality assets, which could be particularly relevant for German collateral during the 2022' energy crisis. To subset our sample of banks into risky and safe, we collect daily credit default swaps. All time series are downloaded from *LSEG Refinitv*, accessed via *Eikon*.

# **3** Preliminaries: Eurosystem Pledging and Secondary Market

As a preliminary step, we test how the haircut reduction on EU-bonds affects banks' decision which bonds to pledge with the Eurosystem. First, we document that euro area banks pledged a significantly higher share of EU-bonds with the Eurosystem after their haircut was reduced in

<sup>&</sup>lt;sup>13</sup>In a spot-next tenor, the first leg of the contract is settled at t+2 and the second leg (e.g. maturity) at T+3. In a tomorrow-next transaction, repos are settled one day after the trade, at t+1 and the bond is repurchased at t+2. In overnight transactions, the agreement and settlement occur on the the trade date and the second leg is settled at t+1

July 2023. This confirms that central bank haircut policy has a direct effect on bank decisions, which is an important prerequisite for our analysis of the private wholesale funding market. Second, we demonstrate that secondary market yields of treated EU-bonds drop significantly relative to the control group after the haircut reduction was announced.

**Banks' Pledging Behavior with the Eurosystem** To test the effect of Eurosystem haircuts on banks pledging behavior, we obtain data of all euro area banks from the Eurosystem's *Use of Collateral Database.* This dataset collects information on the amount of collateral pledged to the Eurosystem by each bank at a weekly frequency. The collateral pool hold by a counterparty can be used for all kinds of collateralised operations with the Eurosystem (e.g. Main Refinancing Operations, Longer-term Refinancing Operations, Targeted Longer-term Refinancing Operations, Pandemic Emergency Longer-term Refinancing Operations and other tender operations, Marginal Lending Facility and intraday credit). The collateral used can be substituted anytime, every day or intraday, independently of the tenor of an operation. UCDB data shows end of day positions. For each bank i, we compute the amount k of pledged EU-bonds and pledged control bonds (issued by Germany, Belgium, the Netherlands and France) in week t, which we denote by  $P_{i,k,t}$ .

In Figure 2, we show the time-varying effect of the haircut reduction for EU-bonds on the pledged amount of EU-bonds and by the control group, relative to week 51 of 2022 when the policy change was announced. The specification includes bank fixed effects  $\chi_i$  and a set of macro controls that we also use in the repo market specifications in Section 4. We include Standards and Poor's GSCI commodity index as a plausibly exogenous measure of real economic activity as far as sovereign bond and repo markets are concerned. To take bond supply factors on the secondary market into account, we include the ratio of EU-bonds over the control's nominal value outstanding. The slope of the yield curve (OIS 10 years - OIS 1 year) captures market expectations about future monetary policy, while the 3-month EURIBOR-OIS spread is a commonly used measure of counterparty default risk on the interbank market. Standard errors are clustered at the bank × bond level to take into account that pledged collateral is subject to substantial auto-correlation at the bank level.

Relative to our control group of highly rated central government bonds, the amount of EUbonds pledged to the Eurosystem does not respond to the policy announcement, but increases significantly around its implementation in June 2023. Furthermore, Figure 2 shows that the coefficient on the treatment indicator is insignificant in almost all weeks prior to the implementation of the haircut reduction. The coefficient size implies that each bank permanently increases its pledging of EU-bonds on average by around EUR 7.5 millions.

We illustrate the macroeconomic relevance of these effects in Figure 3. The left panel shows the weekly amount of EU-bonds and control bonds pledged at Eurosystem facilities for all banks in our sample. While the amounts pledged exhibit a strong co-movement before the haircut reduction on EU-bonds, they started to develop in opposite directions after June 2023. Strikingly euro area banks now pledge more EU-bonds than control bonds *in absolute values*, even though the nominal value of EU-bonds outstanding is slightly less than 10% of all high-quality euro-



Figure 2: Dynamic Effect of Eurosystem Haircut Reduction: Pledging Data

Notes: This figure displays the results of estimating

$$P_{i,k,t} = \sum_{\tau \neq 2022w51} \beta_{\tau} \mathrm{EU}_k \times \mathbf{1}\{\tau = t\} + \chi_i + controls_t + \epsilon_{i,c,t} ,$$

where  $\mathbf{1}\{\tau = t\}$  is a dummy variable that equals one in week t and 0 otherwise and  $P_{i,k,t}$  is the nominal value outstanding of bond k that bank i pledged to the Eurosystem in week t. Week 51 of 2022 is our reference week. Where indicated, we control for Standards and Poor's GSCI Commodity index, the ratio of EU over the control's nominal value outstanding, the slope of the yield curve (OIS 10 years - OIS 1 year) and the 3-months EURIBOR-OIS spread. The (light) blue shaded area represent (95%) 90% confidence intervals. We use bank fixed effects and cluster standard errors at the bank × bond issuer level. The sample period runs from April-1, 2022 to November-30, 2023. All values in EUR millions. *Source:* Use of Collateral Database.

Figure 3: Substitution between EU-bonds and Sovereign Bonds: Pledging Data



*Notes:* The figure shows the weekly outstanding amounts of collateral pledged at the Eurosystem facilities by euro area banks (left panel) and German banks (right panel) of EU-bonds and high quality central government bonds (Germany, France, the Netherlands, Belgium). *Source:* Use of Collateral Database.

denominated public debt (see Figure 1). The right panel shows that the substitution effect is predominately driven by German banks. To shed light on the drivers behind this substitution, we obtain data on the sovereign bond holdings of banks in different euro area countries from the *Securities Holdings Statistics*. As illustrated in Figure 4, the substitution effect is likely to originate in the German banking sector, where banks hold substantially large shares of treated EU-bonds relative to all high-quality public debt.

This massive reallocation of pledged collateral is consistent with the notion that banks prefer to pledge the most illiquid assets with the central bank and supply more liquid bonds to private markets. As we argued in Section 2, EU-bonds are the least liquid of all bonds in liquidity category I that are rated A or higher, i.e. those bonds that receive the lowest Eurosystem haircuts. The shift in Eurosystem pleding behavior can, thus, be interpreted as a form of *collateral arbitrage*.

Secondary Market: Bond Level As a second preliminary step, we document that the haircut category upgrade induces substantial effects on secondary market yields on EU-bonds and German government bonds. We use daily secondary market data for all bonds that are traded actively on the repo market and regress bond yields on a the treatment indicator  $EU_k$  that equals one for an EU-bond and the dummy  $Post_t$  that equals one for all days after the announcement date:

$$y_{t,k} = \beta_0 + \beta_1 Post_t \times EU_k + \kappa_k + controls_t + \epsilon_{t,k} . \tag{1}$$



Figure 4: Share of EU-bond Holdings by Euro Area Banks (2022Q3)

*Notes:* The chart shows the share of holdings of EU-bonds as a total of all high quality public debt, i.e. EU-bonds plus central government bonds (Germany, France, the Netherlands, Beligium) for banks located in the euro area in 2022Q3. *Source:* Securities Holdings Statistics.

Here,  $\kappa_k$  is a bond fixed effect that captures unobserved heterogeneity at the ISIN level. Standard errors are clustered at the bond level. As for the pledging data, we use the GSCI commodity index, the ratio of EU-bonds to control bonds outstanding, the slope of the OIS yield curve, and the 3-month EURIBOR-OIS spread as a macro control. In an alternative specification, we replace the daily macroeconomic control variables by maturity-bucket × date fixed effects. Specifically, we assign bonds into a short (1-5 years), medium (5-10 years) and long (> 10 years) bucket, depending on the bonds time to maturity. These fixed effects are intended to capture a time-varying term structure of interest rates.

Table 2 displays the results. After the haircut reduction was announced in December 2022, secondary market yields on EU-bonds dropped by around 24 basis points. The estimated effected is somewhat smaller when using maturity-bucket  $\times$  date fixed effects, but still large at around 11 basis points. This is consistent with the improved collateral services of EU-bonds (see also Nyborg and Woschitz, 2023) and further underscores the relevance of the haircut policy change for financial markets. Note that EU-bond yields already drop after the haircut reduction was announced. Since bond prices reflect the present value of cash flows plus the present value of service flows, they incorporate their (future) improved usability as Eurosystem collateral very quickly.

By definition, the substantially negative yield reaction is associated with an increase in cash market prices. Consequently, our empirical strategy would capture a mechanical increase in repo market volumes when using the market value of the pledged collateral as a measure. We take this cash market reaction into account when testing for the effects of the haircut reduction on the supply of EU-bonds to the repo market.

	(1)	(2)
$\operatorname{Post}_t \times \operatorname{EU}_k$	-23.44***	-10.49***
	(4.76)	(0.79)
Controls	Yes	No
Constant	Yes	Yes
Bond FE	Yes	No
Maturity x Date FE	No	Yes
R-squared	0.793	0.829
Observations	$66,\!650$	$68,\!833$
Cluster SE	Bond	Mat x Date

Table 2: Bond Level: Yields

Notes: The table shows coefficients of the regression of bond yields on the treatment indicator  $EU_k$  for the announcement window  $Post_t$ , see specification (1). Where indicated, we control for Standards and Poor's GSCI Commodity index, the ratio of EU over the control's nominal value outstanding, the slope of the yield curve (OIS 10 years - OIS 1 year) and the 3-months EURIBOR-OIS spread. When bond fixed effects are not included, the coefficient on the treatment indicator  $EU_k$  is omitted to enhance readability. The sample period runs from April-1, 2022 to June-27, 2023 to capture announcement effects only. We exclude observations of quarter-ends and of September 2022. All results in basis points. t-statistics in parentheses. Significance indicated by \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01.

## 4 Repo Market Effects

We present our main empirical results in several steps. In Section 4.1, we discuss how this policy change should affect banks' bond supply to the private repo market and how we test these expected effects in the data (Section 4.2). The main empirical results are shown in Section 4.3. In Section 4.4, we decompose the repo market effects into demand and supply components, while Section 4.5 presents several robustness checks.

### 4.1 Hypothesis Development

As a next step, we test whether the changes in banks' pledging behavior documented in Section 3 affect the supply of bonds into the private wholesale funding market, i.e. the repo market. To see how the haircut reduction affects banks' bond supply to the repo market, we first describe banks' rationale to enter a private repo transaction, define the key repo parameters that we use as outcome variables, and derive a set of testable hypotheses.

Throughout the analysis, we focus on *borrowing* transactions where banks obtain cash in exchange for supplying bonds as collateral, see Figure 5. In such transactions, counterparties directly compete with the central bank to extend (wholesale) credit to banks. Importantly, central banks apply uniform interest rates to all banks while funding conditions on the repo market depend on the (borrowing) bank and the (lending) counterparty. Borrowing from the central bank might, thus, be particularly profitable for riskier banks that would otherwise face high funding costs on the private market.

Let the repo rate negotiated between bank i and counterparty j for bond k at date t be denoted by  $r_{i,j,k,t}$ . Essentially all highly rated government bonds trade on special, i.e. their repo





rate is below the general collateral rate, which in turn is below the deposit facility rate  $r_t^{DFR}$ .<sup>14</sup> For any well-capitalized bank it is, thus, profitable to borrow cash on the repo market, invest the cash into the Eurosystem deposit facility and earn the spread  $r_t^{DFR} - r_{i,j,k,t}$ . This spread is positive for all observations, since otherwise a bank would make a loss from this trade. The profitability per unit of bonds of such a transaction depends both on the spread of the repo rate over the deposit facility rate, i.e. the *earnings per unit* of cash, and the *amount of cash* (per unit of bonds) obtained by delivering the bond.

To extract the earnings per unit of cash, we exploit that banks report both the cash and the nominal value outstanding of the pledged collateral for any MMSR-transactions. The bond's nominal value exchanged  $NVE_{k,t}$  is related to the cash volume  $CV_{i,j,k,t}$  through the cash-conversion rate (CCR):

$$(1 - ccr_{i,j,k,t})NVE_{t,k} = CV_{i,j,k,t} .$$

$$\tag{2}$$

The CCR is conceptually similar to a collateral haircut, which is implicitly defined through the market value of bonds pledged instead of their nominal value outstanding. We focus on the cash conversion rate since changes to collateral haircuts also reflect valuation effects: if the market value of EU-bonds increases after the Eurosystem haircut change, collateral haircuts defined analogously to (2) increase mechanically, while the CCR is invariant to such changes. Focusing on the CCR allows us to isolate the amount of funding obtained per unit of bonds outstanding.

Building on the notion of cash-conversion rates, we define the per-unit fee that bank i earns from supplying bond k to the repo market as follows:

$$fee_{i,j,k,t} \equiv (r_t^{DFR} - r_{i,j,k,t}) \frac{CV_{i,j,k,t}}{NVE_{k,t}} = (r_t^{DFR} - r_{i,j,k,t})(1 - ccr_{i,j,k,t}) .$$
(3)

The income that banks generate from supplying bonds to the repo market is conceptually related to a securities lending fee and sometimes referred to as *positive carry*. Figure 6 presents a highly stylized representation of the repo market equilibrium, which links the repo fee and quantity of bonds supplied to the repo market. It is reasonable to assume that *bond demand* increases if the

<sup>&</sup>lt;sup>14</sup>Essentially all high-quality bonds trade on special repo rates after the Eurosystem started to purchase these bonds at a large scale.

fee is low, which is equivalent to a low cost of carry for counterparties, which is reflected by the solid black line. The Eurosystem haircut reduction is not directly relevant for bond demand on the repo market. First, many counterparties do not have access to Eurosystem facilities if they are foreign banks or non-banks. Second, counterparties with access to Eurosystem facilities have no incentive to lend cash in order to obtain government bonds, just to convert these government bonds again into cash at Eurosystem facilities.

Furthermore, it is reasonable to assume that *bond supply* to the repo market is upward sloping the fee, corresponding to the black dashed line in Figure 6. Banks face higher opportunity cost if they supply EU-bonds to the repo market after the policy change, since they can use them in Eurosystem facilities at favorable conditions. This is particularly relevant for weakly-capitalized banks that face high borrowing cost on the private segment, or at least do so with a positive probability in the future. This shifts the supply curve up and left, reflected by the dashed red line. In the new equilibrium, the repo fee is larger but the quantity traded is smaller. We conclude from these considerations that the haircut reduction resembles a *bond supply shock* and expect to observe an increase in the fee and a decline in volumes.

Figure 6: Eurosystem Haircut Reduction and Repo Market Equilibrium



Since the profitability of a repo, as measured by its fee, depends on the repo rate and the CCR, we also test which of these components drives potential changes in the repo fee. To do so, we decompose a change in the fee into a change of the repo rate and a cash-conversion rate change:

$$\Delta f e e_{i,j,k,t} = \Delta (r_t^{DFR} - r_{i,j,k,t}) (1 - ccr_{i,j,k,t}) - (r_t^{DFR} - r_{i,j,k,t}) \Delta ccr_{i,j,k,t} .$$
(4)

A decrease in the repo rate  $r_{i,j,k,t}$  is associated with an increase in fee income, since it increases the earnings per unit of cash  $1 - ccr_{i,j,k,t}$ . A CCR-reduction increases the amount of cash banks obtain per unit of bonds, which increases the fee by the repo spread  $r_t^{DFR} - r_{i,j,k,t}$ . Formally, we have  $\frac{\partial fee_{i,j,k,t}}{\partial r_{i,j,k,t}} < 0$  and  $\frac{\partial fee_{i,j,k,t}}{\partial ccr_{i,j,k,t}} < 0$ . Theory on the pricing of repos offers little guidance on the expected effects on CCRs. However, the literature typically relates collateral haircuts either to counterparty default risk or downside risk to the market value of collateral, see Chebotarev (2023) and the references therein. Since the CCR is invariant to changes in asset prices and the Eurosystem haircut reduction does not directly affect counterparty credit risk, we expect no significant effect on the CCR. At the same time, positive valuation effects due to the improved usability as collateral with the Eurosystem - documented in Section 3 - should give rise to a positive effect on collateral haircuts.

## 4.2 Empirical Strategy

Using transaction level data from the euro area repo market, we adopt a canonical differencein-difference strategy to identify the causal effect of the haircut-category upgrade. Specifically, we estimate

$$x_{i,j,k,t} = \beta_1 Post_t \times EU_k + \kappa_k + \chi_i \times \gamma_j + controls_t + \epsilon_{t,i,j,k} , \qquad (5)$$

where  $x_{i,j,k,t}$  is either a repo fee, rate, haircut, or volume. The dummy variable  $Post_t$  indicates the post-implementation window after June-30, 2023 for the baseline specification. The treatment indicator  $EU_k$  equals one if bond k is an EU-bond. As a control group, we use Belgian, Dutch, French and German government bonds.

Our baseline specification (5) uses bond fixed effects at the ISIN level, following the market microstructure literature. ISIN fixed effects would capture a particularly small issuance volume of a specific ISIN, which increases the likelihood of a bond being scarce on the repo market. In a more stringent specification, we also use bank  $\times$  counterparty fixed effects to take potential relationship effects into account. Standard errors are clustered at the bond level, since the treatment takes place at the bond level.<sup>15</sup>

We can exploit the granularity of our dataset to shed light on demand and supply-specific drivers of the repo market effects. Specifically, we first augment our baseline specification using bank × date fixed effects  $\chi_i \times \tau_t$  to absorb bank-specific bond supply factors. For example, some riskier banks might be strongly affected by the haircut-category upgrade since they might borrow from the central bank with a higher probability in the near future. Similarly, we use counterparty × date fixed effects  $\gamma_j \times \tau_t$  to absorb counterparty-specific bond demand factors. In both cases, we include ISIN fixed effects, consistent with our baseline specification.

#### 4.3 Results

In Figure 7, we plot the time-varying effect of the haircut-category upgrade on the fee that banks earn by supplying bonds to the repo market. Consistent with our baseline specification, all values are expressed relative to December 2022. The coefficient on the treatment indicator is insignificant in (almost) every month prior to the haircut-category upgrade. A notable exception is September 2022, which contained the UK gilt crisis and was, thus, characterized by an exceptionally large demand for German government bonds: it is reasonable to expect a decrease of Bund repo rates (the control group) during such a flight to safety event, such that

<sup>&</sup>lt;sup>15</sup>Notably, our results are not affected by clustering standard errors at the relationship level rather than the bond level.

the coefficient on the treatment indicator is significantly positive in that month. The coefficient on the treatment indicator is positive and significant already in January 2023 and maintains a relatively stable level of slightly more than 10bps throughout the post-treatment window.



Figure 7: Dynamic Effect of Eurosystem Haircut Reduction: Fee

Notes: This figure displays the results of estimating

$$y_{i,j,k,t} = \sum_{\tau \neq Dec2022} \beta_{\tau} EU_k \times \mathbf{1}\{\tau = t\} + \kappa_k + \chi_i \times \gamma_j + controls_t + \epsilon_{t,i,j,k}$$

where  $1{\tau = t}$  is a dummy variable that equals one in month t and 0 otherwise. We exclude December 2022 as the reference month. Where indicated, we control for Standards and Poor's GSCI Commodity index, the ratio of EU over the control's nominal value outstanding, the slope of the yield curve (OIS 10 years - OIS 1 year) and the 3-months EURIBOR-OIS spread. We use bond fixed effects, red bars represent 95% confidence intervals, standard errors are clustered at the bond level. The sample period runs from April-1, 2022 to November-30, 2023. All values in percentage points.

Source: Money Market Statistical Reporting (MMSR)

Column (1) of Table 3 displays the result of estimating our baseline specification (5) over the full sample. The coefficient on the  $Post_t \times EU_k$  interaction term implies that the haircut-category upgrade of EU-bonds increased the repo borrowing fee of EU-bonds by slightly more than 10bps. Column (2) demonstrates that this effect is robust to including bank × counterparty fixed effects to account for relationship specific borrowing conditions. In fact, the effect size is even slightly larger than in the baseline specification. We exploit the granularity of our dataset to provide a decomposition into bond demand and supply effects in column (3) and (4) of Table 3. Both effects are relevant for repo market outcomes, although the effect size is slightly larger when including bank × date fixed effects, pointing towards important bond demand factors.

Following the fee decomposition in (4), we test the effect of the central bank haircut upgrade separately on the repo rate and the cash conversion rate. The results on the repo rate in Panel A of Table 4 are consistent with the baseline effects on the repo fee. Again, the key coefficient of

	(1)	(2)	(3)	(4)
$\operatorname{Post}_t \times \operatorname{EU}_k$	9.94***	$11.50^{***}$	8.50***	10.90***
	(7.07)	(10.46)	(6.21)	(7.75)
Controls	Yes	Yes	No	No
Constant	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes	Yes
Bank x Counterparty FE	No	Yes	No	No
Bank x Date FE	No	No	No	Yes
Counterparty x Date FE	No	No	Yes	No
R-squared	0.498	0.608	0.652	0.613
Observations	$539,\!448$	$539,\!332$	$527,\!994$	$539,\!308$
Cluster SE	Bond	Bond	Bond	Bond

Table 3: Repo Market: Borrowing Fee

Notes: The table shows coefficients of the regression of repo fee on the treatment indicator  $EU_k$  for the implementation window  $Post_t$ , see specification (5). Where indicated, we control for Standards and Poor's GSCI Commodity index, the ratio of EU over the control's nominal value outstanding, the slope of the yield curve (OIS 10 years - OIS 1 year) and the 3-months EURIBOR-OIS spread. When bond fixed effects are not included, the coefficient on the treatment indicator  $EU_k$  is omitted to enhance readability. The sample period runs from April-1, 2022 to November-30, 2023. We exclude observations of quarter-ends and of September 2022 and between December-20, 2022 and June-27, 2023 to capture implementation effects only. All results in basis points. t-statistics in parentheses. Significance indicated by \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01.

interest is highly significant in the baseline specification and increases slightly once relationship fixed effects are included. Bond demand seems to be the slightly more important driver of the effect. This effect size is also consistent with the literature studying the effects of Eurosystem collateral framework changes on banks' pricing of eligible collateral, see for example Mésonnier et al. (2021), Pelizzon et al. (2023) or Hüttl and Kaldorf (2023).

Notably, for each specification the effect on repo rates is slightly larger in absolute terms than for the fee. To see why this is the case, it is helpful to revisit Equation (4), which provides a decomposition of the change in fees into a repo rate component and a cash conversion rate component. Banks' fee income per unit of bonds increases if the repo rate is smaller, since this increases the earnings per units of cash. Fee income also increases if the cash-conversion rate is smaller, since this increases the units of cash obtained per unit of bonds. While Panel B of Table 4 shows that cash conversion rates do not respond to the central bank haircut change, the effect of the repo rate on the repo fee is still weighted by (1-ccr) such that the fee effect is slightly smaller. Lastly, Panel B of Table 4 points towards a small but significant increase in haircuts by around three percentage points. As we demonstrated in Section 3, market prices increase with the improved collateral treatment of EU-bonds at Eurosystem facilities: this valuation effect mechanically translates into a positive effect on haircuts.

Table 5 presents the results of using repo volumes as dependent variable. We measure repo volumes by the nominal value outstanding of pledged bonds. Volumes decline by slightly more than EUR 5 millions for repos collateralized by EU-bonds. The effect size economically meaningful, given that the average transaction volume is around EUR 58 millions in the full sample. Different from repo fees, volumes seem to be largely driven by bank heterogeneity:

Panel A: Repo Rate				
	(1)	(2)	(3)	(4)
$\operatorname{Post}_t \times \operatorname{EU}_k$	$-10.54^{***}$	-12.71***	-8.48***	-11.12***
	(-7.60)	(-10.61)	(-6.37)	(-7.88)
Controls	Yes	Yes	No	No
Constant	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes	Yes
Bank x Counterparty FE	No	Yes	No	No
Bank x Date FE	No	No	No	Yes
Counterparty x Date FE	No	No	Yes	No
R-squared	0.986	0.987	0.997	0.997
Observations	$539,\!448$	$539,\!332$	$527,\!994$	$539,\!308$
Cluster SE	Bond	Bond	Bond	Bond
Panel B: Cash Conversion Rate				
	(1)	(2)	(3)	(4)
$\operatorname{Post}_t \times \operatorname{EU}_k$	1.56	$2.08^{**}$	0.49	0.69
	(1.64)	(2.32)	(0.36)	(0.70)
Controls	Yes	Yes	No	No
Constant	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes	Yes
Bank x Counterparty FE	No	Yes	No	No
Bank x Date FE	No	No	No	Yes
Counterparty x Date FE	No	No	Yes	No
R-squared	0.814	0.836	0.838	0.838
Observations	$539,\!399$	$539,\!284$	$527,\!944$	$539,\!263$
Cluster SE	Bond	Bond	Bond	Bond
Panel C: Haircut				
	(1)	(2)	(3)	(4)
$\operatorname{Post}_t \times \operatorname{EU}_k$	$2.46^{***}$	3.00***	$1.67^{**}$	$1.76^{***}$
	(4.92)	(5.71)	(2.47)	(3.45)
Controls	Yes	Yes	No	No
Constant	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes	Yes
Bank x Counterparty FE	No	Yes	No	No
Bank x Date FE	No	No	No	Yes
Counterparty x Date FE	No	No	Yes	No
R-squared	0.264	0.371	0.338	0.362
Observations	$539,\!448$	$539,\!332$	$527,\!994$	$539,\!308$
Cluster SE	Bond	Bond	Bond	Bond

Table 4: Repo Market: Fee Decomposition

Notes: The table shows coefficients of the regression of repo rate, cash conversion rate and haircut on the treatment indicator  $EU_k$  for the implementation window  $Post_t$ , see specification (5). Where indicated, we control for Standards and Poor's GSCI Commodity index, the ratio of EU over the control's nominal value outstanding, the slope of the yield curve (OIS 10 years - OIS 1 year) and the 3-months EURIBOR-OIS spread. When bond fixed effects are not included, the coefficient on the treatment indicator  $EU_k$  is omitted to enhance readability. The sample period runs from April-1, 2022 to November-30, 2023. We exclude observations of quarter-ends and of September 2022 and between December-20, 2022 and June-27, 2023 to capture implementation effects only. Repo rates are expressed in basis points, haircuts and cash conversion rates in percentage points. t-statistics in parentheses. Significance indicated by \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01.

	(1)	(2)	(3)	(4)
$\operatorname{Post}_t \times \operatorname{EU}_k$	-1.79	$-5.37^{***}$	$-18.85^{***}$	-3.82
	(-0.80)	(-2.83)	(-4.68)	(-1.41)
Controls	Yes	Yes	No	No
Constant	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes	Yes
Bank x Counterparty FE	No	Yes	No	No
Bank x Date FE	No	No	No	Yes
Counterparty x Date $FE$	No	No	Yes	No
R-squared	0.0735	0.202	0.127	0.139
Observations	$539,\!448$	$539,\!332$	$527,\!994$	$539,\!308$
Cluster SE	Bond	Bond	Bond	Bond

Table 5: Repo Market: Collateral Volume

Notes: The table shows coefficients of the regression of repo collateral volume on the treatment indicator  $EU_k$  for the implementation window  $Post_t$ , see specification (5). Where indicated, we control for Standards and Poor's GSCI Commodity index, the ratio of EU over the control's nominal value outstanding, the slope of the yield curve (OIS 10 years - OIS 1 year) and the 3-months EURIBOR-OIS spread. When bond fixed effects are not included, the coefficient on the treatment indicator  $EU_k$  is omitted to enhance readability. The sample period runs from April-1, 2022 to November-30, 2023. We exclude observations of quarter-ends and of September 2022 and between December-20, 2022 and June-27, 2023 to capture implementation effects only. All results in millions of EUR. t-statistics in parentheses. Significance indicated by \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01.

when absorbing bond demand with counterparty  $\times$  date fixed effects, the effect size increases almost fourfold to around EUR 19 millions in absolute terms.

#### 4.4 The Role of Bank and Counterparty Heterogeneity

Having documented that a haircut reduction on EU-bonds is associated with a crowding-out of the private wholesale funding market, we exploit additional features of our dataset to uncover potential drivers of this crowding-out. Since the substitution of central government bonds by EU-bonds at the central bank facilities is at the heart of the mechanism, we first consider the role of banks heterogeneity.

The substantial size of the counterparty  $\times$  date fixed effect points towards important bank characteristics driving the negative bond supply effect. The riskiness of banks is a natural candidate in our situation, since central bank borrowing is particularly attractive for riskier banks that would face tighter borrowing conditions on the private market. We measure the riskiness of banks in the pre-announcement period by their credit default swap spreads and classify all above-average banks as risky. The left-hand side panel of Table 6 shows that they earn a 10 bps higher fee on EU-bonds after their haircut reduction. At the same time, the fee income of safe banks increases by around 14 bps. Furthermore, we observe a significant decline in volumes only for the sub-sample of risky banks. In contrast, safe banks exhibit only a tiny reduction in bond supply, which is not statistically significant. Taken together, these results suggest that safe banks, at least partially, replace riskier banks in the private wholesale funding market.

	Risky Banks		Safe I	Banks
	Fee	Volume	Fee	Volume
$\operatorname{Post}_t \times \operatorname{EU}_k$	$9.52^{***}$	-5.60*	$13.89^{***}$	-1.76
	(8.33)	(-1.74)	(-11.53)	(-0.59)
Controls	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes	Yes
Bank x Counterparty FE	Yes	Yes	Yes	Yes
R-squared	0.665	0.255	0.597	0.199
Observations	$140,\!888$	$140,\!888$	$319,\!169$	$319,\!169$
Cluster SE	Bond	Bond	Bond	Bond

Table 6: The Role of Bank Riskiness

Notes: The table shows coefficients of the regression of repo fee and collateral volume on the treatment indicator  $EU_k$  for the implementation window  $Post_t$ , see specification (5). Where indicated, we control for Standards and Poor's GSCI Commodity index, the ratio of EU over the control's nominal value outstanding, the slope of the yield curve (OIS 10 years - OIS 1 year) and the 3-months EURIBOR-OIS spread. When bond fixed effects are not included, the coefficient on the treatment indicator  $EU_k$  is omitted to enhance readability. The sample period runs from April-1, 2022 to November-30, 2023. We exclude observations of quarter-ends and of September 2022 and between December-20, 2022 and June-27, 2023 to capture implementation effects only. Repo rates are expressed in basis points, volumes in millions of EUR. t-statistics in parentheses. Significance indicated by \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01.

The large coefficient size in the specification with bank  $\times$  date fixed effects suggests that counterparty characteristics are a similarly important driver of the effects documented in Section 4.3. Appropriately splitting our sample into trades with different types of counterparties is not trivial due to the co-existence of centrally cleared and bilateral trades. To control for structural differences between centrally cleared and bilateral trades due to market power and the advantages of netting, we focus on the sub-sample of bilateral trades (Eisenschmidt et al., 2022). 30% of our observations are bilateral trades. Decomposing the sub-sample of bilateral trades further into transactions with bank and non-bank counterparties, we observe a staggering difference in Panel A of Table 6: the entire negative effect on bond supply is driven by trades with other banks, while the entire effect on repo fees is driven by trades with non-banks. In both cases, we use the most stringent specification that includes relationship fixed effects.<sup>16</sup> This is consistent with the notion that non-banks have a very inelastic demand for specific bonds. Such counterparties, which includes hedge funds and financial vehicles, have a very high willingness to pay larger securities lending fees or, equivalently, to accept a lower reportate. In contrast, other banks are not willing to accept lower rates or pay higher fees, such that the repo volume declines by more than EUR 20 millions.

Related to the analysis of bank and non-bank counterparties, we also split our sample according to the trading motif. Specifically, we classify all trades with a negative haircut as *collateral-driven*. Such transaction are closely related to a typical securities lending transaction

<sup>&</sup>lt;sup>16</sup>If we add all CCPs that have a banking license to the sub-sample of banks, the effects of the haircut upgrade on repo volumes is virtually unchanged and highly significant. The effect on repo fees is significantly positive, but still considerably smaller than for the sub-sample of non-banks.

Panel A: Banks and Non-Banks				
	Banks		Non-Banks	
	Fee	Volume	Fee	Volume
$\operatorname{Post}_t \times \operatorname{EU}_k$	1.46	-20.39**	$13.12^{***}$	1.60
	(0.86)	(-2.08)	(10.08)	(0.72)
Controls	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes	Yes
Bank x Counterparty FE	Yes	Yes	Yes	Yes
R-squared	0.620	0.631	0.673	0.480
Observations	41,404	41,404	$108,\!621$	$108,\!621$
Cluster SE	Bond	Bond	Bond	Bond
Panel B: Cash- and Collateral-Driven Trades				
	Cash-	Driven	Collatera	al-Driven
	Fee	Volume	Fee	Volume
$\operatorname{Post}_t \times \operatorname{EU}_k$	10.81***	-7.04***	$11.61^{***}$	-5.30**
	(11.69)	(3.27)	(10.52)	(-2.30)
Controls	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes	Yes
Bank x Counterparty FE	Yes	Yes	Yes	Yes
R-squared	0.628	0.211	0.613	0.205
Observations	212,418	212,418	326,753	326,753

Table 7: The Role of Counterparties

Notes: The table shows coefficients of the regression of repo fee and collateral volume on the treatment indicator  $EU_k$  for the implementation window  $Post_t$ , see specification (5). Where indicated, we control for Standards and Poor's GSCI Commodity index, the ratio of EU over the control's nominal value outstanding, the slope of the yield curve (OIS 10 years - OIS 1 year) and the 3-months EURIBOR-OIS spread. When bond fixed effects are not included, the coefficient on the treatment indicator  $EU_k$  is omitted to enhance readability. The sample period runs from April-1, 2022 to November-30, 2023. We exclude observations of quarter-ends and of September 2022 and between December-20, 2022 and June-27, 2023 to capture implementation effects only. Repo rates are expressed in basis points, volumes in millions of EUR. t-statistics in parentheses. Significance indicated by \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01.

Bond

Bond

Bond

Bond

Cluster SE

in which the counterparty is willing to supply comparatively large amounts of cash in exchange for the security. In contrast, we define a repo as *cash-driven* if its haircut is positive. Such a transaction can be associated with cash demand by banks.<sup>17</sup> As Panel B of Table 7 shows, there is a more pronounced decline in the amount of bonds supplied in cash-driven trades. In contrast, there is a larger increase in repo rates for collateral-driven transactions. This distinction is by construction less sharp than the segment decomposition but paints a qualitatively similar picture.

## 4.5 Robustness

In this section, we present a series of robustness checks regarding our baseline results. In column (1) of Table 8, we exclude all green bonds from our sample. The presence of green bonds might confound our results since they might be subject to preferential haircuts in the Eurosystem collateral framework in the future. Column (2) truncates the sample by July 8th, 2022 to take into account that the ECB announced to revert to pre-pandemic haircut schedules on this day. The coefficient of interest hardly changes compared to our baseline results.

In column (3), we exclude several German bonds that were included in the reverse repo facility of Germany's debt management office (*Deutsche Finanzagentur*, *DFA*) in October 2022. A sub-sample of German bonds lost their extraordinary scarcity due to the debt management office's additional supply of these bonds to the repo market. Thus, the difference in repo fees between EU-bonds and a sub-sample of the control bonds declined after October 2022, resulting in a slightly smaller coefficient on the  $Post_t \times EU_k$  interaction term of around 8bps. The fourth column excludes all German bonds. In column (4) of Table 8, we remove all German bonds from the sub-sample to take into account that all German bonds lost some of their specialness over our observation period, for example due to expansionary fiscal policy in Germany. The effect on the repo fee is still highly significant, but its size declines to 5 basis points.

<sup>&</sup>lt;sup>17</sup>Naturally, the cutoff point of a zero haircut is somewhat arbitrary and we verify that our results are robust to using slightly larger cutoffs.

Sample Excluding	Green Bonds	Pre July 8th	DFA bonds	German Bonds
$\operatorname{Post}_t \times \operatorname{EU}_k$	$9.59^{***}$	$9.97^{***}$	$7.66^{***}$	$4.75^{***}$
	(6.45)	(10.09)	(5.53)	(4.57)
Controls	Yes	Yes	No	No
Constant	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes	Yes
Bank x Counterparty FE	No	No	No	No
Bank x Date FE	No	No	No	No
Counterparty x Date FE	No	No	No	No
R-squared	0.504	0.491	0.426	0.327
Observations	$531,\!066$	$415,\!996$	$476,\!935$	$388,\!196$
Cluster SE	Bond	Bond	Bond	Bond

Table 8: Robustness: Borrowing Fee

Notes: The table shows coefficients of the regression of repo fee on the treatment indicator  $EU_k$  for the implementation window  $Post_t$ , see specification (5). Where indicated, we control for Standards and Poor's GSCI Commodity index, the ratio of EU over the control's nominal value outstanding, the slope of the yield curve (OIS 10 years - OIS 1 year) and the 3-months EURIBOR-OIS spread. When bond fixed effects are not included, the coefficient on the treatment indicator  $EU_k$  is omitted to enhance readability. The sample period runs from April-1, 2022 to November-30, 2023. We exclude observations of quarter-ends and of September 2022 and between December-20, 2022 and June-27, 2023 to capture implementation effects only. Fees are expressed basis points. t-statistics in parentheses. Significance indicated by \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01.

# 5 Policy Implications and Outlook

**Relationship to Operational Frameworks** While our results support the notion that expansionary central bank haircut policy crowds out the private wholesale funding market, they are also instructive for the design of central bank operational frameworks more generally. Currently, the relationship between operational frameworks and the private wholesale funding market receives special attention, since many central banks are contemplating to shrink their balance sheets to pre-financial crisis levels during the current monetary policy tightening cycle. To soften adverse effects of shrinking central bank balance sheets on bank funding conditions some central banks, among them the Bank of England and the Eurosystem, narrowed their interest rate corridor. All else equal, this makes both storing excess liquidity and borrowing from the central bank relatively more attractive.

Specifically, a lower central bank borrowing rate increases the valuation of collateral services in similar way as a haircut reduction. This should be particularly relevant for riskier, less capitalized banks. Based on our empirical results, one would expect that a narrower interest corridor also tends to crowd out the private wholesale funding market. Naturally, it is difficult to map the results obtained in a difference-in-difference design with a clearly defined control group (other high quality government bonds) into a setting where collateral service on all eligible securities increases simultaneously due to a shift to a narrow interest rate corridor.

It should also be kept in mind that a higher rate on central bank reserve holdings ceteris paribus increases the fee banks can earn from supplying bonds to the repo market (see Equation (4)). In principle, this should make it more attractive to supply bonds to the repo market. For this channel to be active, however, the spread between repo market rates and the deposit facility actually has to increase in equilibrium. It is not at all clear that this would actually be the case.

More generally, since a narrow interest rate corridor is likely to increase the permanent usage of central bank facilities, central bank collateral policy also becomes more relevant on a permanent basis. Policymakers, therefore, should take potential crowding-out effects into consideration when central bank lending policies directly compete with the private wholesale funding market.

**Conclusion** In this paper, we use a plausibly exogenous haircut reduction of EU-bonds in the Eurosystem collateral framework to demonstrated that expansionary central bank lending policy crowds out the private wholesale funding market. As a preliminary step, we show that this haircut reduction is relevant for banks and financial markets. We first demonstrate that banks replaced high-quality central government bonds with EU-bonds in pledging with the Eurosystem after the haircut reduction was implemented. This effect is economically large: the amount of EU-bonds pledged with the Eurosystem now exceeds the amount of high-quality central government bonds *in absolute terms*, even though the outstanding amount of central government bonds exceeds the amount of outstanding EU-bonds by a factor of 10. At the same time, secondary market yields declined by 10 to 20 basis points in response to this collateral policy change

In our main analysis step, we show that this substitution towards EU-bonds in banks' pledging with Eurosystem facilities is associated with a reduction of bond supply to the private wholesale funding market and an increase in banks' fee income on the repo market. Both observations are consistent with a negative bond supply shock and are particularly pronounced for riskier banks. At the same time, bond demand factors are important as well. We find evidence that the pass-through of central bank lending policies depends on the segment decomposition of repo market counterparties. In particular, a larger share of price-inelastic non-banks relative to price-sensitive banks seems to mitigate the effect on crowding-out but amplify the effect on repo market fees and rates. This has potential implications for the conduct of (unconventional) monetary policy since repo markets are at the heart of the monetary transmission mechanism.

As a by-product of our analysis, we also demonstrate that central bank operational frameworks have real implications for the fiscal sector. The reduction in secondary market yields is also relevant at a macroeconomic level. Using the more conservative effect size of 10 basis points and the nominal amount outstanding of all EU-bonds (approximately EUR 320 billions in November 2022) and a monthly yield of 2.7%, the haircut reduction reduced financing costs of the European Commission by approximately EUR 320 millions in interest payments ( $320 \times 0.027 - 320 \times 0.026$ ) every year. To what extent this changes the composition of public sector debt is left for future research.

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