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* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

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# Safe Asset Scarcity and Re-use in the European Repo Market*

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**Abstract**

We construct the first measure of collateral re-use at the bank and bond level for the European repo market using a regulatory transaction dataset. We show that banks materially increase the rate of re-use in response to tightened asset scarcity induced by the Eurosystem's asset purchase program. We find that dealers accommodate clients' demand for safe assets rather than liquidity and profit from the repo rate spread. Yet, dealers also re-use collateral to source liquidity which exposes them to collateral runs. Our results contribute to the policy debate on trade-offs between shock absorption and financial stability risks of collateral re-use.

**Keywords**: collateral reuse, rehypothecation, safe assets, scarcity, repo market
**JEL classification**: E4, E5, G1, G2

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# 1 Introduction

Safe assets serve multiple purposes in financial markets, for example, the collateralization of liquidity flows in financial markets and fulfilling prudential requirements. The increasing excess demand, accelerated by the 2008 crisis and large scale asset purchase programs to combat low inflation, is a subject of growing concern in the academic and policy debate (e.g., Bletzinger, Greif, and Schwaab 2022; Asgari and Arnold 2022). Valves to alleviate the imbalance include a valuation rise of safe asset producing economies, the issuance of new public or private safe assets, and a change in regulatory frameworks (e.g., Caballero, Farhi, and Gourinchas 2016; Caballero, Farhi, and Gourinchas 2017).

This paper studies another important factor in determining the market equilibrium which to date has been largely ignored in the debate; the velocity of collateral, also known as *collateral re-use*. This is a widespread practice in the financial wholesale market where dealer banks intermediate government bonds using Securities Financing Transactions (SFTs), e.g., repurchase agreements, security lending transactions, or margin loans. This temporary exchange of cash for collateral assets allows dealers to first source safe assets on the market and subsequently sell them onward to third parties, known as re-use. This increases the effective supply of safe assets, because collateral that would otherwise be isolated on market participants' balance sheets thus becomes available to the market again, benefitting the allocative efficiency (e.g., Andolfatto, Martin, and Zhang 2017).

A growing theoretical literature studies negative effects of re-use for financial stability. For example, Infante and Vardoulakis (2021) characterize the risk that liquidity can evaporate when dealers use collateral intermediation as a source of funding. Dealers can create a short term liquidity windfall by concluding repurchase agreements, henceforth repos, with different haircuts in contracts with the cash borrower and lender. The cash borrower may not roll over a repo with a dealer over concerns of her default because she risks losing the amount of overcollateralization on the repo and only retains an unsecured claim alongside other creditors on the dealer's asset holdings. This mechanism creates a first-mover advantage and gives rise to a run on collateral. Brumm et al. (2023) show that while re-use is welfare improving due to more efficient risk sharing, at excessive levels the building up of financial market leverage and price volatility negates the welfare benefits. Luu et al. (2021) study how systemic effects of such precautionary collateral hoarding motives differ by various topologies of re-use chains.

We empirically study the determinants of safe asset re-use in the Eurozone repo market, the most important type of SFTs with a daily transaction volume of more than 600 BN EUR (ECB 2021, section 1.1.). To our knowledge, we construct the most comprehensive measure of re-use at a daily frequency using the Money Market Statistical Reporting (MMSR), a new regulatory dataset which contains the universe of repo transactions conducted by the 53 largest banks in the Eurozone. This is the first dataset that allows us to trace cash and collateral flows across dealer banks and market segments and to study the role of repos' contractual terms.[1]

Previous studies rely on off-balance sheet items in financial reports (e.g., Singh and Aitken 2010; Singh 2011), surveys of market participants (e.g., Keller et al. 2014; Cheung, Manning, and Moore 2014), or country specific regulatory data (Jank, Moench, and Schneider 2022; Infante, Press, and Strauss 2018; Infante and Saravay 2021; Fuhrer, Guggenheim, and Schumacher 2016). In this paper, we develop a matching algorithm analog to Fuhrer, Guggenheim, and Schumacher (2016) which assigns repos, a collateral outflow, to a reverse repo, a collateral inflow, under contractual and budget constraints. Our procedure requires that both transactions are collateralized with the same bond, that the security is recovered before it is to be returned to the originator, and that the sourced collateral can only be encumbered up to its nominal amount. With an average re-use amount of 215 BN EUR we observe a more than seven times larger market activity with more granularity than comparable studies

[1] We acknowledge that as of April 2020 the largest Eurozone banks report repos and their life-cycle events, including the re-use of sourced collateral, under the Securities Financing Transactions Regulation (SFTR). However, the short sample period, at the time of writing, did not qualify the dataset for our analysis.

for individual Eurozone member states.

Our primary variable of interest is the *re-use rate*, the share of the total collateral nominal amount of outstanding reverse repos that is re-used in repos (FSB 2017a). We find that the average re-use rate is 53% for the largest dealer banks in the Eurozone.[2] Results from country specific analyses vary considerably. For the US, Infante, Press, and Saravay (2020) (Figure 2) document a re-use rate of 85% for the nine largest primary dealers, all of which are Globally-Systemically Important Banks (G-SIB), based on SFT disclosures. Our sample includes a larger number of relatively smaller banks which are domiciled or active in Eurozone member states whose capital markets have varying degrees of development. For Germany, Jank, Moench, and Schneider (2022) report a re-use rate of 75% based on month-end disclosures of aggregate securities lending and repo transactions. The smallest rate of 5% is reported for Switzerland based on reported repo transactions (Fuhrer, Guggenheim, and Schumacher 2016, Figure 2).

We expect that dealer banks intermediate safe assets more intensively when availability deteriorates. We find suggestive evidence for our hypothesis in the negative correlation between the average re-use rate and the share of government bonds that is free floating in capital markets (Figure 1). In terms of volume, the growth of re-use has also outpaced the overall growth of the repo market during our sample period. The outstanding volume of re-use transactions has increased by 95% to BN 225 EUR while the collateral volume of outstanding reverse repos increased by 60% to BN 850 EUR between 2017 and February 2019.

We investigate banks' collateral re-use by transaction, collateral, bank, and market segment characteristics in descriptive statistics. Our matching shows that dealers source the majority of the re-used collateral volume from reverse repos with a one week to six months maturity and sell them onwards in successive contracts with a shorter maturity. The maturity of initial transactions thus deviates from the overall repo market volume which is predom-

[2] A cross-section analysis using the SFTR in Jurgiel (2021) suggests that our finding in terms of the re-use rate is in line with actual re-use disclosures.

inantly concentrated in the one-day maturity bucket (ECB 2021, section 1.4). While this maturity mismatch may reflect traditional maturity transformation, it is also consistent with building longer term asset positions and selling them over the short term. Descriptive statistics on collateral characteristics suggest that dealers have a preference for re-using bonds which have a high rating, a long maturity, and are issued by the largest Eurozone member states, i.e., France, Germany, and Italy. The latter finding is consistent with dealers' tendency to intermediate domestic government debt and an overrepresentation of banks from these domicile's in our sample.

Next, we study the association between banks' characteristics, financial regulation, and re-use. We find evidence in support of the common wisdom in the policy debate prior to the introduction of regulatory measures that the Leverage Ratio negatively affects the repo market functioning, and re-use by implication, due to the balance sheet intensive nature of repos (e.g., FSB 2017b). This contrasts Kotidis and van Horen (2018) who find no relationship using regulatory quarter-dealer data from the UK and argue that dealers may alleviate the impact through higher haircuts in reverse repo positions. Our results show a similar negative effect for dealers with a binding Liquidity Coverage Ratio constraint. This is consistent with the incentive to reduce trading in reverse repos backed by lower-quality collateral with a maturity greater than 30 days and in repos with a shorter maturity (Gerba and Katsoulis 2021; Macchiavelli and Pettit 2021). Our result further indicates that banks with a more central position in the over-the-counter segment, measured by the number of counterparties, have a higher re-use rate. This suggests that banks intermediating in this market can leverage their market position to match demand and supply of safe assets while negotiating profitable spreads in repo rates and haircuts. Lastly, we investigate dealers' transaction level profit. With an average re-use amount of MM 36 EUR and a stable 7 bp spread in the annualized repo rate between the source and re-use transaction, the profit is economically significant. The average difference in the haircut is 18 bp. When differentiating between both the source and target segments of the collateral flow, we find that both spreads are largest when the collateral is sourced on the over-the-counter market irrespective of the market to which it is re-allocated. This substantiates the interpretation that dealer banks have a higher negotiation power in the relationship driven repo market segment where participants lack access to the transparent central limit order book based cleared market.

We investigate three hypotheses on the determinants of dealers' re-use activities. First, we test whether dealer banks increase the re-use rate in response to an increase in safe assets' scarcity. We measure scarcity as the share of bonds' free floating amount that is purchased by the Eurosystem in the Public Sector Purchase Program (PSPP) and is thus locked up on the ESCB's balance sheet. The cumulative purchases under the PSPP account for around 30% of the total outstanding amount and consequently purchases induce a sizeable contraction in the amount available to the financial market. We test the causal effect of this exogenous market intervention in a dealer $\times$ bond $\times$ time panel analysis with high dimensional fixed effects controlling for bonds' determinants of demand and supply. We find that in response to a one percent increase in scarcity, dealer banks re-sell 0.5 (se$=0.135$) percentage points more of the securities received as collateral. The effect is stronger for banking groups' subsidiaries than for headquarters, for foreign collateral than for domestic assets, as well as for banks who are registered in primary dealer frameworks of Eurozone member states whose government debt they intermediate. At the extensive margin, we find that although dealers source more safe assets from the market, this is over-compensated by an increase in the re-used collateral amount. Our result is approximately one half of the estimated effect in Jank, Moench, and Schneider (2022) who use end-of-month data of German dealers' incoming and outgoing collateral from securities lending and repo transactions.

Second, we find strong evidence for a collateral driven – as opposed to a cash driven motivation – to re-use safe assets. On the one hand, dealers may intermediate cash between lenders and less creditworthy borrowers who trade on separate repo market segments (cash perspective, e.g., Gottardi, Maurin, and Monnet 2019). On the other hand, dealers may, as a service to their clients, source safe assets from the market, e.g., for the temporary use in margin deposits to CCPs or for regulatory purposes (collateral perspective). We identify the cash driven intermediation based on the expectation that these transactions are concentrated between the cleared and the bilateral repo market. The strict requirements of CCPs for the admission as a clearing member restrict relatively small and risky market participants to the bilateral market while dealer banks have access to both segments. We expect the security driven intermediation to be concentrated within the bilateral market segment where repo agreements allow for more flexibility compared to standardized contracts in centralized repo markets.

Finally, we test whether dealer banks use collateral intermediation as a source of funding. Infante and Vardoulakis (2021) characterize the strategic complementarity which arises among cash borrowers to withdraw their collateral over concerns to lose the amount of over-collateralization on their repo. This introduces financial stability concerns as it threatens to dry up dealers' liquidity. In support of the hypothesis, we find that dealers negotiate contracts with repo buyers and sellers whose difference in haircuts increases in the demand for funding. This strategy allows banks to create a short term liquidity windfall for the duration of the re-use transaction. Because we expect that dealers' decisions to re-use collateral are not random, we correct for a sample selection bias using an extension of Heckman (1976) to panel datasets introduced by Wooldridge (1995) and extended by Semykina and Wooldridge (2010).

# 2 Market Structure and Institutional Setting

## 2.1 Collateral Re-use in the Repo Market

A repurchase agreement is a contract which combines the spot sale and the forward purchase of a security with prices agreed upon when entering into the trade. In the close leg, the cash borrower receives a notional amount $F^c$ in exchange for securities worth $C$ which the lender can liquidate to recoup the amount in case the borrower defaults. Both counterparties may agree on an over- or undercollateralization of the cash loan through haircut $h = 1 - F^c/C$ to reflect the counterparty risk, collateral quality, or the securities' value to the collateral receiver (Krishnamurthy, Nagel, and Orlov 2014; Julliard et al. 2022). For example, a collateral value of 100 EUR allows to borrow a notional amount of 98 EUR at a haircut of 2% or 102 EUR at -2%. In the far leg, when the transaction matures, the securities are returned to the borrower in exchange for an initially specified amount $F^f$. The repo rate, $r = (F^f - F^c)/F^c$, expressed in annualized terms, is effectively the incurred cost of borrowing cash. In a reverse repo the roles of both parties are switched.[3] Dealer banks intermediate safe assets in the repo market by simultaneously entering into a reverse repo and repo *both of which are collateralized with the same security*. Figure 2 shows the purchase of a security worth $C^{HF}$ from a security rich market participant, here a Hedge Fund (HF). The dealer subsequently sells the collateral security through a repo to a cash rich market participant, here a money market fund (MMF).

There are two types of repo contracts. In a General Collateral (GC) repo, the contract defines a set, or basket, of securities any of which the cash borrower can provide to the cash lender at her own choice. She may substitute the security during the contract's lifetime if the replacement belongs to the same basket. Since the cash lender has no right of refusal, this type of repo is considered to be *cash-driven*. In contrast, a Specific Collateral (SC) repo specifies which collateral is to be provided and thus is *security-driven*. Transaction data

[3] The party borrowing (lending) cash is also referred to as a repo buyer (seller).

from electronic trading systems show that GC trades represent approximately 10% of total European repo transactions (ECB 2021, section 1.2.). In this paper, we only consider SC repos because dealers would otherwise be exposed to the risk of failing to deliver back the security if the collateral provider chooses to substitute it.

A repo transaction always trades at or below the rate of a GC repo whose basket includes the security with which it is collateralized. If this was not the case, an arbitrageur would sell this repo and use the collateral to buy a repo on the GC market in order to generate a risk-free repo rate spread. Repos that trade non-trivially below the GC repo rate are referred to as special (Duffie 1996). In our sample period of interest, safe assets are scarce and thus SC repos will often be special. As the need for a security increases to the repo seller, e.g., for regulatory purposes, she will be prepared to accept a lower rate for the secured cash loan and thus compensate the collateral provider for the transfer of ownership to this particular issue. In fact, the collateral taker may even be prepared to sell the collateral security in the forward leg for less than the price at which she bought it; the repo rate is negative. However, specials are a subset of specifics because specifics may also trade at or close to the GC rate in other times.[4] Where possible, an alternative compensation for sourcing a scarce security in repo markets may also be the transfer of a notional amount that is worth more than the collateral she receives in exchange; the loan is undercollateralized and the haircut becomes negative.

## 2.2 Repo Market Segments

The repo market can be divided into a (centrally) cleared, bilateral, and triparty segment. Our dataset shows that cleared repos constitute the majority of repo transactions among reporting agents with a share of 70% in transaction volume while bilateral repos reflect 29%. On the cleared segment, a CCP, recognized under the European Markets Infrastructure Regulation (EMIR), inserts itself into the transaction and directly becomes the buyer to the repo seller

[4] A Specific Collateral repo, a transaction where both the repo buyer and seller agree to use a particular security as collateral, is often incorrectly referred to as Special Collateral repo.

and the seller to the repo buyer (*open order*). As the CCP absorbs the counterparty risk it consequently also sets the haircut which thus becomes exogenous to the original contracting parties. Repos traded on this segment predominantly have a short term and high volume, are collateralized with government bonds, and can be either of the GC or SC type. Cleared repos are almost exclusively concluded anonymously through Automatic Trading Systems (ATS), which integrate the clearing service through organizational links to CCPs, and are traded via transparent electronic central limit order books (ICMA 2022). ATS with the largest market shares are BrokerTec and MTS Repo, which both link to LCH Ltd, LCH SA, and Cassa di Compensazione e Garanzia (CC&G), as well as Eurex Repo, which exclusively links to Eurex Clearing. CCPs generally specialize in particular products, asset classes, and currencies. In the government debt class, CC&G and LCH Ltd only clear Italian and UK government bonds respectively, while LCH SA and Eurex Clearing clear multiple euro area government and supranational bonds. In our dataset, the four CCPs have a combined market share of 92%. The requirements for admission to clearing platforms are restrictive and costly such that relatively few institutions are active on this segment. They are composed of international dealer banks, government owned banks, supranational authorities, and central banks.[5]

The bilateral segment constitutes the over-the-counter market. In a bilateral transaction, both parties know the counterparty ex-ante and take on the default risk. Repos are traded under standard provisions generic to repo agreements which minimizes operational costs but allows for direct negotiation of more complex contractual terms. While bilateral repos may be centrally cleared post-trade, where the contract is replaced by two new agreements in which the CCP becomes both parties' counterparty (*novation*), our dataset shows that the share of this type of cleared transaction is negligible. Bilateral transactions are initiated through Automated Trading Systems, e.g., Tradeweb, where traders submit requests for quotes that remain invisible to other market participants, or other direct means, e.g., electronic messaging,

[5]See Mancini, Ranaldo, and Wrampelmeyer (2016) for a more detailed description of the CCP-based euro area repo market.

telephone, or voice-brokers. Relative to the cleared segment, many institutions are active on this market because they have a smaller repo volume or one-way flows which does not justify the costly access to ATS or clearing platforms. Dealers trade and entertain relationships with those participants; for reverse repos, they trade with bond investors like hedge funds, pension funds, or insurance companies seeking funding, and for repo transactions, counterparties are cash rich market participants like money market funds, smaller commercial banks, and large non-financial corporates. Thus, the repo market exhibits a core-periphery structure where dealer banks trade with one another in the cleared segment (dealer-to-dealer market) and trade with customers in the bilateral segment (dealer-to-customer).[6]

The triparty segment constitutes a subsegment to the bilateral market. Triparty agents offer administrative services to manage the collateral, e.g., selecting the collateral security and handling coupon payments or settlement. However, the risk remains with the contractual parties. In contrast to the US, triparty transactions play an insignificant role in the European market with a share of just 1% in the trading volume of our sample.

## 2.3 Rules on Collateral Re-use in the European Repo Market

The legal framework and the rules on re-use, under which market participants trade repo contracts, differ by the market segment and repo type. On the cleared segment, traders are subject to CCPs' rules and regulations. For GC repos, CCPs generally do not allow the collateral to leave the platform and permit its re-use only for open market transactions with the Eurosystem. In contrast, traders of cleared SC reverse repos generally retain full control over the collateral booked on their account and thus may re-use it in a repo on either the CCP's platform or the bilateral segment.[7]

Bilateral repo transactions are governed by model legal agreements. The predominant

[6] See Hüser, Lepore, and Veraart (2021) for a network analysis of the repo market in the UK.

[7] We thank a CCP for clarifying discussions on its rules and regulations and the industry's treatment surrounding collateral re-use.

model is the Global Master Repurchase Agreement (GMRA) which is developed and maintained by the International Capital Market Association (ICMA).[8] Section 6 (e) states that both parties "[...] take all necessary steps to procure that all right, title and interest in any Purchased Securities, any Equivalent Securities, any Margin Securities and any Equivalent Margin Securities shall pass to the party to which transfer is being made [...]". In the absence of other restricting clauses, this transfer of legal title implies that the security becomes the unencumbered property of the collateral receiver who thus gains the right to use the security, including for subsequent repos, during the term of the repo irrespective of the collateral provider's default.[9]

The legal arrangement of European repos stands in contrast to that used in US repo markets. In the US, collateral is pledged, i.e., the title to the security remains with the collateral provider and its re-use is merely a discretionary right. Unless the collateral provider explicitly grants the right to rehypothecate (or re-pledge), the ownership remains with the collateral provider and the use of the security is prohibited.

# 3 Data and Sample Construction

## 3.1 Transaction Reports

We obtain the universe of repo and reverse repo transactions, including their contractual details, from all 53 reporting agents in the regulatory Money Market Statistical Reporting (MMSR) for the period between July 2016, the start of reporting obligations, until December 2021. This dataset consists of approximately 27.7 million transactions. The reporting agents

[8] In a recent market survey of the European repo market with 60 offices of 55 financial groups conducted by ICMA, respondents indicate that the GMRA was used in over 73% of transactions governed by master agreements. See "European Repo Market Survey, " *International Capital Market Association*, March 2021, available online.

[9] See "A Guide to best Practice in the European Repo Market," *International Capital Market Association*, March 2021, available online.

are the largest Eurozone banks by balance sheet size, both commercial and government institutions. They report transactions conducted by all EU-located branches regardless of the collateral asset class, repo type, or market segment excluding intra-group transactions and transactions related to Eurosystem monetary policy operations and its standing facilities. We report the institutions' balance sheet characteristics in Table 1.[10] While we apply our cleaning procedure on the entire dataset, we drop the first quarter for our analysis because of known data quality issues at the onset of reporting obligations.

Our cleaning procedure described next reduces the sample to 25 million transactions or 90% of initial observations. Since we focus on SC repos only, we drop 8% of transactions which we identify as GC repos. While banks may re-use collateral sourced from cleared GC reverse repos, the dominant group among GC transactions, as long as the security remains on the platform, we assume that banks are unwilling to accept an exposure to the risk of failure to deliver back the collateral if the counterparty requests to substitute it. Our identification of GC repos relies on an optional disclosure by reporting agents. However, our finding is in line with a 10% share of GC repos found in ATS transaction data ECB (2021) (see Chart 1.5). We also clean the transaction sample from cancelled and corrected reports (0.8%) as well as reports that specify multiple collateral securities (0.2%) to simplify our algorithm. Lastly, we drop reports with missing information on the collateral ISIN or collateral nominal amount (1.4%) and reports of repos traded outside business days (0.2%).[11]

Finally, we replace reports of open maturity repo contracts, or open repos, and rolled over repos by *hypothetical* fixed maturity contracts. This reduces the sample further to 17.8 million transactions or 71.1% of the filtered transactions. Open repos do not specify a fixed maturity date and can be terminated by either party at will on any business day subject to a notice period. This contract is used for the investment of cash or the financing of assets for

[10] The full sample of reporting agents is also published on the European Central Bank's website.

[11] Transaction reports may satisfy multiple criteria of our cleaning steps.

a duration of which counterparties are uncertain ex ante.[12] Since the reporting rules require agents to submit a transaction report on each business day when neither counterparty has called the open contract, we would both understate the time period for which the lender effectively holds the collateral security and possibly overstate the total collateral amount of outstanding transactions. This also applies to the ongoing reporting of rollovers. Open repos and rollovers are not flagged in the MMSR. However, agents provide the same contractual details to each report where the trade, settlement, and maturity dates are rolled over to the next business day. On that basis, we group transaction reports by the reporting agent and all available contractual variables.[13] Within each group, we assign all transaction reports which are reported on consecutive business days to one open repo contract. We replace each group of transaction reports with one hypothetical fixed maturity repo to which we assign the first observed trading date and the last observed maturity date. We collapse approximately 8.1 million transaction reports, or one third of the filtered sample, to 0.9 million open repo contracts or rollovers. Consequently, these transactions make up 4% of contracts in our final sample. This is in line with market survey data which reveal an average share of 5% of transactions.[14] Figure C1a shows that failing to correct transaction reports from open maturity repo contracts would overstate the total outstanding collateral amount by 200 BN EUR.

## 3.2 Dealer Bank and Collateral Security Samples

Banks in the reporting sample are heterogenous and thus include specialized institutions with little or one-directional repo flows. To this end, we classify institutions based on whether

[12] See ICMA's guide to best practices in the European repo market, p.15., for an outline of the usage of these types of instruments.

[13] We use the following fields: reporting agent; counterparty LEI (if available); counterparty location, and sector; collateral ISIN; transaction type indicating whether it is a repo or reverse repo; CCP dummy indicating whether the repo is cleared or not, and CCP LEI (if applicable); collateral haircut; transaction and collateral nominal amount; rate type indicating whether it is a fixed or floating rate; deal and reference rate; and maturity and settlement business days.

[14] Compare ICMA European Repo Market Survey 2020, Figure 2.23.

they are controlled by their national government, governance or ownership structure, and business model. On this basis, we construct a *Baseline Sample* and a *Primary Dealer Sample* which we use throughout this paper. Appendix A provides a detailed description of our approach and Table A1 provides our resulting classification. For the Baseline Sample, we drop reporting agents which are controlled by their national government or who are subject to bank resolution. In the event of nationalization, the literature shows that banks' business models and risk preferences become subject to political and societal motives which we expect to affect incentives for collateral re-use (e.g., Iannotta, Nocera, and Sironi 2013). We drop public sector banks as well as specialized commercial business models, e.g., retail banks. We expect these institutions to trade on repo markets for the purpose of internal liquidity management but not intermediating cash or collateral in the wholesale market. This sample retains 19 commercial universal, investment, and cooperative banks from the original set of reporting agents.

We compare collateral re-use of the Baseline Sample to another set of reporting agents, the *Primary Dealer Sample*. To this end, we only consider Primary Dealer (PD) banks registered in Eurozone countries' PD frameworks and transactions collateralized with these countries' bonds. Countries with PD frameworks oblige participating banks to bid in auctions, distribute bonds, and, depending on the arrangement, to provide liquidity in the secondary market. It is our hypothesis that PD banks have expert knowledge in the pricing of these bonds, are familiar with the needs of institutions active in this market, and entertain relationships with them. This advantage relative to other institutions enables them to intermediate government bonds on the repo market through collateral re-use. Table A2 reports banks from the reporting sample that are registered in national PD frameworks. The PD sample retains 29 banks, however only in combination with respective national government issued bonds. The difference in size relative to the Baseline Sample is mainly driven by German state-owned *Landesbanken* which are registered in the German PD framework.

Irrespective of the sample, we drop eight reporting agents who have not been in the reporting sample throughout our sample period. Transactions collateralized with bonds which have a rating below investment grade or are issued by supranational institutions are dropped. This applies to 13% of bonds in the collateral sample.

## 3.3 Identification of Re-use Transactions

We identify repo transactions that re-use collateral securities obtained through reverse repos. We refer to these transactions as re-use transactions and initial transactions, respectively. We operate on all outstanding repos and reverse repos at a time, all of which are traded by the same reporting agent and are collateralized by the same security. First, we sort transactions by the trade date (ascending), the maturity (descending) and the collateral nominal amount (descending), in this order. Next, we start by looping over all reverse repos for each of which we initialize an empty list of re-use transactions. Within each iteration, our algorithm sequentially checks all repos against two sets of constraints. The *contractual constraint* requires that *the reverse repo's lifetime contains the repo's lifetime* and consequently determine whether it is a potential re-use transaction.[15] The timing of the reverse repo ensures that the collateral is recovered by the agent in time to deliver it back to the originating counterparty. The *budget constraint* requires that the *outgoing collateral amount does not exceed the incoming amount* and determines whether a candidate repo is identified as a re-use transaction. It ensures that, at any point in time while the reverse repo is outstanding, the re-used amount does not exceed its total collateral amount. In other words, a candidate repo is only identified as a re-use transaction if during its lifetime there is a strictly positive unencumbered collateral amount available for re-use.

Figure 3a illustrates the implications of our matching algorithm by means of three repo transactions (red rectangles) that are successfully matched to one reverse repo (blue rectangle). A rectangle's width indicates the maturity and its height the collateral nominal amount.

[15] The rules require (a) that the repo's trade date is on the same day or after the reverse repo's trade date and (b) that the repo's maturity date is on the same day or before the reverse repo's maturity date.

In line with the contractual constraint, the blue rectangle contains the red ones horizontally. First, this implies that we allow collateral securities to be re-used sequentially, as R1 and R3 in Figure 3a illustrate. Second, multiple repos may simultaneously re-use collateral sourced through the same reverse repo. Although R1 already re-uses collateral from RR1, the unencumbered amount is sufficient to be re-used in R2. If the unencumbered amount is positive but smaller than the collateral amount of a candidate repo we allow that a repo is financed by multiple reverse repos, as illustrated by R2 in Figure 3b. To this end, our algorithm reduces the repo's collateral amount by the reverse repo's unencumbered amount and allows the remainder to be matched to another reverse repo. Note that we allow R2 to be partially financed by re-using RR2 even in the absence of another collateral source since we assume that the bank has a sufficient stock of this specific issue that it owns outright or can gather it from the market. Lastly, note that our algorithm depends on the ordering of transactions which gives precedence to re-use transactions with longer maturities and larger collateral nominal amounts.

We investigate the characteristics of identified initial and re-use transactions in Table 2. First, Panel A shows that collateral is primarily sourced in long-term reverse repos. On average, 40% of initial transactions have a one-week maturity and 60% have a one to twelve months maturity. Yet, the former account for only 20% of the re-used amount while the latter account for 80%. This contrasts the maturity distribution of the overall repo market which is predominantly concentrated in the overnight bucket (ECB 2021, Section 1.4). We also find that the collateral sourced in long-term initial transactions is re-used in both simultaneous and sequential short term repos. For a maturity of one month or longer, the collateral is re-used in two repos or more and the share of re-use transactions with a maturity of one week is never below 60%. While the maturity mismatch between initial and re-use transactions may reflect traditional maturity transformation, it is also consistent with building longer term asset positions and selling them over the short term. The flexibility for sequential re-sales of collateral also offers an explanation for the positive association between the initial transactions' maturity and re-use rate. Panel B reports descriptive statistics conditional on the number of simultaneously outstanding re-use transactions. While 60% of initial transactions are re-used in a single repo, 70% of the total re-used amount is re-sold in two or more simultaneous repos. Hence, the re-use rate increases in the number of simultaneous re-use transactions.

## 3.4 Re-use Measures and Descriptive Statistics

Our primary focus is to study the extent to which dealer banks re-sell collateral onwards when safe assets become more scarce. To this end, we calculate the share of the total nominal amount of collateral bond $j$ received through all outstanding reverse repo contracts of dealer bank $i$ on day $t$ which is posted in re-use transactions, the *re-use rate* (following FSB 2017b, Section 4.2):

$$\text{ReuseRate}_{ijt} = 100 \times \frac{\text{ReusedCollateralAmount}_{ijt}^{\text{outstanding re-use transactions}}}{\text{ReceivedCollateralAmount}_{ijt}^{\text{outstanding reverse repo contracts}}} \in [0, 100] \quad (1)$$

We construct a three-dimensional panel dataset of dealer banks, bonds, and days. We consider all banks in either the baseline or primary dealer sample, all bonds that have been purchased through the Eurosystem's Public Sector Purchase Program (PSPP) at least once in our sample period, and all days in which bonds are outstanding and the bank remains in the reporting sample *irrespective of whether the bank engages in collateral re-use*. We impose this restriction on the sample of securities because the Eurosystem's bond purchases form the basis of our scarcity measure. Lastly, we exclude bonds issued by supranational authorities and merge our regression variables to the panel dataset.

This construction creates a missing value for our dependent variable in the absence of any outstanding reverse repos, repos, or re-use transactions, i.e., when the bank chooses not to borrow or lend against the bond or re-use the sourced bond as collateral. Consequently, our estimation procedure would discard these observations. This would likely introduce a selection bias because we cannot rule out that unobserved factors determine a bank's decision to re-use the collateral or trade in the bond in the first place. Assuming that re-use is a consideration second to the decision to specialize and trade in a bond, replacing missing observations with zeros would retain the latter instances and thus create an abundance of zeros in which a bank never transacts in a bond. To restrict our sample only to dealers active in a bond, we retain the subset of missing observations where a bank has outstanding repos collateralized with the particular bond on any day over the *preceding two weeks*, irrespective of whether it is sourced from a reverse repo or not. Finally, we downsample the panel to a calendar week frequency because we expect banks to be unable to immediately adjust their collateral re-use to changes in the market environment. To this end, we compute the average daily re-use measure for each week.[16]

We investigate the total nominal amount of outstanding re-use transactions over time in Figure 4. It shows that the volume of re-used collateral has roughly doubled to BN 225 EUR during our sample period between October 2016 and February 2020. This is substantially larger than the repo market's overall growth of 60% to BN 3,000 EUR (ECB 2021, chart 1.2). The total volume shows a significant negative year-end effect which is likely attributable to the well documented window dressing, a practice where financial institutions adjust their activity around public disclosure dates to appear safer or more profitable (Munyan 2017; Bassi et al. 2023). To this end, we drop periods around reporting dates from our sample in later regression analyses because factors unrelated to the economic environments pre-dominantly affect banks' decisions to trade on repo markets and re-use collateral. Subfigure 4a distinguishes the re-used amount where the dealer is domiciled in the country issuing the collateral security (domestic collateral) from the re-used amount where the dealer is domiciled elsewhere in the Eurozone (foreign collateral). It shows a mean share of 60% for domestic collateral which has remained

[16] We repeat out benchmark analyses for an alternative aggregation where we use the latest re-use rate within a week. The results are qualitatively similar.

stable over time. Subfigure 4b distinguishes between the market segments from which the collateral is sourced and to which it is allocated. It shows that overall dealers re-distribute collateral from the over-the-counter to the inter-dealer market. On average 60% of re-used collateral is sourced from the bilateral market but only one third is allocated towards it. While roughly two thirds of collateral sourced from the bilateral market is re-distributed to the inter-dealer market 90% of collateral sourced from the inter-dealer markets remains in this segment.

Next, we study the characteristics of re-used collateral bonds in Table 3. We compare the share of specific bond characteristics in the total nominal amount of collateral re-used in daily outstanding repo transactions with the share in the bonds' outstanding amounts. To this end, we aggregate the re-used amount as well as the total outstanding amount of euro area government bonds in our sample by date and bond characteristic. We compute the daily share of each characteristic's re-used and outstanding amount and report the average share, the difference, and $t$-statistics in Table 3. Panel A shows that 70% of banks' re-used government bonds have a rating of AAA or AA and 30% have a rating of A or BBB. A comparison with shares in the outstanding amount indicates a slight overrepresentation of lower rated investment grade bonds. In Panel B, we report the share by issuer country. The result indicates that 84% of re-used bonds is French, German, or Italian government debt. Relative to the outstanding amount, these bonds are overrepresented by 12 percentage points. This suggests that the previous finding for low rated bonds from Panel A is driven by an overrepresentation of Italian banks in the sample of dealer banks and a strong preference for domestic bonds, i.e., a home bias. Panels C and D report statistics on the bond maturity and remaining time to maturity, respectively. They suggest that banks exhibit a preference for bonds with a long maturity but a remaining time until maturity of five to ten years.

Next, we investigate to what extent dealer bank characteristics are associated with collateral re-use. To this end, we collect banks' balance sheet and capital adequacy measures from

S&P Global Market Intelligence. We merge the latest available information to banks' re-use measure which we average across bonds. Table 4 shows the results of regressing banks' re-use rate on lagged regulatory variables and lagged measures of size and profitability over concerns of reverse causality as well as a contemporaneous measure of market position for both the Baseline and Primary Dealer Sample. We find a statistically and economically significant lower re-use rate for banks who have a close to binding leverage ratio (LR) constraint relative to others. While Kotidis and van Horen (2018) find no relationship using regulatory quarter-dealer data from the UK, our finding confirms the conventional wisdom that the introduction of the LR negatively affects the repo market. This is expected because additional funding raised by re-using collateral triggers a regulatory capital charge equal to the LR multiplied by the amount of funding raised (FSB 2017b; Hill 2015). We find a similarly significant lower re-use rate for dealers with a close to binding Liquidity Coverage Ratio (LCR) constraint relative to others. Because collateral re-use has a negative effect on the regulatory measure, dealers close to breaching the regulatory requirement are likely to monitor their positions closely and reduce their re-use activities. While high-quality collateral sourced through reverse repos counts towards the stock of HQLA and thus increases the numerator, this only applies as long as it is unencumbered, i.e., it is not re-used. Second, the future cash inflow of the reverse repo receives a zero weight if it is re-used for more than 30 days and thus decreases the denominator.[17] Both results are robust across samples and model specifications.

Our results further show a positive association between the re-use rate and bank size. This may appear counterintuitive because re-use is a balance sheet intensive business. The dealer's reverse repo reduces the cash position but increases the collateral received on the balance sheet resulting in a neutral position. Yet, the subsequent repo increases the cash position on the asset side which is balanced with a collateral pledged item in the liabilities. Hence, the transfer of the legal title to the collateral in a repo remains on the balance sheet.

[17] See Basel LCR30.16 and LCR40.79, respectively.

The rationale is that the seller commits to repurchase the collateral and thus retains the risk and return on that collateral (see Table D1 for a stylized balance sheet of a repo dealer). However, larger dealers are likely capable of netting exposures and thus maintaining a higher degree of flexibility to operate a more intensive re-use business. Lastly, our result indicates that banks with a more central position in the over-the-counter segment, measured by the number of counterparties, have a higher re-use rate. This suggests that banks intermediating in this market can leverage their market position to match demand and supply of safe assets while negotiating profitable spreads in repo rates and haircuts.

Finally, we investigate dealers' transaction level profit. Figure 5a shows that the transaction level spread between the rate earned on cash lent (initial or reverse repo transaction) and the rate paid on cash borrowed (re-use or repo transaction) equals 7 bp. With an average re-use amount of MM 36 EUR, the profit for dealer banks is economically significant. While the time series shows a remarkable stability, the spread peaks at year end. When aggregating by source and target segment, we find that the spread for collateral sourced from the bilateral market is 10bp on average and four times larger compared to when it is sourced from the cleared market. Figure 4b reveals that this applies to 60% of the re-use volume.

Figure 5b shows the result for an analogous analysis of the haircut spread. The average spread is 18 bp with a relatively more volatile time series. Again, the spread for collateral sourced from the over-the-counter market is for the most part larger with an average of 40 bp compared to the spread for collateral sourced from the cleared market (-5 bp). As expected, the haircut spread for collateral re-distribution within the cleared market is close to zero because haircuts are determined by CCPs and exogenous to traders who become exposed to the counterparty risk. Relative to the other collateral flows, this substantiates the interpretation that dealer banks leverage their negotiation power in the relationship driven over-the-counter market where participants lack access to the transparent order-book based cleared market.

# 4 Determinants of Dealers' Collateral Re-use

## 4.1 Scarcity Effects on Collateral Re-use

We study how dealers adjust the re-use rate in response to a change in the safe asset supply effectively available to financial markets. To this end, we construct a weekly scarcity measure based on euro area government bonds' outstanding amount which is not siloed on the Eurosystem's balance sheet, using transaction data of the Public Sector Purchase Program (PSPP). In first differences, which our model requires for reasons of stationary, we define scarcity as the change in bond $j$'s free floating amount as

$$\Delta\text{Scarcity}_{jt} = 100 \times \frac{\text{NetPurchases}_{jt}}{\text{FreeFloatAmount}_{j,t-1}} \in [-100, 100], \tag{2}$$

where $\text{FreeFloatAmount}_{jt} = \text{OutstandingAmount}_{jt} - \text{CumulativeNetPurchases}_{jt}$. In contrast, the related literature on the effects of central banks' asset purchases on bond yields use contemporaneous gross purchases relative to the outstanding amount (e.g., Schlepper et al. 2020; D'Amico, Fan, and Kitsul 2018; Arrata et al. 2020). ΔScarcity reflects a series of repeated shocks exogenous to banks' re-use because PSPP purchases are market neutral, i.e., they are distributed across euro area jurisdictions in proportion to the total amount outstanding. We limit our sample period to February 2020 to avoid confounding effects from the Pandemic Emergency Purchase Program (PEEP) which started in March 2020. We obtain outstanding government debt amounts from Refinitiv Eikon.

The PSPP's monthly purchase amounts ranges between 20 and 80 BN EUR, except for one 10 months long period where only principal payments from maturing securities were reinvested (compare Figure C2). Legally, the Eurosystem's holding of the outstanding amount per debt issue is limited to 33%. By the end of February 2020, cumulative net purchases were 2.2 TR EUR. It is the only active asset purchase program of government debt in our sample period.

While at the onset only bonds issued by central government and recognized agencies were eligible, the scope was broadened in March 2017 to include debt issued by regional and local governments domiciled in the euro area (see Schlepper et al. 2020, for a detailed analysis of the PSPP implementation). To alleviate the scarcity inducing asset purchase programs, the Eurosystem introduced a Securities Lending Facility (SLF) in April 2015 through which it lends out securities purchased under the PSPP against either cash or securities. However, the average on-loan balance was EUR 27 BN in February 2020, a share of one percent of total holdings, which we do not expect to materially alleviate the permanent supply shock for euro area government bonds.

In our benchmark model specification, we regress dealers' bond specific re-use rates on safe asset scarcity in first differences to account for serial correlation in security-specific bond demand and supply factors (D'Amico, Fan, and Kitsul 2018):

$$\Delta \text{ReuseRate}_{ijt} = \beta_0 + \beta_1 \Delta \text{Scarcity}_{jt} + \gamma' \Delta X_{jt} + \epsilon_{ijt} \tag{3}$$

Our controls, $X_{jt}$, include bond specific variables to control for supply and demand conditions that affect dealers' incentives for re-use. On the one hand, we include the change in a bond's logarithm of the free floating amount. The outstanding amount can vary over time because treasuries may re-open bonds through additional auctions or make use of bond exchanges and buy-back operations as liability management tools (Blommestein, Elmadag, and Ejsing 2012). On the other hand, we add the specialness premium, the spread between GC and SC repos to proxy for bond demand in repo markets. We include a dummy variable for on-the-run bonds, a country's most recently issued bond within a given maturity bucket, for which the literature documents a higher liquidity compared to off-the-run bonds (cf. Krishnamurthy 2002). We construct the variable from the universe of bonds that are outstanding during our sample period and issued by Eurozone federal governments. Lastly, we include a dummy variable for cheapest-to-deliver bonds. In treasury bond future markets, contracts specify specific characteristics of the underlying asset to be delivered. Since actual outstanding bonds at the time of delivery typically do not match all criteria, contracts allow for some leeway, including an admissible maturity range. As multiple instruments may satisfy these conditions, there is at least one bond that is the cheapest to deliver for the counterparty with the short position. Buraschi and Menini (2002) show that traders borrow these bonds on repo markets which may increase the supply's inelasticity (Arrata et al. 2020). We also control for dealers' collateral inventory, defined as the difference in the collateral amount between outstanding initial and re-use transactions. We provide a detailed description on the construction of variables in Appendix Section B.

We assume a range of unobserved individual and time invariant linear components in the error term following Arrata et al. (2020) and Jank, Moench, and Schneider (2022). First, we absorb dealer×time specific fixed effects to absorb dealer specific factors which affect their willingness to re-use collateral. For example, this accounts for changes in bank regulations like the staggered phase-in period of the LCR between 2015 and 2018, or liquidity events like the US repo market dislocations in September 2019. Second, we absorb dealer×bond fixed effects to account for dealers' specialization in domestically issued bonds. Lastly, we include maturity-bucket×bond-issuer-country×time fixed effects to absorb factors specific to outstanding bonds of an issuer country at various maturities. This allows us to account for issuer risks in various time dimensions. We specify buckets with maturity cutoff values at 2 years, 5 years, 10 years, and 30 years.[18] We cluster standard errors on the bond-issuer-country×time level.

Our benchmark result for the Baseline Sample in Table 5 shows that commercial banks increase their re-use rate by 0.42 percentage points (se$=0.129$) in response to a one percentage point increase in asset scarcity. We test the robustness of this benchmark result for lower

[18]In unreported results, we repeat the analysis for narrower and wider buckets. Our narrow maturity buckets have cutoff maturities at 5 years, 10 years, and 30 years while our wide maturity buckets have cutoff maturities at 2 years, 5 years, 10 years, 20 years, and 30 years. The results are robust to the different choices.

dimensional fixed effects in columns 1 through 4, following Jank, Moench, and Schneider (2022), which show that results are qualitatively and statistically similar. While we expect an instantaneous response of banks' re-use activity when the effective supply of safe assets reduces, a prediction for the response is less clear when the supply increases. However, even if dealers wished to reduce their re-use activity in this case, their response will be lagged because they have already committed the collateral in another repo. As Table 2 shows, a non-negligible share of re-use contracts have maturity of one week or longer. Given our expectation of an asymmetric effect around zero, we re-estimate the effect with $\Delta$Scarcity$^{+}$ where we replace values with zero whenever the change in the free floating amount is positive, i.e., the Eurosystem does not reduce the effective supply of safe assets. The coefficient estimate increases to 0.5 (se$=0.135$).

We repeat our regression analysis to analyze the effect at the extensive margin where we decompose the effect on the logarithm of the sourced and re-used amount. Columns 2 and 3 of Table 6 for the Baseline Sample show that while dealers source a larger amount of bonds when the effective supply decreases, this is over-compensated by a larger re-use amount. We compare the estimated effect for the Baseline Sample and Primary Dealer Sample. Column 1 shows that the scarcity effect for the Primary Dealer Sample is significantly larger with a response of 0.63 percentage points (se$=0.227$).

Next, we investigate whether the scarcity effect is driven by dealers re-using domestic bonds in Table 7. To this end, we restrict the sample to observations where the dealer bank's and bond issuer's domiciles coincide and re-estimate specification (3). Column 1 shows that dealers' response to a decrease in the effective supply of foreign government bonds is larger compared to the entire sample (0.61, se$=0.193$). The effect is positive yet insignificant for dealers re-using domestic government bonds.

## 4.2 Dealers' Motivation for Re-use

We study dealers' motivation to engage in the re-use of government debt. Banks may provide the service of sourcing and distributing safe assets to clients, for example, for margin deposits or regulatory purposes, or they may intermediate cash between lenders and borrowers in a segmented market. Following Infante, Press, and Saravay (2020), we expect that cash driven intermediation is concentrated between lenders on the cleared and less creditworthy borrowers on the bilateral repo market. The strict requirements of CCPs for the admission as a clearing member restrict relatively small and risky market participants to the bilateral market while dealer banks have access to both segments. On the other hand, we expect that security driven intermediation is concentrated in the bilateral market where repo agreements allow for more flexibility compared to standardized contracts in centralized repo markets. Our data allows to trace the flow of re-used collateral. To this end, we construct a source and target specific measure of re-use, $\text{ReuseRate}^{\text{A,B}}$, analog to equation (1) which reflects how much of the collateral sourced in segment $A$ is re-sold to segment B. We estimate the effect for collateral flows within the bilateral and cleared segment as well as from the bilateral to the cleared segment. Table 8 shows that the effect of dealers' re-use rate is statistically significant for collateral intermediated on the bilateral segment (coef $= 0.248$, se$=0.0755$) while it is insignificant for the cross-segment intermediation from the bilateral to the cleared market.

## 4.3 Collateral Re-use as a Source of Funding

We study whether dealer banks rely on re-use as a source for liquidity. Financial intermediaries generate a liquidity windfall if the haircut of the reverse repo exceeds that of the repo when re-using collateral. Denote the cash collateral by $C$, the cash amount by $F$ and the haircut by $h$. Suppose the collateral value is identical in both positions of the dealer, $C^{\text{RR}} = C^{\text{R}} > 0$, then $h^{\text{RR}} > h^{\text{R}}$ reduces to a net-positive liquidity position $L = F^{\text{R}} - F^{\text{RR}} > 0$ with $h = 1 - F/C$.

If re-use is a relevant source of funding to dealers, this potentially has material negative implications for financial stability. Infante and Vardoulakis (2021) argue that dealers become exposed to a "collateral run" where cash borrowers, analog to a traditional bank run, optimally withdraw their collateral when dealers' assets contract. In contrast to the ultimate cash lenders, or collateral receivers, who are insulated from the dealer's default because they can recover the loan by selling the security, ultimate cash borrowers, or collateral providers, are at risk to lose their asset.

We test whether dealers match quotes from repo buyers and sellers that increase the haircut spread when they have a high demand for funding. To this end, we model the spread in volume weighted haircuts of outstanding initial and re-use transactions, HaircutSpread $= h^{RR} - h^{R}$, as a function of dealer $i$'s demand for liquidity and a measure of market stress

$$\text{HaircutSpread}_{ijt} = \beta_0 \text{LiquidityDemand}_{i,t-1} + \beta_1 \text{MarketStress}_{t-1} + \beta' X_{ijt} + c_{ij1} + u_{ijt}. \quad (4)$$

Market stress is the spread between the European Short Term Rate (ESTR) and the overnight index swap (OIS) reflects counterparty risk in the European financial system. Our measure of dealers' demand for liquidity is the variation in banks' weekly total GC repo transaction volume that is orthogonal to determinants of demand. More specifically, we use the residuals from the following regression model, analog to Bechtel, Ranaldo, and Wrampelmeyer (2022):

$$\text{GCRepoVolume}_{it} = \beta' X_{it} + \epsilon_{it} \quad (5)$$

We include the log of banks' lagged total assets, the average return on assets, and the leverage ratio. We do not consider default risk measures because trading in the CCP-based GC market is anonymous. In line with our expectation, results in Table D2 show that the coefficient estimate of an empirical model with CDS spreads is insignificant. We proceed with residuals from the specification in Column 1.

We only observe the haircut spread if the dealer re-uses the collateral. If a bank's choice to re-use is not random but related to unobserved factors, the estimator of regression model (4) is subject to a selection bias. We correct for this in the estimation of a panel data model with sample selection and unobserved heterogeneity following Wooldridge (1995) and Semykina and Wooldridge (2010).[19] To this end, we introduce a selection process by defining a latent variable, $s^*_{ijt}$, as

$$s^*_{ijt} = \gamma' Z_{ijt} + c_{ij2} + v_{ijt} \tag{6}$$

and link this to the selection indicator, $s_{ijt}$, which equals one if dealer $i$ re-uses bond $j$ at time $t$ and otherwise equals zero, as follows:

$$s_{ijt} = \mathbb{1}[s^*_{ijt} > 0] = \mathbb{1}[\gamma' Z_{ijt} + c_{ij2} + v_{ijt} > 0]. \tag{7}$$

The covariate vector $Z_{ijt}$ includes our scarcity measure, the total free floating amount, and dummy variables for on-the-run and cheapest-to-deliver bonds. Finally, we model the unobserved effect as $c_{ij1} = \bar{Z}_{ij} + a_{ij1}$ with $\bar{Z}_{ij} = 1/T \sum_{t=1}^{T} Z_{ijt}$ , i.e., including non-selected observations, which allows for correlated random effects. The estimator is obtained in a two step procedure. First, we estimate $P(s_{ijt} = 1|Z_{ij}) = \phi(\delta_t^{a\prime} Z_{ijt} + \xi_t^{a\prime} \bar{Z}_{ij})$ using probit separately for each week $t$ to construct the estimated inverse mills ratio $\hat{\lambda}_{ijt}$ for all observations where $s_{ijt} = 1$. Second, we estimate the observation equation on the selected sample using Pooled OLS:

$$\text{HaircutSpread}_{ijt} = \beta' X_{ijt} + \eta' \bar{Z}_{ij} + \gamma \hat{\lambda}_{ijt} + e_{ijt} \tag{8}$$

We report the regression results in Table 9 for an analysis of dealers' market wide re-use and separately for each pair of source and target segment. The only specification for which

[19] Heckman (1976) cannot be applied to panel data with fixed effects because of the incidental parameter problem.

we find inconclusive results models the haircut spreads of collateral re-use within the dealer market. This is expected because CCPs set haircuts which are consequently exogenous to dealers. For all other specifications, the result confirms our hypothesis on the presence of sample selection. The by far largest inverse mills ratio applies to the analysis of collateral re-allocation within the client segment. The mean haircut spread is statistically and economically significant and ranges from 0.26% to 1.68%.

While the results suggest no relevance of market stress for the haircut spread, the coefficient of dealers' demand for liquidity is statistically and economically significant for collateral re-use across segments as well as within the client market. In particular for collateral sourced on the cleared market and re-allocated to the bilateral market as well as the re-allocation within the bilateral segment, the estimation suggests that a one million EUR funding demand increases the haircut spread by 25 bp (se=$0.028$) and 12 bp (se=$0.062$), respectively. On the other hand, the coefficient suggests a decrease by 33 bp (se=$0.042$) for the re-allocation from the bilteral to cleared segment. As Figure 5a suggests, however, the repo rate spread is significantly larger for the collateral re-allocation for the latter segment. This observation suggests that dealers target specific market segments for their collateral re-use business either to generate a cash profit or to source liquidity.

# 5 Conclusion

This paper constructs the first dealer, bank and bond specific re-use measure for the European repo market using transaction data from the largest 53 institutions. We document that dealers alleviate the scarcity of safe assets through collateral intermediation in the European repo market. In response to the deterioration of government debt availability following security purchases by the Eurosystem, dealers increase their collateral re-use. This effect is driven by market participants' demand for safe assets as opposed to a demand for cash. Dealers make a profit by matching reverse repo and repo quotes with a positive repo rate spread.

Yet, dealers use collateral intermediation as a vehicle to source liquidity by increasing the haircut differential. This exposes dealers to collateral runs that may also be triggered by shocks unrelated to the dealer's or collateral issuer's financial health. This highlights a trade-off between shock absorption and financial stability risks of collateral re-use. Monetary policy needs to consider re-use as a side effect in the design of quantitative easing.

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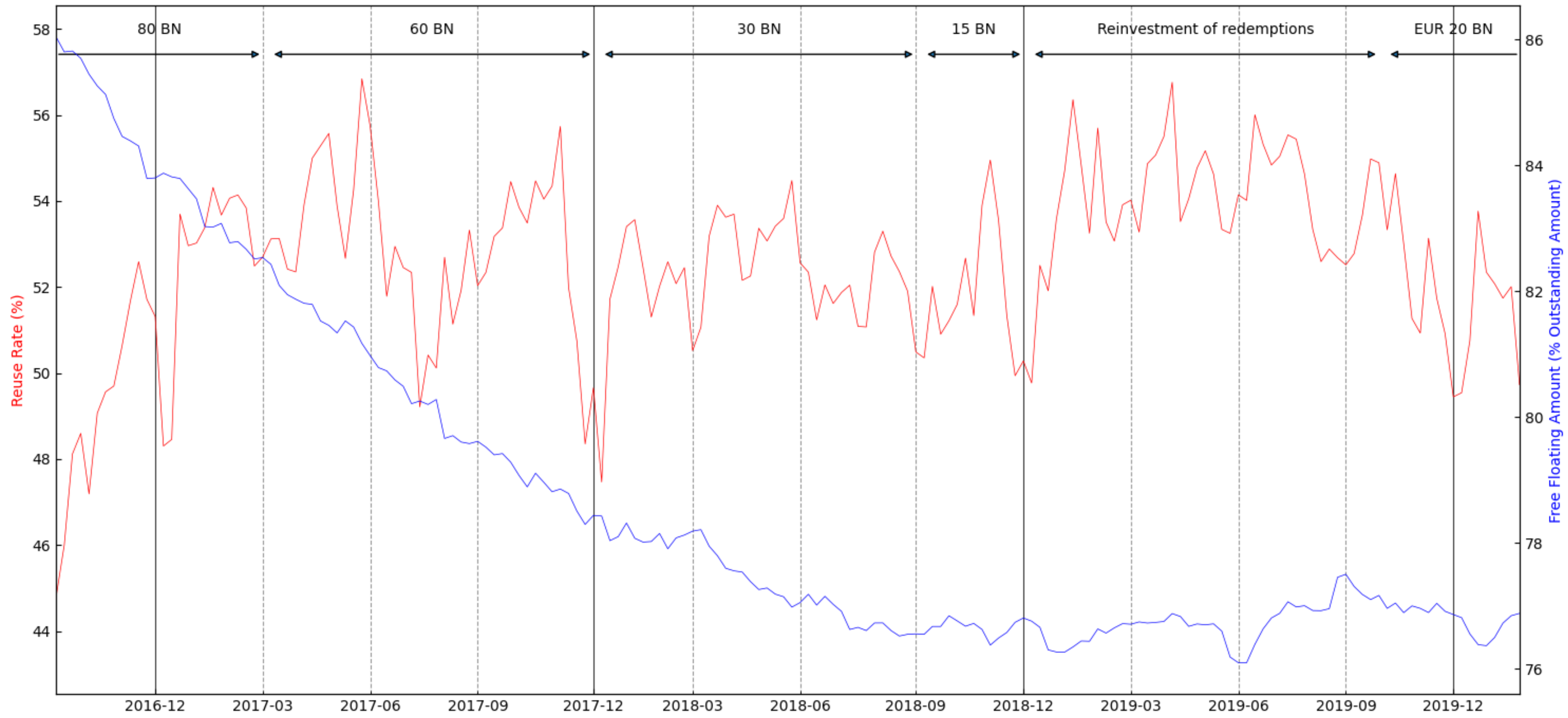



**Figure 1:** Rate of Collateral Re-use and Safe Asset Availability

This Figure shows the bond-level average re-use rate weighted by the posted collatral amount (red line) and the free floating relative to the outstanding amount (blue line) in percent. The re-use rate is the share of the received collateral amount from outstanding reverse repo transactions that is re-used in repo transactions. The free floating amount is the share of the collateral securities' outstanding amount that is not held by the Eurosystem. The arrows at the top indicate the periods of the PSPP and the effective target purchase amount in EUR BN per month. The Figure relies on the baseline sample of reporting agents. The sample period is October 2016 – February 2020.

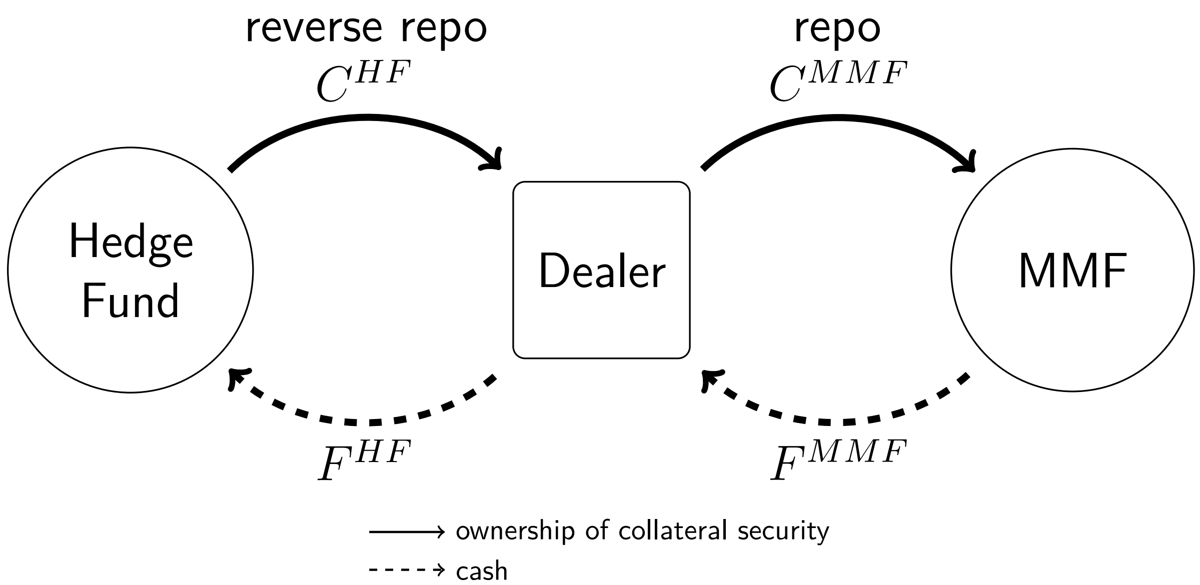
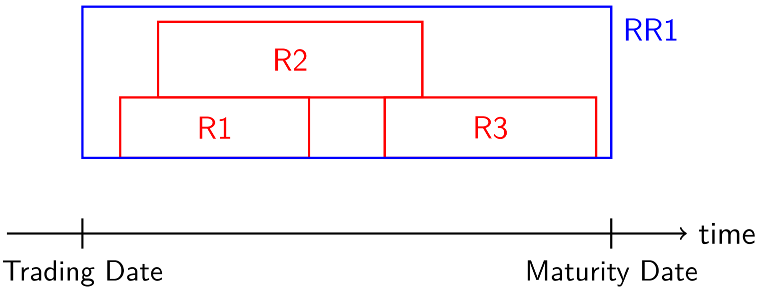
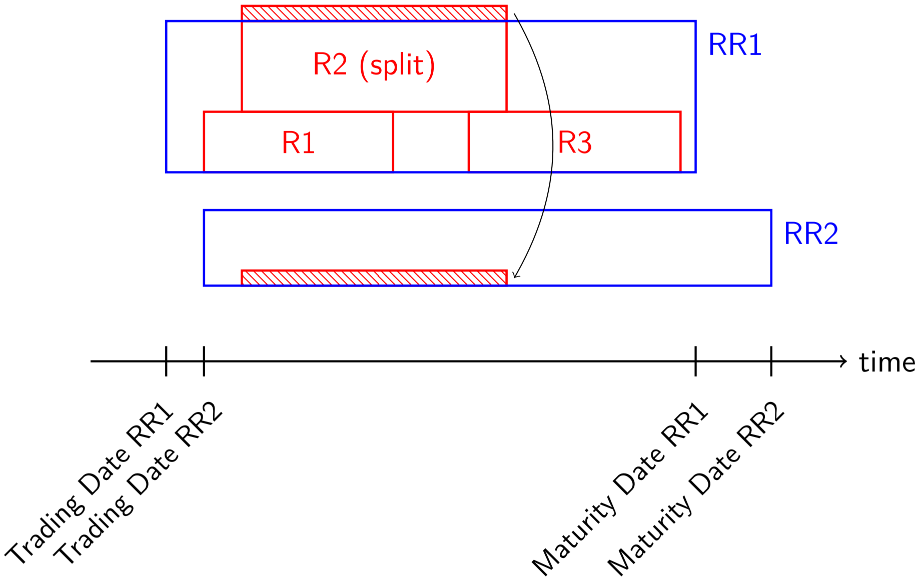



**Figure 2:** Collateral intermediation

This figure shows the near leg of a reverse repo (left) and repo (right) transaction of a dealer that intermediates a security. The dealer lends a notional amount $F^{HF}$ to a Hedge Fund in exchange for a collateral security with market value $C^{HF}$ through a reverse repo. Subsequently, the dealer sells an amount $C^{MMF}$ of *the same security* to a Money Market Fund in exchange for a notional amount $F^{MMF}$.



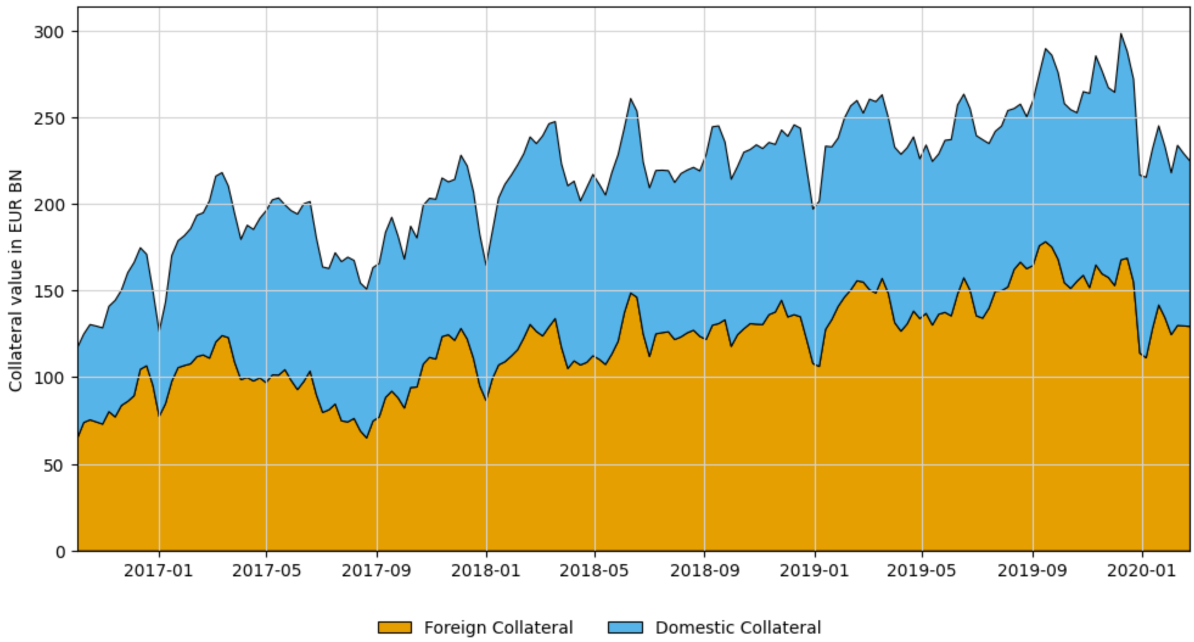

**(a)** Contractual Constraint



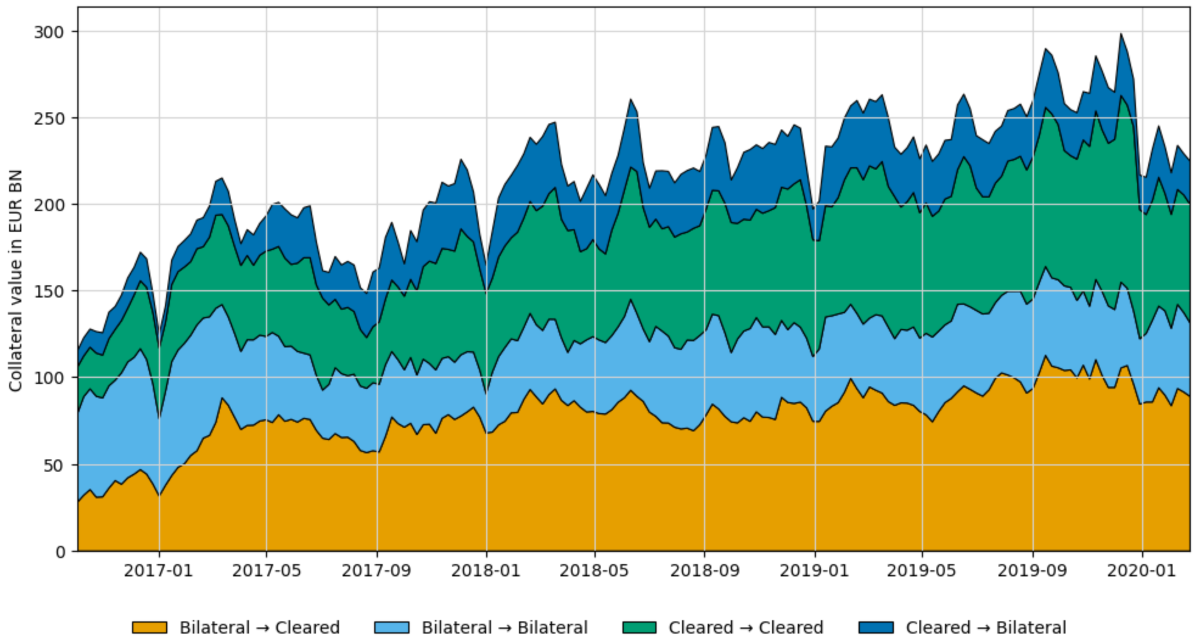

**(b)** Budget Constraint

**Figure 3:** Features of the Matching Algorithm

This Figure illustrates constraints which our algorithm imposes on matches between repo and reverse repo transactions. Each box represents a transaction where red ones indicate a repo (R) and blue ones a reverse repo (RR). The left and right borders represent the trade date and maturity date, respectively, and the height equals the collateral amount. Subfigure 3a illustrates that (a) the maturity of any matched repo must be contained in that of the reverse repo, and (b) that the total collateral amount of matched repos must not exceed that of the reverse repo at any given point in time of the reverse repo's lifecycle. It also shows that the algorithm allows for sequential matches: Once the security from R1 is returned to the dealer, it can repo out the collateral in another transaction R3. Subfigure 3b illustrates that a single repo may be matched to multiple reverse repos. Since the collateral amount of R2 exceeds the unencumbered amount of RR1 on its trade date, the algorithm matches only a share of R2's collateral amount to RR1. The remainder is matched to another reverse repo RR2 with sufficient unencumbered collateral regardless of the counterparty.



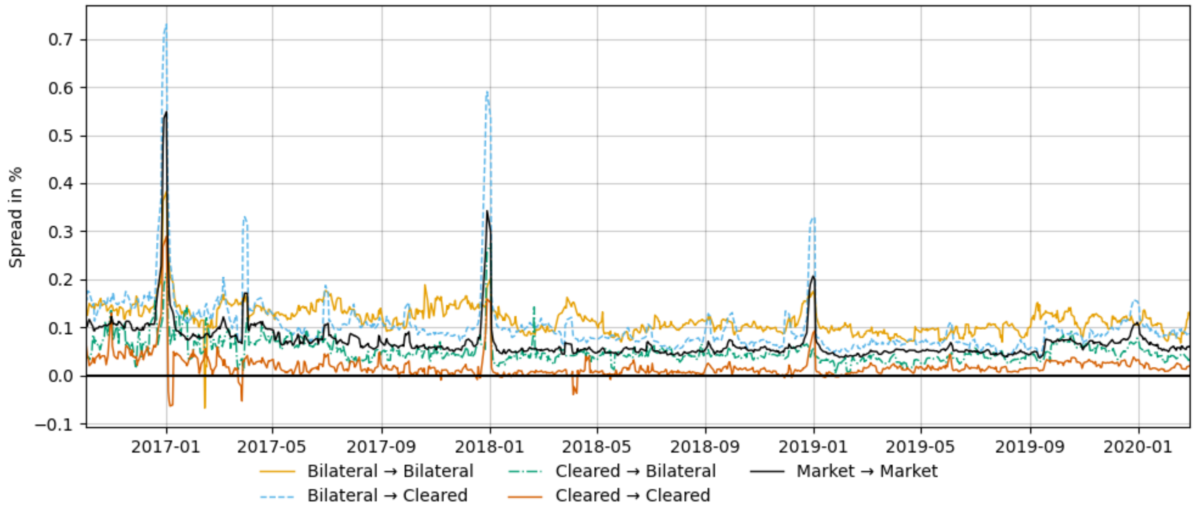

**(a)** Re-used Domestic and Foreign Collateral



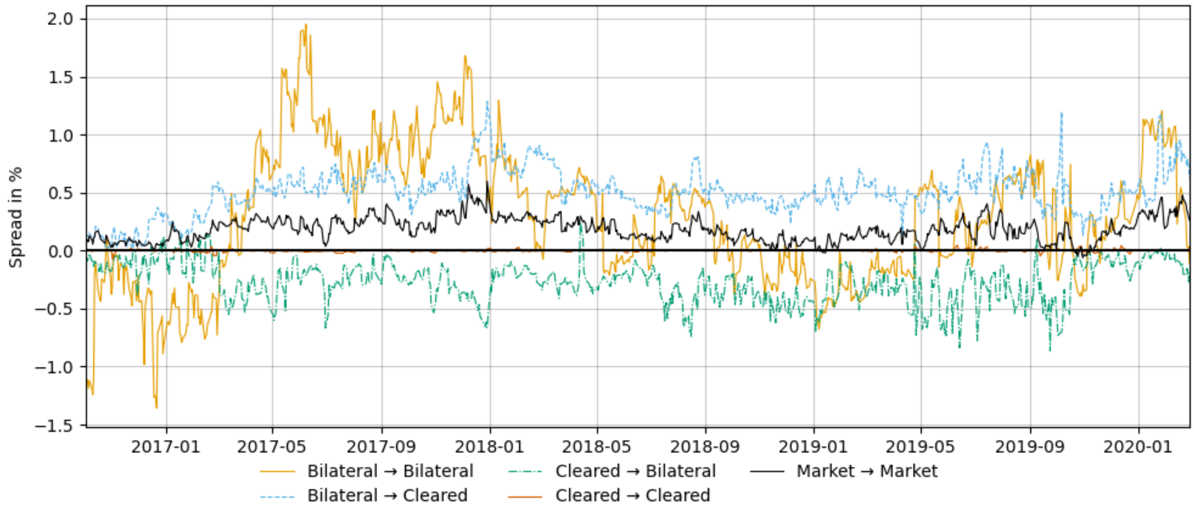

**(b)** Re-used Collateral by Source and Target Segment

**Figure 4:** Re-used Collateral Amount

This Figure shows the total re-used collateral amount in outstanding repo transactions. Subfigure 4a aggregates the amount by domestic and foreign collateral based on the domiciles of the dealer bank and the collateral security issuer. Subfigure 4b aggregates the amount based on the market segments from which the collateral was sourced and to which it is allocated. This Figure uses the Baseline Sample. The sample period is October 2016 – February 2020.




**(a)** Repo Rate Spreads




**(b)** Haircut Spreads

**Figure 5:** Spreads by Collateral Source and Target Segment

Subfigure 5a and Subfigure 5b show the repo rate and haircut spreads, respectively. The spreads are defined as the variables' difference between the initial transaction (reverse repo) and the re-use transaction (repo). We construct a daily dataset of outstanding initial transactions conditional on which we compute the average repo rate and haircut of re-use transactions weighted by the re-use amount. Finally, we compute the transaction-level spreads $\text{RepoRate}^{RR} - \text{RepoRate}^{R}$ and $\text{Haircut}^{RR} - \text{Haircut}^{R}$ conditional on the collateral source and target segment. This Figure uses the Baseline Sample. The sample period is October 2016 – February 2020.

## **Table 1:** Reporting Agents' Balance Sheet Characteristics

This Table provides the average of reporting agents' balance sheet characteristics. TotalAssets is the balance sheet size in BN EUR; TotalDebt and TotalEquity are in BN EUR; ReturnOnAssets, ReturnOnEquity, TotalCapitalRatio, LeverageRatio, LiquidityCoverageRatio, IfrsT1LeverageRatio are in percent. The data is obtained from S&P Capital IQ. Banks are sequentially sorted by country of domicile and name.

| Bank | TotalAssets | TotalDebt | TotalEquity | ReturnOnAssets | ReturnOnEquity | TotalCapitalRatio | LeverageRatio | LiquidityCoverageRatio | IfrsT1LeverageRatio |
|---|---|---|---|---|---|---|---|---|---|
| UniCredit Bank Austria AG | 120 | 29 | 10 | 0.38 | 4.6 | 19.9 | 5.8 | 143.9 | 6.8 |
| BNP Paribas Fortis SA | 291 | 64 | 27 | 0.81 | 8.7 | 16.2 | 6.1 | 126.5 | 6.9 |
| Belfius Banque SA | 172 | 59 | 10 | 0.34 | 6.4 | 18.9 | 5.5 | 130.6 | 5.5 |
| ING Belgique SA | 154 | 23 | 10 | 0.50 | 7.6 | 17.5 | 5.2 | 116.6 | 6.2 |
| KBC Bank NV | 243 | 42 | 15 | 0.93 | 14.9 | 19.7 | 5.2 | 136.2 | 5.2 |
| Bayerische Landesbank | 218 | 115 | 11 | 0.28 | 5.4 | 17.6 | 3.9 | 154.3 | 4.8 |
| Commerzbank AG | 478 | 115 | 30 | 0.14 | 2.3 | 17.0 | 4.9 | 137.5 | 6.1 |
| DB Privat- und Firmenkundenbank AG | 200 | 28 | 5 | 0.25 | 11.0 | | | | 2.9 |
| DEKABANK deutsche Girozentrale | 97 | 50 | 5 | 0.27 | 5.3 | 19.9 | 4.7 | 132.8 | 4.9 |
| DZ Bank AG Deutsche Zentral-Genossenschaftsbank | 500 | 97 | 23 | 0.31 | 6.6 | 17.9 | 4.3 | 144.9 | 3.7 |
| Deutsche Bank AG | 1,468 | 629 | 66 | −0.18 | −4.1 | 17.5 | 3.8 | 131.6 | 4.5 |
| Deutsche Postbank AG | 148 | 10 | 7 | 0.26 | 5.6 | 16.0 | 3.4 | | 4.0 |
| Hamburg Commercial Bank AG | 71 | 29 | 5 | −0.07 | −1.2 | 24.5 | 7.3 | 171.1 | 6.7 |
| ING-DiBa AG | 159 | 93 | 7 | 0.55 | 11.1 | 15.3 | 3.7 | | 3.8 |
| Kreditanstalt fuer Wiederaufbau KFW | 495 | 458 | 29 | 0.35 | 6.4 | 20.5 | | | 5.7 |
| Landesbank Baden-Wuerttemberg | 243 | 111 | 13 | 0.14 | 2.6 | 22.2 | 4.6 | 120.2 | 5.5 |
| Landesbank Hessen-Thüringen Girozentrale | 173 | 83 | 8 | 0.20 | 4.4 | 20.3 | 4.6 | 154.5 | 5.0 |
| NRW. Bank | 146 | 106 | 18 | 0.01 | 0.1 | 45.8 | 11.4 | 215.2 | 12.6 |
| Norddeutsche Landesbank-Girozentrale | 163 | 72 | 6 | −0.47 | −14.2 | 16.9 | 3.5 | 145.8 | 3.8 |
| UniCredit Bank AG | 298 | 100 | 19 | 0.24 | 3.6 | 21.5 | 5.2 | | 6.8 |
| Banco Bilbao Vizcaya Argentaria, S.A. | 709 | 143 | 54 | 0.67 | 8.7 | 15.4 | 6.4 | 126.9 | 6.7 |
| Banco Popular Español, S.A. | 136 | 29 | 9 | −4.34 | −66.5 | 13.2 | 5.5 | 156.9 | 5.8 |
| Banco Santander, S.A. | 1,421 | 311 | 105 | 0.58 | 7.8 | 14.8 | 5.0 | 146.6 | 5.5 |
| Banco de Sabadell, S.A. | 218 | 41 | 13 | 0.32 | 5.3 | 14.6 | 4.8 | 162.4 | 4.8 |
| Bankia, S.A. | 205 | 47 | 13 | 0.34 | 5.5 | 16.8 | 5.4 | 179.7 | 5.9 |
| CaixaBank, S.A | 371 | 41 | 25 | 0.40 | 6.0 | 15.9 | 5.5 | 182.5 | 5.1 |
| Nordea Bank Abp | 590 | 263 | 32 | 0.50 | 9.5 | 22.4 | 5.0 | 171.7 | 4.6 |
| Nordea Bank Finland Abp | 270 | 116 | 12 | 0.34 | 8.9 | 26.3 | 4.7 | 155.0 | 5.6 |
| BNP Paribas | 2,045 | 589 | 105 | 0.39 | 7.7 | 14.7 | 4.4 | 120.6 | 4.3 |
| BPCE | 753 | 426 | 27 | 0.21 | 5.8 | 18.2 | | | |
| Banque Fédérative du Crédit Mutuel | 510 | 177 | 28 | 0.43 | 7.8 | | | | |
| Caisse des dépots et consignations Section géné... | 168 | 43 | 40 | 1.15 | 4.9 | | | | |
| Crédit Agricole SA | 1,599 | 397 | 65 | 0.26 | 6.4 | 18.8 | 4.5 | 133.9 | 2.5 |
| Crédit agricole corporate and investment bank | 525 | 229 | 20 | 0.24 | 6.6 | 18.2 | 3.6 | 116.3 | 3.6 |
| Dexia credit local | 180 | 159 | 5 | −0.10 | 1.4 | 18.1 | 3.8 | 136.2 | 4.8 |
| HSBC France | 185 | 81 | 7 | 0.10 | 3.0 | 15.0 | 3.8 | 134.6 | 3.6 |
| La Banque Postale | 239 | 40 | 10 | 0.33 | 7.9 | 17.7 | 4.3 | 170.6 | 3.5 |
| NATIXIS | 508 | 172 | 21 | 0.35 | 8.6 | 14.9 | 4.2 | 111.1 | 2.7 |
| Société Générale | 1,326 | 325 | 65 | 0.32 | 6.5 | 17.5 | 4.2 | 130.0 | 3.7 |
| Piraeus Bank, S.A. | 72 | 17 | 9 | −0.28 | −3.2 | 15.7 | 10.1 | 63.6 | 11.1 |
| Allied Irish Banks PLC | 90 | | 14 | 0.65 | 4.4 | | | | 11.4 |
| Banca IMI S.p.A. | 162 | 139 | 5 | 0.52 | 17.7 | 13.7 | 4.9 | | 2.4 |
| Banca Monte dei Paschi di Siena S.p.A. | 145 | 44 | 9 | −0.94 | −17.0 | 14.6 | 4.6 | 187.8 | 5.6 |
| Banco BPM | 145 | 54 | 10 | 0.13 | 1.7 | 15.6 | 4.6 | 158.3 | 5.6 |
| Banco Popolare Società Cooperativa | 119 | | 8 | −0.53 | −7.7 | 16.0 | 4.7 | 200.4 | 4.9 |
| Cassa Depositi e Prestiti S.p.A. | 421 | 83 | 36 | 0.59 | 7.0 | | | | |
| Intesa Sanpaolo S.P.A. | 760 | 238 | 53 | 0.54 | 7.8 | 17.4 | 6.1 | 166.3 | 5.4 |
| UniCredit S.p.A. | 849 | 263 | 55 | −0.04 | −1.3 | 15.5 | 4.7 | 147.6 | 5.4 |
| ABN Amro Bank N.V. | 390 | 111 | 20 | 0.56 | 11.2 | 24.3 | 4.2 | 136.4 | 4.9 |
| BNG Bank N.V. | 146 | 134 | 5 | 0.20 | 6.6 | 34.3 | 3.3 | 171.6 | 2.8 |
| Coöperatieve Rabobank U.A. | 625 | 208 | 41 | 0.39 | 6.0 | 25.2 | 5.2 | 129.6 | 5.3 |
| ING Bank N.V. | 894 | 178 | 45 | 0.53 | 10.9 | 17.4 | 4.1 | | 4.7 |
| Nordea Bank AB | | | | | | | | | |

## **Table 2:** Repo Transaction Mapping

This Table shows summary statistics on initial (reverse repo) and re-use (repo) transactions matched by our algorithm. We first construct a dataset of daily outstanding matches. Conditional on each outstanding initial transaction, we then aggregate across matched re-use transactions. For Panel A (Panel B), we finally aggregate by the maturity of each initial transaction (number of re-use transactions). A detailed description of the matching procedure is provided in Section 3.3. AmountReused is in BN EUR and ReuseRate is in percent. This Table uses the baseline sample. The sample period is October 2016 – February 2020.

| **Panel A**: Initial Transaction Maturity | | | | | | |
|---|---|---|---|---|---|---|
| | 1 Day | 1 Week | 1 Month | 3 Months | 6 Months | 1 Year |
| *Matching* | | | | | | |
| % InitialTransactions | 0.8 | 38.9 | 15.6 | 22.1 | 15.8 | 6.8 |
| # ReuseTransaction | 1.1 | 1.0 | 1.9 | 2.0 | 2.0 | 2.3 |
| *Re-use Measures* | | | | | | |
| AmountReused | 0.4 | 37.8 | 35.2 | 54.6 | 44.9 | 27.1 |
| ReuseRate | 68.5 | 66.4 | 79.5 | 81.3 | 82.9 | 82.7 |
| *Share of Matched Re-use Transactions* | | | | | | |
| 1 Day | 100.0 | 4.3 | 2.2 | 2.3 | 1.5 | 1.2 |
| 1 Week | 0.0 | 95.7 | 87.6 | 77.1 | 68.9 | 60.0 |
| 1 Month | 0.0 | 0.0 | 10.2 | 15.0 | 14.2 | 12.6 |
| 3 Months | 0.0 | 0.0 | 0.0 | 5.5 | 12.2 | 12.4 |
| 6 Months | 0.0 | 0.0 | 0.0 | 0.0 | 3.2 | 11.6 |
| 1 Year | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.6 |
| **Panel B**: Number of Re-use Transaction | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | ≥6 |
| *Matching* | | | | | | |
| % InitialTransactions | 58.7 | 19.3 | 9.2 | 5.2 | 3.0 | 4.6 |
| *Re-Use Measure* | | | | | | |
| AmountReused | 60.0 | 44.6 | 30.6 | 21.5 | 14.2 | 29.0 |
| ReuseRate | 69.4 | 78.8 | 82.7 | 84.6 | 85.8 | 86.2 |

## **Table 3:** Collateral Bond Characteristics

This Table shows the percentage share of bond characteristics in total re-used amounts and outstanding amounts. We aggregate the re-used amount and the total outstanding amount by bond characteristic and week. We then report the average weekly share of characteristic and the difference in percent. Numbers in parentheses are $t$-statistics. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. This Table uses the baseline sample. The sample period is October 2016 – February 2020.

| **Panel A**: Collateral Rating | | | | |
|---|---|---|---|---|
| IssuerEntityRating | % AmountReused | % AmountOutstanding | Difference | |
| AAA | 45.2 | 43.4 | 1.84** | (2.13) |
| AA | 26.3 | 30.6 | −4.26*** | (−13.49) |
| A-BBB | 28.5 | 26.1 | 2.42*** | (2.66) |
| **Panel B**: Issuer Country | | | | |
| IssuerCountry | % AmountReused | % AmountOutstanding | Difference | |
| France | 28.3 | 26.5 | 1.85*** | (4.24) |
| Germany | 28.1 | 20.1 | 7.98*** | (8.48) |
| Italy | 27.6 | 25.9 | 1.73 | (1.32) |
| Spain | 9.9 | 12.9 | −2.97*** | (−5.71) |
| Other | 6.0 | 14.6 | −8.59*** | (−37.07) |
| **Panel C**: Maturity Bucket | | | | |
| BondMaturityBucket | % AmountReused | % AmountOutstanding | Difference | |
| 5 Years | 8.1 | 6.6 | 1.50*** | (4.72) |
| 10 Years | 19.2 | 19.2 | 0.00 | (−0.01) |
| 30 Years | 63.7 | 57.8 | 5.91*** | (19.07) |
| $>$ 30 Years | 9.1 | 16.5 | −7.41*** | (−34.03) |
| **Panel D**: Time to Maturity | | | | |
| TimeToMaturity | % AmountReused | % AmountOutstanding | Difference | |
| 5 Years | 40.3 | 47.0 | −6.70*** | (−13.88) |
| 10 Years | 42.2 | 29.9 | 12.25*** | (20.28) |
| 30 Years | 17.2 | 22.8 | −5.56*** | (−15.44) |
| $>$ 30 Years | 0.3 | 0.3 | 0.01 | (0.16) |

## **Table 4:** Dealer Characteristics

This Table reports results from fixed-effects regressions of banks' weighted average re-use rate on balance sheet characteristics. ReuseRate is the percentage share of re-used collateral in outstanding reverse repo transactions. LeverageRatioBinding is a dummy variable equal to 1 if the bank's leverage ratio does not exceed 1 percentage point above the minimum requirement of 3% and 0 otherwise; LiquidityCoverageRatioBinding is a dummy variable equal to 1 where the bank's liquidity ratio does not exceed 10 percentage points above the minimum requirement, i.e., 70% before December 2016, 80% in 2017, and 100% thereafter; TotalAssets is the balance sheet size in EUR MM; CapitalReserves is the cash amount available to absorb losses in EUR MM; ReturnOnAssets is the average return on banks' assets in percent; Counterparties is the number of unique counterparties in all repo transactions. Numbers in parentheses are standard errors clustered on time. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. The sample period is October 2016 – February 2020.

| | Baseline Sample: $\text{ReuseRate}_t$ | | Primary Dealer: $\text{ReuseRate}_t$ | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| $\text{LeverageRatioBinding}_{t-1}$ | −6.555* | −7.359*** | −6.892*** | −7.424*** |
| | (3.874) | (1.976) | (1.435) | (1.770) |
| $\text{LiquidityCoverageRatioBinding}_{t-1}$ | −10.831*** | −8.680*** | −10.947*** | −9.369*** |
| | (0.508) | (1.200) | (1.395) | (1.399) |
| $\text{TotalAssets}_{t-1}$ | 0.00* | 0.00*** | 0.00*** | 0.00*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| $\text{CapitalReserves}_{t-1}$ | 0.000 | 0.000*** | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| $\text{ReturnOnAssets}_{t-1}$ | −0.19 | −0.13 | −0.08 | −0.01 |
| | (0.262) | (0.086) | (0.072) | (0.083) |
| $\text{Counterparties}_t$ | 0.04*** | 0.05*** | 0.02*** | 0.03*** |
| | (0.012) | (0.005) | (0.006) | (0.006) |
| dealer | Yes | Yes | Yes | Yes |
| time | No | Yes | No | Yes |
| Method | PanelOLS | PanelOLS | PanelOLS | PanelOLS |
| Observations | 1,967 | 1,967 | 1,812 | 1,812 |

## **Table 5:** Safe Asset Scarcity and Re-use

This Table reports dealer-bond-week panel regression results of the re-use rate on bond scarcity in first differences. ReuseRate is the percentage share of the bond's total nominal amount received in outstanding reverse repo transactions that is re-used in repo transactions; Scarcity is the percentage share of the bond's free floating amount that is held by the Eurosystem; $\text{Scarcity}^{+}$ is zero whenever the change in the free floating amount relative to the previous period is positive and otherwise equals variable Scarcity; FreeFloatingAmount is the log of bond's total amount outstanding in EUR MM; CollateralInventory is the difference in the total collateral nominal amount of outstanding repo and reverse repo transactions; SpecialnessPremium is the difference in the GC and SC repo rate; CheapestToDeliver and OnTheRun are dummy variables indicating whether a bond is the cheapest to deliver or on the run. Numbers in parentheses are standard errors clustered on the bond-issuer-country×week level. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. This Table uses the Baseline sample. Three weeks around quarter end dates are dropped. The sample period is October 2016 – February 2020.

| | ΔReuseRate | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| ΔScarcity | 0.38*** | 0.39*** | 0.38*** | 0.40*** | 0.42*** | |
| | (0.124) | (0.126) | (0.128) | (0.128) | (0.129) | |
| $\Delta\text{Scarcity}^{+}$ | | | | | | 0.50*** |
| | | | | | | (0.135) |
| ΔFreeFloatingAmount | 0.00 | 0.00 | 0.00 | 0.00 | 0.00* | 0.00** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| ΔCollateralInventory | 0.00*** | 0.00*** | 0.00*** | 0.00*** | 0.00*** | 0.00*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| ΔSpecialnessPremium | 0.37*** | 0.33*** | 0.34*** | 0.36** | 0.35** | 0.35** |
| | (0.111) | (0.111) | (0.113) | (0.151) | (0.154) | (0.154) |
| OnTheRun | −0.47 | −0.46 | −0.50 | −0.57 | −0.73* | −0.77* |
| | (0.386) | (0.387) | (0.422) | (0.424) | (0.429) | (0.429) |
| CheapestToDeliver | 0.05 | 0.07 | 0.11 | 0.12 | 0.11 | 0.11 |
| | (0.243) | (0.244) | (0.258) | (0.259) | (0.261) | (0.261) |
| Constant | −0.05 | −0.05 | −0.05 | −0.05 | −0.04 | −0.04 |
| | (0.057) | (0.057) | (0.059) | (0.058) | (0.057) | (0.057) |
| dealer | Yes | | | | | |
| time | Yes | | | | | |
| bond | Yes | Yes | | | | |
| dealer × time | | Yes | Yes | Yes | Yes | Yes |
| dealer × bond | | | Yes | Yes | Yes | Yes |
| bond-issuer-country × time | | | | Yes | | |
| maturity-bucket × bond-issuer-country × time | | | | | Yes | Yes |
| $R^2$ | 0.00 | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 |
| Observations | 240,682 | 240,671 | 240,409 | 240,251 | 239,748 | 239,748 |

# **Table 6:** Safe Asset Scarcity and Re-use: Primary Dealers

This Table reports dealer-bond-week panel regression results of the re-use rate, the collateral amount re-used and received on bond scarcity in first differences. We use the Primary Dealer sample in Columns 1–3 and the Baseline sample in Columns 4–6. ReuseRate is the percentage share of the bond's total nominal amount received in outstanding reverse repo transactions that is re-used in repo transactions; AmountReused is the total collateral nominal amount that is re-used in outstanding repo transactions; AmountReceived is the total collateral nominal amount that is received in outstanding reverse repo transactions; Scarcity is the percentage share of the bond's free floating amount that is held by the Eurosystem; FreeFloatingAmount is the log of bond's total amount outstanding in EUR MM; CollateralInventory is the difference in the total collateral nominal amount of outstanding repo and reverse repo transactions; SpecialnessPremium is the difference in the GC and SC repo rate; CheapestToDeliver and OnTheRun are dummy variables indicating whether a bond is the cheapest to deliver or on the run. Numbers in parentheses are standard errors clustered on the bond-issuer-country×week level. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Three weeks around quarter end dates are dropped. The sample period runs from October 2016 to February 2020.

| | Primary Dealer Sample | | | Baseline Sample | | |
|---|---|---|---|---|---|---|
| | $\Delta$ReuseRate | $\Delta\log$(AmountReused) | $\Delta\log$(AmountReceived) | $\Delta$ReuseRate$_t$ | $\Delta\log$(AmountReused) | $\Delta\log$(AmountReceived) |
| $\Delta$Scarcity | 0.63*** | 0.03 | 0.05** | 0.42*** | 0.04*** | 0.04*** |
| | (0.227) | (0.027) | (0.023) | (0.129) | (0.016) | (0.012) |
| $\Delta$FreeFloatingAmount | 0.00* | 0.00** | 0.00** | 0.00* | 0.00*** | 0.00*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| $\Delta$CollateralInventory | 0.00*** | 0.00*** | 0.00 | 0.00*** | 0.00*** | 0.00 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| $\Delta$SpecialnessPremium | 0.32* | 0.04* | 0.02 | 0.35** | 0.03* | 0.02 |
| | (0.170) | (0.023) | (0.019) | (0.154) | (0.020) | (0.017) |
| OnTheRun | −0.95** | −0.05 | −0.03 | −0.73* | −0.04 | −0.03 |
| | (0.466) | (0.055) | (0.047) | (0.429) | (0.051) | (0.043) |
| CheapestToDeliver | 0.12 | 0.03 | 0.02 | 0.11 | 0.04 | 0.02 |
| | (0.271) | (0.033) | (0.026) | (0.261) | (0.031) | (0.024) |
| Constant | −0.02 | 0.04*** | 0.06*** | −0.04 | 0.04*** | 0.05*** |
| | (0.070) | (0.009) | (0.007) | (0.057) | (0.007) | (0.006) |
| dealer × time | Yes | Yes | Yes | Yes | Yes | Yes |
| dealer × bond | Yes | Yes | Yes | Yes | Yes | Yes |
| maturity-bucket × bond-issuer-country × time | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.06 | 0.06 | 0.07 | 0.04 | 0.05 | 0.05 |
| Observations | 181,316 | 181,316 | 181,316 | 239,748 | 239,748 | 239,748 |

# **Table 7:** Safe Asset Scarcity and Re-use: Domestic versus Foreign Collateral

This Table reports dealer-bond-week panel regression results of the re-use rate, the collateral amount re-used and received on bond scarcity in first differences In Columns 1–3, we include observations where the banks' domicile coincides with the securities' issuing country (*domestic collateral*) and in Columns 4–6 where this does not apply (*foreign collateral*). ReuseRate is the percentage share of the bond's total nominal amount received in outstanding reverse repo transactions that is re-used in repo transactions; AmountReused is the total collateral nominal amount that is re-used in outstanding repo transactions; AmountReceived is the total collateral nominal amount that is received in outstanding reverse repo transactions; Scarcity is the percentage share of the bond's free floating amount that is held by the Eurosystem; FreeFloatingAmount is the log of bond's total amount outstanding in EUR MM; CollateralInventory is the difference in the total collateral nominal amount of outstanding repo and reverse repo transactions; SpecialnessPremium is the difference in the GC and SC repo rate; CheapestToDeliver and OnTheRun are dummy variables indicating whether a bond is the cheapest to deliver or on the run. Numbers in parentheses are standard errors clustered on the bond-issuer-country×week level. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. This Table uses the Baseline sample. Three weeks around quarter end dates are dropped. The sample period runs from October 2016 to February 2020.

| | Domestic Collateral | | | Foreign Collateral | | |
|---|---|---|---|---|---|---|
| | $\Delta$ReuseRate | $\Delta \log$(AmountReused) | $\Delta \log$(AmountReceived) | $\Delta$ReuseRate | $\Delta \log$(AmountReused) | $\Delta \log$(AmountReceived) |
| $\Delta$Scarcity | 0.23 | 0.05** | 0.02* | 0.61*** | 0.04* | 0.06*** |
| | (0.176) | (0.020) | (0.013) | (0.193) | (0.026) | (0.020) |
| $\Delta$FreeFloatingAmount | 0.00 | 0.00 | 0.00*** | 0.00** | 0.00*** | 0.00*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| $\Delta$CollateralInventory | 0.00*** | 0.00*** | 0.00** | 0.00*** | 0.00*** | 0.00** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| $\Delta$SpecialnessPremium | 0.59** | 0.02 | 0.03 | 0.21 | 0.04* | 0.01 |
| | (0.284) | (0.034) | (0.025) | (0.192) | (0.023) | (0.021) |
| OnTheRun | −1.28* | −0.05 | −0.04 | −0.57 | −0.04 | −0.03 |
| | (0.766) | (0.085) | (0.073) | (0.522) | (0.062) | (0.052) |
| CheapestToDeliver | −0.19 | 0.00 | 0.02 | 0.28 | 0.06 | 0.01 |
| | (0.435) | (0.047) | (0.039) | (0.335) | (0.040) | (0.030) |
| Constant | −0.10 | 0.01 | 0.03*** | −0.01 | 0.05*** | 0.07*** |
| | (0.097) | (0.011) | (0.009) | (0.072) | (0.009) | (0.007) |
| dealer × time | Yes | Yes | Yes | Yes | Yes | Yes |
| dealer × bond | Yes | Yes | Yes | Yes | Yes | Yes |
| maturity-bucket × bond-issuer-country × time | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.08 | 0.07 | 0.07 | 0.06 | 0.06 | 0.07 |
| Observations | 81,679 | 81,679 | 81,679 | 157,969 | 157,969 | 157,969 |

## **Table 8:** Cash versus Collateral Intermediation

This Table reports dealer-bond-week panel regressions of the re-use rate, specific to a source and target segment of the repo market, on bond scarcity. ReuseRate is the percentage share of the bond's total nominal amount received in outstanding reverse repo transactions that is re-used in repo transactions; Scarcity is the percentage share of the bond's free floating amount that is held by the Eurosystem; FreeFloatingAmount is the log of bond's total amount outstanding in EUR MM; CollateralInventory is the difference in the total collateral nominal amount of outstanding repo and reverse repo transactions; SpecialnessPremium is the difference in the GC and SC repo rate; CheapestToDeliver and OnTheRun are dummy variables indicating whether a bond is the cheapest to deliver or on the run. Numbers in parentheses are standard errors clustered on the bond-issuer-country×week level. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. This Table uses the Baseline sample. Three weeks around quarter end dates are dropped. The sample period runs from October 2016 to February 2020.

| | $\Delta\text{ReuseRate}_t^{\text{bilateral,cleared}}$ | $\Delta\text{ReuseRate}_t^{\text{bilateral,bilateral}}$ | $\Delta\text{ReuseRate}_t^{\text{cleared,cleared}}$ | $\Delta\text{ReuseRate}_t^{\text{cleared,bilateral}}$ |
|---|---|---|---|---|
| ΔScarcity | 0.047 | 0.248*** | 0.115 | 0.040 |
| | (0.0914) | (0.0755) | (0.1023) | (0.0427) |
| ΔFreeFloatingAmount | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.0002) | (0.0001) | (0.0002) | (0.0001) |
| ΔCollateralInventory | 0.003*** | 0.001*** | 0.001*** | 0.001*** |
| | (0.0003) | (0.0002) | (0.0002) | (0.0001) |
| ΔSpecialnessPremium | 0.140 | 0.104 | 0.239* | 0.191*** |
| | (0.1067) | (0.0922) | (0.1377) | (0.0595) |
| OnTheRun | 0.105 | −0.256 | −0.211 | −0.227 |
| | (0.3406) | (0.2334) | (0.4476) | (0.1670) |
| CheapestToDeliver | 0.024 | 0.105 | 0.169 | 0.019 |
| | (0.2129) | (0.1442) | (0.2697) | (0.1165) |
| Constant | −0.086*** | −0.014 | 0.092*** | 0.063*** |
| | (0.0239) | (0.0160) | (0.0310) | (0.0128) |
| dealer × time | Yes | Yes | Yes | Yes |
| dealer × bond | Yes | Yes | Yes | Yes |
| maturity-bucket × bond-issuer-country × time | Yes | Yes | Yes | Yes |
| $R^2$ | 0.04 | 0.04 | 0.04 | 0.04 |
| Observations | 239,748 | 239,748 | 239,748 | 239,748 |

## **Table 9:** Funding Demand

This Table reports estimation results from a panel data model of the haircut spread between the initial (reverse repo) and re-use (repo) with sample selection in the presence of unobserved heterogeneity following Wooldridge (1995) and Semykina and Wooldridge (2010). The empirical model is defined by equation (8). LiquidityDemand is the residual from empirical model (5) reported in specification 1 of Table D2 and proxies the demand for liquidity in MM EUR; MarketStress is the spread between the 3 month ESTR and OIS rates; Counterparties is the number of counterparties; Rating is the most recent bond rating; Scarcity is the percentage share of the bond's free floating amount that is purchased by the Eurosystem; FreeFloatingAmount is the log of the bond's total amount outstanding in EUR BN not held by the Eurosystem; CheapestToDeliver and OnTheRun are dummy variables indicating whether a bond is the cheapest to deliver or on the run; The covariate $\hat{\lambda}$ is the estimated inverse mills ratio. Numbers in parantheses are standard errors. We approximate the distribution of the parameter vector using a panel bootstrap where we sample cross-sectional units and all time periods for each unit sampled with replacement. The bootstrap sample has 1,000 replications. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. This Table uses the baseline sample. The sample period is October 2016 – February 2020.

| | $\text{HaircutSpread}_t^{\text{Market,Market}}$ | $\text{HaircutSpread}_t^{\text{Cleared,Bilateral}}$ | $\text{HaircutSpread}_t^{\text{Cleared,Cleared}}$ | $\text{HaircutSpread}_t^{\text{Bilateral,Cleared}}$ | $\text{HaircutSpread}_t^{\text{Bilateral,Bilateral}}$ |
|---|---|---|---|---|---|
| Constant | 0.73*** | 0.26** | 0.00 | 1.68*** | 1.35*** |
| | (0.120) | (0.109) | (0.002) | (0.208) | (0.422) |
| $\text{LiquidityDemand}_{t-1}$ | 0.00 | 0.25*** | 0.00 | −0.33*** | 0.12** |
| | (0.024) | (0.028) | (0.001) | (0.042) | (0.062) |
| $\text{MarketStress}_t$ | 0.00 | 0.00 | 0.00 | 0.00* | 0.00 |
| | (0.001) | (0.001) | (0.000) | (0.002) | (0.003) |
| $\text{Counterparties}_t$ | 0.00** | 0.00 | 0.00 | 0.00*** | 0.00 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.001) |
| $\text{RatingKnot}_t$ | −0.03*** | −0.02*** | 0.00** | −0.06*** | −0.06*** |
| | (0.004) | (0.004) | (0.000) | (0.008) | (0.014) |
| $\text{Scarcity}_{t-1}$ | 0.06 | 0.05 | 0.00 | 0.03 | −0.12 |
| | (0.156) | (0.148) | (0.003) | (0.274) | (0.453) |
| $\text{FreeFloatingAmount}_t$ | 0.00*** | 0.00** | 0.00* | 0.00*** | 0.00*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| $\text{CheapestToDeliver}_t$ | 0.25*** | 0.36*** | 0.00 | 0.20* | 0.37** |
| | (0.094) | (0.096) | (0.001) | (0.166) | (0.250) |
| $\text{OnTheRun}_t$ | 0.02 | 0.08 | 0.00 | −0.09 | 0.07 |
| | (0.210) | (0.139) | (0.001) | (0.306) | (0.609) |
| $\hat{\lambda}_t$ | 2.52** | −36.22*** | −0.01 | 19.04*** | 55.77** |
| | (1.264) | (12.579) | (0.041) | (4.608) | (25.122) |

# Appendices

## Appendix A Reporting Agent Classifications

We estimate multiple regression models on subsamples of euro area banks in the MMSR reporting sample, the *Baseline Sample* and *Primary Dealer Sample*. The Baseline Sample filters on reporting agents based on three criteria which are not mutually exclusive; whether they are controlled by their national government, their governance or ownership structure, and business model. The Primary Dealer Sample includes Primary Dealer banks registered in eurozone countries' Primary Dealer frameworks and transactions collateralized with sovereign government bonds. This section describes our approach in classifying reporting agents. We provide our classification of institutions in Table A1.

- **Nationalized Banks**: We assign 7 reporting agents who are or whose groups are nationalized and/or subject to resolution. The qualifying crtierion is that the institution has been under government control during our sample period after being rescued during the financial crisis. This includes publicly listed banks which are fully owned by their respective national government, whose majority shareholder is the government, and which are in the process of privatization, being wound-up, or which receive state aid. This classification follows Véron (2017).

- **Governance and Ownership Structure**: We assign 10 banks to a group of public and 43 banks to a group of private sector institutions. We classify banks as public which are created by local or national governments and/or fulfill a public interest or non-commercial objectives. These include national policy banks dedicated to funding local government activities as well as local savings banks and regional banks in Germany. We consider the remaining banks as private institutions, including cooperative banks, investment banks, universal banks, and retail banks. This classification follows Véron

(2017).

- **Business Model**: We assign 12 reporting agents to a group of specialized institutions. Based on an analysis of business reports, we include banks which cater to specific industries, e.g., retail or mortgage banks.

- **Primary Dealer Banks**: We assign banks to countries for which they are registered Primary Dealers. We find that 29 banks are Primary Dealers for at least one and at most 31 countries. Our classification reflects that the composition of Primary Dealers changes over time.

  To this end, we use the historic Primary Dealer group composition by Eurozone member states which is frequently published by the Association for Financial Markets in Europe (AFME) and compiled based on public information as well as data shared by AFME members. While the Debt Management Office (DMO) of countries that entertain a Primary Dealer framework publish registered financial institutions' names on their official websites, those lists are updated in-place in the event of a bank's (de)registration.

  First, we collect all Primary Dealer lists from AFME's "Primary Dealers List for the counterparty type definitions under the HRF" publications. We find six versions updated on January and June 2017, January 2018, January 2019, February 2020, and February 2022. Because only the most recent publication identifies financial institutions by their Legal Entity Identifier (LEI), which the MMSR uses as well, we backward fill the identifier based on firms' names. For firms that were deregistered before February 2022, i.e., for which AFME does not provide the identifier, we manually add the LEI using the Global Legal Entity Identifier Foundation (GLEIF) database. Finally, we create two columns to record the start and end date of the period when the firm was a registered Primary Dealer. We assume that the published information applies until the list is updated again. We also assume that the data in the first list applies as of the start of our sample period.

Consequently, our procedure adopts all classifications made by AFME. For example, while Germany officially does not have a Primary Dealer framework, the Deutsche Finanzagentur GmbH only admits members of the "Bund Issues Auction Group" to directly participate in auctions. AFME classifies these set of rules effectively as a Primary Dealer framework. We also record whether Primary Dealer frameworks impose any kind of obligations on registered Primary Dealers to participate in and thus provide liquidity on the repo market. Where such requirements are in place, frameworks usually stipulate the monitoring of Primary Dealers' transaction activity which is evaluated at the end of a cycle. For example, Italy assesses the volume as well as the distributional quality of Dealers' trading activity. We classify all countries' frameworks against Dealers' obligations for the repo market. Access to the countries' repo facility does not qualify. We manually collect this information from the "European Primary Dealers Handbook" which is published along with the Primary Dealer list.

# **Table A1:** Reporting Agents: Classification

This Table reports our classification of reporting agents. UniversalBank: provides wide variety of financial services, is both a commercial bank and an investment bank. InvestmentBank: provides financial services for corporate and institutional customers, particularly investing, raising capital, and arranging M&A. RetailSpecializedBank: banks that provide banking services to individuals and small businesses (retail) or cater to specific needs (specialized). Nationalized: banks that received state aid, were under governmental control, or were in a resolution process. PublicSector: state-owned bank that serves a public interest. BaselineSample and PrimaryDealerSample indicate whether a bank belongs to the relevant sample. We describe our approach in classifying institutions in Section A. Note that while both samples share a large number of banks, our analyses based on the Primary Dealer sample only considers bonds for which banks are registered Primary Dealers. In contrast, we consider all bonds in analyses based on the former sample. Table A2 reports the national Primary Dealer frameworks for which individual reporting agents are registered. In this Table, banks are sequentially sorted by country of domicile and name.

| Bank | Domicile | Headquarter | Bank Types | | | | | Sample Definitions | |
|---|---|---|---|---|---|---|---|---|---|
| | | | UniversalBank | InvestmentBank | RetailSpecializedBank | Nationalized | PublicSector | BaselineSample | PrimaryDealerSample |
| UniCredit Bank Austria AG | AT | | | | ✓ | | | | |
| BNP Paribas Fortis SA | BE | | ✓ | | | | | ✓ | ✓ |
| Belfius Banque SA | BE | ✓ | ✓ | | | ✓ | ✓ | | ✓ |
| ING Belgique SA | BE | | | | ✓ | | | | |
| KBC Bank NV | BE | ✓ | ✓ | | | | | ✓ | ✓ |
| Bayerische Landesbank | DE | ✓ | | | | | ✓ | | ✓ |
| Commerzbank AG | DE | ✓ | ✓ | | | | | ✓ | ✓ |
| DB Privat- und Firmenkundenbank AG | DE | | | | ✓ | | | | |
| DEKABANK deutsche Girozentrale | DE | ✓ | | | | | ✓ | | ✓ |
| DZ Bank AG Deutsche Zentral-Genossenschaftsbank | DE | ✓ | ✓ | | | | | ✓ | ✓ |
| Deutsche Bank AG | DE | ✓ | ✓ | | | | | ✓ | ✓ |
| Deutsche Postbank AG | DE | ✓ | | | ✓ | | | | |
| Hamburg Commercial Bank AG | DE | ✓ | | | ✓ | | | | |
| ING-DiBa AG | DE | | | | ✓ | | | | |
| Kreditanstalt fuer Wiederaufbau KFW | DE | ✓ | | | ✓ | | ✓ | | |
| Landesbank Baden-Wuerttemberg | DE | ✓ | | | | | ✓ | | ✓ |
| Landesbank Hessen-Thüringen Girozentrale | DE | ✓ | | | | | ✓ | | ✓ |
| NRW. Bank | DE | ✓ | | | ✓ | | ✓ | | |
| Norddeutsche Landesbank-Girozentrale | DE | ✓ | | | | | ✓ | | ✓ |
| UniCredit Bank AG | DE | | ✓ | | | | | ✓ | ✓ |
| Banco Bilbao Vizcaya Argentaria, S.A. | ES | ✓ | ✓ | | | | | ✓ | ✓ |
| Banco Popular Español, S.A. | ES | ✓ | | | ✓ | ✓ | | | |
| Banco Santander, S.A. | ES | ✓ | ✓ | | | | | ✓ | ✓ |
| Banco de Sabadell, S.A. | ES | ✓ | ✓ | | | | | ✓ | |
| Bankia, S.A. | ES | ✓ | ✓ | | | ✓ | | | ✓ |
| CaixaBank, S.A | ES | ✓ | ✓ | | | | | ✓ | ✓ |
| Nordea Bank Abp | FI | ✓ | ✓ | | | | | | |
| Nordea Bank Finland Abp | FI | | ✓ | | | | | | ✓ |
| BNP Paribas | FR | ✓ | ✓ | | | | | ✓ | ✓ |
| BPCE | FR | ✓ | | | ✓ | | | | |
| Banque Fédérative du Crédit Mutuel | FR | | | | ✓ | | | | |
| Caisse des dépots et consignations Section géné... | FR | ✓ | | | | | ✓ | | |
| Crédit Agricole SA | FR | ✓ | | | ✓ | | | | |
| Crédit agricole corporate and investment bank | FR | | | ✓ | | | | ✓ | ✓ |
| Dexia credit local | FR | | | | ✓ | ✓ | | | |
| HSBC France | FR | | ✓ | | | | | ✓ | ✓ |
| La Banque Postale | FR | ✓ | | | | | ✓ | | |
| NATIXIS | FR | ✓ | | ✓ | | | | ✓ | ✓ |
| Société Générale | FR | ✓ | ✓ | | | | | ✓ | ✓ |
| Piraeus Bank, S.A. | GR | ✓ | ✓ | | | ✓ | | | ✓ |
| Allied Irish Banks PLC | IE | ✓ | ✓ | | | ✓ | | | |
| Banca IMI S.p.A. | IT | ✓ | | ✓ | | | | ✓ | ✓ |
| Banca Monte dei Paschi di Siena S.p.A. | IT | ✓ | ✓ | | | ✓ | | | |
| Banco BPM | IT | ✓ | ✓ | | | | | | |
| Banco Popolare Società Cooperativa | IT | ✓ | ✓ | | | | | | |
| Cassa Depositi e Prestiti S.p.A. | IT | ✓ | | ✓ | | | ✓ | | |
| Intesa Sanpaolo S.P.A. | IT | ✓ | ✓ | | | | | ✓ | ✓ |
| UniCredit S.p.A. | IT | ✓ | ✓ | | | | | ✓ | ✓ |
| ABN Amro Bank N.V. | NL | ✓ | ✓ | | | ✓ | | | ✓ |
| BNG Bank N.V. | NL | ✓ | | | | | ✓ | | |
| Coöperatieve Rabobank U.A. | NL | ✓ | | | ✓ | | | | ✓ |
| ING Bank N.V. | NL | | ✓ | | | | | ✓ | ✓ |
| Nordea Bank AB | SE | | ✓ | | | | | | |

## **Table A2:** Reporting Agents: Primary Dealer

This Table reports for which countries reporting agents were registered Primary Dealers at least once during our sample period. We provide this information separately for sovereign bonds in Table A2a and for treasury bills in Table A2b. Our analyses based on the Primary Dealer sample only consider sovereign bonds, i.e., bonds issued by the federal government. Gray shaded columns indicate Eurozone countries. Banks are sequentially sorted by country of domicile and name. We describe our data collection in Section A.

| | AT | BE | CY | DE | ES | FI | FR | GR | IE | IT | NL | PT | SI | SK | CZ | DK | HU | PL | RO | SE | UK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BNP Paribas Fortis SA | | ✓ | | | | | | | | | | | | | | | | | | | |
| Belfius Banque SA | | ✓ | | | | | | | | | | | | | | | | | | | |
| KBC Bank NV | | ✓ | | | | | | | | | | | | | | | | | | | |
| Bayerische Landesbank | | | | ✓ | | | | | | | | | | | | | | | | | |
| Commerzbank AG | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | | | ✓ | ✓ | ✓ | | | | | | | | |
| DEKABANK deutsche Girozentrale | | | | ✓ | | | | | | | | | | | | | | | | | |
| DZ Bank AG Deutsche Zentral-Genossenschaftsbank | | | | ✓ | | | | | | | | | | | | | | | | | |
| Deutsche Bank AG | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | | | ✓ |
| Landesbank Baden-Wuerttemberg | ✓ | | | ✓ | | | | | | | | | | | | | | | | | |
| Landesbank Hessen-Thüringen Girozentrale | | | | ✓ | | | | | | | | | | | | | | | | | |
| Norddeutsche Landesbank-Girozentrale | | | | ✓ | | | | | | | | | | | | | | | | | |
| UniCredit Bank AG | ✓ | | | ✓ | | | | | | | | | | | | | | | | | |
| Banco Bilbao Vizcaya Argentaria, S.A. | | | | ✓ | ✓ | | | | | | | ✓ | | | | | | | | | |
| Banco Santander, S.A. | | | | ✓ | ✓ | | | | | | | ✓ | | | | | | | | | |
| Bankia, S.A. | | | | | ✓ | | | | | | | | | | | | | | | | |
| CaixaBank, S.A | | | | | ✓ | | | | | | | ✓ | | | | | | | | | |
| Nordea Bank Finland Abp | | | | ✓ | | ✓ | | | | | ✓ | | | | | ✓ | | | | ✓ | |
| BNP Paribas | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | | ✓ | ✓ | ✓ | | | |
| Crédit agricole corporate and investment bank | | ✓ | | ✓ | ✓ | ✓ | ✓ | | | ✓ | | ✓ | ✓ | | | | | | | | |
| HSBC France | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | | | | |
| NATIXIS | ✓ | ✓ | | ✓ | ✓ | | ✓ | | | | ✓ | | | ✓ | | | | | | | |
| Société Générale | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | | |
| Piraeus Bank, S.A. | | | | | | | | ✓ | | | | | | | | | | | | | |
| Banca IMI S.p.A. | | | | ✓ | | | | ✓ | | ✓ | | | | | | | | | | | |
| Intesa Sanpaolo S.P.A. | | | | ✓ | | | | ✓ | | ✓ | | | | | | | | | | | |
| UniCredit S.p.A. | | | | | | | | ✓ | | ✓ | | | | | | | ✓ | | | | |
| ABN Amro Bank N.V. | | ✓ | | ✓ | | | | | | | ✓ | | | | | | | | | | |
| Coöperatieve Rabobank U.A. | | ✓ | | ✓ | | | | | | | ✓ | | | | | | | | | | |
| ING Bank N.V. | | ✓ | | ✓ | | | | ✓ | | ✓ | ✓ | | | | ✓ | | ✓ | | ✓ | | |

**(a)** Primary Dealer for Sovereign Bonds

| | AT | DE | ES | FI | FR | IE | IT | PT | DK | UK |
|---|---|---|---|---|---|---|---|---|---|---|
| Commerzbank AG | ✓ | | ✓ | | | | | | | |
| Deutsche Bank AG | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Landesbank Baden-Wuerttemberg | ✓ | | | | | | | | | |
| UniCredit Bank AG | ✓ | | | | | | | | | |
| Banco Bilbao Vizcaya Argentaria, S.A. | | | ✓ | | | | | ✓ | | |
| Banco Santander, S.A. | | | ✓ | | | | | ✓ | | |
| Bankia, S.A. | | | ✓ | | | | | | | |
| CaixaBank, S.A | | | ✓ | | | | | ✓ | | |
| Nordea Bank Finland Abp | | | | ✓ | | | | | ✓ | |
| BNP Paribas | ✓ | | ✓ | ✓ | | | | ✓ | | |
| Crédit agricole corporate and investment bank | | | ✓ | ✓ | | | | ✓ | | ✓ |
| HSBC France | | | ✓ | ✓ | | | | ✓ | | |
| NATIXIS | ✓ | | ✓ | | | | | | | |
| Société Générale | ✓ | | ✓ | ✓ | | | | ✓ | | |

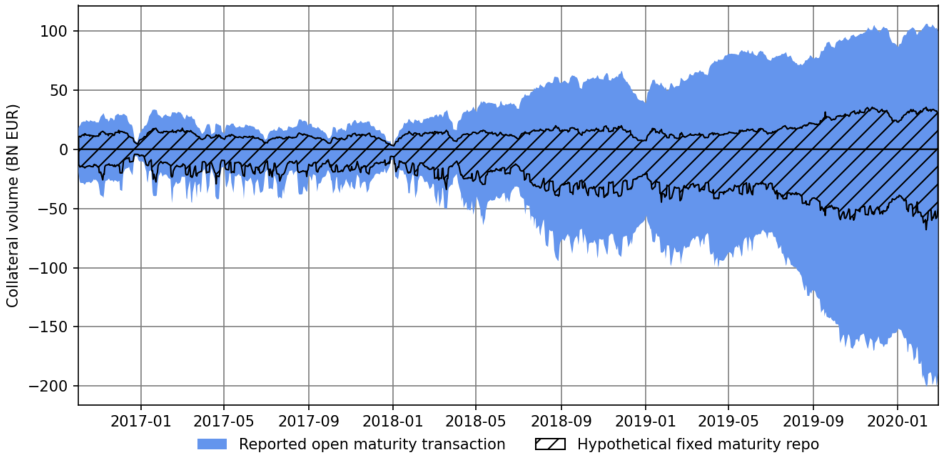
**(b)** Primary Dealer for Treasury Bills

# Appendix B Bond Data

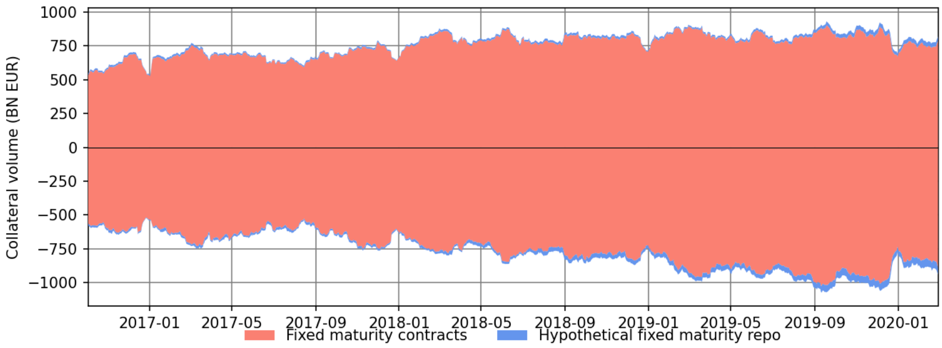
This section describes our approach of constructing bond specific variables that are not readily available from data providers or that require explanation.

- **On-The-Run Bonds**: A bond is on the run if it is a country's most recently issued bond within a given maturity bucket. To identify on the run bonds in our panel of banks' collateral re-use, we obtain the universe of bonds from Refinitiv Eikon that are issued by eurozone federal governments, are issued before our sample period ends but mature after our sample period begins, and are denominated in Euro. This dataset records the issuer country, issurance date, and the maturity bucket. We consider cutoffs at 3 months, 6 months, 1 year, 2 years, 5 years, 10 years, and 30 years following Pasquariello and Vega (2009). In our dealer-bond-week panel of re-use, we create a new dummy variable which indicates whether the bond is on the run by joining the ISIN of the most recently issued bond conditional on the issuer country and maturity bucket. If the ISINs match, we assign a value of 1 and 0 otherwise to the variable.
- **Cheapest to Deliver Bonds**: The cheapest bond among securities that qualify for delivery in treasury bond future markets is the Cheapest to Deliver bond. We collect the readily available ISIN of these bonds for each of the 10 Eurex Eurozone treasury future contracts from Bloomberg. France: Mid-Term Euro-OAT Futures, Euro-OAT; Germany: Euro-Schatz Futures, Euro-Bobl, Euro-Bund, Euro-Buxl Futures; Italy: Short-Term Euro-BTP Futures, Mid-Term Euro-BTP Futures, Euro-BTP; Spain: Euro-BONO. In our dealer-bond-week panel of re-use, we create a new dummy variable which indicates whether a bond is the cheapest to deliver by joining the most recent ISIN for each future contract conditional on the issuer country. If the ISINs match, we assign a value of 1 and 0 otherwise to the variable.

# Appendix C Figures




**(a)** Collapsing of open maturity repo transaction reports




**(b)** Fixed and hypothetical fixed maturity repo contracts

**Figure C1:** Open maturity repo contracts

This Figure quantifies the contribution of open repo contracts to the total nominal collateral amount of outstanding repos (positive values) and reverse repos (negative values) in billions of euro. Subfigure C1a shows the collateral amount of repo transaction reports which our algorithm assigns to open repo contracts (blue area). The hatched area represents the collateral amount after transaction reports are collapsed to hypothetical fixed maturity contracts. The difference between both areas' edges quantifies the overstatement of the outstanding volume if the sample is not corrected for open maturity contracts. Subfigure C1b shows the total nominal collateral amount of outstanding fixed (red area) and hypothetical fixed maturity contracts (blue area). The latter value corresponds to the hatched area in Subfigure C1a. This Figure is based on the Baseline Sample (see Section 3.2).

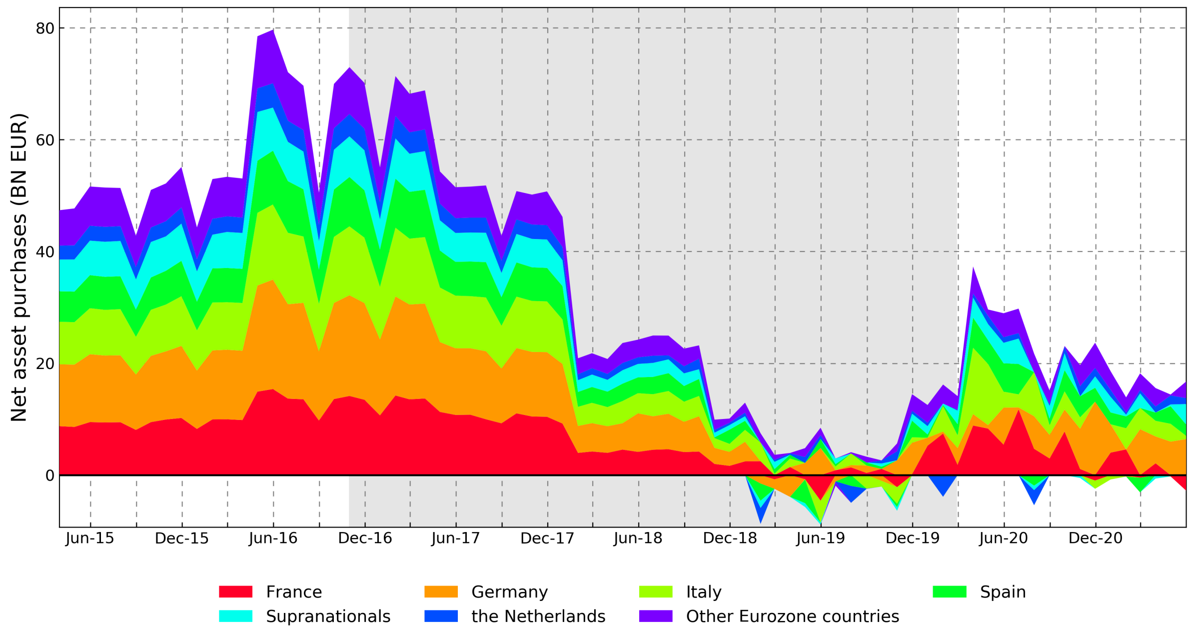



**Figure C2:** PSPP net asset purchases by issuer country

This Figure shows the monthly total net purchases by Eurozone member countries. The shaded area indicates the sample period of our analysis. Source: ECB (accessed June 2021).

# Appendix D Tables

## Table D1: Stylized Balance Sheet of a Security Intermediating Dealer Bank

This Table shows the changes to a stylized balance sheet of a dealer intermediating collateral on repo markets on a matched book. Consider a situation where the dealer lends 1000 EUR cash to a customer against collateral at a zero percent haircut. The reverse repo reduces the dealer's cash position by the contract's notional amount and the security is booked on the Collateral Received account. The transaction is neutral to size of the balance sheet's assets. The dealer maintains a matched-book using a repo with another customer who has excess cash. In contrast to the reverse repo, this transaction adds 1000 EUR to her cash position which is balanced by 1000 EUR on her repo debt account. The dealer also reflects on her balance sheet that the collateral is re-used to distinguish it from other assets. While the legal title of the collateral is transferred in a repo, the IFRS accounting treatment leaves the asset on the balance sheet (compare paragraph 3.2.23). This reflects the economic substance, not the legal form, i.e., the security seller retains the risk and return on the collateral. Consequently, repo trading is a balance sheet intensive business.

| **Panel A: Assets** | | | |
|---|---|---|---|
| Category | Initial Situation | After Reverse Repo | After Repo |
| Cash | 0 | -1000 | 0 |
| Collateral Received | 0 | 1000 | 0 |
| Collateral Re-Used | 0 | 0 | 1000 |
| **Panel B: Liabilities** | | | |
| Category | Initial Situation | After Reverse Repo | After Repo |
| Repurchase Agreement Debt | 0 | 0 | 1000 |

## **Table D2:** Liquidity Demand

This Table shows the regression results used to construct variable LiquidityDemand in equation (4). GCRepoVolume is the total nominal amount of General Collateral repo contracts; TotalAssets is the size of the balance sheet in MM EUR; LeverageRatio is the Tier 1 leverage ratio defined as Tier 1 capital relative to total assets; ROAA is the return on the average asset; CDSReturn is the difference of logged CDS spreads in EUR. Bank and Week indicate fixed effects. The sample period runs from October 2016 to February 2020. Three weeks around quarter end dates are dropped. Numbers in parentheses are $t$-statistics. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

| | $\log(\text{GCRepoVolume})_t$ | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| $\log(\text{TotalAssets})_{t-1}$ | 0.37*** | 0.54*** | 2.11*** | −1.03 |
| | (7.95) | (6.63) | (2.86) | (−0.90) |
| $\text{ROA}_t$ | −0.20** | −0.90*** | 0.18** | 0.01 |
| | (−2.46) | (−6.02) | (2.30) | (0.04) |
| $\text{LeverageRatio}_t$ | 0.16*** | 0.35*** | 0.26** | 0.18 |
| | (5.56) | (7.74) | (2.51) | (1.12) |
| $\text{CDSReturn}_t$ | | −0.07 | | −0.08 |
| | | (−0.39) | | (−0.52) |
| Constant | 1.42** | −1.67 | −22.10** | 19.65 |
| | (2.10) | (−1.34) | (−2.20) | (1.27) |
| dealer | | | Yes | Yes |
| time | | | Yes | Yes |
| Observations | 1,358 | 961 | 1,358 | 961 |
| R2 | 0.050 | 0.085 | 0.541 | 0.560 |

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