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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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The Eurosystem's bond market share at an all-time high: what does it mean for repo markets?

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Abstract

In this paper we study the link between central bank asset purchases and the repo market, to examine the impact of the Eurosystem's increased footprint in financial markets resulting from the response to the Covid-19 crisis. To do so, we exploit different highly granular data on government bond purchases and money market transactions. We find that both marginal purchases (*flow effect*) and aggregate holdings (*stock effect*) have a significant downward impact on repo rates. The *stock effect* is nonlinear, and is amplified when the central bank's holdings are larger. Finally, we find that the Eurosystem's Securities Lending Facility alleviates the downward pressure on repo rates for scarce bonds, but it does not fully compensate for the downward pressure created by purchases. This collateral scarcity may hamper a smooth functioning of repo and underlying bond markets.

JEL classification: E52, E58, G10, G15

Keywords: Asset purchases, Unconventional monetary policy, Money Market, Repo Market, Specialness

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1. Introduction

In response to the Covid-19 crisis, the Eurosystem took unprecedented measures to mitigate the impact of the pandemic on the euro area economy, with an eye on preserving price stability.[1] One of these measures is the Pandemic Emergency Purchase Programme (PEPP), initiated in March 2020. This programme initially started with an envelope of EUR 750 billion of purchases in bond markets, and was extended to a maximum of EUR 1850 billion. The biggest part of the purchases consists of sovereign debt. These purchases under PEPP were in addition to the purchases under the Public Sector Purchase Programme (PSPP) of the Asset Purchase Programme (APP). These combined asset purchases substantially outpaced sovereign debt issuance since the onset of the Covid-19 crisis. This led to an increasing stake of the Eurosystem in the euro sovereign debt market (Figure 1).

Such a sizeable presence of the central bank in the fixed income market involves potential trade-offs. While the upscaling of asset purchases was successful in stabilizing markets, restoring confidence and supporting monetary transmission (Lagarde, 2021), the emergence of a unidirectional market participant as the largest buyer may also come at the cost of unwarranted side-effects. One side-effect of central bank asset purchases is asset scarcity (Altavilla et al., 2021). As the central bank behaves as a buy-and-hold investor in bond markets, its footprint increases and the remaining *free floating* availability of securities in markets diminishes. Investors thus face greater difficulties in finding a specific security, which may result in frictions to a smooth functioning of capital markets.

[Insert Figure 1 about here]

In addition to its asset purchases, the ECB responded to the pandemic by easing the conditions of its Targeted Longer-Term Refinancing Operations (TLTROs). This led to an unprecedented increase in central bank lending and excess liquidity. The large increase in central bank credit entailed a comparable growth in the amounts of securities pledged as collateral in order to participate in TLTRO, fuelling the demand for these securities and de facto contributing to bond scarcity. As a result, the ratio between the free float of sovereign bonds and the amount of extra liquidity in the system declined (Figure 1). Consequently, there is more cash available looking for less available bonds in the market.

[1] Throughout the paper we refer to the Eurosystem and to the ECB interchangeably, unless otherwise stated.

This increase in excess liquidity following the crisis response measures contributed to a downward pressure on money market rates, which remained well below the deposit facility rate (DFR) of the ECB. The dynamics, however, have been dissimilar for collateralized and non-collateralized money market segments. Compared to pre-Covid levels, the aggregate decrease has been stronger for secured (repo) rates (10 bps) than for unsecured rates (€STR, 5 bps) (Figure 2).[2] While both secured and unsecured money market rates are affected by the ample availability of cash, the stronger decline in repo rates can be interpreted as the effect of the underlying collateral becoming more valuable, as a consequence of asset scarcity. Due to the increasing amount of liquidity in the system, and the 'absorption' of collateral by the ECB, repo market activity is increasingly driven by a search for collateral instead of a search for funding (ECB, 2021a). The lower cost of borrowing cash against securities in the repo market corresponds to a greater cost of sourcing a security in exchange for cash.

[Insert Figure 2 about here]

In this paper, we study the link between asset scarcity driven by central bank asset purchases of government bonds and the repo market, in particular to examine the impact of the large footprint caused by the Eurosystem's response to the Covid-19 crisis. The repo market is a key component of the money market and a major channel for circulating cash and collateral through the financial system (Schaffner et al., 2019). The repo segment is by far the largest segment of the euro area money market – representing more than two-thirds of total market turnover (ECB, 2021a) – and thus plays a critical role in the transmission of monetary policy (Arrata et al., 2020).

We examine the impact of purchases on asset scarcity by studying the *flow* effect and the *stock* effect of quantitative easing on repo rates. To measure the flow effect, we estimate the impact of an additional purchase on the 1-day *change* in the repo rate of the purchased bond. We also assess the persistence of the flow effect and the ability of the Eurosystem's Securities Lending Facility (SLF) – intended to mitigate scarcity issues – to alleviate the downward pressure on repo rates. To quantify the stock effect, we estimate the impact of the central bank's greater holdings of a bond on the *level* of this bond's repo rate. By considering flow and stock effects, we provide evidence on both the immediate impact of a negative supply shock – proxied by the

[2] These numbers are based on the decline during our sample period, April 2020-November 2021.

purchase by the central bank (i.e. the flow effect) – and the permanent impact of reducing the total supply of securities available in the private market (i.e. the stock effect), as the central bank behaves like a buy-to-hold investor.

To do so, we exploit highly granular proprietary datasets administered by the Eurosystem. We use Money Market Statistical Reporting (MMSR) data to obtain transaction-level information on the euro money market. In addition, we use transaction-level data containing all (monetary policy) asset purchases by the Eurosystem's central banks to construct a time series of holdings per instrument. Finally, we utilise transaction-level data on the SLF, and data on the pledged collateral volumes per instrument for banks' participation in the ECB's refinancing operations.

We *firstly* hypothesize that large-scale asset purchases contribute to increased specialness in repo markets (see section 2 for an explanation of specialness). Our findings indicate that purchases of one percent of the free float of a bond are associated with a temporary decrease up to half a basis point in the repo rate on subsequent days.

Secondly, as the Eurosystem is a *buy-and-hold* investor, we expect that higher holdings will affect the equilibrium price of collateral in repos, resulting in structurally lower repo rates. The results show a permanent decrease in repo rates up to 3.6 basis points coming from holding 33 percent of a bond's outstanding amount. This stock effect is nonlinear: the larger the Eurosystem's holdings of a security relative to its outstanding amount, the greater the impact of holdings on the level of repo rates.

Finally¸ we hypothesize that the SLF of the ECB helps to alleviate the downward pressure on 'special' bonds in repo markets. We find that when larger volumes of a security are lent via the SLF, its repo rate increases. The opposite sign of the flow effect of the SLF with respect to that of purchases implies that the facility compensates for the downward pressure that purchases cause on repo rates

Given the size of the secured (or 'repo') segment, these findings can have important implications. It follows from our results that decreasing repo rates not only respond to the Eurosystem's accommodative stance, but also to the availability of collateral in the market, as scarcer collateral is priced at a premium. This may be considered an unwarranted side-effect of asset purchases. The shift of repo rates away from monetary policy rates, and the scarcity-driven dispersion across repo rates, may be viewed as having an unwarranted impact on the pass-through of monetary policy to money market rates. Moreover, increasing difficulties in sourcing a specific security in repo markets – in particular bonds in high demand – can result in market frictions, which may hamper a smooth functioning of repo and underlying bond markets. For example, collateral scarcity has been linked to more frequent fail-to-deliver episodes in repo markets (Corradin and Maddaloni, 2019) and with a less efficient price discovery mechanism in the cash bond market (D'Amico et al., 2018). Also, bond specialness may cause frictions in bond market intermediation (Huh and Infante, 2021). When a repo rate is significantly below prevailing market rates, borrowing the asset is more expensive, resulting in higher bid-ask spreads. Yet, our results also imply that, as the Eurosystem's footprint decreases, the scarcity premium declines, leading to some upward pressure on repo rates. This may facilitate monetary policy transmission during a tightening cycle (see e.g. D'Amico et al. (2018) who make this point for the United States), although it may also lead to pressure above the desired monetary stance.

Our paper relates to multiple strands of literature. On a general level, we contribute to the literature on the interaction between central bank interventions and money market rates, as Bech and Klee (2011); Martin et al. (2013); Garratt et al. (2015) and Armenter and Lester (2017) for example do in explaining part of the decline of money market rates after the Global Financial Crisis (GFC). Our paper also relates to the literature on side-effects of asset purchase programmes on financial markets. For example, Lamoen et al. (2017) and Hudepohl et al. (2021) show that quantitative easing may lead to exuberance on financial markets.[3]

In particular, this paper is closely linked to the growing literature on asset scarcity and repo specialness. Duffie's (1996) seminal work represents a cornerstone in this literature, providing a theoretical framework and rationalizing the existence of alternative equilibrium repo rates depending on the supply and demand dynamics for a specific security. Since Duffie (1996), there was a surge in the discussion on bond specialness, leading to early empirical (such as Jordan and Jordan, 1997; Buraschi and Menini, 2002; Krishnamurthy, 2002) and theoretical (Fisher, 2002; Bottazzi et al., 2012) work studying the factors driving repo rates.

Thanks to the availability of new micro data sources containing granular information on repo market activity, and coinciding with periods of active market participation of central banks through asset purchase programmes, some papers have studied the link between quantitative easing, asset scarcity, and repo rates (D'Amico et al., 2018; Corradin and Maddaloni, 2019; Arrata et al., 2020, Baltzer et al., mimeo). Arrata et al. (2020) point out that repo rates have

[3] For an extensive discussion on the recent literature on side-effects of asset purchases on the euro area see Altavilla et al. (2021).

gained substantial attention in recent years after they started declining below the DFR, and try to explain how this development could be linked to the purchase programmes of the ECB. The authors empirically investigate the interaction between the Eurosystem's Public Sector Purchase Programme (PSPP) and repo rates directly after the start of the PSPP (2015-2017) and estimate that purchasing one percent of a bond's outstanding volume is associated with a 0.78 basis points decline in its repo rate. D'Amico et al. (2018) examine the impact of the Federal Reserve's Quantitative Easing on repo rates during the 2009-2012 period. They find that the premium for bonds being special is positively related with the cash price of US Treasuries. This may hamper arbitrage within financial markets, as it suggests that relatively expensive bonds tend to be less arbitraged away when they are scarcer. Finally, Baltzer et al. (mimeo) exploit transaction level data from 2015 to 2019 and find that German securities that are eligible for the Eurosystem's PSPP trade at lower rates in repo markets, and that this eligibility premium is larger in size than the rate change caused by supply shocks from asset purchases and securities lending. This eligibility premium was of particular relevance until 2017, before the eligibility criteria were adjusted, resulting in an expanded eligible universe covering the vast majority of both government debt outstanding amount and traded volumes in repo markets.

Our addition to the literature is *fivefold*. (i) We estimate the stock effect of purchases on repo rates. This stock effect, through which scarcer availability of a bond in the market results in lower repo rates, has not been addressed by earlier papers, which focus on the flow effect of an additional purchase. (ii) We examine the role of the Securities Lending Facility of the ECB as a means to alleviate asset scarcity, reflected in downward pressure on repo rates as a consequence of asset purchases. By doing this, our paper is the first in combining the estimation of a negative (asset purchases) and a positive (securities lending) flow effect on repo rates. (iii) We provide a detailed description of repo market dynamics and the factors driving repo rates through the lens of micro data, extending the relatively scarce existing literature in this field. (iv) We revisit earlier studies (Arrata et al., 2020; D'Amico et al., 2018) in a context of a considerably larger central bank footprint in financial markets, with a specific focus on the Covid-19 crisis. (v) Finally, we make use of data that is reported by banks for the *Money Market Statistical Reporting* (MMSR). This a unique transaction level dataset, collected on the basis of transaction-by-transaction data from a sample of euro area reporting agents, providing information on euro money market segments. The euro short-term rate (€STR) is also based on this dataset. Currently, there are 47 reporting agents (ECB, 2022a). Earlier studies analysing asset scarcity with micro data on the repo market use data obtained from different electronic trading platforms – such as BrokerTec or MTS. To the best of our knowledge, we are the first ones to use the MMSR dataset, which is the most granular dataset on money market activity, to answer our research question.

Section 2 describes basic repo market dynamics. Section 3 goes into the data that we use for our analysis, while Section 4 discusses the empirical analysis and results. Section 5 concludes.

2. Institutional background and repo market dynamics

A repurchase agreement (repo) is a financial transaction in which a party sells a security to another party with a simultaneous promise of a buyback at an agreed price. These transactions are typically conducted as a short-term (usually one-day) collateralized loan. Due to their high market liquidity, low credit risk and limited regulatory costs, repos are the most conventional form of short-term cash funding and securities sourcing for financial institutions. In the euro area, the repo market constitutes by far the largest money market segment, accounting for more than two-thirds of total market turnover and a daily average of EUR 645 billion for MMSR reporting banks (ECB, 2021a).[4] The repo market is a major channel for the flow of cash and securities, and repo rates serve as a reference for the funding costs of multiple credit instruments. This makes the transmission from central bank rates to repos a very important first step in the transmission of monetary policy. See also Schaffner et al. (2019) for a general description of euro repo market functioning.

Given the collateralized nature of the loans, the repo market can be seen as a market where net lenders of cash and net lenders of securities transact with each other.[5] In this context, dynamics in the repo market are affected by supply and demand for both cash and collateral, and the repo rate reflects the equilibrium price outcome of these factors. When the demand for cash grows more than the demand for collateral, repo rates increase, reflecting a higher cost of borrowing cash. On the other hand, when the demand for collateral exceeds the demand for cash, repo rates experience downward pressure. This latter situation characterizes the underlying dynamics of the repo market in the current ample cash environment, where the financial system is saturated with excess liquidity. This reduces the demand for cash, while collateral is in short

[4] This compares with a daily average of EUR 140 billion for the unsecured segment. The difference in turnover between the secured and unsecured segments in the euro money market became considerably larger after the Global Financial Crisis (GFC). Before 2008, unsecured transactions accounted for around three quarters of the volume in the repo market.

[5] Examples of institutions that are structurally net cash providers or net securities providers are money market funds and hedge funds, respectively

(free floating) supply as a consequence of central bank asset purchases outpacing sovereign debt issuance (Figure 1).

While there are several segments of the repo market, on a general level repos can be classified into two broad categories based on the underlying collateral and the motivation of the trade, namely *general collateral (GC) repos* and *specific repos* (see e.g. Mancini et al., 2016; D'Amico et al., 2018; Arrata et al., 2020). *GC repos* are collateralized by a 'basket of collateral'.[6] These transactions are used exclusively for cash management purposes, as the cash lender party does not know in advance what collateral it will obtain in return for the cash. As the cash borrower can decide which security in the basket to deliver, the GC rate can typically be thought of as a ceiling for the repo rates of the individual bonds trading in a *specific repo*.

Specific repos are repurchase agreements where the two parties agree on the specific security that will serve as collateral. These transactions are often driven by the needs of the cash lending party to source a particular security. A classic example of the reasons that could make an investor look for specific collateral is when they have entered a short position on a particular security, and need to borrow that security in order to deliver it in due course. Within the set of *specific repos* bonds trade with different degrees of so-called *specialness*, depending on the demand for them. A bond is considered *special* when it is in high demand from cash lenders, who are willing to pay a premium over the rate for similar collateral in order to borrow a certain bond. The phenomenon of specialness is well-described by Duffie (1996). Currently, the majority of trades in the European repo market consists of *specific repos*. This share has increased over the years and is estimated to be around 90 percent of total secured transactions (ECB, 2021a). The main reason for this is the abundant availability of liquidity. Hence, the major rationale for entering into repo trades is collateral – instead of cash – needs.

A bond's specialness is determined by two key factors, (i) idiosyncratic demand and (ii) liquidity:

(i) An example of idiosyncratic demand consists of securities of bond futures that are cheapest-to-deliver (CTD). These securities are highly demanded by investors that need to deliver an eligible bond on a future contract's due date. The specialness premium of CTD bonds increases sharply as the futures delivery date approaches.

[6] A large number of collateral baskets are available, and the type of instruments these baskets contain is very diverse. The rates at which these GC baskets are lent can also vary depending on how specific the basket is (e.g. ECB-extended GC basket including up to 14.000 securities vs. French cheapest-to-deliver basket), and on the overall credit risk of the basket (e.g. baskets with Italian vs. German collateral).

(ii) Even within a single market (e.g. Dutch government bonds) liquidity differs across individual bonds, with more liquid bonds being easier to borrow in the repo market. One of the factors that determines a bond's liquidity in the repo market is its age (with off-the-runs typically being more special than on-the-runs).[7] Bonds that are on-the-run are typically in high demand from a certain number of investors as they are heavily short-sold (Arrata et al., 2020; D'Amico et al., 2018; Duffie, 1996; Fisher, 2002). Another important determinant of liquidity is the amount that is held by (relatively) inelastic buy-and-hold investors, which is the specialness driver that we focus on in this paper. The Eurosystem's purchase programmes have a negative impact on supply, leading to a lower availability of a bond in the repo market. In other words, a bond's *scarcity* is increased, which makes it more special and leads to a lower repo rate when it is used as collateral.

3. **Data**

3.1 *Repo market data*

We exploit the Money Market Statistical Reporting (MMSR) proprietary dataset, which is administered by the Eurosystem and contains daily transaction-level data on the activity of the 47 largest euro area banks (reporting agents) in the euro-denominated repo market (see also ECB (2022a) for more information). MMSR is the most granular and comprehensive dataset on euro money markets, covering about eighty percent of euro money market activities (Chiu et al., 2020). For each repo transaction, the data includes information about the underlying collateral (at the ISIN-level), interest rate, volume, transacting counterparties and the contract's tenor.[8]

While MMSR is the broadest single source of transaction-level data for the euro repo market, it does not cover trades where none of the involved parties is an MMSR reporting agent, such as a cleared repo between a hedge fund and a money market fund. One complementary data source to MMSR is transaction-level data from BrokerTec and MTS, two of the largest electronic platforms for euro repo transactions. These platforms specialise in different market segments, and together account for approximately forty percent of the euro repo market turnover. Before MMSR became available, these datasets were the most extensive data sources on the euro repo market, and earlier papers have used them to study issues related to those we

[7] On-the-run bonds are the last issued bonds of a given maturity in a given country.
[8] ISIN (International Securities Identification Number) is an alphanumeric code that identifies a security.

cover in this paper (e.g. Corradin and Maddaloni (2020), and Arrata et al. (2020)). For these reasons, we also conduct our analysis with BrokerTec and MTS data as a robustness check for our findings.

For our baseline analysis, we select transactions where MMSR reporting agents lend cash and borrow securities (which from the banks' perspective are *reverse* repos). Eisenschmidt et al. (2021) show, using MMSR data, that as a consequence of dealer market power there is a positive spread between lending and borrowing repo rates (from banks' perspective). Hence, the repo rate obtained by taking the average across lending and borrowing contracts may be affected by a change in the proportions of both trade directions, which does not necessarily reflect a shift in the equilibrium price of a security in the repo market.[9] We choose to focus on (cash) lending transactions because we are interested in the impact of asset purchases on the cost paid by banks to source securities from the repo market. However, as a robustness check we replicate our analysis for data on borrowing transactions. The possibility to split our transaction-level data based on the direction of the trade is an advantage of MMSR relative to the datasets from trading platforms.

We only keep repo transactions with a spot-next tenor. The vast majority of repo transactions have maturity of one day, including overnight (O/N), tomorrow-next (T/N), and spot-next (S/N) tenors (ECB, 2021a).[10] The spot-next tenor is the most widely traded of the one-day tenors, comprising around two thirds of total volumes in MMSR, and has the least volatile rates, making it the preferred tenor for regular transactions. Overnight and tomorrow-next buckets, instead, accommodate a larger share of unforeseen funding or sourcing needs. We use data for transactions with German, French, Italian, and Spanish collateral, which account for 87 percent of the volumes of S/N reverse repo in MMSR. We only include transactions backed by government collateral of these countries, as government bonds are the dominant type of collateral, accounting for 85 percent of all transactions in the euro-denominated repo market (ECB, 2021a).

It is common for multiple transactions to use the same security as collateral on a given date, and these transactions are not necessarily conducted at the same rate. Hence, we follow

[9] Consider the following stylized 2-period example. On day T=1, MMSR banks lend in the repo market EUR 125 mn in exchange of a certain security at an average rate of -55 bps, and borrow EUR 150 mn repo-ing the same security at an average rate of -60 bps. On day T=2, MMSR banks lend EUR 75 mn and borrow EUR 200 mn at the same rates than in T=1, -55 bps and -60 bps, respectively. The weighted-average rate aggregating both lending and borrowing transactions decreases from -57.7 bps in T=1 to -58.6 bps in T=2 without any change in the rate within the same trade directions.

[10] O/N trades settle on the same day as the trade date. T/N trades settle one day after the trade date (T+1), while S/N trades settle two days after the trade date (T+2).

Arrata et al. (2020) and we compute a daily repo rate for each bond *i* (i.e. a certain ISIN) in our sample by obtaining the volume-weighted average rates of all repo transactions θ conducted on day t with the same ISIN as collateral, as indicated by Equation (1). Figure 3 shows the time series for the weighted -average repo rates of the rate per collateral issuer country we include in our sample.

$$Repo\ rate_{i,t} = \frac{\sum_{\theta=1}^{N}(Repo\ rate_{\theta,i,t} \cdot Turnover_{\theta,i,t})}{\sum_{\theta=1}^{N} Turnover_{\theta,i,t}} \tag{1}$$

[Insert Figure 3 about here]

Earlier studies of the repo market using micro data have identified two characteristics of a bond that cause it to have different rate trading patterns than other (a priori) similar securities: *on-the-run* and *cheapest-to-deliver* (D'Amico et al. (2018); Arrata et al. (2020)). First, when a bond is recently issued, or "on-the-run", its traded volume in the secondary market is considerably larger than when it is "off-the-run". This in turn leads to higher volumes in the repo market for that security, as many of the secondary market transactions are financed through repos. Second, when a bond is the cheapest-to-deliver (CTD) in a futures contract, it tends to be used more frequently in short-selling activity, which is commonly financed through the repo market (Buraschi and Menini, 2002; Arrata et al., 2020).[11] CTD bonds are thus subject to a higher demand in repos, and typically trade at lower repo rate levels than similar securities. Also, the rate of change of the repo rate of CTD bonds is different to that of non-CTD instruments, in particular as the futures contract delivery date approaches (Figure 4). As these factors affect the dynamics in repo rates and are not directly related to asset purchases, we control for them in our regressions. We therefore extend our dataset with a time series of on-the-run and CTD bonds.[12]

[Insert Figure 4 about here]

[11] Through a futures contract, the seller party (short seller) is obligated to deliver any bond from a defined basket to the buyer party. Since the short seller may decide which bond from the eligible set to deliver, they choose the cheapest eligible security, the CTD. These futures contracts have delivery dates every quarter, and during their last trading days the demand in the repo market for the cheapest-to-deliver securities increases considerably and the repo rates for these bonds experience relatively high volatility.

[12] For on-the-run securities, we define a 3-weeks window after issuance during which a bond is defined as "on-the-run". For CTD, we obtain daily data from Bloomberg for the ten different futures contracts whose baskets are composed of German, Italian, French, and Spanish government bonds. The contracts are traded in the Eurex platform under the names of FGBM, FBON, FGBL, FGBX, FOAT, FGBS, FBTP, FOAM, FBTS.

3.2 *Asset purchases*

As we focus on repo transactions with government bonds as collateral, we are only interested in the purchases of government bonds by the ECB. The ECB launched its public sector purchase programme (PSPP) in 2015 to preserve price stability (as part of the Asset Purchase Programme, APP) . The initial envelope consisted of monthly volumes of EUR 60 bn.[13] Yet the PSPP was extended multiple times in terms of volumes, length and purchase limits. Net purchases under the PSPP were discontinued in January 2019 and restarted in November 2019, remaining active as of today. As part of the response to the coronavirus pandemic, the ECB launched the PEPP with an initial envelope of €750 billion, later extended to a total of €1850 billion to be conducted until March 2022. As a result, the share of the Eurosystem in the European government bond market increased to record levels (Figure 1). At the end of November 2021, the Eurosystem held almost 34 percent of the total outstanding amount of PSPP- and PEPP-eligible sovereign bonds in circulation. However, there is a wide dispersion in the percentage of debt held by the Eurosystem across different ISINS (Figure 5).

We collect transaction-level data with all the purchases made by the Eurosystem under the PSPP and the public-sector PEPP including German, French, Italian, and Spanish government issued securities. Our data includes information on ISIN, price, purchased volume, and trading counterparties. After aggregating all purchases at the ISIN-date level, 31,272 trades remain, from which it can be derived that, on average, every bond is purchased once per week. Days without purchases of a certain ISIN remain included in the analysis as long as a repo rate for that ISIN is available; in that case purchases are set at zero.

[Insert Figure 5 about here]

3.3 *Collateral pledged for participation in refinancing operations*

In addition to the effect of purchases by the Eurosystem on the free float, the amount of a certain bond that is freely available in the market is also reduced as a result of bonds being pledged as collateral for the Eurosystem's refinancing operations. Pledging a government bond as collateral at the ECB means that it is no longer available in the market. Although these bonds could become available for repo collateralization (in contrast to the purchases of the Eurosystem, as long as they are not sold), they cannot be traded in the market unless banks repay their borrowings from the central bank or change their collateral composition.

[13] Together with purchased volumes under the Asset Backed Security Purchase Programme (e) and the (third) Covered Bond Purchase Programme (CBPP3). In 2016, the Corporate Sector Purchase Programme (CSPP) was added.

As a result of the attractive conditions of the third series of the Targeted Longer Term Refinancing Operations (TLTRO-III), take-up reached record-high values. In September 2021, Eurosystem outstanding credit operations reached a new all-time high (more than EUR 2200 billion). Consequently, also the amount of collateral pledged had to increase. The amount of government bonds pledged as collateral increased from about EUR 200 bn pre-Covid to about EUR 430 bn in November 2021. We include this collateral data as a robustness check to our main specification, by obtaining the amount of pledged collateral per ISIN and reducing the free float accordingly.

Combining these data sources and in line with the literature, we compute our measure for the flow of asset purchases relative to the available stock in the market as the ratio of purchases over each bond's free float, defined as outstanding amount minus holdings of the Eurosystem. Formally, for each bond *i* and date *t*:

$$\Delta\, Eurosystem\ holdings\ over\ FF_{i,t} = \frac{Purchase_{i,t}}{Free\ float_{i,t}} \qquad (2)$$

where $Free\ float_{i,t} = Outstanding\ amount_{i,t} - Eurosystem\ holdings_{i,t-1} - amount\ pledged\ as\ collateral_{i,t}$. We use the amount held by the Eurosystem on the previous trading day so our measure of free float on day *t* is not affected by the Eurosystem's purchases on the same date.

3.4 *Eurosystem's Securities Lending Facility*

With its Securities Lending Facility (SLF), the Eurosystem aims to support bond and repo market liquidity without unduly curtailing private repo market activity (ECB, 2022b). Through the SLF, the Eurosystem makes securities purchased under PSPP and PEPP available for lending via repos. These operations are implemented in a decentralised manner by the Eurosystem and can be either conducted against securities collateral, which is liquidity neutral, or against cash collateral, which is liquidity absorbing and acts as a temporary positive supply shock for the lent bond.

We collect transaction-level data from the SLF and construct a daily series of lent volumes through the SLF per ISIN. We combine both SLF against securities and cash collateral, as their flow effect is identical from the demanded security perspective.[14] Note that our data does not include information on the instrument posted as collateral for transactions against security collateral, thus we do not account for the negative flow effect for the pledged collateral. The impact that this limitation has in our empirical analysis is expected to be rather small however. One would expect that counterparties only select collateral to pledge at the SLF that is in relatively low demand in the repo market. Otherwise it would be more attractive to lend it in the repo market rather than pledging it at the SLF (from a profit maximizing perspective). Consequently, the negative supply effect on the repo rate is likely to be contained.

We combine SLF transactions with free float data to obtain a relative measure of SLF flows. Similar to our measure of the collateral supply absorption effect of asset purchases, we compute for each bond i and date t:

$$\Delta\, SLF\ Balance\ over\ FF_{i,t} = \frac{\Delta\, SLF\ Balance\ _{i,t}}{Free\ float_{i,t}} \quad (3)$$

where $\Delta\, SLF\ Balance\ _{i,t} =\ SLF\ Balance\ _{i,t} -\ SLF\ Balance\ _{i,t-1}$, which is the daily change in the volume lent through the SLF of a certain bond.[15]

Table 1 includes the summary statistics for our main variables. Our sample period runs from April 2020 (to exclude the turbulence on financial markets in March 2020) up to the end of November 2021, covering 419 trading days and including 531 different bonds.

[Insert Table 1 about here]

4. Empirical analysis

4.1 Flow effects

To quantify the impact of Eurosystem purchases on repo rates, we estimate the following panel regression as our baseline specification. This regression captures both the flow effects of asset purchases (as in D'Amico et al., 2018, and Arrata et al., 2020) and the effect of securities lending on repo rates:

[14] Meaning in both cases the security lent becomes available to the market again, regardless of the collateral in return.
[15] While $0 \leq Purchase\ over\ FF_{i,t} \leq 1$ due to the unidirectional activity of the Eurosystem in euro area sovereign bond markets, $SLF\ Balance\ over\ FF_{i,t-1} \leq \Delta\, SLF\ Balance\ over\ FF_{i,t} \leq (Eurosystem\ holdings_{i,t}\ /\ Free\ float_{i,t})$ as the SLF could act as either a positive or negative supply shock following a reduction or an increase in the balance lent of a certain security, respectively. At the moment a security becomes available via the SLF it has a positive supply shock, but when the lent security has to be returned to the Eurosystem when the transaction matures, this results in a negative supply shock.

$$\Delta\, Repo\ rate_{i,c,t} = \beta_1 \Delta\, Eurosystem\ holdings_{\ i,c,t-1} + \beta_2 \Delta\, SLF_{i,c,t-1} + \beta_3 X_{i,c,t} + \gamma_i + \mu_{c,t} + \varepsilon_{i,c,t} \quad (4)$$

where $\Delta\, Repo\ rate_{i,c,t}$ is the one-day change in the repo rate of bond i (issued by country c) between day t and t-1; $\Delta\, Eurosystem\ holdings_{\ i,c,t-1}$ is the one-day change in holdings by the central bank (analogous to purchases on day t-1) of bond *i* over the bond's free float on day t-1; and $\Delta\, SLF_{i,c,t-1}$ is the one-day change in the total balance lent under the Eurosystem's Securities Lending Facility of bond *i* between day *t* and *t-1*. Like previous studies (D'Amico et al., 2018; Arrata et al., 2020) we apply first differences to our regressions to deal with the serial correlation displayed by these variables. $X_{ic,,t}$ is a vector of time-varying bond-specific characteristics; in our baseline specification it includes two dummy variables that are equal to one when a bond is the cheapest-to-deliver or on-the-run, and zero otherwise. We include ISIN fixed effects, γ_i, to capture bond-specific characteristics (e.g. coupon, issue date and time to maturity); and country-time fixed effects, $\mu_{c,t}$, to capture time-varying macro variables (e.g. the general level in repo rates, excess liquidity, issuer information, and market dynamics around reporting dates (quarter- and year-end effects)).[16]

A salient contrast between our specification and those by earlier studies is our choice of one-day lagged variables for the identification of the supply shock, which is underpinned by the intraday timing of repo market turnover. The repo market is a distinctively "early" market, with around three quarters of the daily volumes traded in European repo markets done before 08:30 AM.[17] The Eurosystem's trading activity is conducted during the Eurosystem's working hours, starting at 08:30 AM. Hence, any identification strategy for the impact of asset purchases on repo needs to incorporate a lagged measure of purchases, as the use of contemporaneous variables could in turn capture a potential reverse causality in this relation. Our identification strategy also serves as a workaround for potential endogeneity issues in any characterization using same-day variables, which may be an issue if asset purchases are influenced by the change in repo rates observed on the same day.[18] The outcome of the baseline regression is presented in Table 2.

[16] While time-to-maturity is a time-varying bond-specific characteristic, the short time window of our study (April 2020 – November 2021) makes time to maturity a rather invariant attribute, as securities typically are considered in ample tenor baskets across the yield curve (e.g. 2-to-5 years, or 5-to-10 years).

[17] The "early-skewed" intraday distribution of repo market volumes is also a characteristic of US repo markets (Clark et al., 2021). We thank market participants who kindly provided us with data on the timing of their repo market activity.

[18] Following the market neutrality principle of QE, see Arrata et al. (2020) for a detailed description of this potential endogeneity issue.

The results indicate that a purchase of one percentage point of the (adjusted) free float of a bond leads to a significant decrease of 0.3 basis points in that bond's repo rate on the next day. The magnitude of the impact equals around two thirds of the average change in repo rates (excluding reporting dates). Moreover, an increase of one percentage point of a bond's (adjusted) free float as a result of being lent by the SLF leads to a significant increase of 0.1 basis points in that bond's repo rate. This thus points towards a significant flow effect coming from both negative and positive supply shocks. However, the difference in magnitudes denotes an asymmetric impact. Although the SLF indeed alleviates the downward pressure on repo rates by providing purchased bonds back to the market, it does not fully compensate for the negative supply absorption initially caused by QE. One potential reason for this weaker pass-through may come from the different duration of their impact. QE acts as a *permanent* supply shock for collateral availability, while the SLF's impact is only *temporary* as it only influences the stock of available collateral during the time the repo with the central bank is outstanding. Moreover, the SLF is only intended as a backstop, implying that some of the extra price movement should be absorbed by the market.

[Insert Table 2 about here]

4.2 Persistence of flow effects

Additionally, to examine whether the significant negative flow effect of asset purchases is persistent, we estimate the following regressions (following D'Amico et al., 2018):

$$\Delta\, Repo\ rate_{i,c,t;t-h} = \beta_1 \Delta\, Eurosystem\ holdings_{\ i,c,t-h-1} + \beta_2 \mathrm{X}_{i,c,t} + \gamma_i + \mu_{c,t} + \varepsilon_{i,c,t}\ , h = 0, \dots, T, \qquad (5)$$

where $\Delta\, Repo\ rate_{i,t-h}$ is the change in the repo rate of bond *i* (issued by country *c*) between day *t* and *h*; $\Delta\, Eurosystem\ holdings_{\ i,c,t-h-1}$ is the total volume purchased of bond *i* over the bond's free float on day t-h-1. By estimating equation (5) separately for all values of *h*, our specification resembles in practice to a local projections model where the impact of purchases on repo rates is evaluated at each persistence length. Similar to model (4), we include a vector of time-varying bond-specific characteristics, $\mathrm{X}_{i,c,t}$, ISIN fixed effects, γ_i, and country-time fixed effects, $\mu_{t,c}$.

To examine the persistence of the impact of purchases on repo rates, we *exclude* all observations that had a purchase in between t-1 and t-h, so that we can accurately capture the persistency of the effect of purchasing one additional percentage point of a bond's free float, without our estimations being biased due to the additional purchases in between.[19] Note that, in contrast to the baseline specification, we no longer include the delta of SLF balances in this regression. Almost every day there are small changes in the SLF balances at the security level, which means that we would need to drop almost all observations to obtain an unbiased estimation of the persistence of the SLF flow effect. However, the coefficient on the 1-day flow effect does not change when we exclude the SLF flows, suggesting that our estimations for longer persistence in the flow effect are not prone to omitted variable bias.

Table 3 shows that the flow effect from our baseline regression is persistent and increases at least up to three days after the purchase, up to -0.455 basis points. We estimate equation (5) for $h \in [1; 4]$. As the decreasing number of observations shows, studying 'longer' persistence effects is costly in terms of missed data points: our 4-day persistence regression has 40 percent less observations than for the 1-day impact, and more than 65 percent of the purchases in our original sample are dropped (all resulting from the fact that those ISINs were purchased in between t-1 and t-h). For this reason, the large variance of our estimated coefficient of the 4-day persistence can also be interpreted as consequence of a natural limit in terms of missing observations (and dropped purchases) instead of as the point when the impact of a purchase on repo rates vanishes. As a robustness check, we estimate Equation (5) without dropping observations (not reported in this paper). The estimated coefficients for t=2 and t=3 are indeed amplified, being around 30% larger in absolute terms than those showed in Table 3. The coefficient for h=4 is large and significant, suggesting that flow effects may last longer than 3 days.

[Insert Table 3 about here]

[19] For example, for the 4-day persistence only bonds that were bought on t-4 are included. If an instrument was also purchased between t-1 and t-3, then that observation is dropped. Studying the persistence of the flow effect of QE without removing observations with purchases "in between" would yield biased coefficients to the downside, which would exaggerate the impact.

4.3 Stock effect

In addition to the flow effects, we also investigate whether there is a stock effect of asset purchases driving European repo rates lower. As a certain security may be harder to find in the repo market as the central bank holds a larger share of its outstanding amount, market participants may be willing to pay a higher price to source it, resulting in a lower repo rate, everything else constant. This stock effect is of particular relevance in a context of a large footprint of the Eurosystem in government bond markets. We estimate the following regression:

$$Repo\ rate_{i,c,t} = \beta_1 Eurosystem\ market\ share_{i,c,t-1} + \beta_2 X_{i,c,t} + \gamma_i + \mu_{c,t} + \varepsilon_{i,c,t} \quad (6)$$

where $Repo\ rate_{i,c,t}$ is the repo rate of bond *i* issued by country *c* on day *t*; $Eurosystem\ market\ share_{i,c,t-1}$ is the Eurosystem's market share of bond *i* on date *t-1*, defined as the nominal amount of holdings divided by the outstanding amount of a certain bond. Similar to models (4) and (5), we include a vector of time-varying bond-specific characteristics , $X_{i,c,t}$, ISIN fixed effects, γ_i, and country-time fixed effects, $\mu_{c,t}$. Column 1 in Table 4 includes the results.

[Insert Table 4 about here]

The significant coefficient of the Eurosystem's market share indicates that asset purchases have a permanent negative effect on repo rates. This is plausible, as the Eurosystem's purchases lower the availability of a bond in the private market and therefore increase its collateral value. More specifically, an increase in the Eurosystem's market share of one percentage point of the total outstanding amount of a bond coincides with a lower repo rate of 0.11 basis points for that particular instrument (ISIN). For instance, holding 33 percent of a bond's outstanding amount is associated with a lower repo rate of 3.6 basis points, everything else constant. This is also in line with the graphical evidence (Figure 2), showing – on an aggregate level – a downward pressure on repo rates coinciding with a growing participation of the Eurosystem in the government bond market.

One can imagine, however, that the stock effect of purchases does not yet materialise when only a small amount of a particular bond has been bought, and that the increase in the scarcity premium for a bond in short supply is nonlinear. We therefore add to Equation (6) a quadratic term of the Eurosystem's market share, and estimate the following regression:

$$Repo\ rate_{i,c,t} = \beta_1 Eurosystem\ market\ share_{i,c,t-1} + \beta_2 Eurosystem\ market\ share^2_{i,c,t-1} + \beta_3 X_{i,c,t} + \gamma_i + \mu_{c,t} + \varepsilon_{i,c,t} \quad (7)$$

The elements of this regression are the same as those in Equation (6), with the addition of $Eurosystem\ market\ share^2_{i,c,t-1}$, the squared Eurosystem's market share of bond i on *t-1*. Column 2 in Table 4 includes the estimation of this equation. The coefficient of the linear term is no longer significantly different than zero, while the coefficient on the second order term is significant and equals -0.16. This implies that the stock effect of asset purchases on repo rates is nonlinear, increasing with a higher central bank footprint. In other words, the effect of holding one additional percentage point of the outstanding amount of a security is amplified as the current market share of the Eurosystem gets larger. As a robustness check for this nonlinearity, we re-run model (6) for two subsamples, based on the Eurosystem's market share of a security being lower or higher than 33 percent of the outstanding amount, and find consistent results (see Section 4.4).

Finally, we also test for a nonlinear flow effect, increasing when the Eurosystem's holdings of a security are larger. We do this by adding two interaction terms to Equation (4), $\Delta\ Eurosystem\ holdings\ _{i,c,t-1} \times Eurosystem\ market\ share_{i,c,t-1}$ and $\Delta\ SLF_{i,c,t-1} \times Eurosystem\ market\ share_{i,c,t-1}$. The estimated coefficients from the base effects in this alternative specification remain the same as those displayed in Table 2. The coefficients on the interaction terms are not significantly different than zero, suggesting that the immediate impact of purchases on repo rates is not amplified when a security is structurally scarcer.

4.4 Robustness checks

As a first robustness check, we run our regressions on data obtained from the repo market platforms BrokerTec and MTS instead of on the Eurosystem's MMSR dataset.[20] Market platforms and MMSR are overlapping datasets, and their intersection contains a large portion of the repo market: repo trades conducted in one of these platforms where at least one of the counterparties is an MMSR reporting agent. However, the non-overlapping part also includes

[20] Our BrokerTec and MTS dataset covers the period between April 2020 and August 2021. Repo rates included in these datasets are, for each ISIN, the weighted average rates of all the transactions conducted in these platforms, without differentiating between the type of counterparties. This is a limitation of platform data compared to MMSR, as the repo rate can be susceptible to changes in the composition of counterparty types with different market power.

relevant segments of the repo market. In the case of trades covered by the market platforms data and not by MMSR, this comprises transactions where none of the parties was an MMSR bank. Tables A1 – A4 in the annex present the results of our regressions with BrokerTec and MTS data, which are virtually identical to our estimations using MMSR. This suggests that our findings regarding the impact of asset purchases on the repo market not only hold for banks' activity, but also for other large segments of the secured money market.

In a second robustness check, we include MMSR transactions where reporting banks were the borrowing party instead of the lending party (i.e. repo, instead of reverse repo, from the bank's perspective). There normally exists a positive spread between banks' lending and borrowing repo rates, which may reflect banks' market power because they have direct access to the central bank's balance sheet (Eischenschmidt et al., 2021). By estimating our regressions from the "opposite side of the same coin" we investigate potential asymmetrical effects, depending on the type of institution that trades. Tables A5-A8 in the annex show that the results using borrowing transactions are virtually identical to those using lending transactions. The only nontrivial difference is found in the coefficient for the flow effect of the Securities Lending Facility (Table A5), which is only weakly significant and slightly lower (in absolute value) than our estimated coefficient in Table 2. This weaker effect of the SLF on borrowing rates implies that a positive supply shock coming from the SLF alleviates the downward pressure on the cost of sourcing a security paid by *banks* to a larger extent than on the rate that banks charge a counterparty looking to source a security. This asymmetric impact could be explained by the banks' direct access to the Eurosystem's Securities Lending Facility. Non-banks do not have access to this facility and therefore only benefit from the SLF indirectly through banks. Banks may decide to apply a margin to the pass-through of securities given the balance sheet costs of intermediating between the central bank and end-users.

Thirdly, we assess whether there is a difference if we do not deduct the pledged collateral in our definition of free float in Equation (2). Although the pledged collateral is not available in the market, it may become so if a bank decides to repay or change its collateral composition at the central bank. The results are included in Table A9 and show that this makes no difference.

As a fourth check, we further explore the nonlinear impact of greater holdings on the level of repo rates. As discussed in Section 4.3, the stock effect is amplified when the holdings of a bond by the Eurosystem are larger. An alternative approach to assess this nonlinearity is to perform a sample split based on the Eurosystem's market share relative to a threshold value. Therefore, we re-run Equation (6) for two subsamples, based on the Eurosystem's market share of a security being lower or higher than 33 percent of the outstanding amount. Besides its practicality - as it splits our data in two subsets of relatively similar size - we choose 33 percent as the threshold as that it represents the issue share limit under the PSPP (ECB, 2022c) and hence it was the ceiling for the Eurosystem's market share before the implementation of the PEPP.

Table 5 includes the estimations of our split sample regressions. The coefficient on Eurosystem holdings remains negative and statistically significant on both regressions, but its magnitude in the regression with holdings above 33 percent of securities' outstanding amount is more than three times larger than for the other subsample. This result is consistent with our finding of a relation between the magnitude of the stock effect and the footprint of the Eurosystem in the sovereign bond market. We also try different values of the Eurosystem's market share for the sample-splitting threshold (e.g. 25%, 30%, 35%) and find that, the higher the threshold, the stronger the stock effect for the subsample with the larger share of Eurosystem holdings, which supports the thesis of a nonlinear stock effect (tables not reported in this paper).

[Insert Table 5 about here]

As a fifth check, we delete the controls for bonds being cheapest-to-deliver or on-the-run, to see whether this has any impact. Moreover, we delete the ISIN and country-time fixed effects. Our results do not change in terms of significance and relevance (Table A10) .

Finally, we examine whether there is a difference between the effect of a purchase of a bond with a repo rate that is 'cheaper' than the maximum rate of the SLF, compared to purchases of bonds with repo rates that are more expensive than the maximum rate of the SLF. One may expect a difference between these two types of bonds: when the repo rate of a bond is above the rate at which the bond can be borrowed from the central bank, the SLF is not attractive compared to the private market. On the other hand, when the repo rate of a bond is below the rate of the SLF (-80 or -70 basis points, depending on the date)[21], market participants may try to source that security from the SLF instead of the private market (i.e. Example 2 in Figure 6).

[Insert Figure 6 about here]

[21] As of 2 November 2020, the maximum price of using the SLF against cash collateral was reduced from DFR-30 bps to DFR-20 bps.

We examine this by means of the following regression:

$$\Delta\, Repo\ rate_{i,c,t} = \beta_1 \Delta\, Eurosystem\ holdings\ _{i,c,t-1} \times\ Cheaper\ (above)\ SLF\ rate_{i,c,t-1} + \beta_2 \Delta\, Eurosystem\ holdings\ _{i,c,t-1} \times\ More\ expensive\ (below)\ SLF\ rate_{i,c,t-1} + \beta_3 \mathrm{X}_{i,c,t} + \gamma_i + \mu_{c,t} + \varepsilon_{i,c,t} \quad (8)$$

where $\Delta\, Repo\ rate_{i,c,t}$ is the one-day change in the repo rate of bond i (issued by country c) between day t and t-1. $\Delta\, Eurosystem\ holdings\ _{i,c,t-1}$ is the total volume purchased of bond i over the bond's free float on day t-1; $Cheaper\ (above)\ SLF\ rate_{i,c,t-1}$ is a dummy, being one if a bond trades at a rate above the SLF rate in the repo market, and zero otherwise. $More\ expensive\ (below)\ SLF\ rate_{i,c,t-1}$ is also a dummy, being one if a bond trades with a rate below the SLF rate in the repo market, and zero otherwise; $\mathrm{X}_{i,c,t}$ is a vector of time-varying bond-specific characteristics; similar to model (4), (5), and (6) we include ISIN fixed effects, γ_i, and country-time fixed effects, $\mu_{c,t}$. Results are included in Table 6.

[Insert Table 6 about here]

The results indicate that asset purchases have a statistically significant flow effect on the change in repo rates for bonds that trade in the repo market at levels above the maximum SLF rate. For these instruments, the estimated impact of a purchase of one percentage point of the free float is 0.35 basis points. On the other hand, we do not find a statistically significant flow effect for bonds whose repo rate is below the maximum SLF rate. This suggests that the SLF effectively alleviates the downward pressure for bonds that are sufficiently expensive in repo so that the Eurosystem's facility represents an attractive alternative to the private market. Note, however, that we used a rather pragmatic approach to determine the attractiveness of the SLF price compared to a repo rate. As a reference point, we use the maximum price that is charged by the Eurosystem when lending a security against cash collateral (either DFR -30 basis points or DFR -20 basis points).[22] In practice, national central banks within the Eurosystem have discretion in their price setting when lending bonds, as eligible counterparties are allowed to borrow securities against cash at a rate equal to the DFR minus 20 basis points or the prevailing market rate, whichever is lower (ECB, 2022b). We do not correct for this discretionary element, as we do not have the data to do so.

[22] This price changed as of 1 November 2020.

5. Conclusion and discussion

This paper sheds light on the implications of the increasing Eurosystem's footprint for repo rates, using a unique combination of purchase data, collateral pledged at the Eurosystem, money market transactions and securities lent as part of the SLF. The Eurosystem's purchases contribute to asset scarcity in financial markets, leading to a significant downward pressure on repo rates of scarce bonds. This results from a combination of a *flow* and a *stock* effect: the higher the Eurosystem's market share of a particular bond, the stronger its impact on repo rates of that bond. In other words, the larger central bank purchases and the longer they endure, the greater this unintended side-effect on financial markets. The SLF successfully alleviates some of the downward pressure that is created by the purchases, though not to the same extent.

The implementation of expansive balance-sheet policies increases the ratio of cash over free floating securities in the financial system. We document that repo markets, which are key for the initial steps of monetary transmission, are directly affected by the exacerbation of the ample cash regime caused by quantitative easing. As repo rates not only respond to the Eurosystem's accommodative stance but also to the degree of supply absorption by the central bank, this may impede a 1-to-1 pass-through of monetary policy to money market rates. Moreover, collateral scarcity may hamper a smooth functioning of repo and underlying bond markets. Reverse repo operations (as the SLF) are thus a very useful supplement to quantitative easing programmes, as they alleviate the scarcity effect of asset purchases.

We conclude with some suggestions for further research. Our analysis could be complemented by including a measure for *preferred habitat investors.* Preferred habitat investors prefer bonds with specific characteristics, making them less price elastic and therefore more reluctant to sell their preferred bonds (Andrés et al., 2004; Vayanos and Vila, 2021). This may imply that the effective free float in financial markets is not only reduced due to the buy-and-hold behaviour of the central bank, but also because of similar behaviour by preferred habitat investors, as their holdings of government debt also reduces the available supply of collateral in money markets. Moreover, it would be interesting to investigate how the (pricing of) securities lent via the SLF impact the behaviour of private sector participants, for example regarding their own securities lending behaviour. As the Eurosystem's SLF only acts as a backstop to market functioning, the question is what price levels would trigger market participants to step in.

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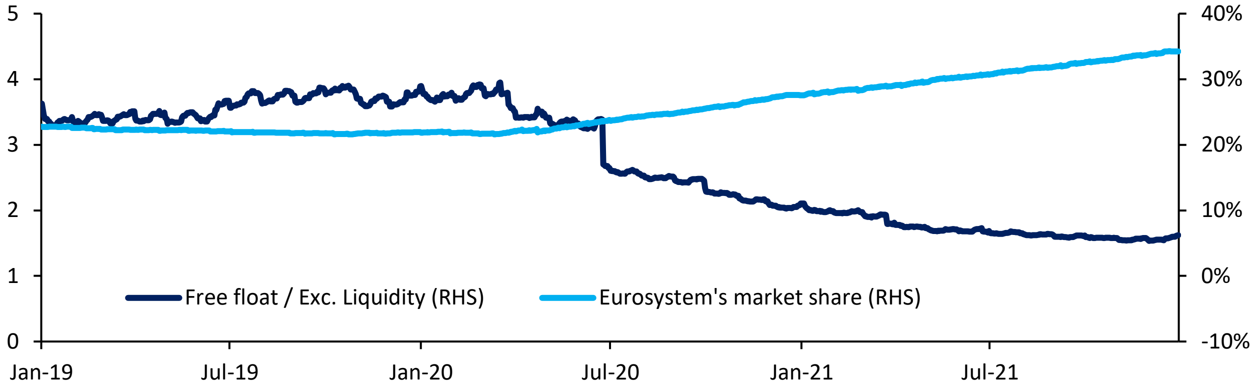
Figures and Tables

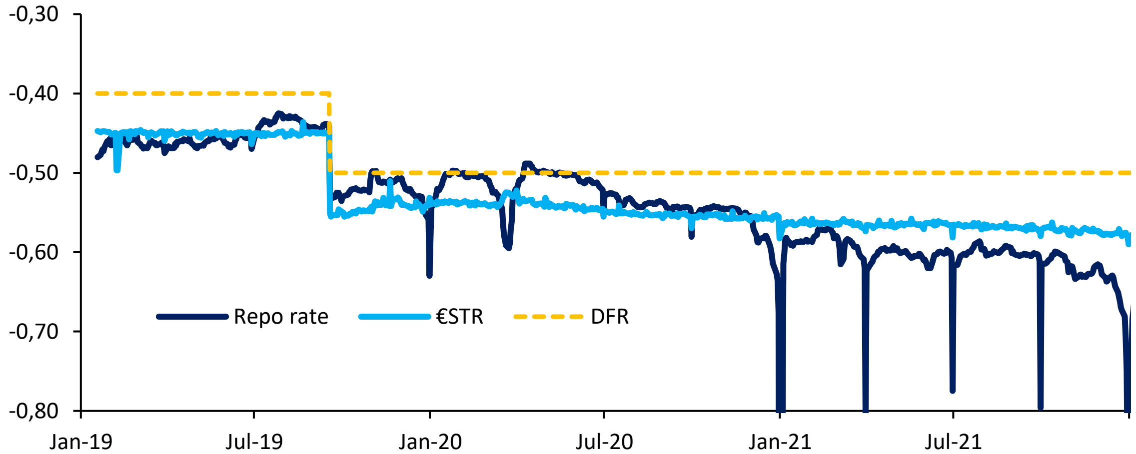
Figures

Figure 1: Ample cash regime following large asset purchase volumes (government debt)



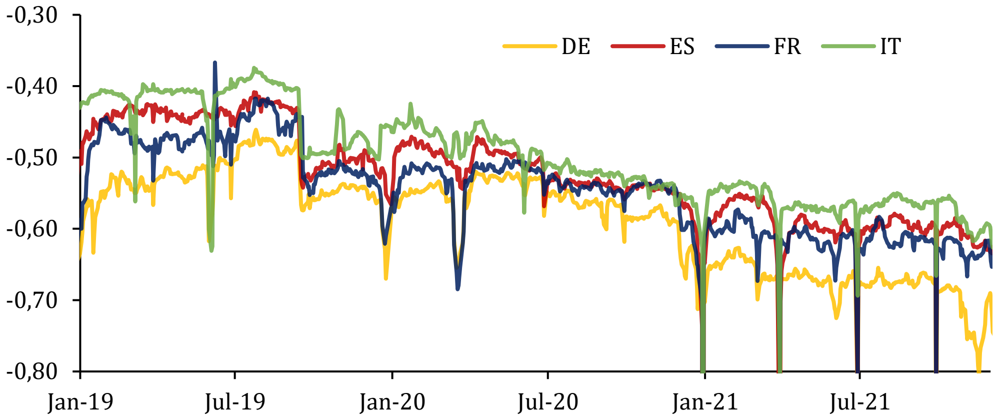
Notes: Eurosystem holdings are based on aggregated data of government bonds (nominal holdings of bonds compared to their total outstanding amount). Free float is defined as the amount outstanding minus Eurosystem holdings. Excess liquidity is the amount of liquidity that banks hold at the Eurosystem minus their minimum reserve requirements.

Figure 2: The evolution of money market rates in the euro area



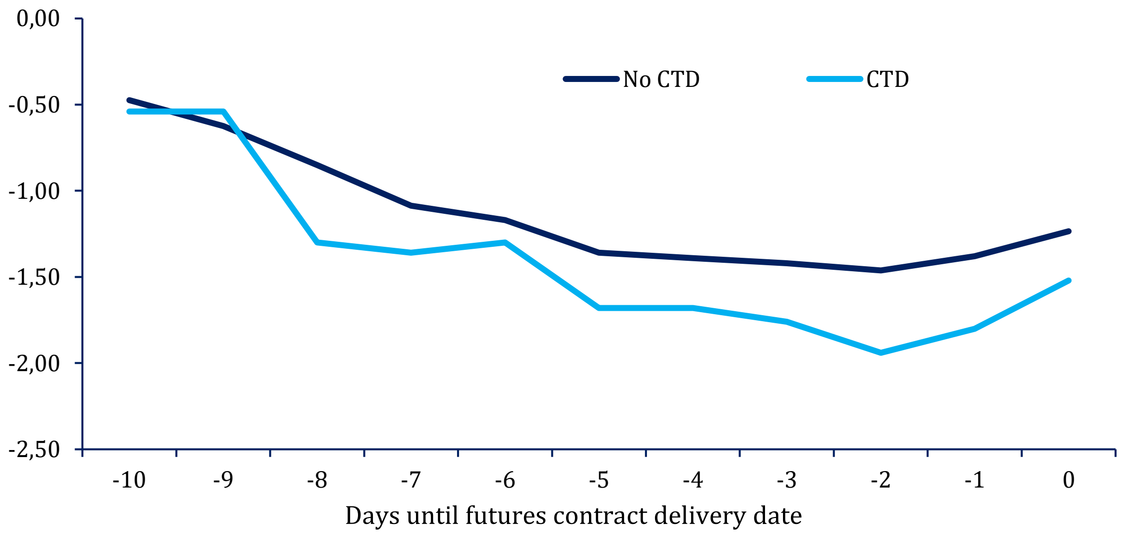
Notes: DFR is the Deposit Facility Rate of the ECB. The Repo rate is a volume weighted average rate based on repo transactions backed by Euro area government bonds as collateral, based on a similar methodology as €STR. Before the start of €STR (2 October 2019), data is based on pre-€STR (both available in the Statistical Data Warehouse of the ECB).

Figure 3: weighted average repo rates (in bps)



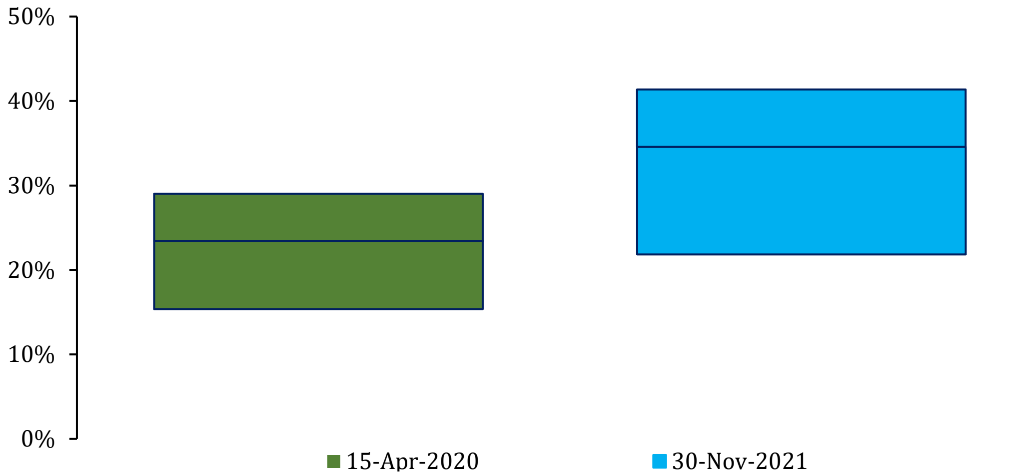
Notes: This figure shows the weighted average rates backed by *central government* collateral from the respective country. Data is based on lending transactions from the MMSR banks' perspective (reverse repo), with S/N tenor.

Figure 4: Cumulative decrease of repo rates ahead of futures contract delivery days



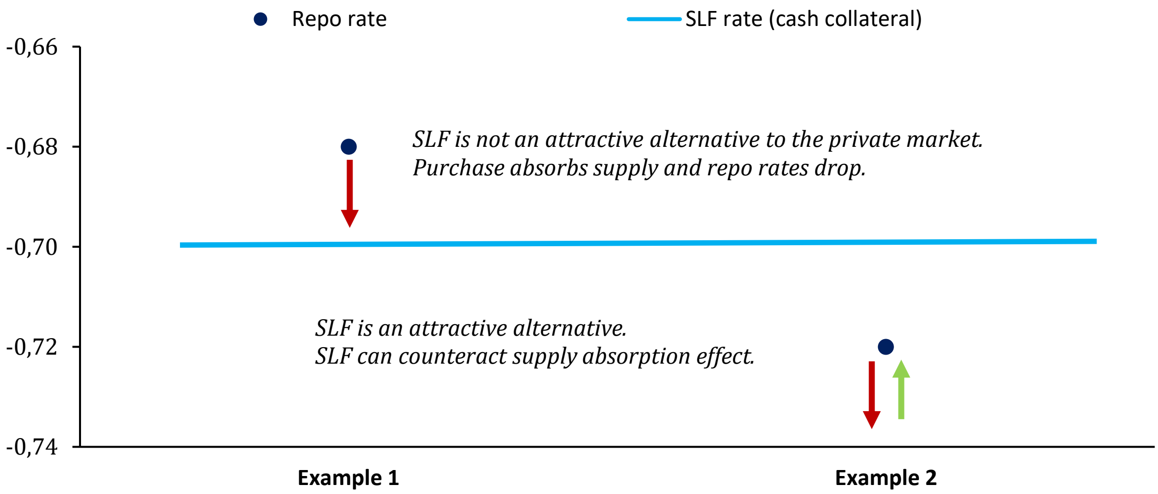
Notes: This figure shows the average cumulative decrease of repo rates from the tenth day ahead of the futures delivery date (T-10) until the delivery date (T) for CTD and non-CTD bonds, for all the delivery dates in our sample. On every day, for each contract, there is one CTD bond. We obtain the ISINs of the CTD instruments per contract from Bloomberg.

Figure 5: Distribution of holdings of the Eurosystem



Notes: this figure shows the distribution of Eurosystem holdings (as a percentage of a bond's outstanding amount) around the start of PEPP and at the end of our sample period. Due to data confidentiality issues we only show the range between the 25th and 75th percentile and not the 'highs' and the 'lows'.

Figure 6: The SLF is an attractive alternative only for special bonds (simplified example)



Notes: Example 1 illustrates bonds with a cheaper (i.e. higher) repo rate than the maximum rate of the SLF. Example 2 illustrates bonds with a more expensive repo rate (i.e. lower) than the SLF. When the repo rate of a bond is above the rate at which the bond can be borrowed from the central bank, the SLF is not attractive compared to the private market. When the repo rate of a bond is below -70 bps, market participants may try to source that security from the SLF instead of via the private market.

Tables

Table 1: Descriptive statistics

Measure	Mean	Standard deviation Full sample	Across bonds	Across time	Min	Max	N
Repo rate (bps)	-58.25	9.78			-408.00	18.00	142,890
Spread w/ GC (bps)	-6.36	7.01			-361.00	0.00	142,890
Change in repo rate (bps)	-0.04	8.64	7.37	2.68	-235.00	226.00	142,890
Change in repo rate, conditional on change ≠ 0 (bps)	-0.08	11.36	9.43	3.39	235.00	226.00	82,659
Change in repo rate (Excl reporting and delivery dates) (bps)	-0.05	2.46	2.48	2.23	-165.00	102.00	125,146
Purchase volume (i.e. flow) over FF (%-points)	0.37	0.47			0.01	10.00	31,272
SLF flow over FF (%-points)	0.03	1.21			-15.70	14.46	15,768
SLF flow over FF, absolute value (%-points)	0.75	0.95			0.00	15.70	15,768

Notes: This table shows summary statistics for the main variables included in our analysis. The covered period is April 2020 – November 2021. All variables concerning the repo markets are obtained from MMSR.The remaining variables are obtained from the Eurosystem's transactions data.

Table 2: Flow effect of asset purchases on repo rates

	ΔRepoRate day 1
$\Delta\ Eurosystem\ holdings\ over\ FF_{\ t-1}$	**-0.302*****
	(0.043)
$\Delta\ SLF_{t-1}\ over\ FF_{t-1}$	**0.103*****
	(0.035)
Control for cheapest-to-deliver	Yes
Control for on-the-run	Yes
ISIN FE	Yes
Country-Time FE	Yes
Adjusted-R^2	0.869
Number of observations	142,878

This table shows the *(flow)* effect of an additional purchase on the change in repo rates and the offsetting impact of a security being lent via the Securities Lending Facility (SLF). The dependent variable is the one-day change in the repo rate of bond *i* between day *t* and *t*-1. $\Delta\ Eurosystem\ holdings\ over\ FF_{t-1}$ is the (nominal) amount a bond that is purchased, scaled by the free float of a bond in the market to determine the Eurosystem's market share. The free float is defined as the outstanding amount of a bond on day *t*, minus the Eurosystem holdings on day *t*-1, minus the amount pledged as collateral at the Eurosystem on day *t.* $\Delta\ SLF_{t-1}\ over\ FF_{t-1}$ is the change in the total balance lent under the Eurosystem's Securities Lending Facility of bond *i* between day *t* and *t-1* scaled by the security's free float. The control for a bond that is the *cheapest-to-deliver* is a dummy that is 1 when a bond is *cheapest-to-deliver* and 0 otherwise. With a Bloomberg function we obtain which bond is the cheapest-to-deliver within a certain futures contract. The control for a bond being on the run works similarly: when a bond is *on-the-run* this dummy is 1, and 0 otherwise. ISIN fixed effects and country-time fixed effects are included to capture bond-specific characteristics and time-varying macro variables, respectively. Data about purchases, outstanding amounts, pledged collateral and the SLF are obtained from the Eurosystem's internal data on its operations. Repo data is obtained from MMSR and only includes lending transactions from the reporting agent's perspective. Sample period: April 2020 up to the end of November 2021. Cluster-robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

Table 3: Persistence of flow effects of asset purchases on repo rates

	ΔRepoRate day 1	ΔRepoRate day 2	ΔRepoRate day 3	ΔRepoRate day 4
Δ *Eurosystem holdings over* FF_{t-1}	**-0.300***** (0.043)	**-0.423***** (0.075)	**-0.455***** (0.134)	**-0.013** (0.191)
Control for cheapest-to-deliver	Yes	Yes	Yes	Yes
Control for on-the-run	Yes	Yes	Yes	Yes
ISIN FE	Yes	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes	Yes
Adjusted-R^2	0.869	0.854	0.837	0.808
Number of observations	142,878	110,521	94,873	84,209

This table shows the *(flow)* effect of an additional purchase on the change in repo rates on 1 day till 4 days after the purchase. The dependent variable is the one-day change in the repo rate of bond *i* between day *t* and *t*-1. Δ *Eurosystem holdings over* FF_{t-1} is the (nominal) amount a bond that is purchased, scaled by the free float of a bond in the market to determine the Eurosystem's market share. The free float is defined as the outstanding amount of a bond on day *t*, minus the Eurosystem holdings on day *t*-1, minus the amount pledged as collateral at the Eurosystem on day *t.* The control for a bond that is the *cheapest-to-deliver* is a dummy that is 1 when a bond is *cheapest-to-deliver* and 0 otherwise. With a Bloomberg function we obtain which bond is the cheapest-to-deliver within a certain futures contract. The control for a bond being on the run works similarly: when a bond is *on-the-run* this dummy is 1, and 0 otherwise. ISIN fixed effects and country-time fixed effects are included to capture bond-specific characteristics and time-varying macro variables, respectively. Purchase data, outstanding amounts and pledged collateral are obtained from the Eurosystem's internal data on its operations. Repo data is obtained from MMSR and only includes lending transactions from the reporting agent's perspective. Sample period: April 2020 up to the end of November 2021. Cluster-robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

Table 4: Stock effect of asset purchases on repo rates

	RepoRate	RepoRate
Eurosystem market share	**-0.108***** (0.018)	**-0.027** (0.040)
Eurosystem market share^2		**-0.164**** (0.076)
Control for cheapest-to-deliver	Yes	Yes
Control for on-the-run	Yes	Yes
ISIN FE	Yes	Yes
Country-Time FE	Yes	Yes
Adjusted-R^2	0.784	0.787
Number of observations	142,878	142,878

This table shows the *(stock)* effect of the total amount of Eurosystem's purchases on the change in repo rates. The dependent variable is the the repo rate of bond *i* on day *t.* The Eurosystem market share is the market share of a bond i on day t-1, defined as the total nominal holdings of a bond divided by the total outstanding amount of that bond. The squared Eurosystem's market share is defined the same, but squared. The control for a bond that is the *cheapest-to-deliver* is a dummy that is 1 when a bond is *cheapest-to-deliver* and 0 otherwise. With a Bloomberg function we obtain which bond is the cheapest-to-deliver within a certain futures contract. The control for a bond being on the run works similarly: when a bond is *on-the-run* this dummy is 1, and 0 otherwise. ISIN fixed effects and country-time fixed effects are included to capture bond-specific characteristics and time-varying macro variables, respectively. Purchase data and outstanding amounts are obtained from the Eurosystem's internal data on its operations. Repo data is obtained from MMSR and only includes lending transactions from the reporting agent's perspective. Sample period: April 2020 up to the end of November 2021. Cluster-robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

Table 5: Stock effect of asset purchases on repo rates

	RepoRate	RepoRate
Eurosystem market share < 33%	**-0.098*** **	
	(0.021)	
Eurosystem market share ≥ 33%		**-0.325*** **
		(0.044)
Control for cheapest-to-deliver	Yes	Yes
Control for on-the-run	Yes	Yes
ISIN FE	Yes	Yes
Country-Time FE	Yes	Yes
Adjusted-R^2	0.753	0.895
Number of observations	101,829	41,009

This table shows the nonlinear impact of greater holdings on the level of repo rates (a nonlinear *stock* effect). The dependent variable is the the repo rate of bond *i* on day *t*. The Eurosystem market share is the market share of a bond i on day t-1, defined as the total nominal holdings of a bond divided by the total outstanding amount of that bond. The control for a bond that is the *cheapest-to-deliver* is a dummy that is 1 when a bond is *cheapest-to-deliver* and 0 otherwise. With a Bloomberg function we obtain which bond is the cheapest-to-deliver within a certain futures contract. The control for a bond being on the run works similarly: when a bond is *on-the-run* this dummy is 1, and 0 otherwise. ISIN fixed effects and country-time fixed effects are included to capture bond-specific characteristics and time-varying macro variables, respectively. Purchase data and outstanding amounts are obtained from the Eurosystem's internal data on its operations. Repo data is obtained from MMSR and only includes lending transactions from the reporting agent's perspective. Sample period: April 2020 up to the end of November 2021. Cluster-robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

Table 6: Impact of repo pricing compared to SLF price

	ΔRepoRate day 1
Δ $Eurosystem\ holdings\ over\ FF_{t-1}$ $\times AboveSLFRate$ (cheaper than SLF)	**-0.354*** **
	(0.034)
Δ $Eurosystem\ holdings\ over\ FF_{t-1}$ $\times BelowSLFRate$ (more expensive than SLF)	**0.232**
	(0.318)
Control for cheapest-to-deliver	Yes
Control for on-the-run	Yes
ISIN FE	Yes
Country-Time FE	Yes
Adjusted-R^2	0.869
Number of observations	142,878

This table shows the (*flow)* effect of an additional purchase on the change in repo rates, interacted with a dummy that qualifies whether a repo rate is above or below the SLF pricing. The dependent variable is the one-day change in the repo rate of bond *i* between day *t* and *t*-1. Δ $Eurosystem\ holdings\ over\ FF_{t-1}$ is the (nominal) amount a bond that is purchased, scaled by the free float of a bond in the market to determine the Eurosystem's market share. The free float is defined as the outstanding amount of a bond on day *t*, minus the Eurosystem holdings on day *t*-1, minus the amount pledged as collateral at the Eurosystem on day *t.* AboveSLFRate is a dummy being 1 if bond *i* trades with a rate above the SLF rate in the repo market on day t-1, 0 otherwise. BelowSLFRate is a dummy being 1 if bond *i* trades with a rate below the SLF rate in the repo market, 0 otherwise. The control for a bond that is the *cheapest-to-deliver* is a dummy that is 1 when a bond is *cheapest-to-deliver* and 0 otherwise. With a Bloomberg function we obtain which bond is the cheapest-to-deliver within a certain futures contract. The control for a bond being on the run works similarly: when a bond is *on-the-run* this dummy is 1, and 0 otherwise. ISIN fixed effects and country-time fixed effects are included to capture bond-specific characteristics and time-varying macro variables, respectively. Data about purchases, outstanding amounts, pledged collateral and the SLF are obtained from the Eurosystem's internal data on its operations Repo data is obtained from MMSR and only includes lending transactions from the reporting agent's perspective. Sample period: April 2020 up to the end of November 2021. Cluster-robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

Annex

Robustness checks using BrokerTec and MTS data

Table A1: Flow effect of asset purchases on repo rates

	ΔRepoRate day 1
Δ $Eurosystem\ holdings\ over\ FF_{t-1}$	**-0.280***** (0.046)
Δ $SLF_{t-1}\ over\ FF_{t-1}$	**0.169***** (0.065)
Control for cheapest-to-deliver	Yes
Control for on-the-run	Yes
ISIN FE	Yes
Country-Time FE	Yes
Adjusted-R^2	0.912
Number of observations	104,363

This table shows the (*flow)* effect of an additional purchase on the change in repo rates and the offsetting impact of a security being lent via the Securities Lending Facility (SLF). The dependent variable is the one-day change in the repo rate of bond *i* between day *t* and *t*-1. Δ $Eurosystem\ holdings\ over\ FF_{t-1}$ is the (nominal) amount a bond that is purchased, scaled by the free float of a bond in the market to determine the Eurosystem's market share. The free float is defined as the outstanding amount of a bond on day *t*, minus the Eurosystem holdings on day *t*-1, minus the amount pledged as collateral at the Eurosystem on day *t.* Δ $SLF_{t-1}\ over\ FF_{t-1}$ is the change in the total balance lent under the Eurosystem's Securities Lending Facility of bond *i* between day *t* and *t-1* scaled by the security's free float. The control for a bond that is the *cheapest-to-deliver* is a dummy that is 1 when a bond is *cheapest-to-deliver* and 0 otherwise. With a Bloomberg function we obtain which bond is the cheapest-to-deliver within a certain futures contract. The control for a bond being on the run works similarly: when a bond is *on-the-run* this dummy is 1, and 0 otherwise. ISIN fixed effects and country-time fixed effects are included to capture bond-specific characteristics and time-varying macro variables, respectively. Data about purchases, outstanding amounts, pledged collateral and the SLF are obtained from the Eurosystem's internal data on its operations. Repo data is obtained from BrokerTec and MTS. Sample period: April 2020 up to the 10th of August 2021. Cluster-robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

Table A2: Persistence of flow effects of asset purchases on repo rates

	ΔRepoRate day 1	ΔRepoRate day 2	ΔRepoRate day 3	ΔReporate day 4
Δ $Eurosystem\ holdings\ over\ FF_{t-1}$	**-0.279***** (0.046)	**-0.429***** (0.073)	**-0.471***** (0.177)	**0.086** (0.730)
Control for cheapest-to-deliver	Yes	Yes	Yes	Yes
Control for on-the-run	Yes	Yes	Yes	Yes
ISIN FE	Yes	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes	Yes
Adjusted-R^2	0.912	0.899	0.884	0.862
Number of observations	104,363	79,459	67,736	59,929

This table shows the (*flow)* effect of an additional purchase on the change in repo rates on 1 day till 4 days after the purchase. The dependent variable is the one-day change in the repo rate of bond *i* between day *t* and *t*-1. Δ $Eurosystem\ holdings\ over\ FF_{t-1}$ is the (nominal) amount a bond that is purchased, scaled by the free float of a bond in the market to determine the Eurosystem's market share. The free float is defined as the outstanding amount of a bond on day *t*, minus the Eurosystem holdings on day *t*-1, minus the amount pledged as collateral at the Eurosystem on day *t.* The control for a bond that is the *cheapest-to-deliver* is a dummy that is 1 when a bond is *cheapest-to-deliver* and 0 otherwise. With a Bloomberg function we obtain which bond is the cheapest-to-deliver within a certain futures contract. The control for a bond being on the run works similarly: when a bond is *on-the-run* this dummy is 1, and 0 otherwise. ISIN fixed effects and country-time fixed effects are included to capture bond-specific characteristics and time-varying macro variables, respectively. Purchase data, outstanding amounts and pledged collateral are obtained from the Eurosystem's internal data on its operations. Repo data is obtained from BrokerTec and MTS. Sample period: April 2020 up to the 10th of August 2021. Cluster-robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

Table A3: Stock effect of asset purchases on repo rates

	RepoRate	RepoRate	RepoRate
Eurosystem market share	**-0.079*** **		
	(0.022)		
Eurosystem market share < 33%		**-0.052** **	
		(0.024)	
Eurosystem market share ≥ 33%			**-0.332*** **
			(0.061)
Control for cheapest-to-deliver	Yes	Yes	Yes
Control for on-the-run	Yes	Yes	Yes
ISIN FE	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes
Adjusted-R^2	0.814	0.796	0.896
Number of observations	104,363	77,248	27,075

This table shows the (*stock)* effect of the total amount of Eurosystem's purchases on the change in repo rates. The dependent variable is the the repo rate of bond *i* on day *t*. The Eurosystem market share is the market share of a bond i on day t-1, defined as the total nominal holdings of a bond divided by the total outstanding amount of that bond. The control for a bond that is the *cheapest-to-deliver* is a dummy that is 1 when a bond is *cheapest-to-deliver* and 0 otherwise. With a Bloomberg function we obtain which bond is the cheapest-to-deliver within a certain futures contract. The control for a bond being on the run works similarly: when a bond is *on-the-run* this dummy is 1, and 0 otherwise. ISIN fixed effects and country-time fixed effects are included to capture bond-specific characteristics and time-varying macro variables, respectively. Purchase data and outstanding amounts are obtained from the Eurosystem's internal data on its operations. Repo data is obtained from BrokerTec and MTS. Sample period: April 2020 up to the 10th of August 2021. Cluster-robust standard errors are given in parentheses.
Significance levels: * p<0.1, ** p<0.05, *** p<0.01

Table A4: Amplification of flow effect: interacting Eurosystem market share with the amount of purchases

	ΔRepoRate day 1
$\Delta\ Eurosystem\ holdings\ over\ FF_{t-1}$ interacted with Eurosystem market share	**-1.039*** **
	(0.200)
$\Delta\ SLF_{t-1}\ over\ FF_{t-1}$ interacted with Eurosystem market share	**0.495** **
	(0.199)
Control for cheapest-to-deliver	Yes
Control for on-the-run	Yes
ISIN FE	Yes
Country-Time FE	Yes
Adjusted-R^2	0.911
Number of observations	104,363

This table shows the (*flow)* effect of an additional purchase on the change in repo rates and the offsetting impact of a security being lent via the Securities Lending Facility (SLF), both interacted with the Eurosystem's market share. $\Delta\ Eurosystem\ holdings\ over\ FF_{t-1}$ is the (nominal) amount a bond that is purchased, scaled by the free float of a bond in the market to determine the Eurosystem's market share. The free float is defined as the outstanding amount of a bond on day *t*, minus the Eurosystem holdings on day *t*-1, minus the amount pledged as collateral at the Eurosystem on day *t.* The Eurosystem market share is the market share of a bond i on day t-1, defined as the total nominal holdings of a bond divided by the total outstanding amount of that bond. $\Delta\ SLF_{t-1}\ over\ FF_{t-1}$ is the change in the total balance lent under the Eurosystem's Securities Lending Facility of bond *i* between day *t* and *t-1* scaled by the security's free float. The control for a bond that is the *cheapest-to-deliver* is a dummy that is 1 when a bond is *cheapest-to-deliver* and 0 otherwise. With a Bloomberg function we obtain which bond is the cheapest-to-deliver within a certain futures contract. The control for a bond being on the run works similarly: when a bond is *on-the-run* this dummy is 1, and 0 otherwise. ISIN fixed effects and country-time fixed effects are included to capture bond-specific characteristics and time-varying macro variables, respectively. Data about purchases, outstanding amounts, pledged collateral and the SLF are obtained from the Eurosystem's internal data on its operations. Repo data is obtained from BrokerTec and MTS. Sample period: April 2020 up to the 10th of August 2021. Cluster-robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

Robustness checks using borrowing transactions instead of lending transactions

Table A5: Flow effect of asset purchases on repo rates

	ΔRepoRate day 1
$\Delta\ Eurosystem\ holdings\ over\ FF_{t-1}$	**-0.316***** (0.043)
$\Delta\ SLF_{t-1}\ over\ FF_{t-1}$	**0.065*** (0.035)
Control for cheapest-to-deliver	Yes
Control for on-the-run	Yes
ISIN FE	Yes
Country-Time FE	Yes
Adjusted-R^2	0.871
Number of observations	142,984

This table shows the *(flow)* effect of an additional purchase on the change in repo rates and the offsetting impact of a security being lent via the Securities Lending Facility (SLF). The dependent variable is the one-day change in the repo rate of bond *i* between day *t* and *t*-1. $\Delta\ Eurosystem\ holdings\ over\ FF_{t-1}$ is the (nominal) amount a bond that is purchased, scaled by the free float of a bond in the market to determine the Eurosystem's market share. The free float is defined as the outstanding amount of a bond on day *t*, minus the Eurosystem holdings on day *t*-1, minus the amount pledged as collateral at the Eurosystem on day *t.* $\Delta\ SLF_{t-1}\ over\ FF_{t-1}$ is the change in the total balance lent under the Eurosystem's Securities Lending Facility of bond *i* between day *t* and *t-1* scaled by the security's free float. The control for a bond that is the *cheapest-to-deliver* is a dummy that is 1 when a bond is *cheapest-to-deliver* and 0 otherwise. With a Bloomberg function we obtain which bond is the cheapest-to-deliver within a certain futures contract. The control for a bond being on the run works similarly: when a bond is *on-the-run* this dummy is 1, and 0 otherwise. ISIN fixed effects and country-time fixed effects are included to capture bond-specific characteristics and time-varying macro variables, respectively. Data about purchases, outstanding amounts, pledged collateral and the SLF are obtained from the Eurosystem's internal data on its operations. Repo data is obtained from MMSR and only includes borrowing transactions from the reporting agent's perspective. Sample period: April 2020 up to the end of November 2021. Cluster-robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

Table A6: Persistence of flow effects of asset purchases on repo rates

	ΔRepoRate day 1	ΔRepoRate day 2	ΔRepoRate day 3	ΔReporate day 4
$\Delta\ Eurosystem\ holdings\ over\ FF_{t-1}$	**-0.315***** (0.043)	**-0.481***** (0.067)	**-0.464***** (0.128)	**-0.014** (0.181)
Control for cheapest-to-deliver	Yes	Yes	Yes	Yes
Control for on-the-run	Yes	Yes	Yes	Yes
ISIN FE	Yes	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes	Yes
Adjusted-R^2	0.871	0.857	0.841	0.815
Number of observations	142,984	110,561	94,815	84,068

This table shows the *(flow)* effect of an additional purchase on the change in repo rates on 1 day till 4 days after the purchase. The dependent variable is the one-day change in the repo rate of bond *i* between day *t* and *t*-1. $\Delta\ Eurosystem\ holdings\ over\ FF_{t-1}$ is the (nominal) amount a bond that is purchased, scaled by the free float of a bond in the market to determine the Eurosystem's market share. The free float is defined as the outstanding amount of a bond on day *t*, minus the Eurosystem holdings on day *t*-1, minus the amount pledged as collateral at the Eurosystem on day *t.* The control for a bond that is the *cheapest-to-deliver* is a dummy that is 1 when a bond is *cheapest-to-deliver* and 0 otherwise. With a Bloomberg function we obtain which bond is the cheapest-to-deliver within a certain futures contract. The control for a bond being on the run works similarly: when a bond is *on-the-run* this dummy is 1, and 0 otherwise. ISIN fixed effects and country-time fixed effects are included to capture bond-specific characteristics and time-varying macro variables, respectively. Purchase data, outstanding amounts and pledged collateral are obtained from the Eurosystem's internal data on its operations. Repo data is obtained from MMSR and only includes borrowing transactions from the reporting agent's perspective. Sample period: April 2020 up to the end of November 2021. Cluster-robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

Table A7: Stock effect of asset purchases on repo rates

	RepoRate	RepoRate	RepoRate
Eurosystem market share	**-0.109***** (0.018)		
Eurosystem market share < 33%		**-0.099***** (0.021)	
Eurosystem market share ≥ 33%			**-0.359***** (0.043)
Control for cheapest-to-deliver	Yes	Yes	Yes
Control for on-the-run	Yes	Yes	Yes
ISIN FE	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes
Adjusted-R^2	0.779	0.751	0.895
Number of observations	142,984	101,967	40,976

This table shows the (*stock)* effect of the total amount of Eurosystem's purchases on the change in repo rates. The dependent variable is the the repo rate of bond *i* on day *t*. The Eurosystem market share is the market share of a bond i on day t-1, defined as the total nominal holdings of a bond divided by the total outstanding amount of that bond. The control for a bond that is the *cheapest-to-deliver* is a dummy that is 1 when a bond is *cheapest-to-deliver* and 0 otherwise. With a Bloomberg function we obtain which bond is the cheapest-to-deliver within a certain futures contract. The control for a bond being on the run works similarly: when a bond is *on-the-run* this dummy is 1, and 0 otherwise. ISIN fixed effects and country-time fixed effects are included to capture bond-specific characteristics and time-varying macro variables, respectively. Purchase data and outstanding amounts are obtained from the Eurosystem's internal data on its operations. Repo data is obtained from MMSR and only includes borrowing transactions from the reporting agent's perspective. Sample period: April 2020 up to the end of November 2021. Cluster-robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

Table A8: Amplification of flow effect: interacting Eurosystem market share with the amount of purchases

	RepoRate
Δ $Eurosystem\ holdings\ over\ FF_{t-1}$ interacted with Eurosystem market share	**-1.126***** (0.174)
Δ $SLF_{t-1}\ over\ FF_{t-1}$ interacted with Eurosystem market share	**0.155*** (0.091)
Control for cheapest-to-deliver	Yes
Control for on-the-run	Yes
ISIN FE	Yes
Country-Time FE	Yes
Adjusted-R^2	0.871
Number of observations	142,984

This table shows the (*flow)* effect of an additional purchase on the change in repo rates and the offsetting impact of a security being lent via the Securities Lending Facility (SLF), both interacted with the Eurosystem's market share. Δ $Eurosystem\ holdings\ over\ FF_{t-1}$ is the (nominal) amount a bond that is purchased, scaled by the free float of a bond in the market to determine the Eurosystem's market share. The free float is defined as the outstanding amount of a bond on day *t*, minus the Eurosystem holdings on day *t*-1, minus the amount pledged as collateral at the Eurosystem on day *t.* The Eurosystem market share is the market share of a bond i on day t-1, defined as the total nominal holdings of a bond divided by the total outstanding amount of that bond. Δ $SLF_{t-1}\ over\ FF_{t-1}$ is the change in the total balance lent under the Eurosystem's Securities Lending Facility of bond *i* between day *t* and *t-1* scaled by the security's free float. The control for a bond that is the *cheapest-to-deliver* is a dummy that is 1 when a bond is *cheapest-to-deliver* and 0 otherwise. With a Bloomberg function we obtain which bond is the cheapest-to-deliver within a certain futures contract. The control for a bond being on the run works similarly: when a bond is *on-the-run* this dummy is 1, and 0 otherwise. ISIN fixed effects and country-time fixed effects are included to capture bond-specific characteristics and time-varying macro variables, respectively. Data about purchases, outstanding amounts, pledged collateral and the SLF are obtained from the Eurosystem's internal data on its operations. Repo data is obtained from MMSR and only includes borrowing transactions from the reporting agent's perspective. Sample period: April 2020 up to the end of November 2021. Cluster-robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

Table A9: Flow effect of asset purchases on repo rates

	ΔRepoRate day 1
$\Delta\ Eurosystem\ holdings\ over\ FF, not\ adjusted\ for\ pledged\ collateral\ _{t-1}$	**-0.308***** (0.044)
$\Delta\ SLF_{t-1}\ over\ FF_{t-1}$	**0.103***** (0.035)
Control for cheapest-to-deliver	Yes
Control for on-the-run	Yes
ISIN FE	Yes
Country-Time FE	Yes
Adjusted-R^2	0.869
Number of observations	142,878

This table shows the *(flow)* effect of an additional purchase on the change in repo rates and the offsetting impact of a security being lent via the Securities Lending Facility (SLF). The dependent variable is the one-day change in the repo rate of bond *i* between day *t* and *t*-1. $\Delta\ Eurosystem\ holdingsover\ FF_{t-1}$ is the (nominal) amount a bond that is purchased, scaled by the free float of a bond in the market to determine the Eurosystem's market share. The free float is defined as the outstanding amount of a bond on day *t*, minus the Eurosystem holdings on day *t*-1, while the amount pledged as collateral at the Eurosystem on day *t* is no longer subtracted. $\Delta\ SLF_{t-1}\ over\ FF_{t-1}$ is the change in the total balance lent under the Eurosystem's Securities Lending Facility of bond *i* between day *t* and *t-1* scaled by the security's free float. The control for a bond that is the *cheapest-to-deliver* is a dummy that is 1 when a bond is *cheapest-to-deliver* and 0 otherwise. With a Bloomberg function we obtain which bond is the cheapest-to-deliver within a certain futures contract. The control for a bond being on the run works similarly: when a bond is *on-the-run* this dummy is 1, and 0 otherwise. ISIN fixed effects and country-time fixed effects are included to capture bond-specific characteristics and time-varying macro variables, respectively. Data about purchases, outstanding amounts, pledged collateral and the SLF are obtained from the Eurosystem's internal data on its operations. Repo data is obtained from MMSR and only includes lending transactions from the reporting agent's perspective. Sample period: April 2020 up to the end of November 2021. Cluster-robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

Table A10: Flow effect of asset purchases on repo rates

	ΔRepoRate day 1	ΔRepoRate day 1
$\Delta\ Eurosystem\ holdingsover\ FF\ _{t-1}$	**-0.309***** (0.043)	**-0.263***** (0.034)
$\Delta\ SLF_{t-1}\ over\ FF_{t-1}$	**0.103***** (0.035)	**0.102***** (0.035)
Control for cheapest-to-deliver	No	Yes
Control for on-the-run	No	Yes
ISIN FE	Yes	No
Country-Time FE	Yes	Yes
Adjusted-R^2	0.869	0.869
Number of observations	142,878	142.890

This table shows the *(flow)* effect of an additional purchase on the change in repo rates and the offsetting impact of a security being lent via the Securities Lending Facility (SLF). The dependent variable is the one-day change in the repo rate of bond *i* between day *t* and *t*-1. $\Delta\ Eurosystem\ holdingsover\ FF_{t-1}$ is the (nominal) amount a bond that is purchased, scaled by the free float of a bond in the market to determine the Eurosystem's market share. The free float is defined as the outstanding amount of a bond on day *t*, minus the Eurosystem holdings on day *t*-1, minus the amount pledged as collateral at the Eurosystem on day *t*. $\Delta\ SLF_{t-1}\ over\ FF_{t-1}$ is the change in the total balance lent under the Eurosystem's Securities Lending Facility of bond *i* between day *t* and *t-1* scaled by the security's free float. Controls for cheapest-to-deliver and bonds being on-the-run are excluded. ISIN fixed effects and country-time fixed effects are included to capture bond-specific characteristics and time-varying macro variables, respectively. Data about purchases, outstanding amounts, pledged collateral and the SLF are obtained from the Eurosystem's internal data on its operations. Repo data is obtained from MMSR and only includes lending transactions from the reporting agent's perspective. Sample period: April 2020 up to the end of November 2021. Cluster-robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

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