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Liquidity transformation and Eurosystem credit operations

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Abstract

Banks in the euro area can generate high-quality liquid assets (HQLA) by borrowing central bank reserves from the Eurosystem against non-HQLA collateral. This paper quantifies the extent of this liquidity transformation and finds that on average EUR 0.92 of net HQLA are generated for each euro of credit provided by the Eurosystem. The paper then identifies *intentional* liquidity transformation using two novel approaches: The first approach compares the liquidity profile of already pledged vs new collateral, and the second approach compares the liquidity profile of the pool of pledged securities with banks' total eligible securities holdings. Both approaches show that banks use their least liquid assets as collateral first and pledge more liquid assets only at the margin. This intentional liquidity transformation is sizable and accounts for 30-60% of generated HQLA. These results are relevant for calibrating the collateral framework as well as the optimal size and composition of the Eurosystem balance sheet.

Keywords: Liquidity transformation, collateral framework, central bank operational framework, Liquidity Coverage Ratio, reserve demand
JEL codes: C23, E52, E58, G28

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Non-technical summary

The Eurosystem provides central bank reserves against a broad range of marketable and non-marketable collateral by conducting refinancing operations with its counterparties. At the same time, these counterparties need to hold sufficient amounts of high-quality liquid assets (HQLA) for regulatory purposes, i.e. to fulfil their liquidity-coverage ratio (LCR). They therefore have an incentive to pledge illiquid non-HQLA assets as collateral with the Eurosystem and receive HQLA-eligible central bank reserves in return. Matching the eligibility criteria and valuation haircuts of the Eurosystem collateral framework with those of the LCR framework, this paper shows that banks generate on average EUR 0.92 of *net* HQLA for each euro of reserves they borrow from the Eurosystem (totalling more than EUR 1.6 trillion at its peak). In a second step, the paper shows that this liquidity transformation not only arises mechanically due to the structural difference between the Eurosystem- and LCR-haircuts but that banks intentionally mobilise collateral which is less liquid than their overall portfolio of Eurosystem-eligible assets. To show this, the paper uses two new identification approaches: The first approach shows that the flow of additional collateral is significantly more liquid than the stock of already mobilised collateral, suggesting that banks mobilise their least liquid collateral first and only use more liquid assets at a later stage. The second approach matches the collateral data of banks with their holdings of Eurosystem-eligible securities using proprietary data of the Security Holding Statistics by Banking Group (SHS-G). Doing that, the paper finds that banks' portfolios of eligible marketable assets are significantly more liquid than the composition of the marketable assets they are using as collateral with the Eurosystem. That supports the hypothesis that banks prefer pledging their least liquid assets as collateral.

These findings have fundamental implications for designing the features of the monetary policy operational framework, in particular deciding how broad the collateral framework should be and what role credit operations should have as a monetary policy instrument as compared to outright holdings: A stricter collateral framework as well as a smaller share of credit operations reduce the total amount of HQLA available to banks which could make liquidity constraints more binding. While this may adversely affect financial stability, it would also reduce banks' reliance on the central bank for fulfilling their liquidity requirements. A smaller supply of HQLA could also increase the demand for reserves as banks become more eager to hold on to them for LCR-purposes when overall HQLA becomes scarcer. At the same time, a stricter collateral framework may *reduce* the demand for Eurosystem credit and thereby the demand for reserves because banks can no longer use credit operations to generate HQLA. That implies that there is an overall ambiguous link between the breadth of the collateral framework and the demand for reserves. Finally, a stricter collateral framework or a shift in the composition of the Eurosystem balance sheet from credit operations to outright holdings would imply that a higher amount of highly liquid assets, such as government bonds, is absorbed by the Eurosystem - either

as collateral or as outright holdings. This could aggravate market distortions and lead to scarcity in certain market segments such as repo markets.

The results are also important for assessing whether banks have sufficient collateral available to participate in Eurosystem credit operations which is important for a smooth transmission of monetary policy. In particular, the results of this paper suggest that banks have usually exhausted most of their eligible illiquid assets by the time they pledge more liquid assets. Therefore it is more important to understand how much more liquid assets banks have available to participate in new credit operations.

1 Introduction

When the Covid-19 crisis swept European economies and financial markets in early March 2020, non-financial corporations and banks were in dire need of liquidity as funding markets dried up. The Eurosystem reacted swiftly by providing additional liquidity through more favourable longer-term refinancing operations and by easing the rules in its already broad collateral framework further in order to ensure that banks were able to participate in these operations. The immediate and sizable response by the Eurosystem helped to stabilise funding conditions (see Barbiero et al. (2021)) and demonstrated once again - after years of relatively calm financial markets - that the provision of liquidity remains a crucial task of central banks and a key pillar of monetary policy implementation.
At the same time, there is a fundamental interaction between this role of the Eurosystem as a provider of liquidity and the new regulatory landscape governing the financial sector which emerged after the financial crisis: Since October 2015, European banks are required to hold sufficient amounts of high-quality liquid assets (HQLA) to accommodate large liquidity outflows, i.e. they need to maintain a liquidity-coverage-ratio (LCR) of at least 100%. Since central bank reserves are treated as HQLA, banks can fulfil these requirements by borrowing from the Eurosystem against eligible collateral which comprises a broad range of assets - including non-HQLA such as credit claims or securities issued by the bank itself. As a consequence, banks can "generate" HQLA to fulfil their regulatory liquidity requirements by pledging non-HQLA assets as collateral and receiving central bank reserves in return.

This paper investigates to which extent banks exploit these differences between the Eurosystem collateral framework and the LCR-regulation, and deliberately transform illiquid collateral into HQLA-eligible reserves in order to fulfill their LCR requirements. In doing that, the paper has two main contributions: First, it presents a new measure - the *liquidity transformation rate* (LTR) - which takes into account that assets that are used as collateral can no longer be used directly as unencumbered HQLA for LCR purposes. It therebey quantifies how much *net* HQLA a bank can generate for each euro borrowed from the Eurosystem if it pledges a particular asset as collateral. Not accounting for this LCR-related opportunity costs that banks incur when pledging HQLA would lead to biased estimates of LCR-related liquidity transformation.
The second main contribution of the paper is to disentangle quantitatively to which extent banks transform non-HQLA into HQLA *intentionally* as compared to *coincidental* liquidity transformation. The latter arises mechanically because the Eurosystem applies more lenient eligiblity criteria and haircuts than the LCR regulation. Intentional liquidity transformation, in contrast, is related to banks selecting less liquid assets in their portfolio when pledging collateral for the Eurosystem. Concretely, the paper presents two new empirical approaches to disentangle intentional from coincidental liquidity transformation. Both approaches assume that the composition of pledged collateral of any given bank

would not be less liquid than a representative sample of the bank's overall portfolio of Eurosystem-eligible assets if liquidity transformation would be purely coincidental. If, in contrast, a bank pledges assets with the Eurosystem that are systematically less liquid than its average portfolio, then this is an indicator for intentional liquidity transformation. The first approach tests this hypothesis by comparing the average liquidity transformation rate of the stock of already mobilised collateral with the liquidity profile of the flow of newly mobilised collateral. If banks prefer to use illiquid assets as collateral, then the flow of additional collateral should on average be *more* liquid from an LCR-perspective then the stock of already mobilised collateral. Hence the liquidity transformation rate should fall if a bank mobilises additional collateral. The second approach compares more directly the average liquidity profile of mobilised marketable collateral with banks' balance sheet, using granular data on banks' holdings of Eurosystem-eligible securities.[1] Although this second approach is limited to marketable assets due to the scope of the data set (excluding non-marketable assets such as credit claims), it allows for a more direct comparison of banks' collateral pools with their balance sheet composition.

Results

The paper finds that LCR-related liquidity transformation is quite substantial on aggregate: For each euro that banks borrow from the Eurosystem, they generate on average EUR 0.92 of net HQLA by pledging assets that are either not eligible as HQLA or command a higher haircut under the LCR than under the Eurosystem collateral framework. Furthermore, this *liquidity transformation rate* drops after large Eurosystem credit allotments as banks pledge additional assets that are on average more liquid from an LCR-perspective than the average stock of collateral that banks had already pledged.

Looking at whether this liquidity transformation is intentional or purely coincidental, the first identification approach finds that a one percent increase in mobilised collateral from one week to the next is associated with a 0.051 percentage point drop in the liquidity transformation rate, controlling for changes in outstanding credit as well as bank- and time-fixed effects. This result indicates that banks indeed follow a hierarchical approach in managing their collateral pools: They prefer to mobilise the least liquid assets which generate the most net HQLA and resort subsequently to more and more liquid asset types as they increase their collateral pools, e.g. to take up more credit. This effect is persistent over different time horizons but varies substantially across countries.

The second identification approach confirms these findings and shows that banks' portfolios of eligible marketable assets are significantly more liquid from an LCR-perspective, i.e. they have a lower average liquidity transformation rate, than their collateral pools mobilised with the Eurosystem. While eligible marketable assets in banks' security portfolios would generate on average EUR 0.29 of net HQLA for each euro of central bank reserves if they were used as Eurosystem collateral, the actual mobilised marketable collateral has

[1] Based on the Securities Holdings Statistics by Banking Group (SHS-G)

a liquidity transformation rate of 0.45, i.e. is substantially less liquid. While this second approach confirms that banks choose less liquid marketable assets as collateral, it does not allow for a comprehensive picture as it excludes non-marketable collateral which account for a substantial fraction of Eurosystem collateral (34%).

Finally, the aggregate amount of intentional liquidity transformation is sizable, accounting for 30-60% of the net HQLA generated via the Eurosystem collateral framework and close to EUR 600 bn at its peak in 2021. While coincidental liquidity transformation co-moves in lockstep with credit outstanding, intentional liquidity transformation is much more stable throughout the cycle. This is driven by the countercyclical pattern of the liquidity transformation rate which decreases when Eurosystem borrowing goes up because banks encumber more liquid assets. This partially offsets the effect of larger loan volumes on the total amount of net HQLA generated intentionally.

Related literature

This paper adds to the literature on liquidity transformation and the role of central bank collateral frameworks in that regard. As this paper focuses on the role of the LCR as a regulatory driver for banks to transform illiquid into liquid assets, the two most relevant related papers are Kedan and Veghazy (2021) and Schmidt (2019) which investigate the interaction between LCR-requirements and the Eurosystem collateral framework. Both papers analyse how the introduction of LCR requirements in October 2015 affected the demand for central bank credit and banks' collateral pledging behavior by exploiting that some jurisdictions had introduced national LCR regulations already before 2015 which serves as a quasi-natural experiment. Kedan and Veghazy (2021) focus on the aggregate demand for central bank reserves and find that banks with low liquidity coverage ratios increased their demand for central bank reserves more after the introduction of LCR requirements. The paper by Schmidt (2019) uses the same quasi-natural experiment across countries as Kedan and Veghazy (2021), but focuses on the composition of collateral pledged. She finds that banks mobilised more illiquid collateral after the introduction of LCR requirements which is measured as the average weighted haircut applied by the Eurosystem, indicating that LCR-related liquidity transformation may have impacted banks' collateral choice.

This paper complements the study by Schmidt (2019) along two dimensions: First, it takes into account that HQLA which is encumbered as collateral with the Eurosystem can no longer be used directly for a bank's LCR. Hence, banks incur an opportunity cost from an LCR-perspective when they encumber LCR-eligible assets as collateral with the Eurosystem. This paper takes into account this LCR-related opportunity cost by constructing an empirical measure as the main variable of interest that is based on the relative difference of LCR- and Eurosystem haircuts. From an economic viewpoint, this is more relevant for the LCR-related collateral choice of a bank than the absolute level of Eurosystem haircuts which is used in Schmidt (2019). Second, I use a different identification

strategy based on dynamic changes in banks' collateral pool over time and banks' overall securities holdings rather than the quasi-natural experiment of the LCR-introduction in 2015. That strategy allows to estimate the extent of liquidity transformation for each jurisdiction separately and over time which contrasts with Schmidt (2019), which is focused on the LCR-driven collateral choice at one point in time (the time of the LCR introduction in 2015). This in turn allows to analyse how intentional as compared to coincidental liquidity transformation evolves over time and to which extent both types of liquidity transformation depend on the total amount of credit outstanding.

Also refering to the LCR-regulation and the associated demand for HQLA, Grandia et al. (2019) estimate the aggregate amount of HQLA generated in monetary policy operations through liquidity transformation which matches with the estimate provided in this paper (EUR 633 billion in February 2019). However, their study focuses on the aggregate supply of HQLA and the role of monetary policy operations (both asset purchases and credit operations) in generating net HQLA, whereas this paper looks at liquidity transformation through credit operations at the individual bank level and disentangles whether this liquidity transformation is purely coincidental or intentional. Although not related to the regulatory demand for liquidity and liquidity transformation, Cassola and Koulischer (2016) study how banks choose the composition of their collateral pool in a structural model, depending on the opportunity costs of pledging collateral with the Eurosystem in terms of haircuts. They find that a 5% higher haircut for a particular asset reduces the mobilisation of that asset by 10%, most of which (70%) is substituted for by other types of collateral.

Finally, this paper relates to the wider literature on the central bank's role as the lender of last resort (LOLR), which goes back to the seminal book by Bagehot (1873). In this context, Corradin and Sundaresan (2022) estimate the overall borrowing capacity of Eurosystem counterparties and show in a structural model that the possibility to generate liquidity by pledging less liquid assets with the central bank reduces the incentives of banks to issue equity or hold cash buffers. Similarly, Drechsler et al. (2016) find that weakly capitalised banks mobilised more risky assets as collateral with the Eurosystem during the European Sovereign Debt Crisis.

Policy relevance

Understanding whether and to which extent banks use the Eurosystem collateral framework to generate HQLA for LCR-purposes is important for monetary policy implementation and financial stability, in particular with respect to different design choices for the operational framework of the central bank.[2]

First, from an analytical perspective, this study shows to which extent banks take the opportunity costs of mobilising different asset classes as collateral into account. This helps to

[2]Note that these policy considerations are not necessarily related to the recently concluded review of the Eurosystem's operational framework review and only reflect the author's not the ECB's or Eurosystem's views.

understand how important certain drivers are for banks' participation in Eurosystem credit operations, in particular the possibility to generate HQLA via the collateral framework for regulatory purposes.

Second, the liquidity transformation through the Eurosystem collateral framework implies that both (i) the collateral policy and (ii) the split between asset purchases and credit operations as monetary policy instruments can have a fundamental impact on the demand for central bank reserves: (i) On the one hand, a stricter collateral framework makes borrowing from the central bank less attractive because the additional benefit from generating HQLA for LCR purposes is smaller. Ceteris paribus, this reduces demand for central bank credit which is mirrored by a lower demand for reserves. On the other hand, the smaller scope for liquidity transformation shrinks the aggregate supply of HQLA in the system for any given level of Eurosystem credit. Amid scarcer HQLA banks might be more willing to hold on to reserves which implies a *larger* demand for reserves for any given price. Hence, a stricter collateral framework may have an ambiguous effect on the demand for reserves. The net effect of these opposing forces depends on the relative importance of HQLA-considerations for banks' participation in Eurosystem credit operations and the elasticity of substitution between central bank reserves and other sources of HQLA. (ii) A shift in the mix of monetary policy instruments from credit operations that allow for substantial liquidity transformation towards asset purchases, which generate only negligible amounts of HQLA in net terms,[3] would decrease the overall supply of HQLA in the financial system. To the extent that the supply of other sources of HQLA remains constant, this would put upward pressure on the relative price of HQLA. As a consequence, the overall demand for central bank reserves that are held for HQLA-purposes would increase unambiguously.

Third, the scope for liquidity transformation has different implications for financial stability and the Eurosystem market footprint under different operational frameworks. A stricter collateral framework or a smaller share of credit operations in the monetary policy portfolio of the central bank would limit liquidity transformation. This would reduce the supply of HQLA in the system which could possibly have adverse consequences for financial stability while incentivising a more prudent market-based liquidity management. It might also lead to a larger encumbrance of HQLA with the central bank - either as collateral under stricter collateral rules or as outright holdings that compensate for a smaller amount of credit operations. The ensuing larger central bank footprint could lead to market distortions and collateral scarcity, e.g. in repo markets.

Fourth, the selective collateral mobilisation behavior of banks has substantial implications for assessing collateral availability: What matters for assessing collateral availability is the amount of available collateral that a bank would mobilise *at the margin*, i.e. in addition

[3]See Grandia et al. (2019)

to its already existing collateral pool. This paper shows that this marginal collateral is significantly more liquid than the average composition of already mobilised collateral suggests. Consequently, the availability of marketable securities such as government bonds, which are mobilised at the margin, appears to be more relevant for taking up additional credit than for example non-marketable assets.
While the focus of this paper is on assessing the empirical relevance of liquidity transformation via the Eurosystem collateral framework, these policy considerations can be a starting point for future analyses on the optimal operational framework of the Eurosystem.

The remainder of this paper is structured as follows: Section 2 outlines conceptually how the Eurosystem collateral framework interacts with the LCR regulation and thereby creates an incentive to pledge non-HQLA rather than HQLA as collateral. Section 3 presents the data used and introduces the concept of the *liquidity transformation rate*, which is the main variable of interest in this paper. Section 4 presents aggregate evidence that banks prefer mobilising their least liquid assets first and use more liquid assets only at the margin. Section 5 turns towards identifying intentional as opposed to coincidental liquidity transformation, first introducing two empirical strategies before presenting the main results. The section finally presents an aggregate approximation of intentional vs coincidental liquidity transformation and its evolution over time. Section 6 explains in more detail the relevance of this paper for different parameters of the operational framework and monetary policy implementation.

2 Institutional context

2.1 Eurosystem collateral framework

The collateral framework of the Eurosystem allows counterparties to pledge a wide range of asset types as collateral to participate in Eurosystem credit operations which can be broadly divided into marketable and non-marketable assets. Marketable assets include public sector bonds that are issued by central or regional governments, supranational institutions or agencies, but also private sector securities such as covered bonds, asset-backed securities (ABS), corporate bonds or unsecured bank bonds. Non-marketable assets primarily comprise credit claims subject to Eurosystem-wide eligibility criteria laid down in the General Documentation[4] as well as additional credit claims (ACC) that are subject to general and country-specific eligibility criteria and are only eligible in those jurisdictions that maintain an ACC framework. As these asset classes differ in terms of liquidity, credit and market risk, the Eurosystem risk control framework contains several layers that efficiently protect the Eurosystem balance sheet and ensure risk equivalence from an ex ante perspective. While credit and market risk is predominantly addressed by the eligibility criteria and the daily valuation of assets at market prices, liquidity risk is

[4]Guideline (EU) 2015/510

primarily addressed through differentiated valuation markdowns (haircuts) to each asset depending inter alia on the asset type, its credit rating and maturity.[5] In addition, specific haircuts apply for own-used assets, i.e. covered bonds or ABS that were originated and are largely held by the mobilising bank itself. Within the limits of the collateral and risk control frameworks, counterparties can choose relatively freely which types of collateral to mobilise with few specific limitations such as the concentration limit for unsecured bank bonds (UBB) that are issued by a single banking group. Lastly, mobilised collateral is not earmarked for specific credit operations, i.e. counterparties' collateral is pooled and used to secure all outstanding credit without being attributed to specific monetary policy operations or a specific facility (such as the marginal lending facility or intraday credit).

As counterparties face few limitations within the collateral framework regarding the eligible assets they mobilise, the actual composition of assets used as collateral depends on each bank's asset-liability management which in turn depend on a variety of idiosyncratic factors that affect the opportunity cost of using specific assets as collateral. These bank-specific factors are in particular related to the business model, size and location of a bank and include, inter alia:

- banks' asset-side composition, e.g. share of eligible credit claims to NFCs and households; share of eligible marketable assets
- access to covered bond and ABS markets as sources of funding including operational considerations and the costs of issuing own-usable securities
- access to repo markets for funding purposes and the related encumbrance of collateral in repo transactions
- maturity mismatch between assets pledged as collateral and central bank funding (in particular in relation to NSFR-requirements)
- regulatory liquidity requirements (LCR), stability of deposit base and availability of HQLA
- operational considerations, e.g. costs of actively managing the pool of collateral pledged with the Eurosystem or identifying eligible non-marketable assets (credit claims)

Analysing and decomposing the relevance of all of these factors is beyond the scope of this paper. Instead, this paper focuses on investigating the importance of one of these drivers for collateral mobilisation patterns, namely the regulatory liquidity requirements. These requirements fundamentally affect the relative attractiveness of using different asset classes as collateral and therefore can substantially influence not only banks' collateral mobilisation patterns but also their credit take-up more generally.

[5] See for example Bindseil et al. (2017).

2.2 Interaction between LCR and the Eurosystem collateral framework

Since 2015, regulation (EU) 575/2013 (Capital Requirements Regulation) - requires European banks to maintain a *liquidity-coverage-ratio* (LCR) of 100%. This LCR is essentially the ratio between a bank's eligible HQLA that can be liquidated at short notice and the expected liquidity outflows on the bank's funding side in a 30-day window. Accordingly, banks need to hold sufficient amounts of HQLA which are defined in detail in the Delegated Regulation (EU) 2015/61 and can be grouped into the following 3 categories:[6]

- **Level 1 (L1):** highly liquid assets such as cash, central bank reserves, bonds issued or guaranteed by the central government of EU member states, certain securities issued by regional governments, public agencies and public credit institutions; certain types of high-quality covered bonds with a minimum rating of CQS 1
- **Level 2A (L2A):** assets issued by regional governments that are assigned a risk-weight of 20% according to Art 115-116 of the Capital Requirements Regulation[7]; certain types of covered bonds with a minimum rating of CQS 2; debt securities issued by non-financial corporations with a minimum rating of CQS 1
- **Level 2B (L2B):** ABS (most senior tranche) with a minimum rating of CQS 1 and a pool of underlying exposures to residential, commercial, auto or consumer loans; covered bonds that are fully backed by either loans to public entities or residential mortgages; debt securities issued by non-financial corporations with a minimum rating of CQS 3

Each of these asset categories is subject to specific haircuts which are summarised in Table 1 of Grandia et al. (2019) and range from 0% for central bank reserves and central government bonds to 50% for eligible corporate bonds of CQS 3. Furthermore, banks are subject to a diversification requirement and cannot fulfil more than 40% of their HQLA requirements with L2A assets and not more than 15% with L2B assets.
As mentioned in the introduction, this regulatory treatment creates a fundamental interaction between the LCR-regulation and the Eurosystem collateral framework: The LCR framework allows counterparties to generate HQLA in the form of central bank reserves by borrowing from the Eurosystem against collateral that is either not eligible for LCR-purposes or for which the LCR-regulation applies a larger haircut than the Eurosystem collateral framework. This is in particular important in the context of the fixed-rate full allotment policy (FRFA) which was introduced in 2008 and allows counterparties to borrow as much liquidity as they need, subject to collateral availability constraints and operation-specific borrowing allowances. While liquidity transformation is in general also

[6]The list of HQLA-eligible assets shown here focuses on assets that are potentially eligible in the Eurosystem collateral framework and is therefore non-exhaustive as it does not include HQLA-eligible assets that are not eligible as collateral with the Eurosystem such as equity shares or FX reserves.

[7]Article 115 and 116 of Regulation (EU) 575/2013 (Capital Requirements Regulation) assign a risk weight of 20% to assets issued by regional governments that are not treated as exposures vis-a-vis the central government.

possible under variable rate tenders, the overall amount of liquidity provided is in this case determined by the central bank and therefore limited. Hence, the requirement to maintain a sufficient HQLA buffer for LCR purposes, together with the acceptance of non-HQLA collateral and the FRFA policy, created the economic incentive for banks to (i) borrow more from the Eurosystem than they otherwise would have (*extensive margin*) and (ii) to pledge collateral with the Eurosystem which is on average less liquid (*composition margin*).

While the extensive margin of this liquidity transformation through the Eurosystem collateral framework has been discussed in previous studies (see for example Kedan and Veghazy (2021)), the composition margin has not been analysed in detail and deserves some further elaboration regarding the underlying mechanisms:
First of all, the LCR regulation does not count assets towards a bank's stock of HQLA if they are encumbered as collateral, for example in repo transactions or in refinancing operations with the central bank. Due to this regulatory treatment banks face a trade-off for assets that are both LCR-eligible and Eurosystem-eligible: They can either use these assets directly as HQLA to fulfil their LCR-requirements or pledge them with the Eurosystem and obtain LCR-eligible central bank reserves in return. The size and direction of this trade-off depends primarily on the difference in haircuts that are applied by the Eurosystem as compared to the haircuts in the LCR regulation and can go either way: In the case of an EU central government bond, for example, the LCR regulation applies a haircut of zero percent whereas the Eurosystem applies a haircut larger than zero, depending on the maturity and the credit rating of the bond. Hence, the bond has a higher value in terms of HQLA if it is unencumbered on the bank's balance sheet rather than used as collateral with the Eurosystem to obtain less than the par value in central bank reserves. A corporate bond with a credit rating of CQS 3, in contrast, faces a haircut of 50% in the LCR framework but significantly lower haircuts in the Eurosystem collateral framework. Hence, the incentive to use a particular asset that is both LCR- and Eurosystem-eligible as collateral with the Eurosystem to generate HQLA, depends on the *difference* between the LCR haircuts and the Eurosystem haircuts applicable.
Second, for non-HQLA assets, the opportunity cost of mobilising these assets with the Eurosystem is zero from a regulatory perspective as they cannot be used directly to fulfil LCR requirements. These non-HQLA assets encompass in particular all own-used covered bonds and retained ABS, all unsecured bank bonds issued by private credit institutions as well as all non-marketable assets (credit claims and ACCs) and together account for more than 74% of mobilised collateral.

Third, the LCR regulation only treats assets as encumbered if they are actually used as collateral to obtain credit. This is in so far important, as counterparties have mobilised on average twice as much collateral with the Eurosystem as they have borrowed. This over-collateralisation implies that half of the mobilised collateral is not considered to be encumbered from a regulatory perspective and can still be used to fulfil LCR-requirements.

Furthermore, the LCR Delegated Act (Art. 7.2a) specifies in that context that banks that are over-collateralised are allowed to follow a "waterfall" approach and consider the most liquid assets in their collateral pools as unencumbered:

> *"Credit institutions shall assume that assets in the pool are encumbered in order of increasing liquidity on the basis of the liquidity classification set out in Chapter 2, starting with assets ineligible for the liquidity buffer"*

This regulatory treatment implies that the collateral which is encumbered with the Eurosystem is on average composed of less liquid assets than the composition of mobilised collateral would suggest. In order to quantify the extent of liquidity transformation through the Eurosystem collateral framework it is therefore necessary to compute the actual amount of encumbered collateral for each bank, taking into account the liquidity hierarchy of its mobilised collateral and the amount of over-collateralisation at any given point in time. Section 3.1 explains in detail how this waterfall approach is applied to data in order to identify which part of the collateral that banks have mobilised with the Eurosystem, is considered encumbered under the LCR.

3 Data

This section presents the data used in this paper for quantifying LCR-related liquidity transformation and the subsequent identification of intentional vs coincidental liquidity transformation.

The main data source comprises proprietary Eurosystem data on the amount of collateral mobilised by banks with the Eurosystem which is available at a weekly frequency and at the granular ISIN-level, i.e. at the asset level. This collateral data set is further complemented by information on certain characteristics of the mobilised securities that are relevant for their classification under the LCR, in particular the issuer, credit rating, maturity, issuance size and in the case of covered bonds and ABS the type of exposure. These supplementary information are taken from the eligible assets data which contains data on approximately 30,000 Eurosystem-eligible securities on a daily basis. In addition to the collateral information, the data set contains the amount of credit outstanding at the bank level in any given week.

The analysis spans the period from January 2017 to June 2023 which covers the TLTRO-III series including the very favourable operations conducted during the pandemic. It also covers the temporary collateral easing measures that were introduced during the pandemic and substantially expanded the amount of collateral against which banks could borrow from the Eurosystem.

The second main data source used in this paper are the Securities Holdings Statistics by Banking Group (SHS-G) which is based on supervisory reporting and contains information on the securities holdings of more than 100 significant institutions in the euro area. The holdings data are available at the ISIN-level at a quarterly frequency but only cover marketable assets and hence contain no information on non-marketable assets - such as credit claims - that are also eligible as Eurosystem collateral. The SHS-G data is then merged with the first data set on mobilised marketable collateral. As the SHS-G data is available only at a quarterly frequency, data on mobilised collateral is taken for the last weekly snapshot date in each quarter between 2018-Q3 and 2023-Q2. Furthermore, the data is aggregated at the banking group level for both the mobilised collateral and the securities holdings.[8] Finally, the data is then merged with the eligible assets data which allows to classify each asset into LCR categories based on the asset's characteristics (e.g. credit rating, maturity, issuance size). Eurosystem-eligible assets and the appropriate haircuts are identified at the individual ISIN-level in the SHS-G data. In addition to already mobilised own-used covered bonds and retained ABS, add-on haircuts for own-usage are also applied to covered bonds and ABS in the security portfolio of banks which are not yet mobilised in case the respective bank has a close link with the issuer of that asset.

Note that only a subset of counterparties can be matched with the banks represented in the SHS-G data set (15.5% of counterparties with outstanding credit in Q2-2023). At the same time, these counterparties account for 79% of mobilised collateral and 83% of outstanding Eurosystem credit, indicating that banks represented in the SHS-G are on average larger in terms of balance sheet size than the full sample of Eurosystem counterparties (see Table 1 for a detailed comparison). The composition of collateral also differs between entities covered by the SHS-G data set and those not covered: Banks in the SHS-G sample mobilise more illiquid assets such as own-used covered bonds, retained ABS and credit claims. Banks not in the SHS-G sample, in contrast, mobilise twice as many public sector bonds (28.1% of mobilised collateral compared to 14% for the SHS-G sample) and other relatively liquid assets such as covered bonds issued by other banks (10%). Despite these structural differences between the SHS-G sample and banks that are not covered by the SHS-G data, the asset composition of the full sample (first column in table 1) is quite similar to the asset composition in the SHS-G sample. This is the case because the SHS-G sample accounts for more than 80% of mobilised collateral and therefore the banks not covered by the SHS-G carry little weight in the overall sample.

[8] While SHS-G data is generally reported also at the individual counterparty level, i.e. MFI-level, a cross-check of selected banking groups revealed that the reported mobilisation in the collateral data is not always consistent with the reported security holdings in SHS-G at the MFI-level but at the banking group level.

Table 1: Sample comparison all counterparties with SHS-G sample

		Full sample (1)	non-SHSG sample (2)	SHSG sample (3)	share covered by SHSG (in %)	Δ SHSG (3)-(2)
aggregate statistics	number MFIs	1,098	928	170	15.5%	-
	Mobilised collateral	1,819,257	384,547	1,434,710	78.9%	-
	Outstanding credit	634,495	109,892	524,603	82.7%	-
	Over-collateralisation	65.1%	71.4%	63.4%	-	-8.0%
	Liquidity transformation rate	75.1%	55.6%	80.4%	-	24.8%
asset class composition	public sector bonds	14.0%	28.1%	10.2%	-	-17.9%
	corp. bonds / UBBs	7.7%	17.2%	5.1%	-	-12.1%
	ABS (not retained)	3.7%	2.9%	3.8%	-	0.9%
	ABS (retained)	17.1%	4.5%	20.4%	-	15.9%
	cov. bonds (not retained)	6.2%	10.0%	5.2%	-	-4.8%
	cov. bonds (retained)	17.5%	7.7%	20.1%	-	12.5%
	non-marketables	33.9%	29.6%	35.0%	-	5.4%

Notes: Descriptive statistics of comparing the collateral mobilised and outstanding credit of the full sample of Eurosystem counterparties with positive outstanding credit and the sample that can be matched with banks represented in the SHS-G. Data refers to Q2-2023 (snapshot date: 29 June 2023).

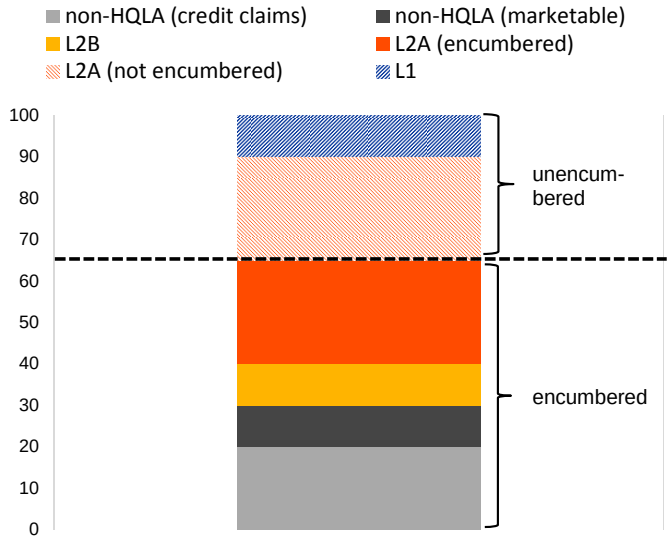
3.1 Mapping LCR-haircuts and accounting for encumbrance

Based on these two data sets (the weekly data on mobilised collateral and the quarterly data on Eurosystem-eligible SHS-G holdings), one can compute how much HQLA-eligible reserves banks can obtain against the Eurosystem-eligible collateral they have available. However, banks can not use any assets for their LCR once they are encumbered as collateral with the Eurosystem. In order to calculate how much HQLA banks can generate for LCR purposes in *net* terms by borrowing from the Eurosystem, it is therefore necessary to account for the LCR-value of each asset that banks forego by encumbering it as collateral with the Eurosystem. Defining which assets in a bank's collateral pool is actually encumbered is not straight forward as banks hold considerable collateral buffers and the LCR does not follow a simple pro-rata approach when assigning which assets are actually encumbered. This section outlines how asset encumbrance is computed at the asset-level when used as collateral with the Eurosystem is computed.

In a first step, each eligible asset is assigned to one of the liquidity categories of the LCR-regulation based on its specific features, such as its issuer, credit rating, issue size, remaining maturity or the type of exposures (in the case of covered bonds and ABS). This mapping also allows to assign each asset the LCR-haircut laid down in the LCR Delegated Act. The diversification requirement and the associated caps for each liquidity category of 40% for L2A and 15% for L2B assets are not taken into account here, as it would require detailed data on all LCR-eligible assets on each bank's balance sheet which is not available. Note that this caveat implies that the liquidity transformation reported in this paper is a *lower* bound because L2A and L2B-assets above the cap are assigned an LCR-haircut of 25-50% whereas they would be counted as non-HQLA assets in practice corresponding to an LCR-haircut of 100%.

Next, for each bank and date, the amount of encumbered collateral is computed in ascending order of liquidity following the "waterfall" approach outlined in the LCR regulation. In particular, non-HQLA assets which are credit claims are encumbered first, then marketable non-HQLA assets, then L2B, L2A and finally L1 assets. Figure 1 illustrates this sequential pattern of asset encumbrance up to the point at which total outstanding credit (black dashed line) is fully backed by encumbered collateral. Within each liquidity category, assets are considered to be encumbered pro rata. In the example in figure 1 this means that non-HQLA and L2B assets are considered to be fully encumbered, L1 assets are not encumbered and each asset belonging to the L2A category is considered to be 50% encumbered because the remaining credit after accounting for non-HQLA and L2B assets accounts for 50% of mobilised L2A assets. This approach allows to compute encumbrance at the granular asset level and aggregate the value of encumbered assets at the bank-level, the liquidity category, date or country thereafter.

Figure 1: Stylised example of hierarchical asset encumbrance



Notes: Illustration of how assets are encumbered in ascending order of liquidity from an LCR-perspective. The black dashed line indicates total outstanding credit, i.e. the amount of Eurosystem credit that needs to be backed by encumbered collateral. HQLA denotes 'High Quality Liquid Assets' which count towards the liquidity buffer required under the LCR and can be grouped into the most liquid L1 category (e.g. government bonds) and less liquid L2A and L2B assets (such as certain covered bonds or ABS).

As a consequence of this 'waterfall' approach set out in the LCR regulation, the composition of encumbered collateral is by construction biased towards less liquid assets compared to the overall composition of pledged collateral: While the most liquid L1 assets account for 23% of pledged collateral, they make up only 7% of encumbered collateral.[9]

[9]These specific numbers refer to the latest snapshot date on 29 June 2023.

3.2 Liquidity transformation rate

The final data sets now contain information on the LCR-value of each asset either used as collateral or held on banks' balance sheet i) when pledged with the Eurosystem to obtain HQLA-eligible reserves and ii) when used directly as unencumbered HQLA for LCR-purposes. In order to quantify the extent of liquidity transformation across banks and over time, it is necessary to derive in a final step a quantitative measure that expresses how much net HQLA banks generate from an LCR-perspective when borrowing reserves from the Eurosystem against a specific asset used as collateral.

For that purpose, this paper introduces the *liquidity transformation rate* (LTR) which is defined at the level of each individual asset i at time t as follows:

$$LTR_{i,t} = 1 - \frac{HQLA^{LCR}_{i,t}}{CVAH^{ECB}_{i,t}} \quad (1)$$

$$= 1 - \frac{1 - h^{LCR}_{i,t}}{1 - h^{ECB}_{i,t}} \quad (2)$$

Here, $HQLA^{LCR}$ denotes the value of an asset in terms of HQLA to fulfil requlatory liquidity requirements after applying the asset-specific LCR-haircut h^{LCR}. The term $CVAH^{ECB}$ denotes the collateral value after haircuts of that asset in the Eurosystem collateral framework and captures how much HQLA-eligible central bank reserves a bank receives if it pledges that asset with the Eurosystem. Note that the actual nominal amount of the asset does not matter as it drops out of the equation.

There are two possible interpretations of the LTR: First, it captures how much HQLA is generated by encumbering a sufficient nominal amount of a particular asset with the Eurosystem to borrow one euro of central bank reserves. To illustrate this interpretation, consider two polar cases: In case one, a counterparty encumbers EUR 1.50 of non-marketable credit claims with the Eurosystem subject to a haircut of 33% such that it receives one euro of fully HQLA-eligible central bank reserves in return. At the same time, the counterparty foregoes nothing in terms of HQLA by encumbering these credit claims as they are not eligible as HQLA for LCR purposes in the first place. Hence the LTR of that asset is one, meaning that for each euro of central bank liquidity obtained by pledging that asset with the Eurosystem, one euro of *additional* HQLA is generated. Consider in contrast the case where the LCR-haircut is equal to the Eurosystem haircut: In that case, the counterparty receives one euro of fully HQLA-eligible central bank reserves for a sufficient nominal amount pledged, but at the same time foregoes the exact same value in terms of HQLA from an LCR-perspective because the asset is now encumbered with the Eurosystem. Hence, the net amount of HQLA generated and therefore the LTR is zero.

An alternative interpretation of the LTR is more directly linked to the trade-off banks face in terms of fulfilling LCR requirements: The ratio $HQLA/CVAH$ on the right-hand side represents the opportunity costs of encumbering a particular asset with the Eurosystem, i.e. it shows how much euro of HQLA after LCR-haircuts a counterparty foregoes if it

pledges a sufficient amount of that asset with the Eurosystem to receive one euro of fully HQLA-eligible central bank reserves.
Of course, the LTR is not bounded at zero as the LCR-haircut can be smaller than the Eurosystem haircut, as for example for government bonds. However, there is a lower bound of the LTR by construction, as only Eurosystem-eligible assets for which the haircut is less than 100% are considered. In practice, this lower bound is approximately -45% at the asset level.

The main advantage of the liquidity transformation rate is that it can be computed at the granular asset level but can also be easily aggregated for each bank or jurisdiction j by computing the sum of $HQLA$ and $CVAH$ in equation 2 separately:

$$LTR_{j,t} = 1 - \frac{\sum_i HQLA^{LCR}_{i,j,t}}{\sum_i CVAH^{ECB}_{i,j,t}} \quad (3)$$

At the bank level, the $LTR_{j,t}$ represents how much HQLA a bank generates on average for each euro borrowed from the Eurosystem, given the composition of its encumbered collateral.

4 Liquidity profile of mobilised collateral and liquidity transformation

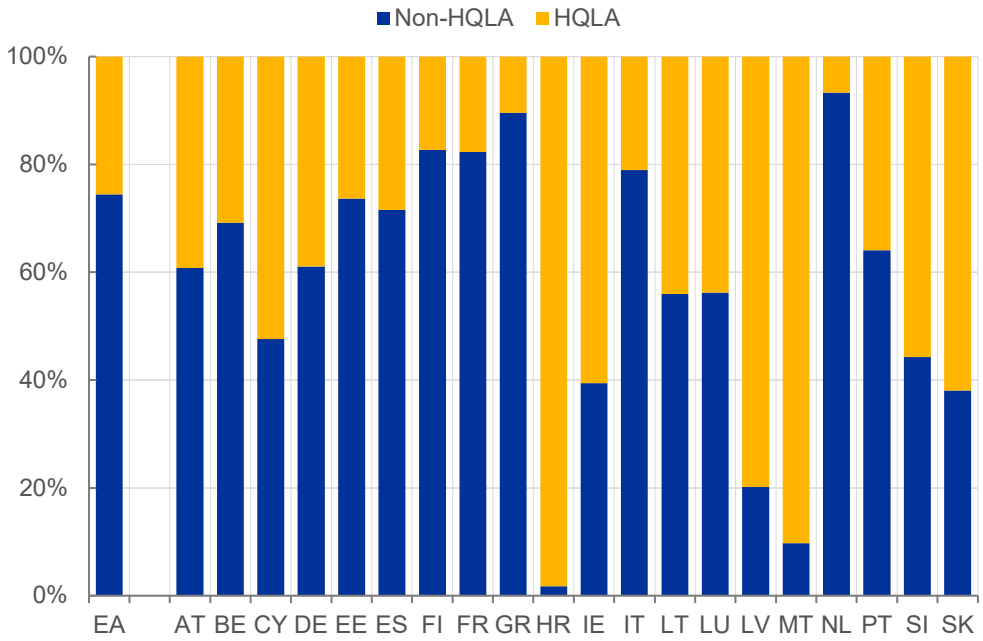
The previous section highlighted that the possibility to generate HQLA via the Eurosystem credit operations and the wide collateral framework incentivises banks to fulfill their LCR requirements by pledging non-HQLA as collateral with the Eurosystem. Before quantifying the amount of liquidity transformation via the collateral framework more granularly, it is useful to understand how banks on aggregate collateralise their participation in Eurosystem credit operations and how they adjust their collateral pools over time. This section therefore provides an overview of (i) the composition of the *stock* of mobilised collateral across time and jurisdictions and (ii) the composition of the *flow* of additionally mobilised collateral following large Eurosystem credit allocations.

4.1 Liquidity profile of mobilised collateral

In aggregate terms, the collateral composition seems indeed biased towards less liquid assets with non-HQLA collateral accounting for 74% of mobilised collateral (see figure 2). HQLA, accordingly accounts for only 26% of collateral and mostly consists of the most liquid L1 assets, while the less liquid L2 assets are negligible. This masks a considerable heterogeneity across countries with banks in some smaller jurisdictions relying more on highly liquid assets, e.g. in Malta, Latvia and Slovakia. However, the banks in the largest 5 jurisdictions (DE, FR, IT, ES, NL) which also account for the bulk of outstanding

Eurosystem credit are using predominantly non-HQLA as collateral. This heterogeneity across countries extends also to different types of non-HQLA being used, e.g. own-used covered bonds or credit claims, which often reflects country-specific differences in financial market structures such as for example the depth of the ABS or covered bond markets or the market standards for credit claims.[10] Furthermore, these cross-country differences arise from the existence of ACC frameworks in certain jurisdictions and country-specific rules regarding the mobilisation of credit claims (e.g. different minimum size thresholds), which affect the relative attractiveness to use for example credit claims or ACCs relative to retained marketable assets such as covered bonds or ABS. [11]

Figure 2: Composition of pledged collateral by asset type by jurisdiction (29 Jun 2023)



Notes: This figure shows the composition of pledged collateral value after haircuts by jurisdiction and HQLA category according to the LCR regulation on 29 June 2023.

While the stock decomposition indicates that banks tend to use predominantly non-HQLA collateral, it does not allow to infer how counterparties manage the size and composition of their collateral pools over time. One possibility to do that is to compare the flow of additional collateral with the stock of already pledged collateral, for example following the allotment or repayment of Eurosystem credit operations. Since the start of the pandemic, there were several dates at which Eurosystem credit expanded or contracted

[10] This heterogeneity is one major reason for accepting a relatively broad set of asset classes in the Eurosystem collateral framework as it ensures that counterparties across all jurisdictions and with different business models can participate in the Eurosystem credit operations and are not constrained by country- or business-model specific characteristics.

[11] Koulischer and Van Roy (2017) show for Belgium that even across banks within the same jurisdiction, the operational costs of switching between using credit claims directly as Eurosystem collateral and issuing retained ABS or own-used covered bonds can be sufficiently high to outweigh the possible benefits of switching between different collateral sources.

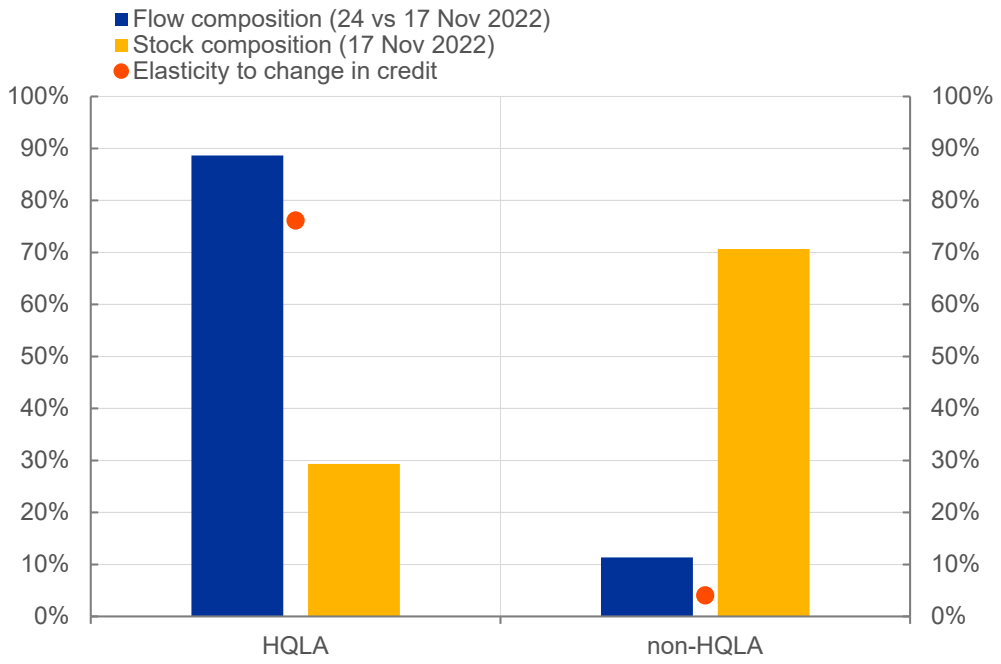
substantially. The most recent event with a sizable change in Eurosystem borrowing that did not coincide with a change in other parameters of the collateral framework was the large early repayment following the recalibration of TLTRO-III in November 2022 when banks repaid EUR 296 bn of credit. Figure 3 compares the stock of mobilised collateral with the composition of collateral that banks demobilised from their collateral pools in the first week after the repayment, i.e. the flow. It illustrates that the banks released predominantly HQLA - mostly public sector bonds - which accounted for 89% of demobilised collateral compared to only 29% of the collateral stock before the repayment. In contrast, only 11% of released collateral was non-HQLA even though they accounted for 71% of the collateral stock before the repayment. The collateral release is therefore highly biased towards the most liquid assets, indicating that banks take into account the opportunity costs of different asset types and release the costliest collateral first. Accordingly, the elasticity with respect to each percentage point of credit repaid is substantially higher for HQLA collateral than for less liquid types of assets (red dots).

A more holistic approach shows that this is not specific to that particular repayment but follows a more general pattern: Figure A.2 in the Appendix shows the average elasticity of mobilised HQLA vs non-HQLA with respect to a one percentage point change in credit in the weeks after a credit allotment or repayment between 2017 and 2023.[12] Two aspects stand out: First, the elasticity of both asset types is significantly below one which means that banks do not adjust their collateral pools one-for-one if they take up or repay Eurosystem credit. Instead, they use pre-existing collateral buffers for additional borrowing and similarly do not demobilise all the collateral that is freed up after a repayment. Second, the usage of non-HQLA collateral responds much more sluggishly to a change in outstanding credit than the mobilisation of HQLA. That indicates that banks indeed prefer to use less liquid assets as collateral with the Eurosystem and mobilise their most liquid assets only at the margin once they have exhausted their readily available non-HQLA assets.[13]

[12]The elasticities result from local projections of mobilised collateral in week h on percentage changes in outstanding credit in week $t = 0$. The estimation is based on aggregate weekly data between 1 January 2017 and 29 June 2023 and based on collateral values before haircuts, i.e. abstracting from changes to the haircut schedules in particular following the collateral easing measures during the pandemic.

[13]The elasticity of non-HQLA mobilisation eventually converges to the elasticity of HQLA collateral as banks tend to increase the supply of available non-HQLA collateral after an increase in Eurosystem borrowing, e.g. by issuing own-used covered bonds or ABS, which they then move into their collateral pools over time.

Figure 3: Marginal vs average composition of mobilised collateral after November 2022 repayment



Notes: The chart shows the composition of average stocks of collateral ahead of the first voluntary TLTRO-III repayment following the repricing in November 2022. The repricing made the rate less favourable to most banks incentivising substantial early repayments in that month. Flows refer to changes in collateral by asset class in the week after the repayment, i.e. the composition of demobilised collateral. Red dots indicate the asset class-specific elasticity of collateral demobilisation with respect to a 1 percentage point reduction in outstanding credit in November 2022.

4.2 Liquidity transformation over time and role of asset encumbrance

Figure 4 illustrates for the euro area as a whole how the LTR evolved over time, based on encumbered collateral (yellow line) and total mobilised collateral (blue line) respectively. The grey area (right scale) shows how much HQLA was thereby generated in million euros. Two points stand out: First, the amount of liquidity transformation is quite substantial, with the LTR of encumbered collateral standing currently at 92%, i.e. for each euro of credit the Eurosystem provides, EUR 0.92 of HQLA are generated in net terms. In absolute terms, banks as a result generated more than EUR 1.6 trillion of HQLA at the peak in early 2022, corresponding to 28% of total HQLA held by euro area banks.

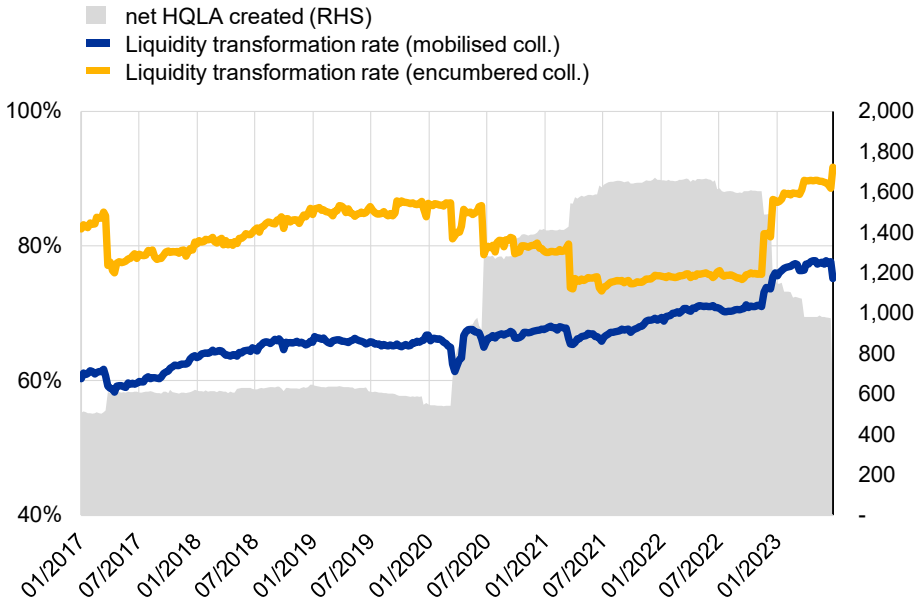
Second, the LTR of both mobilised and encumbered assets drops markedly amid large net allotments of Eurosystem credit, e.g. in March 2017 after the allotment of TLTRO-II.4 or in March 2020 when banks participated widely in the bridge LTROs following the start of the Covid-19 crisis.[14] Similarly, the LTR increases when banks repay credit and release collateral such as at the end of 2022 and early 2023. This is consistent with the evidence shown in figures 3 and A.2: Banks tend to mobilise their least liquid assets first and their

[14]The subsequent increase in the LTR in April 2020 is driven by the additional mobilisation of non-HQLA collateral after the first weeks of the crisis and the implementation of the reduced haircuts schedule on 20 April which disproportionately increased the collateral value after haircuts of non-marketable assets.

most liquid assets only at the margin. Hence, the average liquidity transformation rate in banks' collateral pool decreases when they borrow more from the Eurosystem and mobilise additional - mostly liquid - assets. For mobilised collateral, this effect is, however, relatively temporary as the rebound of the liquidity transformation rate after the allotments in March 2017 and June 2020 shows.

While the LTR of mobilised assets is generally stable over time and reverses quickly after large changes in outstanding credit, the LTR of encumbered assets co-moves more closely with the amount of outstanding credit. This co-movement mechanically arises due to a combination of two factors: First, banks adjust their collateral pools less than one-for-one with respect to changes in outstanding credit which means they partially use their pre-existing collateral buffers when credit expands. As a direct result the share of encumbered assets in banks' collateral pools increases. Second, mobilised assets are counted as encumbered in an increasing order of liquidity ('waterfall approach'). When banks take up more credit and encumber a larger share of their collateral pool, these newly encumbered assets are therefore more liquid than the already encumbered ones and hence the average liquidity transformation rate of the encumbered collateral decreases. This effect comes on top of the bias towards mobilising more liquid assets at the margin. It explains why the LTR of encumbered collateral dropped persistently between 2020 and 2022 when credit outstanding was at its peak and banks consequently had low collateral buffers resulting in a large share of encumbered assets.

Figure 4: Liquidity transformation rate and net HQLA generated through Eurosystem credit operations



Notes: The blue (yellow) line displays the liquidity transformation rate based on the composition of mobilised (encumbered) collateral (left axis). Mobilised collateral refers to collateral that banks have pledged with the Eurosystem irrespective of whether they are used for collateralising outstanding credit. Encumbered collateral refers to assets that are actually used for outstanding credit following the LCR rules on counting assets as encumbered, starting with the least liquid assets mobilised. The liquidity transformation rate denotes how much net HQLA is generated at the bank level via collateral transformation (see text for details). The grey area shows the absolute amount (in EUR million) of net HQLA generated through the Eurosystem collateral framework based on encumbered collateral.

5 Identifying intentional liquidity transformation

The previous section has shown that banks generate on average a substantial amount of HQLA by pledging less liquid assets as collateral with the Eurosystem. At the same time, this liquidity transformation might be entirely coincidental arising from the differences between eligibility and haircut rules in the Eurosystem as compared to the LCR framework: Consider a bank that uses a representative subset of its Eurosystem-eligible marketable and nonmarketable assets as collateral to participate in Eurosystem credit operations. The general differences in haircuts applied by the Eurosystem vis-à-vis those applied by the LCR-regulation might result in the net generation of HQLA even if the bank is not selecting its least liquid assets on purpose. This section therefore investigates whether and to which extent counterparties *intentionally* generate LCR-eligible HQLA by pledging less liquid assets as collateral with the Eurosystem.

5.1 Identification approach and empirical strategies

To illustrate how the intentional creation of HQLA can be identified, consider the above example: If a counterparty does *not* create HQLA via its Eurosystem collateral pool on

purpose, then there should be no significant difference between the composition of the collateral it has already mobilised with the Eurosystem and the remaining Eurosystem-eligible assets on its balance sheet. If, on the other hand, the composition of a bank's Eurosystem collateral pool is significantly less liquid from an LCR-perspective than the overall asset composition of its balance sheet, then this is an indication that the bank is intentionally pledging those assets as collateral which have the lowest opportunity costs in terms of HQLA.

In order to operationalise that hypothesis, this paper follows two separate approaches: The first approach relates to the differences between stocks and flows of mobilised collateral which was pointed out in section 4 and tests whether the flow of additional collateral is significantly more liquid from an LCR-perspective than the stock of already mobilised collateral. The underlying assumption behind this approach is that banks which create HQLA intentionally through the Eurosystem collateral framework, mobilise collateral in an ascending order of liquidity: They first pledge the least liquid assets which yield the largest net gain in terms of LCR-eligible HQLA and then subsequently fill up their collateral pool with more and more liquid assets. This would imply that additionally mobilised collateral has a lower LTR than the average stock of already mobilised collateral. Hence an increase of mobilised collateral should be associated with a drop in the average LTR of the collateral pool of that bank. To test this empirically, I compute the average LTR of mobilised collateral pool for each counterparty j at the weekly snapshot date t and run the following panel regression:

$$\begin{aligned}\Delta LTR_{j,t,t+h} &= \beta_1 \Delta CVAH_{j,t,t+h} \\ &+\beta_2 \Delta MPO_{j,t+h,t} \\ &+\beta_3 \left(\Delta CVAH_{j,t,t+h} X \Delta MPO_{j,t+h,t}\right) \\ &+\beta_4 LTR_{j,t} \\ &+\gamma_t + \lambda_j\end{aligned}$$

Here, ΔLTR denotes the percentage point change in the average liquidity transformation rate of bank j's collateral pool between period t and and $t+h$ where h represents different time horizons. On the right-hand side, $\Delta CVAH$ refers to the relative change of mobilised collateral in percent between period t and $t+h$. Similarly, ΔMPO denotes the difference in outstanding credit of that particular counterparty.[15] Furthermore, the regression controls for bank-fixed effects in order to account for bank-specific characteristics that may be correlated with changes in the liquidity transformation rate. [16] Lastly, it controls for time-fixed effects to control for aggregate changes that affect the LTR, such as aggregate

[15] MPO is short for credit obtained from the Eurosystem in monetary policy operations.

[16] Note, that banks do not switch countries in the sample and hence it is not possible to identify country-fixed effects on top of the already included bank-fixed effects due to the resulting collinearity. However, it is possible to run this regression separately for each country which will result not only in different intercepts but also different slopes which is more interesting for the purpose of this paper (see figure **??**).

changes in the ECB haircut schedule.

The second approach compares the composition of banks' collateral pools more directly with the composition of their overall portfolio of Eurosystem-eligible assets using data from the Security Holdings Statistics by Banking Group (SHS-G) which contains detailed holdings of marketable securities for more than 100 significant institutions from 2018-Q3 onwards. For each of these banking groups, it is possible to compute the average liquidity transformation rate of all Eurosystem eligible assets on their balance sheets which can then be compared with the average LTR of their Eurosystem collateral pools with a paired t-test. Unfortunately there is no data available on the amount of Eurosystem-eligible non-marketable collateral on banks' balance sheets and hence this comparison is limited to banks' portfolio of marketable assets.

5.2 Results I: Stocks vs flows of mobilised collateral

Based on the first identification approach described in the previous section, table 2 shows by how much the liquidity transformation rate of a counterparty's collateral pool changes from one week to the next ($h = 1$) if that counterparty increases mobilised collateral by one percent. In all specifications, the coefficient on mobilised collateral is significantly negative at the 95%-confidence interval. The coefficient of 0.051 in the baseline regression (last column) implies that the average liquidity transformation increases by 0.051 percentage points, e.g. from 74% to 74.051%, if mobilised collateral decreases by one percent. While excluding bank- and time-fixed effects does not change these results substantially, controlling for the take-up in credit has an impact on the size of the coefficient. Controlling for an increase in credit results in a larger coefficient because it reduces the number of observations to those periods in which banks adjusted not only the size of their collateral pool but also their outstanding credit. As an increase in credit is often accompanied by the additional mobilisation of more liquid assets (see section 4), discarding periods without changes in credit yields a higher coefficient. Table A.1 in the appendix shows that the results are robust if as dependent variable the liquidity transformation rate (LTR) of encumbered is used instead of the LTR for all mobilised collateral.

Table 2: Changes in liquidity transformation rate vs changes of mobilised collateral

	(1)	(2)	(3)	(4)	(5)
	Δ LTR	Δ LTR	Δ LTR	Δ LTR	Δ LTR
Δ CVAH	-0.034***	-0.034***	-0.034***	-0.051***	-0.051***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
LTR (T=0)			-0.021***	-0.024***	-0.024***
			(0.001)	(0.002)	(0.002)
Δ credit				0.000	0.000
				(0.000)	(0.000)
Δ Credit x Δ CVAH				0.007	0.007
				(0.008)	(0.008)
Bank FE	NO	YES	YES	YES	YES
Time FE	NO	NO	NO	NO	YES
Observations	435,412	435,412	435,412	289,198	289,198
Adjusted R^2		0.009	0.019	0.030	0.034

Notes: Panel regression across counterparties and weeks of changes in the liquidity transformation rate (Δ LTR) on changes in mobilised collateral (Δ CVAH, i.e. collateral value after haircuts). Both the LTR and CVAH are based on mobilised collateral and changes refer to one-week changes ($h = 1$). Δ LTR denotes percentage point changes ($\Delta LTR = LTR_t - LTR_{t-1}$) whereas Δ CVAH refers to percent changes ($\Delta CVAH = CVAH_t/CVAH_{t-1} - 1$). Asterisks *,** and *** denote significance at the 10%-, 5%- and 1%-significance levels respectively. The negative coefficient on Δ CVAH indicates that a 1 percent increase in collateral reduces the average liquidity transformation rate of a bank by 0.051 percentage points in the baseline regression which controls for the initial level of liquidity transformation, as well as changes in credit and bank- and time-fixed effects.

In order to understand whether this correlation between additional mobilisation of collateral and a lower liquidity transformation rate is persistent or quickly reversed, I re-estimate the baseline regressions (last column in table 2) using a time lag of up to 10 weeks. I find that the coefficient shown in table 2 remains remarkably stable and significant which indicates that the correlation between inflows of new collateral and a more liquid collateral composition is neither spurious nor short-lived but rather a persistent pattern (see Appendix for regression results). In turn, this persistence implies that the more liquid profile of additional collateral is not driven by timing-related operational considerations: If it were the case that counterparties mobilise liquid collateral first and then replace the more liquid collateral with less liquid non-HQLA assets subsequently, then the significant coefficient would be less persistent and dissipate over time.

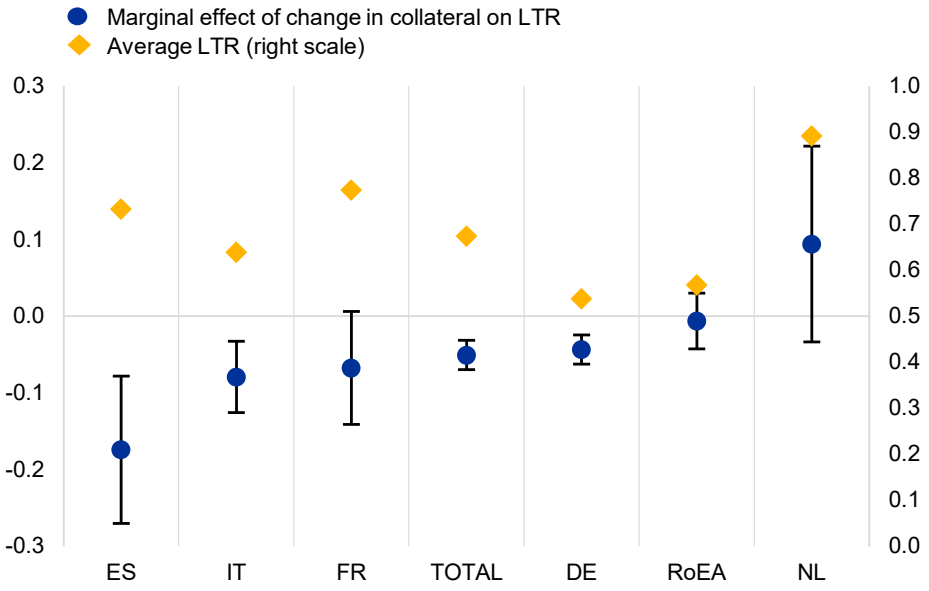
Lastly, the link between changes in mobilised collateral and changes in the average liquidity profile of the collateral pool varies quite substantially across jurisdictions. Figure 5 shows the coefficient β_1 from running the main regression separately for the 5 largest jurisdictions in the euro area together with the respective average liquidity transformation rate.[17] The relatively large dispersion of coefficients indicates that banks make use of liquidity transformation via the collateral framework to a different extent across countries. However, this is not necessarily linked to the average LTR in each country (yellow diamonds) which shows the importance to differentiate between two drivers of liquidity transformation:

[17]The remaining countries are grouped together as the 'Rest of the euro area' (RoEA).

One is the coincidental liquidity transformation which reflects the average liquidity profile of banks' assets on their balance sheet from an LCR perspective. The other factor is the amount of intentional liquidity transformation as indicated by the marginal coefficients, i.e. the blue dots, which reflect how much banks are deliberately preferring to pledge their least liquid assets first. Both factors combined result in the average LTR that is shown in the yellow diamonds.

In order to properly quantify the relative importance of intentional as compared to coincidental liquidity transformation, it is however necessary to compare the composition of mobilised collateral with the composition of eligible collateral on banks' balance sheets which is the purpose of the next section.

Figure 5: Coefficient β_1 of regressing ΔLTR on $\Delta CVAH$ and average LTR by country



Notes: The blue dots display the coefficient of regressing Δ LTR (liquidity transformation rate) on Δ CVAH (collateral value after haircuts) for each jurisdiction separately at a one-week horizon ($h = 1$), controlling for changes in credit as well as bank- and time-fixed effects. They provide an indication how much *intentional* liquidity transformation banks are doing. The yellow diamonds indicate the unweighted average liquidity transformation rate in each country over the estimation horizon 2017-2023 (right scale) which is a combination of intentional and coincidental liquidity transformation. LTR and CVAH are based on mobilised collateral and whiskers denote the 95% confidence intervals. RoEA stands for the rest of the euro area, i.e. all countries except the 5 countries shown in the figure.

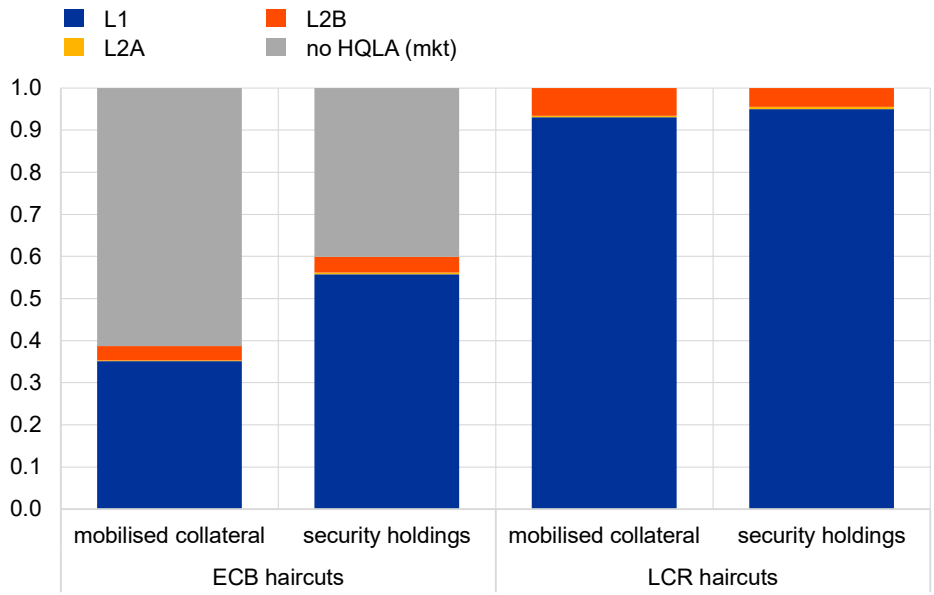
5.3 Results II: Mobilised marketable collateral vs securities holdings

This section presents the results of the second identification approach which directly compares the liquidity profile of the marketable securities that banks have pledged as Eurosystem-collateral with their total portfolio holdings of Eurosystem-eligible marketable securities based on SHS-G data. While this covers only a part of bank's collateral pools, it provides a more direct indication to which extent banks select their less liquid assets as

collateral.

At an aggregate level, figure 6 shows the asset composition of securities pledged with the Eurosystem and of the security holdings of banks by liquidity category, applying Eurosystem haircuts (left bars) and the LCR-haircuts (right bars) to each ISIN.
Evidently, the asset composition in the securities holdings of banks is tilted towards more liquid securities as compared to banks' collateral pools with the Eurosystem. The most liquid L1 assets account for 35% of marketable assets mobilised with the Eurosystem but for 56% of all security holdings of these banks (after applying Eurosystem-haircuts). On the other hand, non-HQLA assets - in particular own-used covered bonds and ABS - make up 61% of marketable assets used as collateral but only 40% of the overall holdings of Eurosystem-eligible assets.

Figure 6: Asset composition of mobilised marketable collateral vs SHSG security holdings

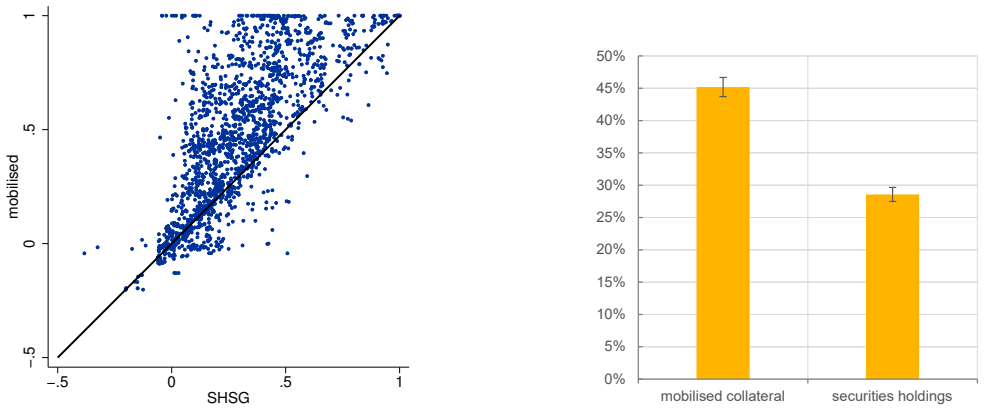


Notes: The graph shows the composition of marketable assets in the pool of mobilised collateral and their security holdings based on SHS-G data. Observations are aggregated at the euro area level and refer to Q2-2023. The left-hand side bars apply valuation haircuts according to the Eurosystem collateral framework. The RHS bars apply haircuts laid down in the LCR regulation. The grey area shows marketable non-HQLA assets, such as own-used covered bonds or retained ABS, that do not count towards the LCR (i.e. the LCR haircut is 100%). The chart illustrates that i) mobilised collateral is less liquid than banks average security holdings in particular due to the high share of non-HQLA assets. These assets are not eligible under the LCR which is why they are not visible in the right two bars.

In order to quantify the amount of intentional liquidity transformation at the individual banking group level, I compute the average liquidity transformation rate of the securities portfolio of each banking group and compare it with the LTR of mobilised marketable collateral of that banking group. Figure 7a plots the LTR of mobilised marketable collateral

(vertical axis) against the LTR of total eligible securities for each bank and snapshot date. Dots above the black 45-degree line denote banking group/date observations for which the respective banking group mobilised less liquid marketable assets than a representative sample of its securities holdings would suggest. The distribution of observations is clearly tilted to the upper side of the 45-degree line, supporting the hypothesis that banks choose less liquid securities for their Eurosystem collateral pool as compared to their overall asset portfolio.

Figure 7: Liquidity transformation rate of mobilised marketable collateral vs SHS-G security holdings



(a) Bank-level correlation

(b) Average LTR and t-test

Notes: The scatter plot in the left chart shows the average liquidity transformation rate (LTR) of banking groups' mobilised marketable collateral pool (vertical axis) vis-à-vis their Eurosystem eligible security holdings (horizontal axis) for 566 bank-quarter observations. Dots above the 45-degree line indicate that banks mobilise less liquid assets with the Eurosystem than a representative sample of their holdings of Eurosystem eligible securities would suggest. The right chart shows the average liquidity transformation rate (LTR) across all banking groups for the pool of mobilised marketable collateral vis-à-vis banks' holdings of Eurosystem-eligible securities with whiskers indicating the 95%-confidence interval from a t-test. It formally shows that the liquidity transformation rate of mobilised marketable collateral is higher (i.e. they are less liquid) than for banks' average securities holdings.

Finally, to test this hypothesis more formally, one can compare the LTR of banks' securities holdings with the LTR of their Eurosystem collateral pools either directly through paired t-tests or by taking the difference between both LTR's for each bank and testing whether this difference is significantly different from zero. Figure 7b shows the average LTR of securities holdings, the collateral mobilised and indicates the statistical significance from a paired t-test.

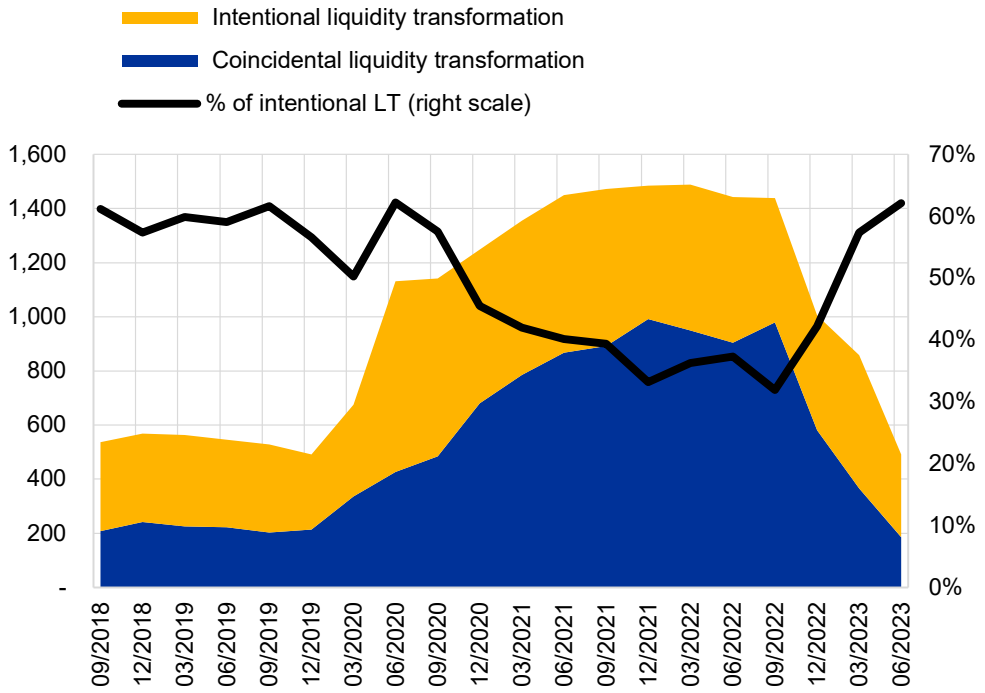
The chart shows that the difference between the average liquidity transformation of mobilised marketable collateral and securities holdings is not only statistically significant but also sizable: Banks could hypothetically generate EUR 0.29 of HQLA for each Euro of credit they borrow from the Eurosystem if they would pledge a representative sample of their Eurosystem-eligible securities holdings. In contrast, they generate on average EUR 0.45 of HQLA for each Euro of collateral actually mobilised with the Eurosystem. In addition, this pattern varies widely across countries (see figure **??** in the appendix for a

country breakdown). While the difference in the liquidity transformation rate between the securities portfolio and mobilised marketable collateral is particularly pronounced for banking groups in Spain (0.28), it is less than 0.07 for counterparties in Germany. These results square with the coefficients from the first estimation shown in figure 5 which indicated that banks in Spain, Italy and France are transforming illiquid into liquid assets via the collateral framework more proactively than banks in Germany or the rest of the euro area.

5.4 Magnitude of intentional vs coincidental liquidity transformation

The previous section has shown that banks take into account the opportunity cost of different asset classes in their collateral choices and accordingly prefer pledging their least liquid assets as collateral first. To better understand the aggregate relevance of this selective pledging behavior, it is necessary to disentangle quantitatively how much of the net HQLA generated via Eurosystem credit is due to intentional as compared to coincidental liquidity transformation. Ideally one would do that by comparing the net HQLA generated by each bank with the net HQLA it *would* generate if it pledged a representative sample of its eligible collateral. The former captures actual liquidity transformation, whereas the latter captures coincidental liquidity transformation that is purely due to the differences between the LCR- versus the Eurosystem treatment of assets. While this is feasible for marketable assets based on the results on banks' securities holdings in the previous section, it is not possible for non-marketable assets due to the lack of data on banks' holdings of eligible but not yet mobilised assets. For non-marketable assets it is therefore assumed that the split between intentional and coincidental liquidity transformation is the same for non-marketable collateral as for marketable assets for each banking group. This approximation implicitly assumes that banks are equally selective towards less liquid assets within their pool of eligible non-marketable assets as they are within their portfolio of marketable assets. Based on this classification of coincidental and intentional liquidity transformation, figure 8 shows the breakdown of net HQLA generated by the banks covered in the SHS-G data set distinguishing between intentional and coincidental liquidity transformation.

Figure 8: Quantifying intentional vs coincidental liquidity transformation



Notes: Decomposition between coincidental and intentional liquidity transformation for marketable assets is identified by comparing the actual liquidity transformation of each bank with the hypothetical liquidity transformation if the bank were to pledge a representative sample of its eligible marketable securities. For non-marketable collateral it is assumed that the split between intentional and coincidental liquidity transformation is the same as for marketables at the bank level.

Figure 8 shows that the amount of intentional liquidity transformation, which is due to banks pledging their least liquid assets first, is quite sizable in aggregate terms: Before the pandemic, approximately 60% of net HQLA generated via the Eurosystem collateral framework was due to intentional liquidity transformation, totalling more than EUR 300 billion. This share, however, dropped significantly after the pandemic-induced expansion of Eurosystem credit to less than 40% and rebounded when banks started repaying their TLTRO-III funds at the end of 2022. This pattern illustrates that the amount of HQLA generated intentionally increases (decreases) less than coincidental HQLA when outstanding credit expands (contracts). The reason is that the banks use a larger share of their collateral pools when taking up more credit due to the sluggish response of collateral mobilisation. Due to the waterfall encumbrance approach under the LCR, this additional collateral encumbrance disproportionately affects the most liquid assets in banks' collateral pools (see section 4.2) . Consequently, the share of more liquid assets that is encumbered increases when credit expands which reduces the amount of liquidity transformation for each euro borrowed and hence makes the pledged collateral more similar to banks' overall portfolio of eligible assets. The resulting drop in the liquidity transformation rate of encumbered collateral partially offsets the impact of the larger volume of outstanding credit on the absolute amount of HQLA generated intentionally. This counterveiling effect means that net

HQLA generated intentionally (yellow area) does not increase one-for-one when outstanding credit expands. In contrast, coincidental liquidity transformation only depends on the amount of outstanding credit and the average liquidity transformation rate of a bank's securities portfolio which is much more slow-moving than the liquidity transformation rate of actually encumbered collateral. Hence, the absolute amount of HQLA that is generated via coincidental liquidity transformation moves almost in lockstep with outstanding credit whereas intentional liquidity transformation is much more stable throughout the cycle.

6 Relevance for central bank policy

The analytical results in this paper have multiple concrete implications for the operational framework of the Eurosystem and for monetary policy implementation going forward. In particular, the possibility to generate HQLA by borrowing from the Eurosystem implies that (i) the breadth of the collateral framework and (ii) the size and composition of the Eurosystem balance sheet affect the overall supply and composition of HQLA available to banks. That in turn has an impact on the demand for central bank reserves under a floor system and consequently the amount of central bank liquidity below which money market rates start lifting off from the interest rate floor. In addition, there are financial stability implications arising from the amount of liquidity transformation under different alternative operational frameworks.

6.1 Breadth of collateral framework and demand for reserves

The possibility to generate HQLA by borrowing from the Eurosystem implies that the breadth of the collateral framework has an impact on the overall demand for central bank reserves and Eurosystem credit operations, especially if reserves are allocated at fixed rates and with full allotment.[18] To illustrate that link, consider a stricter collateral framework which would allow for less liquidity transformation than is currently the case. This would, ceteris paribus, reduce the amount of liquidity transformation for each euro of Eurosystem credit and thereby decrease the net supply of HQLA in the financial system. The lower supply of HQLA that would be generated under a less lenient collateral framework, would have two opposing effects on the demand for Eurosystem credit and thus central bank reserves: On the one hand, a negative substitution effect would reduce the demand for Eurosystem credit as banks need to pledge more HQLA to obtain one euro of Eurosystem credit. This smaller scope for liquidity transformation reduces the LCR-related benefits of Eurosystem credit which makes it less attractive from an LCR perspective than other ways of obtaining HQLA. On the other hand, the overall decrease in the supply of HQLA would make LCR-induced liquidity constraints more binding and thereby increase the overall demand for generating additional HQLA - including via liquidity transformation

[18] In a scarce reserve system where reserves are priced competitively and where the central bank determines the total amount of reserves allocated, the scope for liquidity transformation is limited by the amount of reserves alloted.

at the central bank. This negative wealth effect would therefore increase the demand for Eurosystem borrowing and hence the demand for reserves. The net effect of a stricter collateral framework on the demand for Eurosystem credit depends on how important HQLA-considerations are for banks' participation in Eurosystem credit operations as well as the distribution of central bank reserves across banks which are more or less constrained by the LCR-requirements. Which of the two effects prevails therefore also depends on the aggregate amount of liquidity in the system and how binding LCR constraints are for banks.

6.2 Composition of Eurosystem balance sheet and demand for reserves

The amount of liquidity transformation via Eurosystem credit operations not only depends on how broad the collateral framework is, but also on the amount of outstanding Eurosystem credit. The size and composition of the Eurosystem balance sheet therefore have a fundamental impact on the amount of HQLA generated via liquidity transformation. First, a smaller balance sheet which is accompanied by a reduction in outstanding credit mechanically reduces the amount of HQLA generated by the Eurosystem. Second, not only the size but also the relative share of credit operations as compared to outright asset holdings matters: Outright purchases mostly absorb highly liquid assets such as government bonds and therefore generate only EUR 0.06 of additional HQLA for every euro of central bank reserves created (see Grandia et al. (2019)).[19] This is in stark contrast to the EUR 0.92 of HQLA that are created for each euro of reserves that is provided via credit operations. Hence, a shift in the Eurosystem's monetary policy instruments from collateralised credit operations to outright holdings could reduce the overall supply of HQLA in the financial system, even if the total size of the Eurosystem balance sheet and the amount of central bank reserves remains constant.

Smaller credit operations - be it via an overall contraction of the Eurosystem balance sheet or a shift in its composition towards outright holdings - would consequently also affect the demand for central bank reserves. Similarly as for a stricter collateral framework, smaller credit operations reduce the total supply of HQLA and thereby could make LCR-constraints of banks more binding. This negative wealth effect increases the demand for Eurosystem credit and hence for central bank reserves as banks are more eager to generate HQLA via liquidity transformation. In contrast to changes in the collateral framework, a smaller volume of outstanding credit however does not lead to a substitution effect because the amount of liquidity created for each euro of credit remains unchanged and hence the relative attractiveness vis-a-vis other sources of HQLA is unaffected. Smaller credit operations therefore increase the demand for reserves unambiguously due to the negative wealth effect

[19] The paper shows in Table 2 that 96% of assets absorbed via asset purchases are L1 assets. Hence the liquidity transformation rate of outright holdings is only 5.8%. However, this abstracts from the role of non-banks: Outright holdings might absorb mostly non-reserve HQLA held by non-banks while providing HQLA in the form of reserves to banks. In turn, this redistribution between banks and non-banks could imply that a reduction in the Eurosystem's outright holdings might reduce the amount of HQLA held by banks, to the extent that the 'freed up' public sector bonds are held by non-banks.

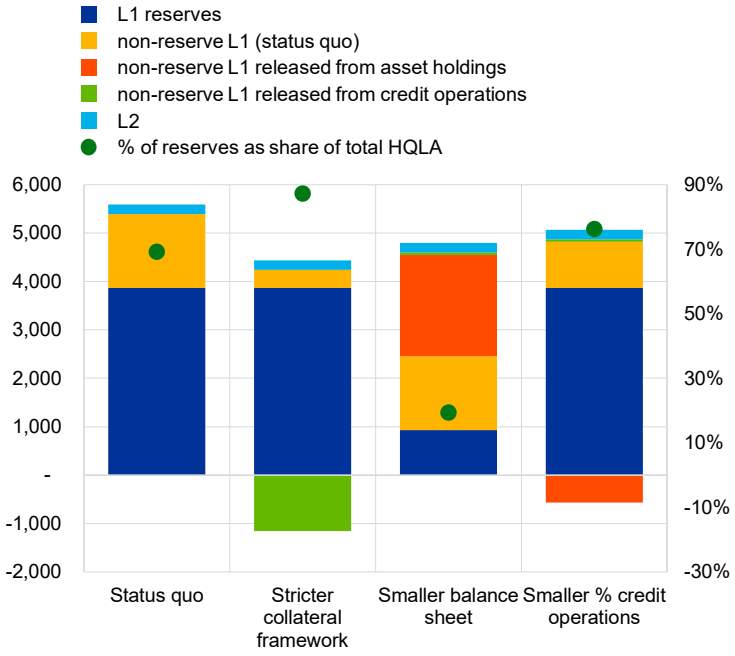
and the more binding LCR-constraints. For any given level of interest rates, the reserve demand curve therefore shifts outwards pushing the point at which money market rates start lifting off towards higher levels of excess liquidity.

6.3 Financial stability implications of different operational frameworks

The breadth of the collateral framework as well as the size and composition of the Eurosystem balance sheet not only affect the demand for central bank reserves but also financial stability and the market footprint of the Eurosystem via the net supply and composition of HQLA. To illustrate that link, figure 9 shows the composition of HQLA held by euro area banks for 4 stylised variants of hypothetical operational frameworks for the Eurosystem. The first bar shows the status quo, indicating the amount of central bank reserves in blue and other unencumbered L1 assets - in particular public sector bonds - held by euro area banks (yellow).

The second bar shows a scenario with a stricter collateral framework in which no liquidity transformation is possible, i.e. only HQLA is accepted as collateral and the same haircuts as in the LCR regulation are applied. For simplicity it is assumed that the total amount of Eurosystem outright holdings and credit operations remains constant. Evidently, the overall amount of HQLA is substantially smaller than in the status quo due to the lack of liquidity transformation. At the same time, banks need to pledge additional HQLA as collateral which is therefore encumbered with the Eurosystem and no longer available for LCR purposes (see smaller yellow area and negative green bar). For banks, such a scenario would reduce the amount of HQLA available which might raise liquidity concerns for banks that are close to their LCR constraint and relying particularly on HQLA generated via liquidity transformation. In addition to this financial stability concern, a larger amount of currently unencumbered L1 assets (e.g. government bonds) would be encumbered with the Eurosystem and no longer available for other uses. This could have spillovers to repo markets raising specialness premia in certain market segments.

Figure 9: Bank HQLA holdings under stylised operational frameworks



Notes: Blue areas show central bank reserves under the different scenarios and the yellow areas show unencumbered L1 HQLA holdings of euro area banks other then central bank reserves based on aggregate supervisory data. The amount of non-reserve L1 assets to be released denote the amount of HQLA that would be freed up if outright holdings (red) or credit operations (green) are reduced respectively. The stricter collateral framework assumes that only HQLA is eligible as collateral. The smaller balance sheet assumes a 50% reduction in outright holdings, credit operations and the resulting reduction in reserves. The last bar assumes a 50% reduction in credit operations which is compensated by more outright holdings. All other variables remain unchanged (ceteris paribus).[20]

The third bar shows a scenario in which the Eurosystem balance sheet shrinks by half which substantially reduces the amount of reserves held by banks but at the same time releases a considerable amount of non-reserve HQLA that was previously held outright by the Eurosystem (red area). In contrast, the share of released HQLA collateral from the repaid credit operations is negligible due to its minor relevance as collateral source. From a financial stability perspective, the overall amount of HQLA is slightly smaller than in the status quo making liquidity constraints of banks somewhat more binding. More importantly, though, the composition of HQLA held by banks shifts substantially from reserves towards non-reserve L1 assets, in particular government bonds. To the extent that government bonds cannot be used for immediate settlement and carry a certain liquidity risk, this might be a more problematic constellation from the perspective of banks' internal liquidity management who may prefer to hold reserves as compared to public sector bonds as liquidity buffer.

The last bar shows a scenario in which half of the outstanding credit operations is replaced by outright holdings while maintaining the overall size of the Eurosystem balance sheet and the amount of reserves. Under this scenario, the total amount of HQLA is smaller as the lower volume of credit operations provides less scope for liquidity transformation. In addition, a substantial portion of currently unencumbered L1 assets would be absorbed by

the larger outright portfolio (smaller yellow bar and negative red bar). Assuming a constant size of the balance sheet, this scenario would therefore reduce HQLA available to banks somewhat and increase the Eurosystem footprint in government bond markets with possible repercussions for repo markets and repo specialness premia. In that sense, the scenario is qualitatively similar to the second scenario with a stricter collateral framework but quantitatively less problematic with respect to financial stability as well as the Eurosystem footprint.

While these scenarios are only partial and do not take into account the interaction between the different components of the operational framework and the demand for reserves, there are still some general take-aways:

1. A smaller amount of credit operations - via a smaller balance sheet or a shift towards outright holdings - reduces the scope for liquidity transformation and hence the net supply of HQLA. That in turn makes liquidity constraints more binding which can have an adverse impact on financial stability.

2. A shift towards a stricter collateral framework or a shift from credit operations towards more outright holdings increases the amount of HQLA that is encumbered with the Eurosystem (assuming a constant balance sheet size). That in turn may increase the Eurosystem footprint in certain market segments and lead to collateral scarcity for certain asset types in private repo markets.

3. An overall reduction of the Eurosystem's balance sheet size would reduce the amount of reserves but at the same time release currently encumbered HQLA, such as government bonds, especially from its outright holdings. Banks would therefore be forced to hold a larger share of their liquidity buffers in the form of non-reserve HQLA. To the extent that reserves and other non-reserve HQLA are not perfect substitutes, this may pose a challenge for banks' liquidity management and increase banks' reliance on government bonds as sources of liquidity.

6.4 Relevance for assessing collateral availability

Aside from these more general implications of liquidity transformation on operational frameworks, the results in this paper are important for assessing whether counterparties have sufficient collateral available - especially ahead of new refinancing operations - in order to ensure that monetary policy is equally transmitted throughout the banking sector. What matters for the collateral availability of a particular bank is the marginal collateral that a bank would add to its collateral pool in order to take up additional credit. As this paper has shown, the composition of additionally mobilised collateral is significantly more liquid from an LCR-perspective than the stock of already mobilised collateral, indicating that counterparties mobilise collateral in an ascending order of liquidity. As a consequence, it is likely that banks have already mobilised a larger fraction of their eligible non-HQLA assets such as credit claims as compared to the share of more liquid assets in their portfolio.

To the extent that this is the case, non-HQLA assets are less relevant as a collateral source for the take-up of additional credit than more liquid asset classes. In other words, the elasticity of mobilised collateral with respect to additional demand for Eurosystem credit depends on the specific asset class and is arguably smaller for non-HQLA assets such as non-marketable assets, own-used covered bonds or retained ABS. Hence, the availability of more liquid asset classes such as government bonds should be the focus when assessing banks' capacity to take up additional credit from the Eurosystem rather than the availability of non-marketable assets that have not been mobilised yet. Evidently, this depends largely on the jurisdiction and the specific bank as the previous analysis has shown which warrants further analysis at the bank level.

7 Conclusion

The Eurosystem accepts a broad range of collateral in its refinancing operations in order to ensure that its monetary policy is transmitted to all parts of the euro area and to sectors of the economy, irrespective of a counterparty's business model or jurisdiction. While liquidity provision against adequate collateral is an essential task of the Eurosystem, this breadth of the collateral framework interacts with the new regulatory environment in the financial sector. In particular, the broad collateral framework of the Eurosystem allows counterparties to transform relatively illiquid assets, such as credit claims or securities they have issued themselves, into high-quality liquid assets which they need to fulfil their liquidity requirements. At its peak in 2021/22, Eurosystem counterparties have created a net amount of more than EUR 1.6 trillion of HQLA through this mechanism. Based on granular data on assets mobilised with the Eurosystem, this paper furthermore shows that this liquidity transformation is not only coincidental but that banks take these liquidity characteristics into account when managing their collateral pools: They follow a hierarchical mobilisation pattern mobilising less liquid collateral first, and they choose securities as collateral which are on average less liquid from a regulatory perspective than their overall portfolio. This intentional liquidity transformation is substantial and amounted to approximately EUR 600 bn of net HQLA generated in 2021.

These findings are relevant for monetary policy implementation and in particular for assessing the advantages and disadvantages of different operational framework constellations:

- *Breadth of the collateral framework:* A stricter collateral framework would limit the scope for liquidity transformation which would reduce the net supply of HQLA. This might adversely affect financial stability and encumber a larger amount of HQLA with the Eurosystem (assuming a constant balance sheet size). At the same time, a stricter collateral framework would reduce banks' reliance on the central bank for fulfilling their regulatory liquidity requirements. A stricter collateral framework

would have ambiguous effects on the demand for reserves depending on the relative size of the substitution and wealth effects.

- *Size and composition of central bank balance sheet:* The split between credit operations and outright holdings as monetary policy instruments affects the aggregate amount of HQLA generated by the Eurosystem. A smaller share of credit operations makes liquidity constraints of banks more binding and would unambiguously increase the demand for reserves which thereby shifting out the point of excess liquidity below which money market rates start lifting off from the floor. In addition, a more pronounced role of outright holdings would encumber more HQLA (e.g. government bonds) which would increase the Eurosystem market footprint possibly leading to market distortions.

- *Collateral availability:* This paper shows that the additional collateral mobilised by banks is significantly more liquid from an LCR-perspective than the average stock of mobilised collateral. Hence, the availability of more liquid assets such as government bonds is more relevant for assessing collateral availability ahead of new credit operations than the availability of non-marketable or other non-HQLA assets.

The relevance of this paper for monetary policy implementation and the trade-off's regarding different operational framework choices highlights that there should be further analysis focusing on these different aspects. With respect to the operational framework implications, a more thorough analysis is warranted to better understand the link between the strictness of the collateral framework, the share of credit operations and the demand for reserves. Regarding financial stability concerns, follow-up work could investigate to which extent banks rely on HQLA generated via Eurosystem credit operations and what share of credit take-up is driven by binding LCR-constraints. With respect to the Eurosystem market footprint, additional work could investigate in more detail the impact liquidity transformation has on collateral scarcity in repo markets and compare that to the market impact of outright holdings. From a collateral availability perspective, the analysis could be extended by estimating bank-specific elasticities for each asset class with respect to the bank's overall collateral pool. That would give an indication - at the individual bank level - which asset classes are particularly relevant for mobilising additional collateral in order to participate in Eurosystem credit operations which would enhance the analysis of collateral availability concerns ahead of new refinancing operations.

References

Bagehot, Walter, "Lombard Street," 1873.

Barbiero, Francesca, Miguel Boucinha, and Lorenzo Burlon, "TLTRO III and bank lending conditions," *ECB Economic Bulletin*, 2021, *6.*

Bindseil, Ulrich, Marco Corsi, Benjamin Sahel, and Ad Visser, "The Eurosystem collateral framework explained," *Occasional Paper Series*, 2017, (189).

Cassola, Nuno and Francois Koulischer, "The collateral channel of open market operations," *ECB Working Paper Series*, 2016, (1906).

Corradin, Stefano and Suresh Sundaresan, "LOLR policies, banks' borrowing capacities and funding structures," *ECB Working Paper Series*, 2022, (2738).

Drechsler, Itamar, Thomas Drechsel, David Marques-Ibanez, and Philipp Schnabl, "Who Borrows from the Lender of Last Resort?," *Journal of Finance*, 2016, *71* (5).

Grandia, Roel, Petra Haenling, Michelina Lo Russo, and Pontus Aberg, "Availability of high-quality liquid assets and monetary policy operations: an analysis for the euro area," *ECB Occasional Paper Series*, 2019, (218).

Kedan, Danielle and Alexia Veghazy, "The implications of liquidity regulation for monetary policy implementation and the central bank balance sheet size: an empirical analysis of the euro area," *ECB Working Paper Series*, 2021, (2515).

Koulischer, Francois and Patrick Van Roy, "Using bank loans as collateral in Europe: The role of liquidity and funding purposes," *Working Paper Research, National Bank of Belgium*, 2017, (318).

Schmidt, Kirsten, "Does liquidity regulation impede the liquidity profile of collateral?," *ECB Working Paper Series*, 2019, (2256).

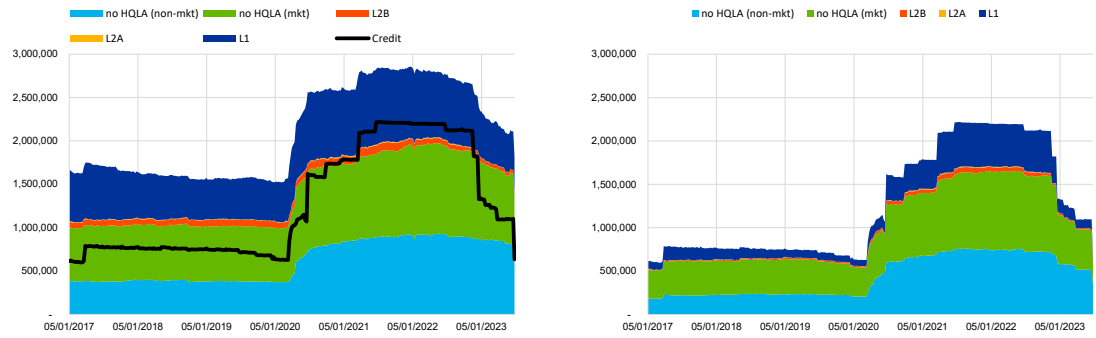
Appendix

This appendix collects supplementary analyses, charts and robustness checks mentioned in the main paper.

Composition of mobilised vs encumbered collateral over time

Section 4.2 shows how the liquidity transformation rate evolves on aggregate over time. This reflects the composition of different asset types in terms of LCR categories ranging from the least liquid categories (non-HQLA non-marketable) to the most liquid (L1 HQLA). Based on the mapping of assets to LCR-liquidity categories, figure A.1a shows how the underlying composition of mobilised collateral evolved over time, split by asset class, together with total outstanding credit (black line). Applying the "waterfall" approach to identify the amount of encumbered assets for each bank and liquidity category results in the composition of encumbered assets in figure A.1a. By construction, the composition of encumbered collateral (figure A.1b) is strongly tilted towards less liquid assets: While L1 assets account for 23% of mobilised collateral, they make up only 7% of encumbered collateral. On the other side, non-HQLA assets (both marketable and non-marketable) account for 74% of mobilised collateral but for 92% of encumbered collateral. More than half of these mobilised non-HQLA assets is comprised by marketable non-HQLA assets which primarily consist of own-used covered bonds and retained ABS. Finally, both L2A and L2B assets play only a minor role for both mobilised and encumbered collateral, accounting for 2% of mobilised and 1% of encumbered collateral.

Figure A.1: Mobilised and encumbered collateral by LCR liquidity category (2017 - 2023



(a) Mobilised collateral and credit outstanding

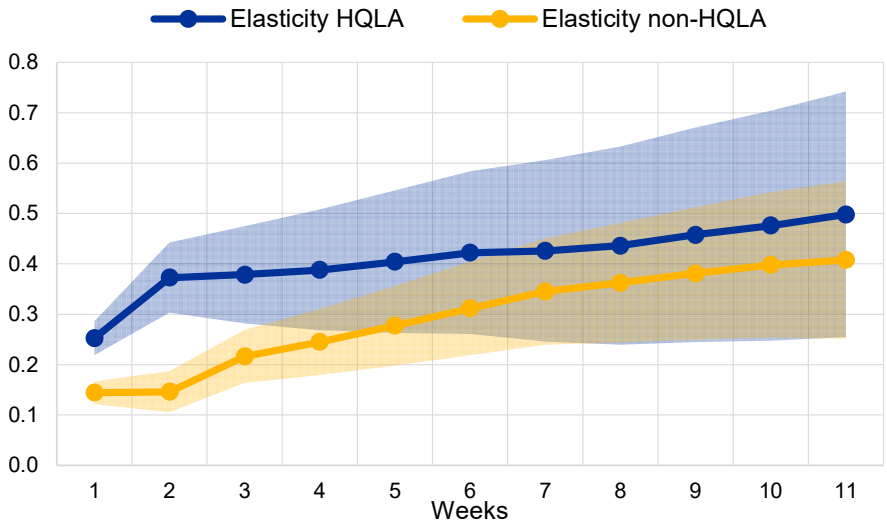
(b) Encumbered collateral

Notes: Left graph shows the composition of value after haircuts of mobilised collateral in EUR million by LCR liquidity category together with outstanding Eurosystem credit (black line). The right graph shows the value after haircuts of encumbered collateral which by construction adds up to total outstanding credit. Encumbrance is defined at the counterparty level applying the "waterfall" approach outlined in the text.

Elasticity of different collateral types with respect to outstanding credit

Figure 3 in section 4.1 shows that banks demobilised HQLA much more proactively than non-HQLA following the repricing of the TLTRO-III operations in November 2022. While this is just one snapshot date, figure A.2 shows the elasticity of HQLA vs non-HQLA with respect to a one percentage point change in outstanding credit for a larger set of data points (ranging from 2017 to June 2023). It also shows how the elasticity evolves in the weeks after a change in outstanding credit.

Figure A.2: Elasticity of collateral mobilisation to changes in credit (2017 - 2023)



Notes: The chart shows the elasticity of HQLA vs non-HQLA mobilisation (before haircuts) with respect to a 1 percentage point change in outstanding credit in week zero. It is based on a local projection regression using weekly data from Jan 2017 to June 2023.

Main results of first identification approach with *encumbered* collateral

Table 2 in section 5.2 shows the main results for the first identification approach which regresses changes in the liquidity transformation rate (Δ LTR) on changes in *mobilised* collateral. Table A.1 below shows the same results using however *encumbered* rather than mobilised collateral, i.e. applying the LCR 'waterfall' approach which counts only assets as encumbered if they are actually used for outstanding credit starting with the least liquid collateral first. The coefficient in the first three specifications that do not control for changes in credit is almost 3 times as large as in the regression with mobilised collateral on the left-hand side. The reason is that the larger share of encumbered assets in conjunction with the waterfall encumbrance approach mechanically increase the share of encumbered liquid assets in the collateral pool (see section 4.2). This mechanical effect is not present for mobilised collateral and hence the coefficient is larger. Once controlling for changes in credit, the coefficient of collateral value after haircuts (CVAH) on changes in the liquidity transformation rate is very similar as in table 2. That illustrates that the marginal effect of changes in the amount of collateral on the liquidity profile of the collateral pool does not depend on whether only encumbered collateral is considered or the overall portfolio of mobilised collateral.

Table A.1: Changes in liquidity transformation rate vs changes of *encumbered* collateral

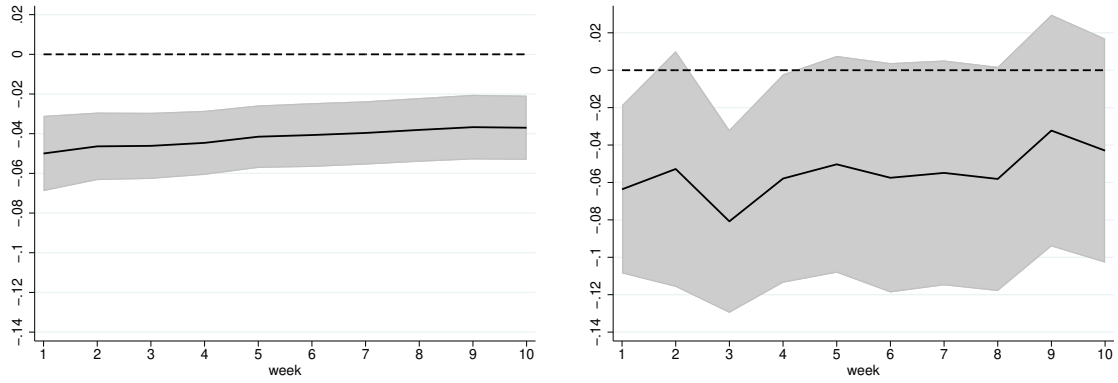
	(1) Δ LTR	(2) Δ LTR	(3) Δ LTR	(4) Δ LTR	(5) Δ LTR
Δ CVAH	-0.098***	-0.099***	-0.097***	-0.063***	-0.062***
	(0.014)	(0.015)	(0.014)	(0.023)	(0.023)
LTR (T=0)			-0.036***	-0.036***	-0.037***
			(0.003)	(0.003)	(0.003)
Δ credit				-0.034*	-0.034*
				(0.020)	(0.020)
Δ Credit x Δ CVAH				-0.000	0.000
				(0.002)	(0.002)
Bank FE	NO	YES	YES	YES	YES
Time FE	NO	NO	NO	NO	YES
Observations	281210	281210	281210	281210	281210
Adjusted R^2		0.131	0.147	0.147	0.153

Notes: Panel regression across counterparties and weeks of changes in the liquidity transformation rate (Δ LTR) on changes in encumbered collateral (Δ CVAH, i.e. collateral value after haircuts). Both the LTR and CVAH are based on encumbered collateral following the LCR 'waterfall' approach of counting least liquid assets as encumbered first up to a point when all outstanding credit is backed by encumbered collateral and changes refer to one-week changes ($h = 1$). Δ LTR denotes percentage point changes ($\Delta LTR = LTR_t - LTR_{t-1}$) whereas Δ CVAH refers to percent changes ($\Delta CVAH = CVAH_t/CVAH_{t-1} - 1$). Asterisks *,** and *** denote significance at the 10%-, 5%- and 1%-significance levels respectively. The negative coefficient on Δ CVAH indicates that a 1 percent increase in collateral reduces the average liquidity transformation rate of a bank by 0.062 percentage points in the baseline regression which controls for the initial level of liquidity transformation, as well as changes in credit and bank- and time-fixed effects.

Persistence of main results of first identification approach

Tables 2 and A.1 show that the liquidity transformation rate decreases when banks mobilise (or encumber) additional collateral. These results are based on one-week changes in collateral and the respective LTR. To better understand how persistent these relationships are, figures A.3a and A.3b show the coefficient of $\Delta CVAH$ on the liquidity transformation rate for up to 10 weeks together with the 95% confidence intervals. I find that the coefficient remains remarkably stable and significant which indicates that the correlation between inflows of new collateral and a more liquid collateral composition is neither spurious nor short-lived but rather a persistent pattern. In turn, this persistence implies that the more liquid profile of additional collateral is not driven by timing-related operational considerations: If it were the case that counterparties mobilise liquid collateral first and then replace the more liquid collateral with less liquid non-HQLA assets subsequently, then the pattern in figure A.3a would be less persistent and dissipate over time.

Figure A.3: Coefficient of Δ CVAH on LTR for different horizons



(a) Mobilised collateral

(b) Encumbered collateral

Notes: The graph displays the coefficient of regressing Δ LTR (liquidity transformation rate) on Δ CVAH (collateral value after haircuts) for different time horizons h (horizontal axis), controlling for changes in credit as well as bank- and time-fixed effects. LTR and CVAH are based on mobilised (encumbered) collateral in the left (right) graph. The shaded area denotes the 95% confidence band.

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Banks in the euro area can generate high-quality liquid assets (HQLA) by borrowing central bank reserves from the Eurosystem against non-HQLA collateral. This paper quantifies the extent of this liquidity transformation and finds that on average EUR 0.92 of net HQLA are generated for each euro of credit provided by the Eurosystem. The paper then identifies intentional liquidity transformation using two novel approaches: The first approach compares the liquidity profile of already pledged vs new collateral, and the second approach compares the liquidity profile of the pool of pledged securities with banks' total eligible securities holdings. Both approaches show that banks use their least liquid assets as collateral first and pledge more liquid assets only at the margin. This intentional liquidity transformation is sizable and accounts for 30-60% of generated HQLA.
These results are relevant for calibrating the collateral framework as well as the optimal size and composition of the Eurosystem balance sheet.

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