Safe Asset Scarcity and Monetary Policy Transmission [*]

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Abstract

Most central banks exited their decade-long accommodative monetary policy cycle by first raising rates, rather than starting by reducing their balance sheet. We show that the scarcity of government bonds—which were purchased under QE and held by central banks—reduces the transmission of rate hikes to money market rates. In July 2022, when the ECB increased its policy rates by 50bp for the first time in a decade, rates of repo transactions collateralized by the scarcest bonds increased by only 30bp. We show that this imperfect pass-through to repo rates is priced in treasury yields. Heterogeneous bond holdings across institutions imply that collateralized funding costs vary significantly across European institutions.

JEL Classification Codes: E51; E52; E58; G21.

Keywords: Monetary policy; repo market; safe assets; quantitative easing; ECB.

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1 Introduction

> *The Eurosystem's outright holdings of euro area sovereign bonds currently amount to more than a third of the outstanding market (...) As a result, the "scarcity premium" that market participants must pay to obtain these assets has often been considerable, both in the repo and the bond market (...) Such asset scarcity can delay, or even impair, the transmission of monetary policy [and] implies that sovereign yields in the euro area's largest economy remain more accommodative than intended by our policy stance.*
>
> —Isabel Schnabel, Member of the Executive Board of the ECB, Money Market Contact Group meeting, Frankfurt am Main, 2 March 2023

In the last 15 years, the expansion of central banks' balance sheet went hand-to-hand with low interest rates. Most central banks decided to exit these accommodative monetary policies by hiking interest rates before shrinking their balance sheets. Under this sequencing, "quantitative tightening" occurs only after policy rates have been increased substantially.[1]

The recent experience, however, suggests that the choice of the sequencing of tightening measures is not trivial, in terms of its impact on the transmission of monetary policy. On July 27, 2022 the Eurosystem increased its policy rates by 50bp, the first hike since 2011 (Figure 1). The pass-through of this rate hike to money markets, however, was imperfect. While unsecured market rates increased one-to-one with the change in policy rates, the largest segment of the money market—the repo market— was sluggish, missing the target by more than 10 basis points, or 20% of the increase.

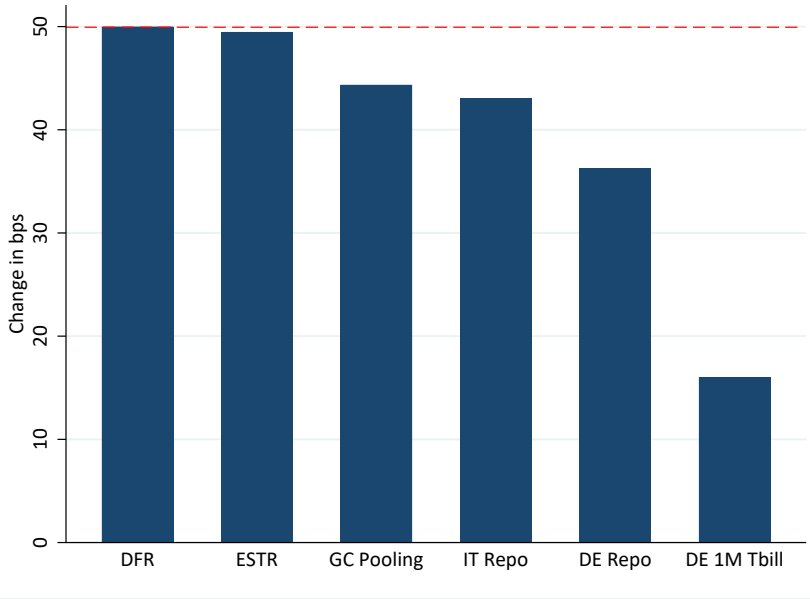
In this paper, we show that the main driver of this imperfect pass-through to money market rates is the safe asset scarcity that was partly the result of the ECB's QE. We characterize safe asset scarcity by looking at bonds' "specialness premium", the spread between the repo rate quoted for a specific bond and the risk-free rate. The specialness phenomenon was initially characterized by Duffie (1996), who identified it in the context of the US debt issuance cycle. However, it has become a structural feature of the Euro-Area money market, and is far from restricted to on-the-run sovereign bonds: in July 2022, for example, more than 80% of sovereign debt traded on special.

Using transaction-by-transaction data from the repo market, we show that contracts backed by bonds with the lowest repo rate, i.e., by the most special bonds, experienced the lowest pass-through. In other words, market participants that owned a very scarce bond and used

[1] "Our normalisation process entails a sequence whereby interest rate increases precede the reduction in our balance sheet", Pablo Hernández de Cos, member of ECB Governing Council. See also "Lagarde Says ECB Will Debate QT Once It Has Normalized Rates", Bloomberg, 26 September 2022.

Figure 1. Pass-through of money market rates for the July 2022 rate hike

The bars show the change between the 5-day average before and after the ECB rate hike by 50bp on July 27, 2022. For DFR, ESTR, GC Pooling and Repo rates, we use the relevant implementation dates. For Tbill, we use the announcement date. Repo rates are computed as the volume-weighted repo rates using transactions settled at DFR-5bps and below, ie. below the GC Pooling rate. GC Pooling is against the extended GC basket, from Eurex. Data on repo transactions are obtained from MTS, Brokertec, and MMSR.



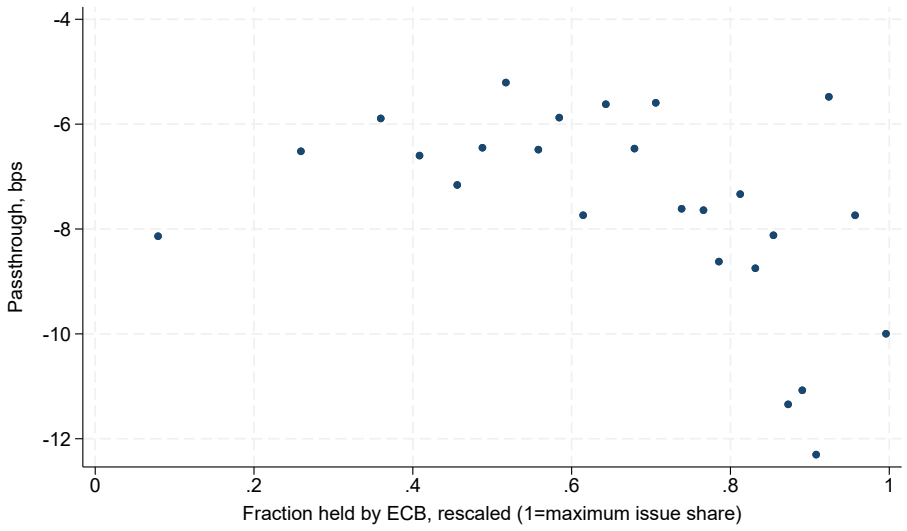
it as collateral to borrow cash saw their borrowing cost increase by less than the change in the main monetary policy rate, contrary to what was experienced by a market participant pledging a widely-available bond.

We trace the source of a bond's specialness to the bond scarcity that resulted from the central bank's QE programs. The fraction of a bond's amount outstanding held by the central bank precisely and persistently predicts that bond's specialness rate and, thus, the extent to which a change in policy rate is passed-through to money market transactions involving that bond. Figure 2 illustrates our main finding: when the central bank increased their policy rate by 50bp in July 2022, the degree to which the rate was reflected in a loan collateralized by a given security depended on the how scarce the central bank purchases had made that security—as measured in December 2021.

A sluggish response of repo rates is a clear symptom of lack of passthrough to money markets, the first step of monetary policy transmission. Moreover, we show that the in-

Figure 2. Pass-through and QE purchase quantities

This figure shows the relation between the pass-through of the July 2022 interest rate hike for a given bond and the fraction of that bond's amount outstanding that had been purchased by the ECB in the APP and PEPP programs. Passthrough is defined as the change in individual bond repo rate, ie. at which a trader could borrow using a specific bond as collateral, minus the chnage in DFR rate. A perfect passthrough would be then at 0. The plot is a binscatter plot, showing the aggregated holdings and passthrough of securities issued by Germany, France, Italy, and Spain. X-axis reports the share held by the Eurosystem over the amount outstanding, rescaled by the maximum issue share, as issue shares themselves are confidential. Sources: MTS, Brokertec, and MMSR.



creased specialness premia also affect i) bond prices and ii) investors' funding costs. First, we find that a lack of passthrough on the repo market, which corresponds to an increased specialness premium, is reflected in bond prices: As specialness premium constitutes an additional 'dividend' for investors holding scarce bonds, the prices of bonds that are scarce decrease less around rate hikes. Second, we consider banks' portfolio holdings and show that banks funding costs display a significant heterogeneity in their increase surrounding rate hikes. We show further that funding costs increased heterogeneously across countries and investors types, based on the composition of their bond portfolio.

We explain the heterogeneity in pass-through by way of the composition of bonds' holders, specifically considering their propensity to participate to the repo market. We show that bonds with the weakest pass-through are held by investors whose elasticity to the repo rate is lower. On the one side of the spectrum, inelastic investors (among which is the Eurosystem itself, who limits the amount of bonds it lends back against cash) scarcely increase the amount of bonds they lend, as rates increase. On the opposite side, repo rates

of bonds held more heavily by financially sophisticated investors such as banks react more in line with changes in risk-free rates. That is because banks take advantage of the cheap borrowing afforded to them by the special bonds they hold, meaning that they cash in on the specialness premium, lending the proceeds at a higher risk-free rate.

Our paper is the first to document the tension between the effectiveness of interest rate policy and the size of the central bank's balance sheet. The decision to engage in tightening conventional monetary policy separately from, and prior to, Quantitative Tightening results in a higher dispersion of repo rates and yields. Our analysis has clear policy implications: in the context of rising interest rates, a central bank may improve the transmission of its monetary policy rates to money markets by increasing the provision of safe assets to the market. In other words, our findings support synchronizing interest rate hikes with the reduction of a central bank's footprint on bond markets. Alternatively to engaging in Quantitative Tightening, the Eurosystem can modulate scarcity by adjusting its securities lending facility's conditions.

The remainder of this paper is organized as follows. Section 2 details our contribution to the literature. Section 3 describes the institutional environment of the euro area money markets, how it is affected by monetary policy and the lack of safe assets. Section 4 details our empirical analysis. We offer policy implications in Section 5.

2 Literature Review

Our paper relates to three strands of literature. First, our paper relates to the body of work investigating how well a central bank can control short-term interest rates in an environment when its balance sheet is large. Many papers including by Bech and Klee (2011), Frost, Logan, Martin, McCabe, Natalucci, and Remache (2015) and Copeland, Duffie, and Yang (2021) have investigated the matter in the US since 2008 and showed that such control is more difficult than one would have anticipated, suggesting that the Fed should introduce news tools to ensure a smooth transmission of its interest rate hikes (Bech and Klee, 2011). In the case of the euro area, papers have shown that money market rates may fluctuate within the central bank corridor (Vari, 2020) and even fall below due to asset purchases (Arrata, Nguyen, Rahmouni-Rousseau, and Vari, 2020). Eisenschmidt, Ma, and Zhang (2022) show that competition in the money market has reduced monetary policy pass-through in a context of rate cut. Ballensiefen, Ranaldo, and Winterberg (2020) show that differentiated access to the remuneration of reserves at the central bank and

bond eligibility to QE participate to disconnect the repo rates of collateral-driven vs cash-driven transactions.Our paper is the first to document that policy rate hikes are imperfectly transmitted as a consequence of safe asset scarcity.

Second, our paper deal with the specialness premium quoted on the repo market (Duffie, 1996; Krishnamurthy, 2002), specifically in how it is affected by monetary policy (Arrata, Nguyen, Rahmouni-Rousseau, and Vari, 2020; Corradin and Maddaloni, 2020; Pelizzon, Subrahmanyam, Tomio, and Uno, 2018). We show that contrary to US, in the Euro-Area all bonds are special and that specialness reduces the interest rate pass-through.

Third, we also contribute more broadly to the literature on the demand for safe assets (Krishnamurthy and Vissing-Jorgensen, 2012; Greenwood, Hanson, and Stein, 2015). Nagel (2016) shows that demand for short-term safe investment engenders a premium, in particular for short-term Treasuries. Greenwood, Hanson, and Stein (2015) and Caballero, Farhi, and Gourinchas (2017) stress the adverse financial stability and macroeconomic effects of a lack of safe assets. We contribute to this literature by showing the interaction of safe asset scarcity and monetary policy.

3 Tightening monetary policy in times of large central bank balance sheet and safe asset scarcity

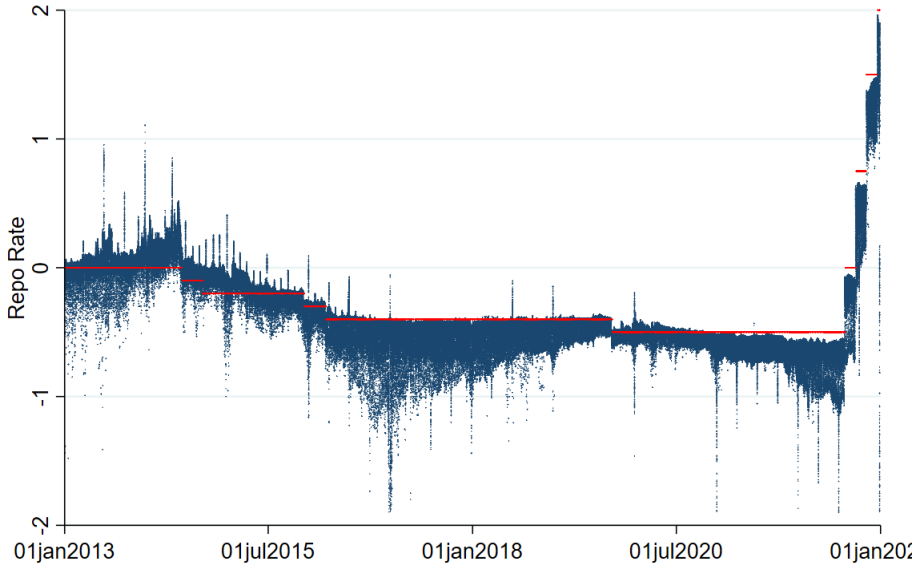
In this section, we elaborate on the effect that QE had on repo rates and bond yields, on mechanisms that can lead to an imperfect passthrough on repo rates, and on the link between repo rates, yields and asset swap spreads.

3.1 The impact of central bank asset purchases on the repo market

Since 2015, bond repo rates have declined substantially below the deposit facility rate (Figure 3), a timing that coincided with the Eurosystem foray into large-scale asset purchases. In fact, as the Public Sector Purchase Program (PSPP) and the Pandemic Emergency Purchase Programme (PEPP) started in 2015 and 2020 respectively, the percentage of bonds trading "on special" increased dramatically and reached 100% in 2015 and 2022 for Germany, and 50% and 100% for Italy (other countries follow similar patterns), as shown in Figure 4. The co-movements between central bank asset purchases and declining repo rates has several causes.

Figure 3. Security-specific interest rates on the repo market

This figure shows the rates at which repo transactions took place. Each point represents the weighted-average repo rate for a specific sovereign bond issued by Germany, France, Italy, and Spain, the four largest Euro-Area countries. We focus on spot-next transactions. We report the ECB's main policy rate, the deposit facility rate, in red. Data on repo transactions are obtaind from MTS, Brokertec, and MMSR.

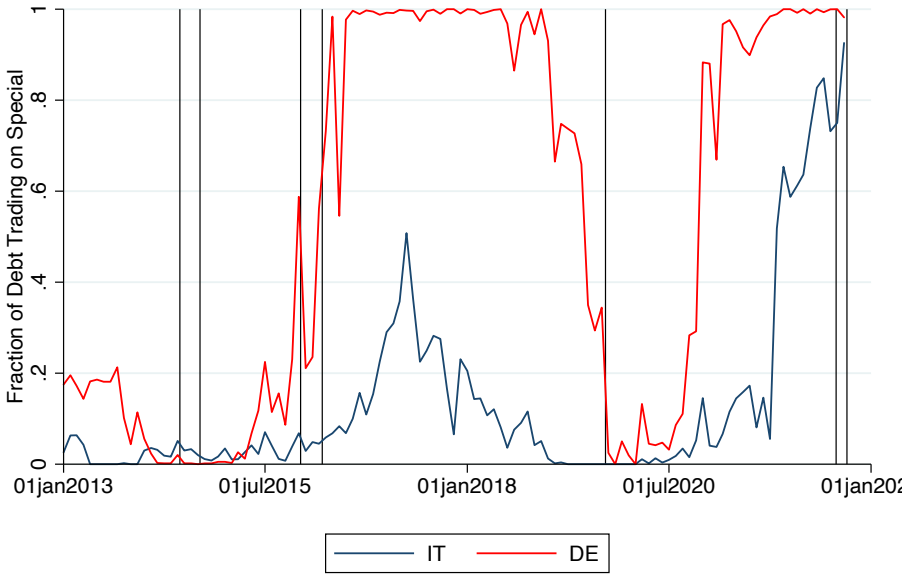


In the very short run, the large amounts of purchases from the central bank coupled with search frictions force dealers receiving these orders to borrow these bonds on the SC market to short-sell them to the central bank (Ferdinandusse, Freier, and Ristiniemi, 2020). Beyond these flow effects, once dealers have shorted the bonds, they need to roll-over the repo position until they have managed to purchase the bonds, prolonging their specialness. In principle, the market could remain structurally short of the bond forever, if dealers prefer to roll-over their repo position rather than buy the bond. Given the current amount of bonds held by the Eurosystem, it is likely that dealers face only very inelastic sellers on the bond market, chiefly the Eurosystem (which never sold any bond it purchased) and other long term holders such as insurance companies and pensions funds (Koijen, Koulischer, Nguyen, and Yogo, 2021). In the medium run, central bank asset purchases may structurally increase demand on the repo market and decrease supply, because the Eurosystem lends its bonds at market conditions or worse (Arrata, Nguyen, Rahmouni-Rousseau, and Vari, 2020; Baltzer, Schlepper, and Speck, 2022; Greppmair and Jank, 2022).

More importantly, repo rates may fall not because of market microstructure mechanism but because of an imbalance between safe asset supply and demand, exacerbated by central

Figure 4. Fraction of sovereign debt trading on special

This figure show the fraction of sovereign debt issued by Italy in blue (Germany in red) that trades on special on the repo market. We calculate this quantity on a monthly frequency and identify a bond as trading on special if the volume-weighted average rate for repo transactions using it as collateral is 10bp or more below the ECB's main policy rate, the deposit facility rate. Data on repo transactions are obtained from MTS, BrokerTec, MMSR, while data on debt outstanding are obtained from the ECB's Centralized Securities Database (CSDB).



banks. As the central bank buys Government bonds, the cash balances of non-bank increases and eventually find their way to the banking system (Koijen, Koulischer, Nguyen, and Yogo, 2021; Acharya and Rajan, 2022). One safe way to hold such large amount of cash in banks may be the repo market. Central bank asset purchases thus lower repo rates as they increase the supply of cash from non-banks and reduce the amount of bonds available. While in theory, this phenomenon should affect only the least scarce of the bonds (those trading on the GC market), recent literature shows that bonds with very low repo rates are also used to secure cash-driven trades, or GC transactions (Ballensiefen, 2022).

3.2 Rate Hikes when Assets Are Scarce

In the next section, we show that when interest rates increase, the repo rates (specialness premia) for the most special bonds do not increase as much as (increase more than) they do for less special bonds. As our finding is consistent with an increase in the demand for repo trades around rate hikes and, alternatively or in addition to it, a decrease in the supply of

bonds on the repo market, we lay out in this section the theoretical work consistent with this set of styled facts.

Nagel (2016) shows that, as interest rate rise, the demand for money-like assets increases, as well. Money-like assets include Treasury bills, certificates of deposit, commercial paper, and repo transactions. As rate increase, investors opportunity cost for holding cash increases as well, and so does their demand for repos, which depresses repo rates. The increase in money-like demand is proportional to the willingness of investors to substitute between cash and a given asset, i.e., with an asset's convenience yield. To the extent that bonds' specialness captures the asset's convenience, we expect that the increase in demand will be most prominent for the most special bonds.

Also, following monetary policy shocks, the demand for hedging against further rate hikes may also increase. Hedging can be done by buying bond futures or short-selling long-dated bonds. Both strategies structurally increase demand for bonds on the repo market. Future require posting collateral (initial margins), while short selling is implemented by borrowing a bond on the repo market and selling it on the bond market with the intention to buy at future date.

An increase in interest rates, however, can also affect the supply of securities on the repo market. Duffie and Krishnamurthy (2016) develop a model where the passthrough of changes in interest rates to deposit rates depends on how actively depositors adjust their savings decision, the larger a proportion of depositors is likely to stick with the same bank (the less competitive the market for deposit), the worse the pass-through will be. We expect for a similar mechanism to be at play in the repo market: Investors who are more attentive to a bond's specialness will adjust their supply more aggressively, thus contributing to a more precise pass-through; on the other hand, passive bond holders will not increase their supply to benefit from a bond's richness and impede the pass-through. To the extent that bonds that are more special are held by less sophisticated investors, we expect that repo rates for richer bonds will increase less around rate hikes, owing to the composition of their holders. This argument is similar to the heterogeneous repo supply curves found in Duffie (1996) and Krishnamurthy (2002)—specifically, with more special bonds being held by less elastic investors.

Finally, rate hikes can affect investors' propensity to engage in arbitrage trades, specifically, the special-to-GC arbitrage trade found in Duffie (1996): Rate hikes are passed through to money markets if investors holding a scarce bond lend it against cash and invest the cash at the risk free rate (GC or DFR/IOER). To the extent that this arbitrage trade requires capital—for example, because investors fund haircuts at unsecured rates—as rates increase,

so does the cost of engaging in this arbitrage, leading to passthroughs that are worse the higher the level or interest rates.

4 Results

Our main data source, is the money market statistical reporting (MMSR). This trade-by-trade reporting was introduced in 2016 to monitor the money market and includes all trades between wholesale market participants in the money market, i.e., borrowing/lending transaction with a maturity lower than one year. MMSR contains repo transactions in Euro conducted by the 50 largest dealers. For each transaction, we can observe its trade date, counterparties, rate, amount, and collateral used. We merge this dataset with the Securities Holdings Statistics (SHS), which reports quarterly data holding for every security, aggregated at the sector-country level. We obtain daily bond prices and yields from Bloomberg.

4.1 Specialness, Scarcity, and Rate Hike Pass-through

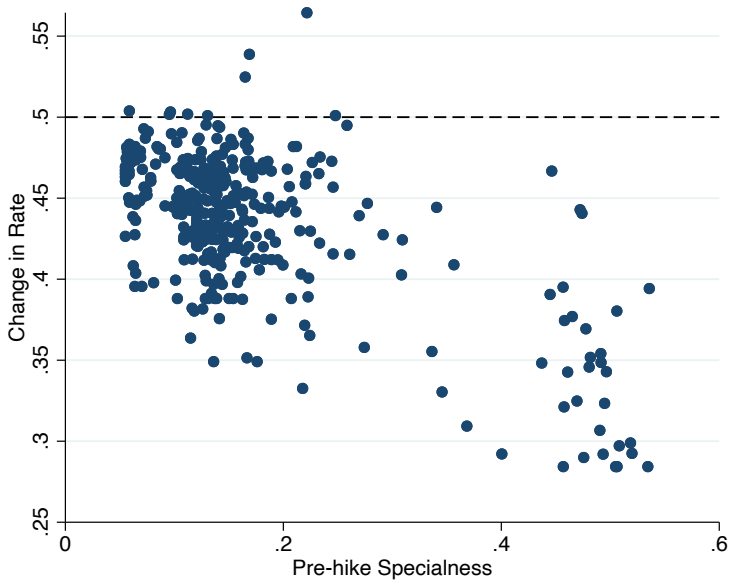
We define pass-through as the change in repo rates for each individual bond. We compute the change as the difference between the average rate over five business days before the implementation of the hike and the five days after, $\Delta Specialness = Specialness_i^{Aft} - Specialness_i^{Bef}$. $Specialness_i^{Bef}$ ($Specialness_i^{Aft}$) is the average specialness premium for bond-i, averaged over the five business days that preceded (follow) the implementation of the rate hike.

Figure 5 provides a graphical representation of our first set of results, where we plot $\Delta Specialness$ on the y-axis.. As the central bank increased rates by 50bp, the interest rate in repo transactions similarly increased by 50bp, but only for the least special of assets. A trader pledging an asset with a specialness of 60bp, on the other hand, would have only experienced an increase of 28bp in their borrowing rate.

For the remainder of the paper, as our interest is on the passthrough of monetary policy to repo rates, we focus on the changes in specialness premium net of changes to the policy rate, $Passthrough_i = \Delta Specialness_i - \Delta DFR$, allowing us to extend the analysis to other rate hikes. Specialness, however, may be correlated with other bond characteristics, which could similarly impact changes in the bond's repo rate around rate hikes. We regress the pass-through measures on $Specialness_i^{Bef}$, the bond's coupon rate, initial and residual maturity,

Figure 5. Scarcity and change in repo rates

In this figure, we show the relation between the repo market specialness prior to the July-2022 rate hike, and the change in repo rate around the rate hike, $\Delta Specialness$. Repo rates are calculated as a weighted average of transactions that took place five days before or after the rate hike. Data on spot-next repo transactions are obtained from MMSR.



and the haircut quoted if the bond was pledged at the ECB for cash:

$$Passthrough_i = \alpha + \beta_1 * Specialness_i^{Bef} + \beta_2 * X_i + \epsilon_i \quad (1)$$

Allowing for country-specific drivers of changes in repo rates, we include country–fixed effects. We report the results in Table 1, which shows that a bond's scarcity, as measured by its repo specialness, is highly statistically significant in its subsequent change in repo rate: a 50bp-increase in specialness decreases the pass-through by 14bp. The result is robust to including bond- or country-specific controls. In other words, bonds that were the most scarce before the hike have witnessed a lower pass-through, and impeded the transmission of monetary policy.

While the focus of this section is the first rate hike, in July 2022, our findings apply to subsequent rate hikes as well, as we show in Table 2. We report the results of a specification similar to that of Eq. 1, where we regress changes in specialness premia surrounding the four rate hikes between July and September on a set of four dummies, each of them equal to one for the change around a specific hike, multiplied by a bond's pre-hike specialness.

Table 1
Pass-through to Money Market Rates and Bond Specialness

This table reports the estimation of Eq.1. The left-hand side variable is the pass-through for each bond i in the repo market, ie. the change in its repo rate between 5 business days before and after the July 2022 rate hike net of changes to the deposit facility rate, $Passthrough_i$ (or PT_i, for short). For each bond i the repo rate is the weighted average repo rate of the transactions reported in MMSR and collateralized by this bond. The pass-through variable takes the value of zero in case of a perfect transmission of the 50bp rate on bond i repo rate. $Specialness_i^{Bef}$ is the average repo rate of bond i the 5 business days preceding the implementation of the rate hike. Initial maturity and residual maturity are expressed in years. Country-FE are issuer-country fixed effects.

	PT_i	PT_i	PT_i
$Specialness_i$	-0.541***	-0.553***	-0.499***
	(-9.23)	(-8.49)	(-6.06)
Coupon rate		0.000677	0.00340
		(0.14)	(0.70)
Init. maturity		-0.000735	-0.00116
		(-0.50)	(-0.82)
Resid. maturity		0.00152	0.00339*
		(0.99)	(1.89)
ECB haircut		-0.00142	-0.00717*
		(-0.80)	(-1.70)
Country FE	No	No	Yes
Adj. R2	0.31	0.31	0.34
Obs	357	357	357

Table 2
Pass-through to Money Market Rates for Different Hikes

This table reports the results of a regression of bonds specialness changes around four rate hikes between July and December 2022 on a dummy that equals one for the change surrounding a specific rate hike, and zero, otherwise. The dependent variable measures the change in a bond's repo rate between 5 business days before and after each rate hike. The pass-through variable takes the value of zero in case of a perfect transmission of the 50bp rate on bond i repo rate. Each hike dummy is interacted with the weighted average repo rate of the transactions reported in MMSR and collateralized by a specific bond five days before the hike. We control for bond-, and time-fixed effects.

	(1) PT_i	(2) PT_i	(3) PT_i
July x $Specialness_i^{Bef}$	0.147***	0.323***	0.428***
	(3.85)	(2.75)	(3.71)
Sept x $Specialness_i^{Bef}$	0.130**	0.191***	0.193***
	(2.27)	(3.04)	(2.96)
Oct x $Specialness_i^{Bef}$	-0.00444	0.166***	0.133
	(-0.07)	(2.72)	(1.30)
Dec x $Specialness_i^{Bef}$	0.0832*	0.355***	0.280***
	(1.95)	(3.44)	(2.90)
ISIN FE		Yes	Yes
Time FE	Yes		Yes
Adj. R2	0.10	0.13	0.14
Obs	1295	1295	1295

This specification allows us to compare rate hikes of different magnitude and, similarly to the results in Table 1, we show that specialness increased around all rate hikes, and more so the larger it was prior to the hike, resulting in a passthrough that is inversely proportional to scarcity.

Regressing changes in the repo rates on the previous level of repo rate can give rise to concerns of endogeneity. To address these concerns, we take an instrumental variable approach. Specifically, we use the shares of a bond's outstanding amount held by the central bank in December 2021 to forecast the level of the bond specialness in July 2022. That is, we perform this first-stage regression:

$$Specialness_i^{Bef} = \alpha + \beta_1 * Share\ held\ ECB_i + \beta_2 * X_i + \epsilon_i \tag{2}$$

and a second stage as in Eq. 1:

$$Passthrough_i = \alpha + \beta_1 * \widehat{Speialness}_i^{Bef} + \beta_2 * X_i + \epsilon_i \tag{3}$$

We report the reduced form, first- and second-stage regression in Table 3. The reduced form in Column 1 shows the tension between conventional and unconventional monetary policy: Bonds that have been purchased more aggressively by the central bank well before the rate hike display a significantly decreased pass-through. Column 2 confirms the results including controls. Column 3 shows that the instrument is strong and that ECB holdings positively forecast future specialness many months ahead. Columns 4 and 5 show that central bank-driven scarcity, created by QE purchases and manifested in repo specialness, impedes the pass-through of rate changes: A 50bp increase in rate hikes increases money market rates by only 32bp for bonds with a 50bp level of specialness.

Table 3
Pass-through to Money Market Rates and Bond Specialness - Instrumental Variables

This table reports the estimation of Eq.3. The left-hand side variable is the pass-through for each bond i in the repo market, taking the value of zero in case of a perfect transmission of the 50bp rate on bond i repo rate. $Specialness_i^{Bef}$ is the average repo rate of bond i the 5 business days preceding the implementation of the rate hike. The first column is the reduced-form estimation of the 2SLS: Share held by the ECB, at the righ-hand side, is the fraction of bond i amount outstanding held by the Eurosystem in 2021Q4 (APP and PEPP holdings cumulated). In column (2) the first stage instruments $Specialness\_i^{Bef}$ by the share held by the ECB. Columns (3) and (4) report the results of the second stage.

	OLS		1st	2nd stage	
	(1)	(2)	(3)	(4)	(5)
Share held ECB	-0.0909**	-0.0909**	0.137***		
	(-2.32)	(-2.38)	(3.71)		
$Specialness_i^{Bef}$				-0.665***	-0.636***
				(-2.63)	(-2.60)
Coupon rate		0.0144***			-0.00175
		(2.61)			(-0.23)
Init. maturity		-0.00290*			-0.000186
		(-1.89)			(-0.10)
Resid. maturity		0.00218			0.00123
		(1.35)			(0.77)
ECB haircut		0.00382**			-0.00221
		(2.16)			(-0.75)
F-stat	5.4	4.7	13.8	6.9	7.0
Adj. R2	0.02	0.04	0.04	0.29	0.30
Obs	357	357	357	357	357

4.2 Competition and Regulation

We attribute the lack of pass-through to bond scarcity, as measured by high specialness premia. But other phenomena may impede the transmission of monetary policy. Two other explanations have beeen put forward by the literature: the structure of competition of the Euro-Area repo market (Eisenschmidt, Ma, and Zhang, 2022) and the ability of market participants to access the Eurosystem's deposit facility (Ballensiefen, Ranaldo, and Winterberg, 2020). According to Eisenschmidt, Ma, and Zhang (2022), dealers—the large banks that intermediate the repo market and report their trades to the MMSR database—are able to extract rents from their customers. Most notably, they show that dealers did not lower the rate at which they borrowed cash (lent securities) as much as the central bank cut the rate in September 2019. The pass-through, therefore, varied according to whether dealers where trading with other dealers or with non-dealers, and further varied according to the client's degree of sophistication.

In order to control for this phenomenon, we calculate the pass-through at the ISIN-dealer-customer level. We repeat the analysis in Eq. 1 and saturate the regression with dealers-, customers-, and dealers-by-customers-fixed effects to allow for the nature of the business relationship between a customer and a dealer to impact the pass-through. The regression writes as follows:

$$Passthrough_{icd} = \alpha + \beta_1 * Specialness_{icd}^{Bef} + \beta_2 * X_i + FE_d + FE_c + \epsilon_{icd} \tag{4}$$

where $Passthrough_{icd}$ is the pass-through of repo contracts backed by bond-i and agreed between between dealer-d and customer-c.

We show the results in Table 4. Although the coefficients associated with specialness are more muted than in baseline regressions shown in Table 1, they are strongly significant and negative, at -0.437 in the most conservative estimation (vis-a-vis -0.499 in Table 1). Moreover, the comparison between the R^2 in Specification 1 and 4 indicate that scarcity explains a larger fraction of the variation in pass-through than competition. It implies that the structure of competition matters for the pass-through of monetary policy to repo rates, but that specialness seems to be a more important factor in this case.

Table 4
Pass-through and Customer-Level Effects

This table reports the estimation of Eq.4. The left-hand side variable is the pass-through for each bond i at the ISIN-customer-dealer level. We define dealers as the reporting banks to MMSR and customers their counterparties in the repo transactions. $Specialness_i^{Bef}$ is the average repo rate of bond i the 5 business days preceding the implementation of the rate hike at the ISIN-customer-dealer level. Columns (1) to (4) report the estimation of Eq.4 introducing fixed-effects once at a time. Column (5) gives the variance explained by the fixed effects and the controls, excluding our specialness variable. Standard errors are clustered at the ISIN level.

	(1)	(2)	(3)	(4)	(5)
$Specialness_i$	-0.442***	-0.445***	-0.430***	-0.437***	
	(-8.60)	(-8.39)	(-8.05)	(-8.28)	
Coupon rate	0.00258	0.00224	0.00196	0.00208	0.0174***
	(0.54)	(0.48)	(0.43)	(0.45)	(3.10)
Init. maturity	-0.000149	-0.000317	-0.000262	-0.000318	-0.00364**
	(-0.10)	(-0.23)	(-0.19)	(-0.23)	(-2.27)
Resid. maturity	0.000570	0.000641	0.000552	0.000669	0.00279*
	(0.38)	(0.43)	(0.37)	(0.44)	(1.67)
ECB haircut	0.000213	0.000518	0.000272	-0.0000345	0.00385**
	(0.14)	(0.33)	(0.18)	(-0.02)	(2.30)
Customer FE	No	No	Yes	Yes	Yes
Dealer FE	No	Yes	Yes	Yes	Yes
Deal.-Cust. FE	No	No	No	Yes	Yes
Adj. R2	0.21	0.22	0.25	0.27	0.13
Obs	4,090	4,090	4,086	4,071	4,071

4.3 Passthrough and repo participation

Duffie (1996) and Krishnamurthy (2002) show that limited repo participation entails a larger specialness premium and a larger yield spread. Krishnamurthy (2002) describes the arbitrage for arbitrageurs/bond holders in the repo market: when bonds' supply is unconstrained, *"an investor who has a bond that is available for lending (...) could always take the funds received on lending the bond, invest them at the riskless rate (...) When the supply constraint binds, the financing rate falls below the riskless rate in order to ration the scarce supply of bonds available for borrowing. An investor owning these bonds earns a premium on lending the bonds and is able to borrow funds at the (special repo rate) and invest this at the riskless interest rate"*.

Figure 6. Passthrough and volumes traded as collateral

Passthrough in bps, averaged for all rate hikes between July and December 2022. A perfect passthrough is at 0. Average volumes at the ISIN level of collateral amount lent in the repo market around rate hikes scaled by the ISIN amount outstanding.Sources: MTS, Brokertec, and MMSR.

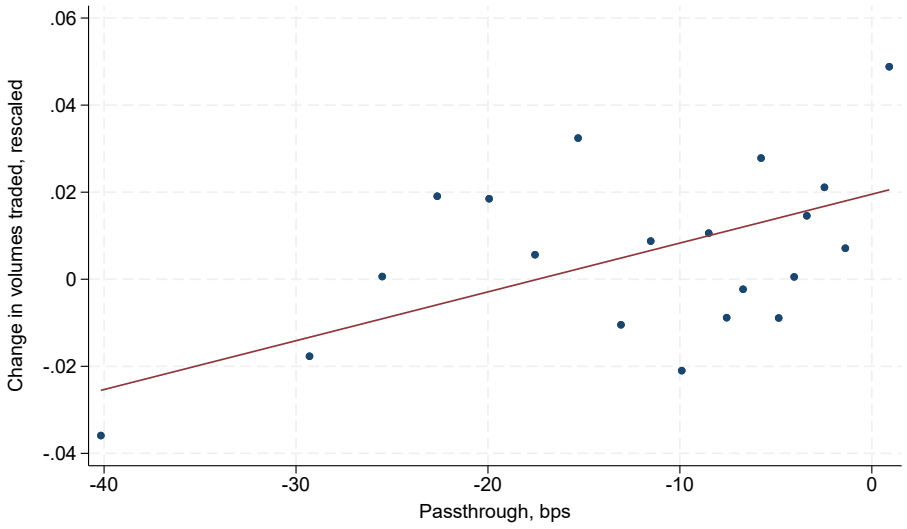
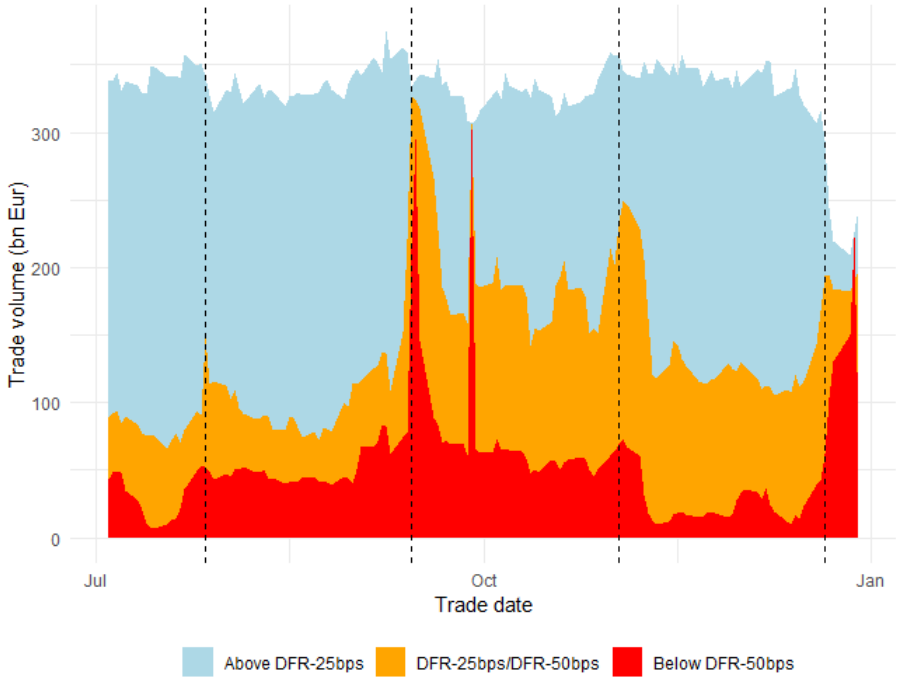


Fig. 6 shows the relation between the passthrough around rate hikes, and the increase in repo transactions that have that bond as collateral, also around the rate hikes. The figure confirms that the more a bond has been lent as collateral on the repo market, the better has been the passthrough to those transactions. Fig. 7 suggests also that indeed the most special bonds have seen an increase in usage as collateral around rate hikes, consistent with market participants engaging in the special-GC arbitrage laid out in Krishnamurthy (2002)
.

Figure 7. Repo Volume by Specialness

Trade volumes reported in MMSR on DE, FR, ES, IT government collateral, S/N tenor only. Vertical doted bars correspond to rate hikes in July, September, October and December 2022.



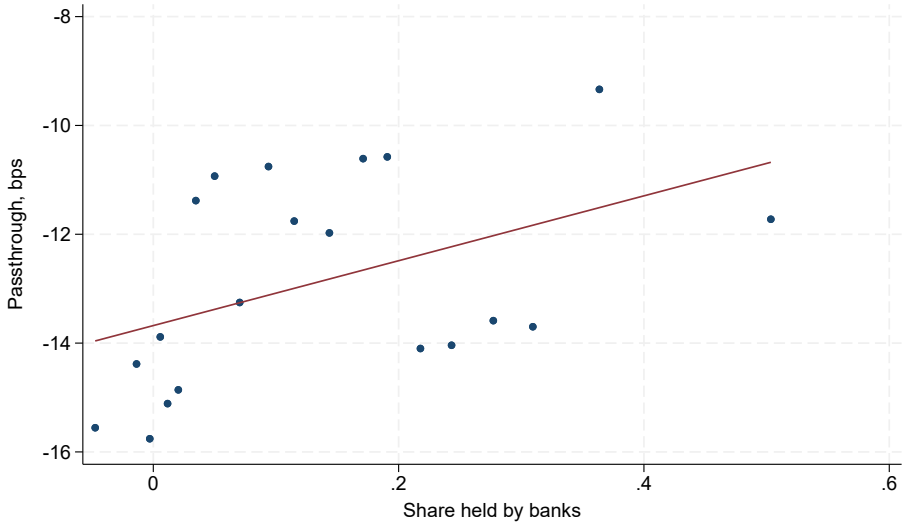
The arbitrage mechanism between repo and risk free rate is however not only affected by the limited repo participation, but also by the fact not every investor has access to the DFR, precisely the policy rate hiked by the central bank. To test whether limited repo participation and arbitrage activity may be at play, we take two approaches. First, we approximate repo participation by a bond's holder composition, assuming that an investor's sector approximates for its likelihood to engage in the repo market. Figure 8 plots a bond's passthrough for the July hike against the fraction of the bond held by banks. The plots promptly support the hypothesis that bonds that are held to a larger extent by banks exhibit better passthrough , consistent with sophisticated financial investors being more likely to engage in the arbitrage.

An investor sector, however, is only a rough proxy for its likelihood to engage in the repo market. In the second approach, we aim at capturing repo market participation directly. Fig. 9 shows that bonds that were lent more aggressively specifically by banks exhibit the most seamless passthrough.

In Table 5, we interact specialness with the share of trades by investor sector. The coefficient

Figure 8. Passthrough and the impact of bond holding structure

Passthrough in bps, averaged for all rate hikes between July and December 2022. Holding data are from the SHSS dataset as of December 2021. Data on repo transactions are obtained from MTS, Brokertec, and MMSR.



on $Specialness_i^{Bef}$ indicates that a bond with a specialness of 50bp which is entirely only transacted by the central bank (i.e., borrowed from the bank's securities lending desk) experiences a passthrough that was 27.5% of the increase in deposit rate. On the contrary, the passthrough for a bond with a similar level of specialness but which is most heavily traded by banks reflected 95% of the rate change.

Results confirm bonds have the best pass-through conditionally of being traded primarily by banks, followed by other financial institutions and lastly the Foreign sector, while bonds traded in the repo market by ICPF, Non-Financial and the Eurosystem have the worst passthrough. This is consistent with our mechanism that banks, when faced a increase in the risk free rate at which they can deposit money (eg. the DFR) engage in arbitrage between repo rates and the risk free rate, and as such transmit the rate hike to the repo rates.

Figure 9. Passthrough and volumes traded as collateral by banks

Passthrough in bps, averaged for all rate hikes between July and December 2022. Average volumes at the ISIN level of collateral amount lent in the repo market around rate hikes scaled by the ISIN amount outstanding. Sources: MTS, Brokertec, and MMSR.

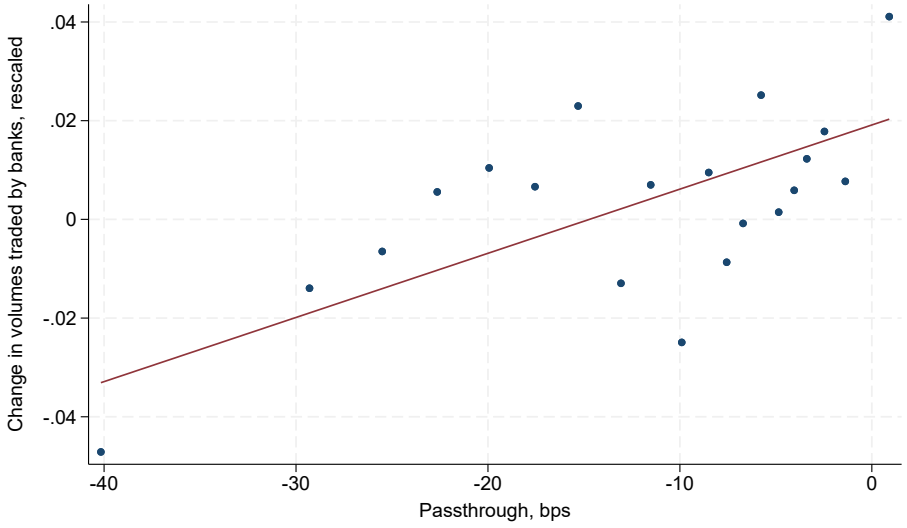


Table 5
Pass-through and investor participation in the repo market

This table reports the estimation of Eq.4 where specialness is interacted with the participation of each investor sector in the repo market. The left-hand side variable is the pass-through for each bond i at the ISIN-level. $Specialness_i^{Bef}$ is the average repo rate of bond i the 5 business days preceding the implementation of the rate hike at the ISIN level. Share volume is defined by investor sector and the Eurosystem. "Share volume MFI" is equal to 1 when only MFIs traded this bond as collateral in the repo market. Other comprises Non-financial institutions and Other financial institutions.

	(1)	(2)
$Specialness_i^{Bef}$	-5.501***	-5.149***
	(-3.34)	(-3.22)
$Specialness_i^{Bef}$ × Share volume MFI	5.402***	5.070***
	(3.20)	(3.10)
$Specialness_i^{Bef}$ × Share volume ICPF	2.378	0.306
	(0.89)	(0.13)
$Specialness_i^{Bef}$ × Share volume OFI	4.761***	4.285***
	(2.92)	(2.64)
$Specialness_i^{Bef}$ × Share volume Foreign	4.446**	4.230**
	(2.45)	(2.41)
$Specialness_i^{Bef}$ × Share volume Non-Financials	-16.76	-17.96
	(-1.29)	(-1.37)
Share volume MFI	-0.783**	-0.611**
	(-2.54)	(-2.01)
Share volume ICPF	-0.250	0.0164
	(-0.58)	(0.04)
Share volume OFI	-0.650**	-0.423
	(-2.17)	(-1.34)
Share volume Foreign	-0.595*	-0.427
	(-1.81)	(-1.34)
Share volume Non-Financials	2.359	2.802
	(1.21)	(1.43)
Country FE		Yes
Adj. R2	0.36	0.40
Obs	357	357

4.4 Lack of Pass-through and Bond Yields

In this section, we turn our attention to the impact the lack of passthrough has on the cash bond market. The impact of specialness on the market for US on-the-run Treasuries has been explored theoretically by Krishnamurthy (2002). The main intuition is that a bond which is "expensive" on the repo market (*i.e.* which has a significant specialness premium) should be "expensive" on the bond market (*i.e.* have a relatively low yield). Investors will attribute value to a bond not just because of its exposure to interest rates, liquidity, or issuer's credit risk, but because it is used as collateral.

We test that a lack of pass-trough in the repo market translates into lower yields. We estimate the following regression:

$$\Delta Y_i = \alpha_i + \beta_1 * Specialness_i^{Bef} + \beta_2 * X_i + \epsilon_i \tag{5}$$

where ΔY_i is the change in the yield of bond-i around the implementation date of the July 2022 rate hike, based on five-day median yields, and $Specialness_i^{Bef}$ is defined as before. X_i are controls and include the duration and the convexity of bond-i. We include country-, maturity-, and country-by-maturity-fixed effects, where bonds are grouped by their closest five-year round time-to-maturity for defining maturity fixed effects. We show the raw relation between the two variables of interest in Figure 10. We report the regression results in Table 6.

Coefficients are robustly negative and significant indicating that those bonds that were most special before the hike (and had the lowest pass-through) experienced the smallest increase in their yields: every specialness basis point implied a yield 0.2bp lower. This result underscores the impediment that specialness represents for monetary policy transmission: Not only does bond scarcity prevent interest rates on the repo market from rising, it also dampens the response of the yields of government bonds, the keystone of financial markets, to monetary policy.

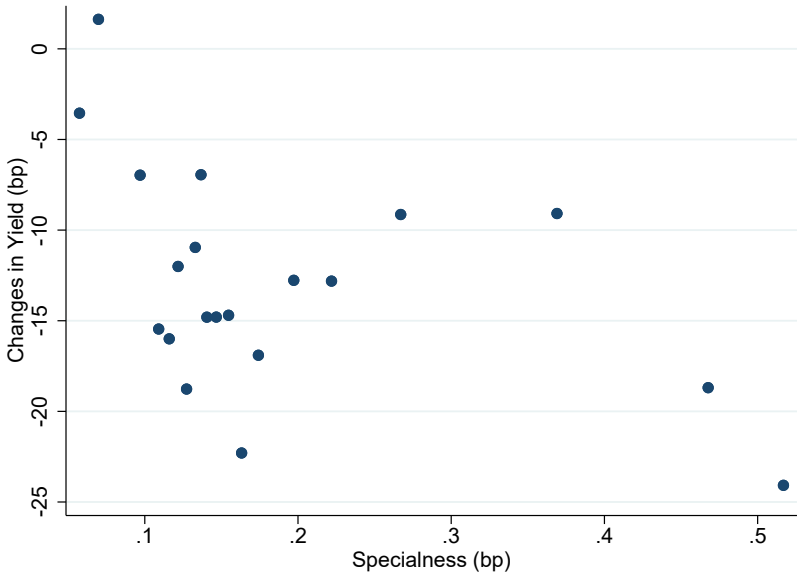
Table 6
Yield Change and Specialness

This table shows the result of regressing a bond's changes in yield around the July 2022 rate hike on its specialness prior to the rate change. The yield change is calculated as the change in the median rate five days before and five after the rate chnage. Specialness is the average specialness prior to rate change. We include duration and convexity as controls, and include country-, maturity-, and country-by-maturity-fixed effects, each maturity group (rounded to the closest five-year) is attributed a maturity-fixed effect, We include bonds from Germany, France, Italy and Spain. We obtain yield data from Bloomberg and bond characteristics from CSDB. Data on repo transactions are obtained from MTS, Brokertec, and MMSR.

	(1) ΔY_i	(2) ΔY_i	(3) ΔY_i	(4) ΔY_i	(5) ΔY_i
$Specialness_i^{Bef}$	-0.213^{***}	-0.208^{***}	-0.194^{***}	-0.199^{***}	-0.208^{***}
	(-4.537)	(-5.273)	(-3.366)	(-4.649)	(-3.140)
$Duration_i$		-0.023^{***}	-0.022^{***}		
		(-6.927)	(-7.114)		
$Convexity_i$		0.000^{***}	0.000^{***}		
		(4.839)	(5.070)		
Adj. R^2	0.038	0.269	0.491	0.230	0.489
Obs	312	312	312	311	303
Country FE	No	No	Yes	No	No
Maturity FE	No	No	No	Yes	No
Maturity× Country FE	No	No	No	No	Yes

Figure 10. Yield Change around Rate Hike and Specialness

This figure shows the binscatter for the relation between a bond's specialness and its yield change around the July 2022 rate hike. Specialness is measured as the (DFR minus the) average special rate in the five days prior to the rate hike. The change in yield is the difference between the median yield five days after and before the rate hike. Yield data are from Bloomberg. Data on repo transactions are obtained from MTS, Brokertec, and MMSR.



As in our baseline regressions, concerns over endogeneity could arise. For that purpose we again instrument specialness of bond-i in the run-up to the July rate hike, with the holdings of this bond by the Eurosystem as of December 2021. The first-stage regression is, thus:

$$Specialness_i^{Bef} = \alpha_i + \beta_1 * Share\ held\ ECB_i + \beta_2 * X_i + \epsilon_i. \tag{6}$$

The second-stage:

$$\Delta Y_i = \alpha_i + \beta_1 * \widehat{Specialness}_i^{Bef} + \beta_2 * X_i + \epsilon_i \tag{7}$$

where all variables are the same as previously defined. We show the results in Table 7. The instrumental variable analysis confirms the coefficient of interest to be still strongly negative and significant.

Table 7
Yield Change and Specialness - Instrumental Variables

This table reports the estimation of Eq.7. It is the analogue of Table 3 but with the change in yield of bond i at the left hand side. The first column is the reduced-form estimation of the 2SLS: Share held by the ECB, at the right-hand side, is the fraction of bond i amount outstanding held by the Eurosystem in 2021Q4 (APP and PEPP holdings cumulated). In column (2) the first stage instruments $Specialness_i^{Bef}$ by the share held by the ECB. Columns (3) and (4) report the results of the second stage.

	OLS	1st	2nd stage	
	(1)	(2)	(3)	(4)
Share held ECB	-0.287***	0.137***		
	(-6.54)	(3.71)		
$Specialness_i^{Bef}$			-2.434***	-2.372***
			(-3.17)	(-2.97)
Coupon rate	-0.00905			-0.117***
	(-1.25)			(-2.99)
Init. maturity	-0.000180			0.0230**
	(-0.09)			(2.44)
Resid. maturity	-0.00467**			-0.0212***
	(-2.16)			(-2.82)
ECB haircut	0.0162***			-0.000468
	(8.67)			(-0.08)
F-stat	41.4	13.8	10.0	6.3
Adj. R2	0.32	0.04	-4.13	-3.22
Obs	294	357	294	294

4.5 Lack of Pass-through and Asset Swap spreads

While a bond's yield captures the overall value of a bond, it aggregates determinants of the value of a bond—expectations of future interest rates or the issuers' credit risk—that are unrelated to the valuation of the bond on the repo market. To show more precisely which component of a bond's value is affected by a sluggish passthrough of rate hikes to the repo market, we next focus on the changes in a bond's net-asset swap spread, akin to the spread between a bond's yield and the OIS curve (in turn netted of bond's credit risk).

We calculate a bond's net-asset swap spread as the level shift such that, when a bond's future coupon and face value payments are discounted at the corresponding spot-Euribor rate increased by this fixed spread, the present value of this future stream of payments equal the bond's price. Once the asset swap spread is calculated, we remove its credit risk component by substracting the CDS par spread for a contract written to insure against the default of the bond's issuer with a tenor equal to the bond's time-to-maturity. We obtain CDS spread data from Markit and interpolate benchmark tenors using a Nelson-Siegel model fitted to the CDS par spreads.

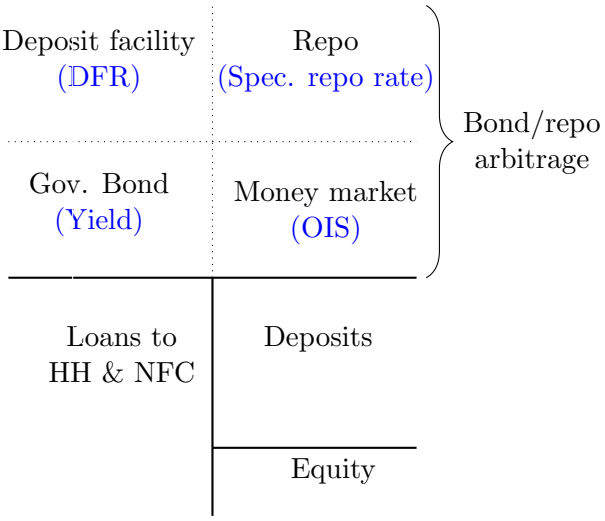
To see why we should expect repo rates to be priced in asset swaps, we can consider the case of a representative bank, with a stylized balance sheet initially composed of loans to households and corporations, on the asset side of its balance sheet, and deposits and equity as its liabilities (Figure 11). The bank identifies a bond that trades on special on the repo market, and decides to profit from its high specialness premium. The bank can borrow on the unsecured euro-area money market, at the overnight, unsecured rate ESTR, and use the proceeds to purchase a German zero coupon bond with a 10-year residual maturity. In order to hedge its exposure to changes in the borrowing rate, the bank enters into a 10-year Overnight Interest rate Swap (OIS), paying the floating leg (indexed on ESTR) and receiving a fixed rate.

To capture the specialness premium on the repo market, the bank lends the bond, borrowing cash against it, and deposits the proceeds at the deposit facility. As most European bonds trade on special, the bank is able to borrow cash at an interest rate substantially below the deposit facility rate. The bank would, thus, realize a negative carry on the yield-OIS spread, but a positive carry on the DFR-repo spread. Given that this arbitrage is free of credit and interest rate risk, the two spreads (yield-OIS and DFR-repo) should .[2]

[2]In practice, at least two frictions may prevent this equality to hold. First, borrowing on the repo market might be subject to haircuts. Second, there might be variations in the DFR-repo spread. The first friction implies that for a given yield-OIS spread, the specialness premium needs to be larger to compensate the holder of the bond. The second friction implies that banks may find it advantageous to enter into a "term repo" rather than a one-day repo to lock in the premia over a long horizon.

The yield-OIS spread is sometimes refereed as the "asset swap spread" and is used to measure how expensive a bond is, taking into account expectations of future monetary policy and term premia (which are both reflected in the OIS). The presence of a specialness premium on the repo market incentivizes investors to buy bonds to profit from the low funding rate offered by these scarce securities on the repo market. This simple example shows how specialness premia are linked to asset swap spread. In our empirical application, we subtracting the bond's corresponding CDS spread from the asset swap spread to obtain the net-asset swap spread. This adjustment is not fundamental when considering a German bond, but it becomes necessary to extend the analysis to peripheral countries.

Figure 11. Stylized balance of a representative bank



We report in Figure 12 the binscatter plot of the relation between a bond's net-asset swap spread and its overnight repo specialness. The observations are at the bond-daily level for the July 2022–December 2022 period. The tight link between overnight repo rates and longer term net-asset swaps is apparent.

If the lack of passthrough to the money market that we document in the previous sections implies that bonds that are more special see their collateral value decrease less around rate hikes, we should expect the net-asset swap spread to increase the least for very special bonds. In other words, we should expect the results we established for bond yields to be confirmed by analyzing changes in net-asset swap spreads. In Figure 13, we plot the relation between pre-hike specialness for the July hike, and changes in net-asset swap spreads around the rate hike. Indeed, the figure is remarkably similar to Figure 10, indicating that pre-hike specialness predicts changes in the value of the bond because it predicts changes to the value of the bond *as collateral*.

Figure 12. Net-Asset Swap Spreads and Specialness

This figure shows the binscatter for the relation between a bond's specialness and its net-asset swap spread. The net-asset swap spread is the level-shift applied to the spot-Euribor curve such that, when the future cash flow of a bond are discounted at this rate, their present value equals the bond's price. To this spread, we subtract the bond issuer's maturity-matched CDS spread. Specialness is measured as the (DFR minus the) average special rate in the five days prior to the rate hike. Yield data are from Bloomberg. Data on repo transactions are obtained from MTS, Brokertec, and MMSR. The underlying data is at a bond-day level and it covers the July 2022-December 2022 period.

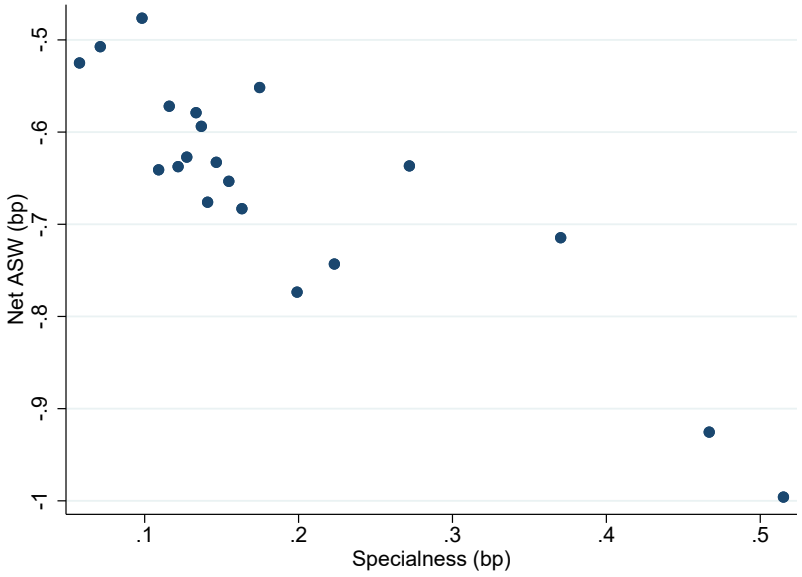
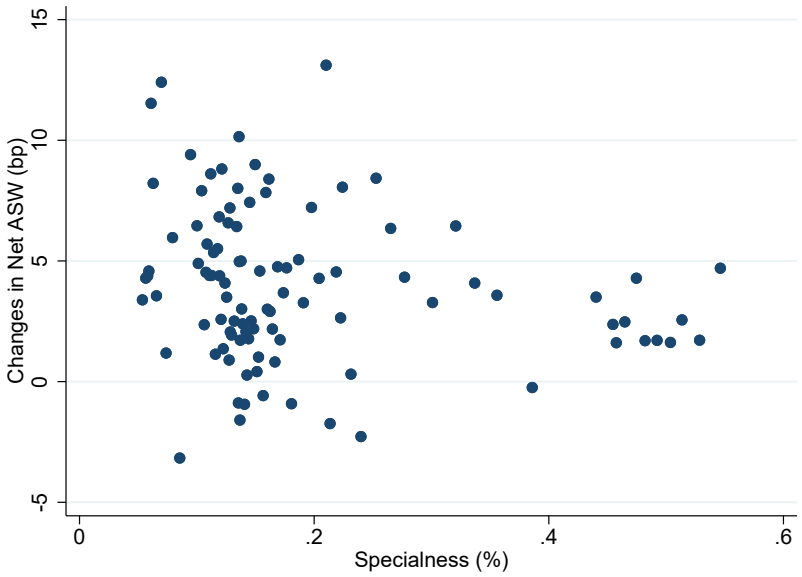


Figure 13. Changes in Net-Asset Swap Spreads around Rate Hike and Specialness

This figure shows the binscatter for the relation between a bond's specialness and its change in net-asset swap spread around the July 2022 rate hike. Specialness is measured as the (DFR minus the) average special rate in the five days prior to the rate hike. The change in net-asset swap spread is the change in the level-shift applied to the spot-Euribor curve such that, when the future cash flow of a bond are discounted at this rate, their present value equals the bond's price. To this spread, we subtract the bond issuer's maturity-matched CDS spread. Yield data are from Bloomberg. Data on repo transactions are obtained from MTS, Brokertec, and MMSR.



4.6 Lack of Pass-through and Distribution of Funding Rates

As previously shown, specialness implies a low pass-through to repo market rates. Rates that are kept artificially low represent a boon for the holders of special bonds. This in turn might have some distributional consequences between the different groups of financial intermediary depending on which bonds they hold.

We match data on the repo market (MMSR) with securities holdings statistics (SHS) and calculate the average change in repo rate, given a market participant's sovereign bond portfolio. That is, we calculate the rate at which an investor could fund themselves if the were to lend out the entirety of their portfolio. We conduct the analysis at the investor type–country level, the highest level of detail available in SHS.

We plot the distribution of these hypothetical funding rates in Figure 14. The plot shows that Other Financial Institutions (OFI) and foreign investors (Foreign) have on average experienced lower increase in the rates at which they borrow on the repo market. Most importantly, banks (MFI) showcase a tremendous dispersion in the pass-through of their funding costs. These results highlight that a change in monetary policy stance can have vastly heterogenous effects on agents' funding costs in a way that is unrelated to the characteristic of the market participants and solely depend on their holdings.

In Fig. 15, we plot the histogram of the implied passthrough dispersion across banks, using the same matching but at the banking group level, using SHS-G data. It shows that across all rate hikes in 2022, banks' funding costs have been -5bps below what it should have been without repo specialness, and even for some of them up to -30bps, thanks to their bond holdings.

As a final evidence of the relation between rate hikes and lack of passthrough of monetary policy, we plot the distribution of repo specialness by level of deposit facility rate. In the spirit of the rate dispersion measure by Duffie and Krishnamurthy (2016), Figure 16 shows that, as the ECB increased their main policy rates, the heterogeneity in funding rates increased as well.

Figure 14. Distribution of pass-through across institutional investor sector

This graph shows the distribution in the theoretical change in collateralized rate for European institutions. We calculate the change in rate as the weighted-average pass-through, based on the institutions bond portfolio, assuming that they lend out their whole portfolio on the repo market. We group each institution type by country and show the distribution of 19 Euro-area countries. ICPF are insurance companies and pension funds, MFI are monetary financial institutions, and OFI, are other financial institutions. Holdings data come from SHS, as of 2022Q2.

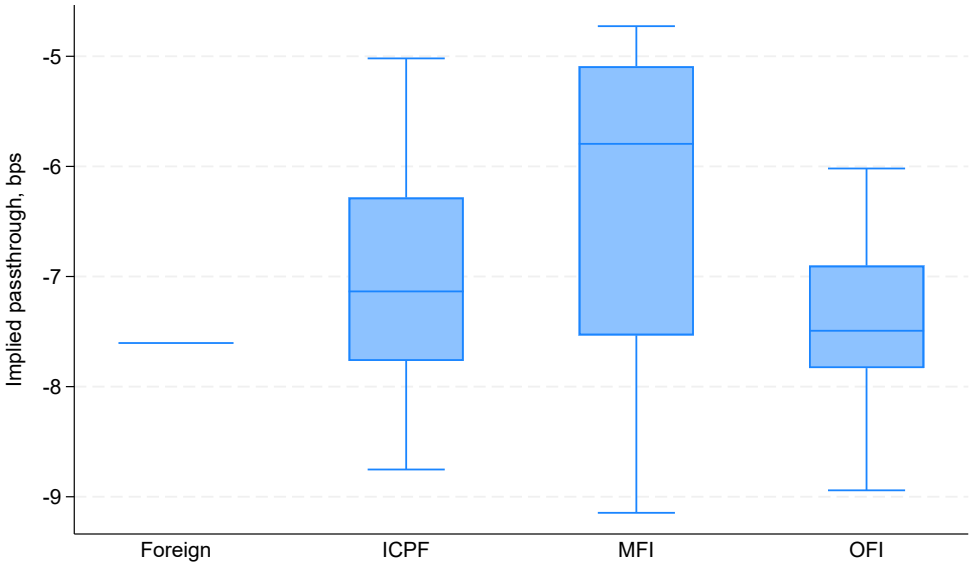


Figure 15. Implied pass-through across banking groups

This graph shows the distribution of the implied passthrough in collateralized rate for European banking groups around the July 2022 hike. We calculate the change in rate as the weighted-average passthrough, based on the banking group bond portfolio, assuming that they lend out their whole portfolio on the repo market. Holdings data come from SHSG, as of 2022Q2.

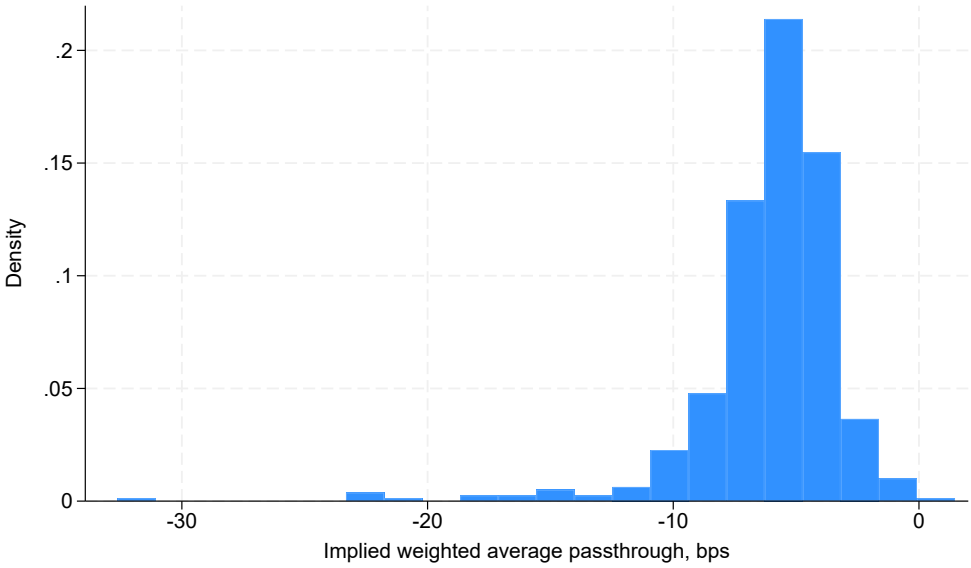
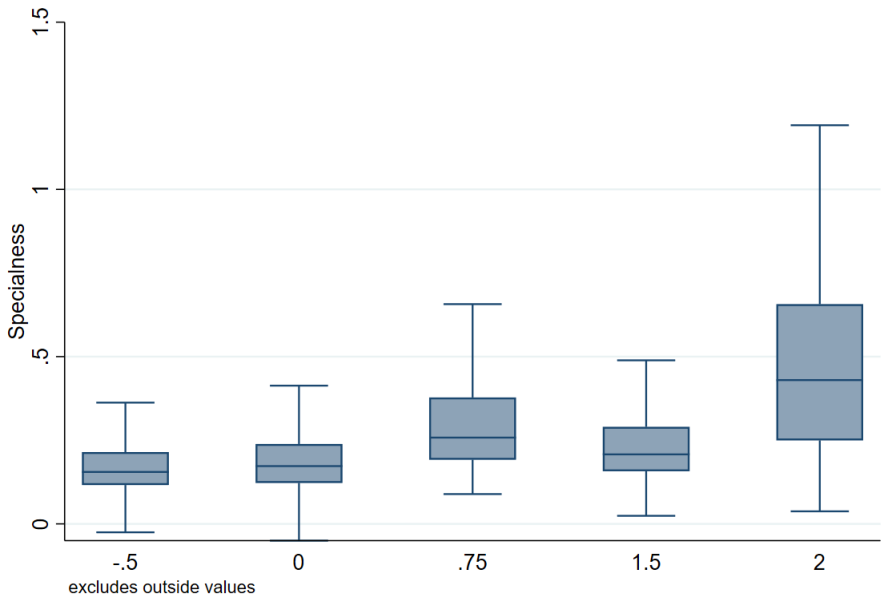


Figure 16. Money Market Rate Dispersion by Policy Rate

This graph shows the distribution of specialness for different levels of deposit facility rate, from July 2022 to December 2022.



5 Conclusion and policy implications

Ensuring an effective pass-through of policy rate changes to money market is key to transmit monetary policy. It is true for the repo market, of course for cash-driven transactions which reflect the price of cash for a large range of market participants, but also for collateral-driven transactions to the extent the specialness premium reflects in the cash bond yields. As such, an imperfect passthrough to special repo rates increases the dispersion of money market rates, even beyond the repo market.

To reduce the imbalance between supply and demand of safe assets, a central bank has several options. One option is to dispose of the safe assets it bought, reducing its balance sheet and the amount of cash in the hand of non-banks, that is, to engage in Quantitative Tightening (QT). QT has clear downsides, however. First, selling a large amount of securities can destabilize bond markets, especially in the most vulnerable countries, an option that is politically fraught with difficulties. Second, QT may materializes losses in the central bank balance sheets. Central bank negative equity was long thought not to be an issue, yet recent literature shows that central bankers may be averse to losses on the back of political economy considerations.

If the sovereign portfolio cannot be sold, the ECB can alternatively issue securities, allowing market participants to buy central bank-issued safe assets, rather than placing their cash in the repo market. This process, while legally feasible in the euro area, would however amount to issuing a Eurobond, an option that once again may run into political economy considerations.

A third option is for the Eurosystem to expand its Securities Lending Facility (SLF), modifying its quantities, pricing, and counterparties requirements. For instance, current limits on quantities lent could be removed, and the pricing would be set closer to the deposit facility rate. Moreover, this facility could be made available to non-banks. This would *de facto* provide an access to non-banks to secured deposits with the Eurosystem and would make it closer to the Federal Reserve Overnight Reverse Repo Programme (ONRRP).

References

Acharya, V. V., and R. G. Rajan (2022): "Liquidity, liquidity everywhere, not a drop to use - Why flooding banks with central bank reserves may not expand liquidity," CEPR Discussion Papers 16907, C.E.P.R. Discussion Papers.

Arrata, W., B. Nguyen, I. Rahmouni-Rousseau, and M. Vari (2020): "The scarcity effect of QE on repo rates: Evidence from the euro area," Journal of Financial Economics, 137(3), 837–856.

Ballensiefen, B. (2022): "Collateral Choice," mimeo 2003, University of St. Gallen, School of Finance.

Ballensiefen, B., A. Ranaldo, and H. Winterberg (2020): "Monetary policy disconnect," Working Papers on Finance 2003, University of St. Gallen, School of Finance.

Baltzer, M., K. Schlepper, and C. Speck (2022): "The Eurosystem's asset purchase programmes, securities lending and Bund specialness," Discussion Papers 39/2022, Deutsche Bundesbank.

Bech, M. L., and E. Klee (2011): "The mechanics of a graceful exit: Interest on reserves and segmentation in the federal funds market," Journal of Monetary Economics, 58(5), 415–431.

Caballero, R. J., E. Farhi, and P.-O. Gourinchas (2017): "The Safe Assets Shortage Conundrum," Journal of Economic Perspectives, 31(3), 29–46.

Copeland, A., D. Duffie, and Y. Yang (2021): "Reserves Were Not So Ample After All," NBER Working Papers 29090, National Bureau of Economic Research, Inc.

Corradin, S., and A. Maddaloni (2020): "The importance of being special: Repo markets during the crisis," Journal of Financial Economics, 137(2), 392–429.

Duffie, D. (1996): "Special Repo Rates," Journal of Finance, 51(2), 493–526.

Duffie, D., and A. Krishnamurthy (2016): "Passthrough efficiency in the fed's new monetary policy setting," in Designing Resilient Monetary Policy Frameworks for the Future. Federal Reserve Bank of Kansas City, Jackson Hole Symposium, pp. 1815–1847.

Eisenschmidt, J., Y. Ma, and A. L. Zhang (2022): "Monetary policy transmission in segmented markets," Working Paper Series 2706, European Central Bank.

Ferdinandusse, M., M. Freier, and A. Ristiniemi (2020): "Quantitative easing and the price-liquidity trade-off," Working Paper Series 2399, European Central Bank.

Frost, J., L. Logan, A. Martin, P. E. McCabe, F. M. Natalucci, and J. Remache (2015): "Overnight RRP Operations as a Monetary Policy Tool: Some Design Considerations," Finance and Economics Discussion Series 2015-10, Board of Governors of the Federal Reserve System (U.S.).

Greenwood, R., S. G. Hanson, and J. C. Stein (2015): "A Comparative-Advantage Approach to Government Debt Maturity," The Journal of Finance, 70(4), 1683–1722.

Greppmair, S., and S. Jank (2022): "Securities lender of last resort: On the causal effects of central banks' securities lending facilities," Available at SSRN.

Koijen, R. S., F. Koulischer, B. Nguyen, and M. Yogo (2021): "Inspecting the mechanism of quantitative easing in the euro area," Journal of Financial Economics, 140(1), 1–20.

Krishnamurthy, A. (2002): "The bond/old-bond spread," Journal of Financial Economics, 66(2-3), 463–506.

Krishnamurthy, A., and A. Vissing-Jorgensen (2012): "The Aggregate Demand for Treasury Debt," Journal of Political Economy, 120(2), 233–267.

Nagel, S. (2016): "The Liquidity Premium of Near-Money Assets," The Quarterly Journal of Economics, 131(4), 1927–1971.

Pelizzon, L., M. G. Subrahmanyam, D. Tomio, and J. Uno (2018): "Central bank-driven mispricing," SAFE Working Paper Series 226, Leibniz Institute for Financial Research SAFE.

Vari, M. (2020): "Monetary Policy Transmission with Interbank Market Fragmentation," Journal of Money, Credit and Banking, 52(2-3), 409–440.