Non-technical summary

Research Question

The Eurosystem's Public Sector Purchase Programme (PSPP) strongly increased the scarcity of safe assets in the euro area. This led to worries about possible negative implications for the transmission of euro area monetary policy. However, at the same time, refinancing costs for safe assets on the repo market decreased significantly. This leads to the question whether the increased scarcity of safe assets also had positive effects, at least for the incumbent owners of these assets.

Contribution

Using granular data on securities holdings and loans of German banks, I analyze the effects of asset scarcity on banks. I first measure the extent to which banks were exposed to scarcity. Using this measure, I study the effects on banks, specifically their profits on secured money market activity as well as their credit supply. I distinguish between effects of lower refinancing costs and effects of higher security prices, which were driven by asset scarcity.

Results

Banks use of repo collateral is determined by securities they already own. Hence, banks had different exposure to asset scarcity on the repo market. Banks with higher exposure had lower refinancing costs, which led to higher profits in their repo intermediation business. Furthermore, the lower refinancing costs increased credit supply, as banks charged lower rates for short-term corporate loans. The results hold for German and European banks as well as when controlling for credit demand on the borrower level. This leads to the conclusion that the scarcity of safe assets had positive effects on the credit supply of the owners of these safe assets.

Nicht-technische Zusammenfassung

Fragestellung

Das Programm zum Ankauf von Wertpapieren des öffentlichen Sektors (PSPP) verstärkte die Knappheit an sicheren Wertpapieren im Euroraum. Dies führte zur Sorge, dass die monetäre Transmission des geldpolitischen Impulses dadurch negativ beeinflusst werden könnte. Gleichzeitig sanken jedoch die Refinanzierungskosten sicherer Wertpapiere am besicherten Geldmarkt deutlich. In diesem Zusammenhang stellt sich die Frage, ob die verstärkte Knappheit sicherer Anleihen auch positive Auswirkungen hatte, zumindest für die Halter der knapp gewordenen sicheren Anleihen.

Beitrag

Mittels granularer Daten zu den Wertpapier- und Kreditbeständen deutscher Banken untersuche ich die Auswirkungen der Sicherheitenknappheit auf Banken. Dabei bemesse ich zunächst das Ausmaß, in dem Banken unterschiedlich von der Knappheit sicherer Anlagen betroffen sind. Mit Hilfe des Maßes untersuche ich die Auswirkungen auf Banken, insbesondere auf deren Profite im besicherten Geldmarktgeschäft und ihr Kreditangebotsverhalten. Dabei unterscheide ich zwischen Effekten, die den gesunkenen Refinanzierungskosten auf der einen Seite und durch die Knappheit gestiegenen Anleihepreisen auf der anderen Seite zuzuordnen sind.

Ergebnisse

Die Verwendung von Sicherheiten in besicherten Geldmarktgeschäften wird für Banken maßgeblich durch die Anleihen bestimmt, die sie bereits halten. Daher waren sie unterschiedlich von der Sicherheitenknappheit am Repomarkt betroffen. Banken, die stärker betroffen waren, hatten niedrigere Refinanzierungskosten, wodurch ihre Gewinne im Repogeschäft stiegen. Des Weiteren erhöhten die niedrigeren Refinanzierungskosten das Kreditangebot, indem Banken niedrigere Zinsen für kurzfristige Unternehmenskredite verlangten. Die Ergebnisse halten für deutsche, aber auch für europäische Banken und wenn man für die Kreditnachfrage einzelner Kreditnehmer kontrolliert. Daraus lässt sich schließen, dass die Knappheit an sicheren Wertpapieren positiv auf das Kreditangebot der Halter sicherer Anleihen gewirkt hat.

Quantitative Easing, Safe Asset Scarcity and Bank Lending *

Johannes Tischer
DG Economics
Deutsche Bundesbank

Abstract

The Eurosystem's Public Sector Purchase Programme (PSPP) increased the scarcity of safe assets, which caused significant declines and substantial dispersion in European repo rates. However, banks holding these safe assets benefited from this development: First, using the German security register, this paper shows that scarcity affects bank funding costs, as their collateral supply is determined by their ex ante securities holdings and repo rates. Second, it makes use of the German credit register to show that asset scarcity had real effects: Banks more exposed to asset scarcity increased their credit supply.

Keywords: Quantitative easing, safe asset scarcity, repo rates, bank lending, monetary transmission

JEL classification: E51, E58, G11, G21.

*Contact address: Deutsche Bundesbank, Wilhelm Epstein Strasse 14, 60431 Frankfurt am Main, Germany. Phone: +49 69 9566 2753. Email: johannes.tischer@bundesbank.de. Discussion Papers represent the authors' personal opinions and do not necessarily reflect the views of the Deutsche Bundesbank or the Eurosystem.

1 Introduction

A scarcity of safe assets is generally associated with a decline in economic activity once the economy reaches the lower bound of interest rates, as the market for safe assets cannot clear anymore (Caballero and Farhi, 2018). In such a "safety trap", quantitative easing (QE) is not seen as a helpful tool for reviving the economy, as it merely swaps one safe asset (government bonds) for another (reserves), even though an increase in safe assets would be needed to rectify the imbalance (Caballero, Farhi, and Gourinchas, 2017). The situation might even deteriorate owing to the fact that non-banks cannot hold central bank reserves, so that they actually swap a safe asset (government bonds) for a potentially risky asset (bank deposits). In that respect, the findings in Arrata, Nguyen, Rahmouni-Rousseau, and Vari (2017) seem worrying, as they show that QE led to a scarcity of safe assets in the repo market, causing significant declines in repo rates. Even worse, scarcity, and hence changes in repo rates, occurred heterogeneously across securities and across jurisdictions, prompting monetary policymakers to worry that "there is a risk that ... a continued dispersion of short-term rates would adversely impact the transmission of our monetary policy stance." (Cœuré, 2018).

The aim of this paper is to analyze whether scarcity can have *positive* effects, at least for the incumbent owners of safe assets, as their asset valuations increase and secured funding costs decrease. This effect should be particularly pronounced for banks, which participate regularly in the repo market. At the same time, banks can be the source of positive real effects for the economy when they increase their loan supply. When this occurs very heterogeneously across banks, this certainly also affects monetary policy transmission, which becomes more dispersed. Hence, this paper asks whether the scarcity-induced decline in repo rates had effects on banks, or, more specifically, whether it increased their loan supply. The question is akin to the bank lending channel literature, which argues that changes in bank funding costs due to monetary policy affect loan supply (See, e.g., Bernanke and Blinder, 1988, 1992), but has a focus on unsecured funding costs.[1]

The Public Sector Purchase Programme (PSPP) of the European Central bank acts as a laboratory: it caused a scarcity of safe assets, which expressed itself in a hunt for collateral in the repo market, where an increasing portion of euro area government bonds became special (Arrata et al., 2017). The repo market is now by far the largest segment of the money market. Banks fund a sizeable portion of their balance sheet using repos: German banks active in the repo market funded 6% of their balance sheet in gross terms in the repo market in February 2015, just before the start of the PSPP. In the repo market, asset scarcity is directly measurable on the ISIN-level by changes in the repo rate. Hence, scarcity surfaced heterogeneously across securities and thus banks, which can be used to identify the effects of asset scarcity on banks.

To identify the causal effect of repo funding costs on loan supply, I make use of two simple facts: first, repo rates were affected by the PSPP heterogeneously, creating a substantial dispersion in repo rates for different underlying securities. Second, banks hold different securities portfolios (e.g. Hildebrand, Rocholl, and Schulz, 2012), so that some banks are more exposed to securities with strongly declining repo rates than others. A bank-level measure of the change in repo funding costs due to asset scarcity can therefore

[1] Seminal contributions include Disyatat (e.g. 2011); Jiménez, Ongena, Peydró, and Saurina (e.g. 2012); Kashyap and Stein (e.g. 1995, 2000); Peek and Rosengren (e.g. 1995).

be calculated by weighting repo market rates on a wide range of collateral by each bank's ISIN-level securities holdings. This measure, which I refer to as the funding rate, shows substantial dispersion on the bank-level, with even stronger effects on the European level.

This measure of the exposure to asset scarcity can be regarded as exogenous under three conditions: first, repo rates and their dispersion should be independent of bank conditions. Second, banks' securities holdings should determine their subsequent actual repo borrowing. Third, the distribution of securities should be random with respect to their subsequent repo rate. If all conditions hold, the measure of changes in bank repo funding costs is exogenous to bank lending, so that a negative relationship between bank funding costs and loan growth can be interpreted as a causal effect.

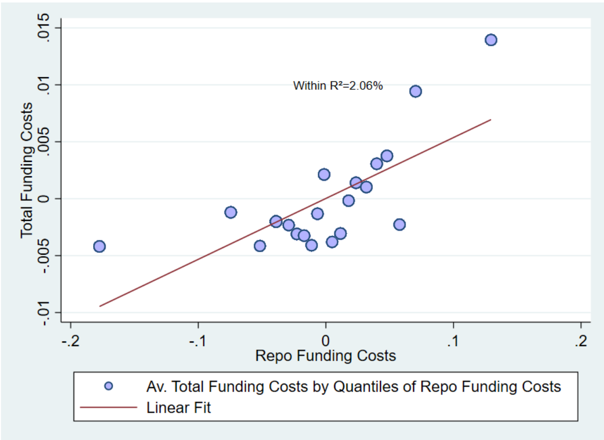
I provide evidence in this paper that the three conditions hold. First, the dispersion in repo rates should not be caused by bank-individual characteristics likely correlated with their lending supply. Fortunately, the collateralisation makes repo rates relatively unresponsive to bank characteristics. Furthermore, Arrata et al. (2017) show that central bank asset purchases have a distinct impact on repo rates.[2] They argue that asset purchases reduce the supply of securities in the repo market, leading repo rates to decline. Second, changes in repo rates can only shock bank funding costs when securities holdings matter for banks' repo borrowing. I combine data on German banks' repo transactions with their cash market transactions and portfolio holdings on the security level and show that portfolio holdings determine banks' subsequent repo borrowing, but not their repo lending. This result holds on the bank-ISIN-date level after controlling for the full set of possible fixed effects and after controlling for banks' cash market trading volume. In addition, banks increase their repo borrowing for securities with lower repo rates, which I verify in an IV setting where repo rates are instrumented by PSPP purchases. Third, I show that banks' security purchases do not strategically depend on the subsequent repo rate, nor on the bank funding rate. Taken together, these results imply that the funding rate is an exogenous measure of banks' exposure to asset scarcity.

Indeed, some suggestive evidence for the basic premise can already be seen on an aggregate level: banks' repo funding costs correlate with the cross-section of overall funding costs (panel a in Figure 1), which is reinforced by higher net repo borrowing when repo funding costs decline (panel b in Figure 1). Funding costs, in turn, are an important determinant of loan pricing and loan supply (e.g. Gambacorta, 2008), which is reflected in the positive correlation between banks' overall funding costs and credit growth (panel c in Figure 1). At the same time, repo volumes are also linked to the credit business of banks, as the net repo position of banks correlates strongly with credit growth (panel d in Figure 1).

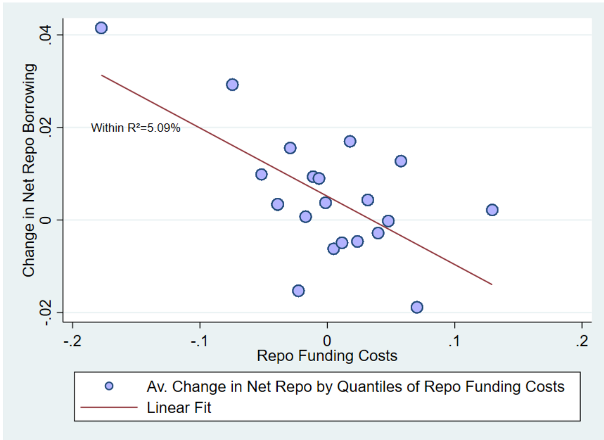
Using the funding rate as an exogenous measure of banks' exposure to asset scarcity, I test the suggestive evidence more thoroughly. First, I show that banks' actual repo borrowing costs are correlated with the funding rate, while their repo lending income is not (leading to a net profit on the repo book for banks with higher exposure to asset scarcity). Second, regarding bank lending, I show that banks with higher exposure to asset scarcity, i.e. a lower funding rate, have higher loan growth, but only when they are actually active in the repo market. This result helps to distinguish the channel through which scarcity affects lending: as special repo rates go hand in hand with higher asset

[2]Similar results can be found in D'Amico, Fan, and Kitsul (2018) for QE in the US and in Corradin and Maddaloni (2020) for the Securities Markets Programme (SMP) during the sovereign debt crisis.

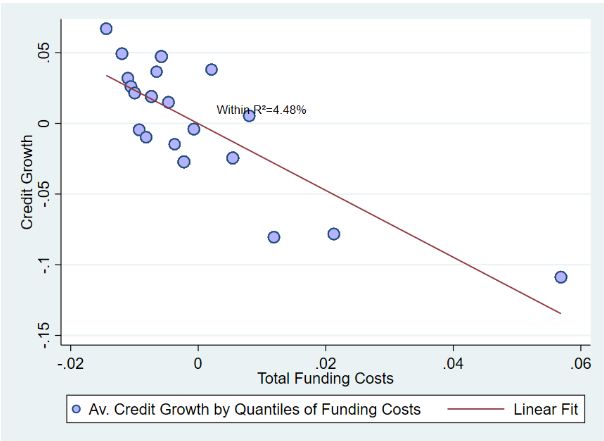
Figure 1: Repo, Funding Costs and Credit



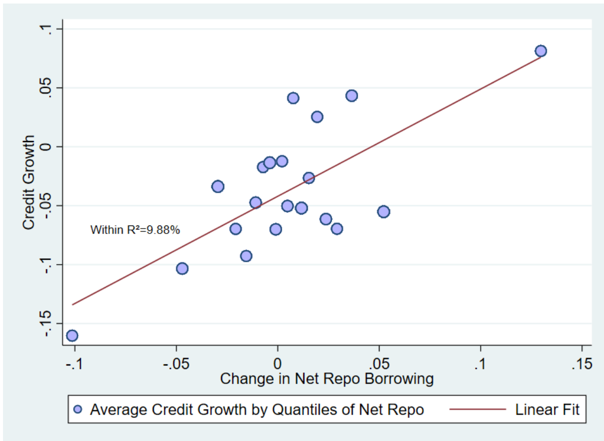
(a) Repo Rates and Funding Costs



(b) Repo Rates and Net Repo Borrowing



(c) Funding Costs and Credit Growth



(d) Repo Borrowing and Credit Growth

Notes: All graphs show scatter plots where both variables are averaged within each 5% quantile of the x-variable together with a linear fit of the underlying data (all coefficients are significant). All variables are yearly and adjusted for yearly fixed effects. Credit Growth is the growth rate of loans to non-banks, Change in Net Repo Borrowing is the change in the balance sheet share of the difference between repo borrowing and lending. Repo Funding Costs is the yearly average overnight repo rate for a bank's actual repo borrowings, Total Funding Costs are total interest payments divided by balance sheet size. Sources: GuV, BISTA, WpInvest, BrokerTec, MTS.

valuations (see Jordan and Jordan, 1997), a significant effect could also be driven by higher bank capital due to higher asset valuations. But since the effect of the funding rate exists only for banks active in the repo market, whereas higher asset valuations would impact all asset holders, the results suggest that funding costs are the driving force behind the effect. The results do not only hold in Germany, but also in a sample of the largest euro area banks.

The previous result raises endogeneity concerns as the decision to tap the repo market might depend on loan demand. To alleviate the concerns, I proceed in three steps. First, I show that the result does not change when I use an indicator for a fixed set of banks that is continuously active in the repo market. Second, I demonstrate that the effect holds within this subsample of banks as well. Third, I repeat the bank level regressions on the borrower level. Borrowers with multiple bank connections allow the inclusion of borrower-time fixed effects, which effectively control for credit demand at the borrower level. There, too, the result still holds, thus accommodating endogeneity concerns. The channel through which the higher loan growth is likely achieved is via reductions in the interest rates on short term corporate loans, as banks with high scarcity exposure offer lower interest rates and show higher loan growth than other banks.

Besides the literature on safe assets, the paper links to the following strands of the literature. First, the paper builds on the discussions about the relationship between the bond and repo markets. Whereas earlier contributions saw short seller demand as a reason for very low ("special") repo rates (Duffie, 1996; Jordan and Jordan, 1997; Krishnamurthy, 2002; Vayanos and Weill, 2008), later studies identified a reduced collateral supply due to central bank asset purchases as a second factor (Arrata et al., 2017; D'Amico et al., 2018; Corradin and Maddaloni, 2020). This paper establishes a link between securities holdings, special repo rates and collateral supply.

Second, the paper contributes to the literature on bank funding costs and their transmission to bank lending. The bank lending channel literature posits that changes in monetary policy affect bank lending heterogeneously, depending on the changes in funding costs. More liquid, larger and better capitalised banks were found to react less to changes in policy, as they can access non-deposit funding more easily and at lower rates (Gambacorta, 2011; Jiménez et al., 2012; Kashyap and Stein, 1995, 2000; Peek and Rosengren, 1995). Changes in bank loan rates also depend on funding costs (see, e.g. Gambacorta, 2008; Altavilla, Carboni, Lenza, and Uhlig, 2019). I show that bank lending also reacts to changes in secured funding costs, which should not be driven by bank fundamentals. Hence, the results here are complementary to the bank lending channel literature.

Third, the paper contributes to the literature on the effects of central bank asset purchase programmes. These programmes are found to have an impact on, amongst other things, asset prices (e.g. Altavilla, Carboni, and Motto, 2015; Krishnamurthy and Vissing-Jorgensen, 2011), growth and inflation (e.g. Weale and Wieladek, 2016), bank lending (e.g. Darmouni and Rodnyansky, 2017) and repo rates (e.g. Arrata et al., 2017). A related paper is Giambona, Matta, Peydró, and Wang (2020), who find that QE, by creating a vacuum of safe assets, allowed corporations to issue more bonds, ultimately spurring on investment. I show that through the impact on repo rates, there is a distinct transmission channel to bank lending, as asset purchases affect repo rates and hence bank funding costs.

A further related paper is Abbassi, Iyer, Peydró, and Tous (2016), which also combines the German security and credit registers to show that conditions in the securities portfolio can have repercussions for lending. In their setting, banks with trading expertise curtailed their credit supply during the financial crisis in order to free up capital to make use of trading opportunities in the securities market. In contrast, I look at a shock to the securities portfolio that affects bank funding costs instead of trading opportunities.

Section 2 presents stylised facts on repo rates and the data used in the paper. Section 3 shows that banks' securities holdings determine their repo borrowing and banks react to lower repo rates by increasing their collateral supply. Section 4 presents the funding rate, the exogenous measure of banks' exposure to asset scarcity, and shows that the securities portfolio composition is independent of subsequent repo rates. Sections 5 and 6 explore the implications of asset scarcity for banks, with the former estimating the impact on repo book profits and the latter showing the impact on bank lending.

2 Data

The repo market is by far the largest segment of the euro money market (ECB, 2017). In 2017, repo turnover accounted for 60% of the total turnover in the money market (repo, unsecured, overnight indexed swaps and foreign exchange swaps) according to ECB calculations (ECB, 2017). The unsecured segment has declined substantially since the great financial crisis as high excess liquidity removed the incentives for unsecured trades. GC repo trades declined in a similar fashion so that the largest part of repo activity is now in specific repos (Brandt, Ferrante, and Hubert, 2019). [3] German banks also make active use of the repo market: in 2015, banks with persistent repo exposure funded around 6% of their balance sheet in the repo market on a gross basis.[4] Net repo funding, i.e. repo borrowing − repo lending was on average 2%. Banks had heterogeneous exposures as around one-third of banks using repos were net repo lenders. But the majority of the banks using repos were net repo borrowers, which financed around 9% of their balance sheet using repos in net terms.[5]

As shown by Arrata et al. (2017) (see also Figure A.I.1), special repo rates (i.e. repo rates below comparable money market rates) occurred in European repo markets before the start of the PSPP, too, but were usually confined to individual bonds. After the start of the PSPP in March 2015 and even more so in 2016, repo rates started to diverge more strongly as more and more bonds became special in the repo market. This phenomenon was somewhat reduced in 2017 and 2018 (likely due to the acceptance of cash collateral by the Eurosystem in the national central banks' (NCB) collateral lending schemes in December 2016 (see Jank and Moench, 2018), but remained elevated compared to the pre-PSPP period. This suggests that part of the dispersion in rates was driven by PSPP asset purchases, which reduced the availability of collateral on the repo market, making repos of those securities costlier. Arrata et al. (2017) examine this idea in more detail, showing that bonds with higher PSPP purchases had lower repo rates.

[3] BrokerTec and MTS are the largest European platforms for specific repo trading (Mancini, Ranaldo, and Wrampelmeyer, 2016).

[4] This figure does not include repos with central banks.

[5] We will tackle the question whether banks with fewer holdings of scarce bonds suffer from scarcity as they might have to borrow them at higher costs in Chapter 5, showing that these banks do not face consistently higher lending (i.e. collateral borrowing) rates.

To capture the longer-term trends in European repo rates, depicted in Figure A.I.1, I use specific repo trades with the euro as the underlying currency on the trading platforms BrokerTec and MTS between 2013 and 2018.[6] I use all overnight rates, i.e. overnight, spot-text and tomorrow-next.[7] The remaining data covers a total of over 1.2 million transactions in 1,821 securities with an average daily trading volume (single count) of Eur 280 million per security and are described in more detail in Arrata et al. (2017). A longer-term view of repo rates is necessary to construct the measure of exposure to repo scarcity, the funding rate, over a sufficiently long period.

For a more detailed view of banks' use of repos, I obtain all repo transactions of all German banks engaged in repos from the Eurosystem's Money Market Statistical Reporting (MMSR)[8]. The data are from July 2016 to December 2017 and make it possible to extract the entire repo book for each bank for transactions settled in euro.[9] It includes over 2.8 million transactions by 55 banks in 11,400 securities with an average daily turnover of Eur 150 billion and an average daily outstanding volume of Eur 315 billion (borrowing + lending, over all banks and securities). MMSR repo rates are also used in the paper, but only for the regressions in Table 3 and for the repo borrowing and lending costs (and hence repo book profits) in Table 5, which both build on MMSR data. Apart from that, repo rates are taken from BrokerTec/MTS, as they are available for a longer time period.

I combine the data on repo activity with data on banks' securities holdings from the Bundesbank's Securities Holdings Statistics (SHS)[10] and their trading activity from the Bundesbank's WpHMV dataset. The SHS contains monthly information on all securities with an ISIN held by German banks, most notably the amount.[11] The WpHMV dataset collects each transaction by German banks in all assets that are traded on an organised market in the European Economic Area (EEA), including over-the-counter transactions. While this excludes some asset classes, it covers most assets that are used as repo collateral, especially government bonds. To reduce data complexity, I focus only on bonds (equities are used in repo as well, but are far less important than bonds).[12] The remaining data set contains 3.7 million transactions in 32,000 assets with an average daily turnover of Eur 31 billion between July 2016 and December 2017.

To gauge the impact of funding costs on lending, I rely on the Bundesbank's balance sheet statistics (BISTA)[13], the profit and loss statistics (GuV)[14], the interest rate statistics (ZISTA)[15] and the credit register (MiMiK) for German banks as well as the ECB's

[6] "Specific repo" describes trades where the collateral security is exactly specified, as opposed to general collateral trades (GC), where the cash lender does not know the exact security it obtains because the collateral is chosen from a basket of eligible securities.

[7] Overnight trades are settled on the same day, "tomorrow-next" and "spot-next" on the following day and after two days, respectively.

[8] See Hirsch and Yalcin (2021) for more information on that dataset.

[9] With the exception of intra-group transactions and transactions with a tenor of more than 397 days, which should be very infrequent, however.

[10] See Blaschke, Sachs, and Yalcin (2021) for more information on that dataset.

[11] I also make use of the euro area version of this data set which contains securities holdings information on 21 large euro area banks.

[12] Security characteristics come from the ECB's Centralised Securities Database (CSDB).

[13] See Gomolka, Schaefer, and Stahl (2021) for more information on that dataset.

[14] See Stahl and Rauth (2021) for more information on that dataset.

[15] See Blaschke, Krueger, and Sachs (2021) for more information on that dataset.

individual balance sheet items (IBSI) for European banks. BISTA and IBSI contain balance sheet information, including information on aggregate loan volumes, total assets and repo usage. BISTA contains information on all roughly 1,500 German banks, while IBSI covers around 400 European banks. ISIN-level securities holdings can be matched only for 21 IBSI banks. However, these banks account for a substantial portion of aggregate euro area bank assets (Albertazzi, Becker, and Boucinha, 2018).

3 Bond Holdings and Repo Borrowing

3.1 Empirical Strategy

The first step in analysing the effect of asset scarcity on banks is to establish a link between repo rates and bank funding costs. Furthermore, to identify the subsequent effect on bank lending, it is important to establish whether it is possible to measure exogenous variation in this link. Both questions depend on the way the repo exposure of a given bank is determined.

Take a bank with a focus on trading bonds in the cash market. It could use repo for the sole reason of supporting its trading activity, either to borrow securities it does not own for delivery, to create short positions, or to finance temporary inventory. In that case, the bank's repo activity would be determined mainly by its trading flows. Due to the more short-term nature of these flows, there is less room for the repo rate to change, i.e. to be shocked, while the bank is holding the asset. Rather, it is more likely that banks trade and repo assets that are already special, so that lower repo rates are incorporated in the asset's price (see Jordan and Jordan, 1997), which basically eliminates a net impact on the bank. Also, as trading flows (in the aggregate) might be related to other contemporaneous decisions on the structure of the balance sheet, like that on credit supply, it might be difficult to extract variation in repo that is exogenous to bank lending.

As a counterexample, take a bank that holds a long-term portfolio of securities that it partly finances in the repo market. In this case, repo volumes are determined to a large extent by the securities holdings. In turn, there may be an exogenous impact of scarcity shocks to repo rates on bank funding costs: the repo exposure is predetermined and securities that become special lead to a net decrease in bank funding costs.

This means that bank funding costs can be exogenously affected by scarcity shocks to repo rates if banks use their pre-existing securities holdings as collateral for repo transactions. A given heterogeneous allocation of securities across banks will then result in heterogeneous evolution of repo funding costs.

To establish a link between banks' stock of securities and their repo borrowing, I rely on a unique combination of transaction level data. First, I use all euro repo transactions of German banks between July 2016 and December 2017 from the German MMSR.[16] I combine this with the monthly snapshot of the same banks' securities holdings from the SHS. I exclude equities, funds and derivatives and focus exclusively on bonds.[17]

[16] Intra-group transactions as well as transactions where the cash leg is not in euro are excluded.

[17] Technically, I use CSDB attributes to exclude variables with a CFI code beginning with E (equities), with a primary asset classification (PAC2) beginning with E or F (equities and funds), with a debt type beginning with D.18 (derivatives) and drop all remaining assets with a debt type not beginning with D (debt instruments) that were never used as collateral in a repo transaction. The remaining sample

As argued before, the cash market trading activity of banks could be an important determinant of repo activity. Banks can use repos either to initiate short positions for themselves or for customers they trade with, or to source securities they want to sell but currently do not own. Hence, if banks specialise in trading specific assets and hold more of these assets in stock, a correlation between holdings and repo activity could be entirely driven by their trading motives. To rule this out, I use a transaction-level account for the same period of all cash market trades by German banks from the WpHMV to control for banks' cash market trading activity.

I start by aggregating the cash market and repo market turnover over the entire sample period at the bank-ISIN level and match this with banks' holdings at the end of June 2016 (immediately before the start of the sample period). This allows me to estimate the relationship between bond holdings and subsequent repo market outcomes while controlling for bank and ISIN fixed effects (standard errors are double clustered by bank and ISIN):

$$\text{Repo Indicator}_{ij} = \beta_1 \text{Cash Turnover}_{ij} + \beta_2 \text{Initial Holdings}_{ij} + \gamma_i + \delta_j + \text{u}_{ij} \tag{1}$$

Here, Repo Indicator is either a dummy indicating whether bond j was used by bank i in any repo transaction, or the natural logarithm of the aggregate repo turnover or outstanding. Cash Turnover is the logarithm of the gross trading volume of bond j in the cash market by bank i between June 2016 and December 2017.[18] Initial Holdings is the natural logarithm of the holdings of bank i in bond j in June 2016.

While Equation 1 is interesting in itself because it enables relations to be captured over a long period of time, it is less suitable to controlling for market maker activity, which could bias the relation between holdings and repos, as argued above. To better control for these bank-ISIN specific effects, I extend the analysis to a panel on bank-ISIN-time level.

To that end, for each asset ever used by a bank in repo I construct a full time series of daily repo turnover or outstanding volumes, including zeros. I then match the daily cash market trading volumes of that bank in that asset and the securities holdings at the end of the preceding month. This structure makes sure that the timing of holdings, repo and cash transactions is accounted for correctly. Furthermore, it is possible to control for the full set of fixed effects on the bank-day, the bank-security and the security-day-level. For example, market maker activities or specialisation in specific securities would be captured by bank-security fixed effects. Bank funding shocks would be captured by bank-day fixed effects and security characteristics such as "cheapest-to-deliver" or the "on-the-run" security would be captured by security-day fixed effects. The remaining variation is unlikely to be biased by omitted variables, as they would have to vary over time within each bank-ISIN combination. Standard errors are double clustered by bank and ISIN in the following regression:

$$\text{Repo Indicator}_{ijt} = \beta_1 \text{Cash Turnover}_{ijt} + \beta_2 \text{Holdings}_{ijm-1} + \alpha_{jt} + \gamma_{it} + \delta_{ij} + \text{u}_{ijt} \tag{2}$$

consists solely of debt instruments.

[18] Results remain broadly similar when net cash market buying/selling figures are used.

3.2 Results

When estimating Equation 1, we see that higher initial holdings predict higher repo turnover among all assets that were held or traded by the bank in the period between June 2016 and December 2017 (column 1 of Table 1). This result holds similarly for banking book and trading book positions (column 2) and also on the intensive margin, among all assets that were used by that bank in a repo transaction (column 3). To rule out the possibility that the results are driven by the choice of the specific sample, which is partly determined by the different data sources (assets held in the portfolio from SHS, assets repoed from MMSR and assets traded from WpHMV), Table A.II.2 in the Appendix further shows that the results also hold in the sample of all assets that were in banks' portfolios, all repoed assets held in banks' portfolios and all repoed assets issued before July 2016, the start of the sample period.[19]

We now turn to the intensive margin by restricting the sample only to assets that are indeed used in repos. Hence, the question now is not whether trading or portfolios predict any repo activity, but whether they can predict the extent to which an asset is used as collateral. When splitting the aggregate repo turnover at the bank-ISIN level into borrowing and lending volumes, we observe an interesting difference in the results. Higher banking book holdings of a bank reduce the lending turnover and outstanding for the same collateral by the same bank (columns 4 and 6 of Table 1). This suggests that higher holdings reduce the need for banks to borrow these securities, e.g. for trading motives. However, borrowing turnover and outstanding increase in the volume held on the balance sheet, which implies that banks use the existing securities on their balance sheet as collateral for repo borrowing transactions (columns 5 and 7). So given that banks have heterogeneous holdings of bonds, banks' funding costs would reflect the dispersions in repo rates.

The results for the cash market turnover show the opposite pattern: higher cash turnover significantly predicts higher repo lending turnover and outstanding (columns 4 and 6), but not repo borrowing volumes (columns 5 and 7). Again, this evidence suggests that the repo and the cash market are linked by the need to source securities or initiate short positions.[20]

One further aspect to note is that trading book positions have a smaller and less significant impact on repo borrowing than banking book positions (columns 5 and 7 of Table 1). There could be two reasons for this. Either securities in the trading book are less likely to be repo financed, or the aggregation over time biases the results as banking book positions are much more persistent than trading book positions, which strengthens their predictive power for future repo usage. I will now explore this nexus in more detail using Equation 2, where the time dimension is explicitly taken into account.[21]

The results for Equation 2 can be found in Table 2. An increase in the cash market

[19]Table A.II.1 in the appendix shows that on the ISIN level, too, higher initial holdings and a higher trading volume across all banks imply a greater probability of use in repo.

[20]This result changes slightly when net cash market trading figures are used: higher net trading conditional on trading and banking book holdings increase borrowing outstandings, but not lending outstandings, suggesting that the use of repo differs between trades that can and cannot be netted.

[21]Note that this could also stem from a multicollinearity problem between trading volume and trading book assets. However, also individually, trading book holdings and trading volumes are unable to predict repo borrowing volumes on the intensive margin.

trading volume for a given bank and security on a given day leads to an increase in repo turnover in that security for the same bank, irrespective of other bank or security characteristics on that day (column 1). This clearly shows a strong connection between repo and cash markets: an increase in the cash market trading by 100% leads to an increase in repo turnover on that day by 5%. The result for holdings are even stronger. An increase in holdings of a specific security by 100% leads to a 30% increase in next month's repo turnover of that security by the same bank.

To test the robustness of this result regarding the sample of assets used, columns 1 to 4 of Table A.II.3 in the Appendix show significant results also for the sample of all assets held in the portfolio of the bank and of all repoed assets held in the portfolio of the bank, but also on the intensive margin (for all observations with a positive dependent variable as well as for all observations which at the same time have a positive dependent variable and positive holdings).

Coming back to the question of whether banking or trading book holdings matter for repo turnover, column 2 shows that both types have an effect of comparable size. This suggests that the effect of trading book holdings could not be properly detected in the aggregated variables in Equation 1 due to a lower persistence of trading book positions.

When the dependent variable is split between lending and borrowing turnover in columns 3 and 4, a picture roughly comparable to columns 4 and 5 in the previous table emerges: the cash market turnover has higher predictive power for repo lending, while the holdings have a higher predictive power for repo borrowing turnover. The only notable exception is that both variables also significantly predict repo borrowing or lending, respectively.

Turning to the outstanding repo, we see no correlation between bond holdings and outstanding lending in column 5, which is roughly consistent with the evidence in Tables A.II.1 and 1. But, as in the other tables, holdings have a significant and strong predictive power for outstanding repo borrowing (column 6). An increase in holdings by 100% increases the subsequent repo borrowing outstanding by 44% for the same security and the same bank. This result strongly suggests that heterogeneous securities holdings can lead to diverging funding costs if repo rates diverge.

Now how do banks react when the repo market is hit by an asset scarcity shock? Is their use of collateral entirely mechanically determined by their securities holdings? Or do they react dynamically to movements in market rates, e.g. by supplying more of a security that is scarce and hence expensive to borrow? Such a reaction would reinforce the effect of a scarcity shock to the repo rate on overall funding costs. At the same time, it would suggest that banks actively manage their funding costs and increase their borrowings when they are hit by a funding cost shock.

Evidence for such a dynamic reaction can be seen in column 1 of Table 3: banks respond to lower repo rates by increasing the volume of their repo borrowing for a given security. A decrease in the repo rate from the 75th to the 25th percentile of its unconditional distribution would imply a change in the repo borrowing outstanding by 10.8%.[22]

This regression includes ISIN*day fixed effects so that the result stems from the comparison of multiple banks trading the same ISIN on the same day, which to some extent

[22] 25th percentile of the repo rate: -90bp, 75th percentile: -54bp. The coefficient has to be multiplied by 100 as the dependent variable is in logs. Therefore, the effect is calculated as $(-90-(-54))*(-0.003)*100 = 10.8\%$.

alleviates the endogeneity problem when regressing volumes on prices. However, the individual trades and their individual repo rates that are compared here might be influenced by trade-specific characteristics such as trade size, time of the day or trade venue. While the result still holds without ISIN*day fixed effects (see column 2), a thorough analysis of the reaction of volumes to changes in prices requires an instrumental variable approach.

Therefore, in columns 3-6, I instrument the repo rate by the daily central bank purchases in the PSPP for that ISIN. PSPP purchases have been shown to be relevant for repo rates in Arrata et al. (2017). To rule out the possibility that PSPP purchases directly influence repo volumes, thus violating the exclusion restriction, I control for each bank's cash trading volume. This should pick up movements in repo volumes that might be driven by PSPP purchases through increases in cash market trading activity, which might prompt the bank to increase repo volumes irrespective of interest rates. In order to increase the number of observations, I do not use the repo rate on the trade level, but instead construct a repo rate on the ISIN-date level, so that the regression can also make use of observations where a bank did not enter a new repo contract on the exact same day as PSPP purchases occurred. While columns 3 and 5 make use of all ISINs in the sample, columns 4 and 6 restrict the sample to ISINs that were actually purchased under the PSPP to reduce the influence of observations that are irrelevant with respect to the IV.

The instrument is indeed highly relevant and the IV regressions confirm the results from the first two columns: repo borrowing volumes in a security increase when repo rates decrease owing to the PSPP purchases (see columns 3 and 4). Importantly, this result does not hold for lending volumes, which are not significantly affected by repo rates (columns 5 and 6), suggesting a positive net effect on repo borrowings.

This chapter has revealed four main facts about banks' use of repo. First, trading activity in the cash market is linked to repo activity, confirming that repo plays an important role in facilitating trading and taking positions. Second, securities holdings determine which assets banks use as collateral in their repo borrowing. Third, the relationship between initial holdings and subsequent repo borrowing holds over longer time periods, as shown in Table 1, where the securities holdings in June 2016 predicted repo borrowing in the period from July 2016 to December 2017. Fourth, banks react to changes in repo rates by increasing their borrowing against cheaper collateral, which should reinforce the effects of asset scarcity and of portfolio holdings on subsequent funding costs.

These facts suggest that asset scarcity in the repo market affects bank funding costs in a sense that it constitutes a shock to the bank. Second, they suggest that banks' predetermined securities holdings can be used to isolate exogenous variation in the exposure to asset scarcity across banks. Ways to measure this exposure will be discussed in the next chapter.

4 An Exogenous Measure of Asset Scarcity Exposure

The question this paper ultimately tackles is whether asset scarcity had any effect on banks' loan growth owing to a change in funding costs. To explore this question, we need to identify exogenous variation in banks' exposure to asset scarcity and the resulting dispersion in repo rates. However, banks' actual repo funding costs could be endogenous, as prospects regarding loan growth could affect funding decisions. Fortunately, the micro evidence in the previous chapters provides the prerequisites for constructing a credible measure of exogenous shocks to bank funding costs. First, the dispersion in repo rates was caused by an exogenous monetary policy shock. Second, bank securities holdings determine subsequent repo borrowing. Hence, combining market repo rates and banks' securities holdings makes it possible to create a measure of banks' potential funding costs that does not suffer from the same endogeneity as the actual funding costs.[23]

More specifically, for each bank i, I weight the average overnight market repo rates from BrokerTec/MTS for each security j in bank i's portfolio J_i with the securities holdings from the previous period. This results in a volume-weighted average potential funding rate for the bank, called Funding Rate, which depends on its initial securities holdings:

$$\text{Funding Rate}_{it} = \frac{\sum_{j \in J_i} \text{Repo Rate}_{jt} * \text{Holdings}_{ijt-1}}{\sum_{j \in J_i} \text{Holdings}_{ijt-1}} \tag{3}$$

The idea is that the rates for repo collateral are the outcome of a market process and hence independent of individual bank conditions, whereas securities holdings are fixed at the end of the previous period and hence predetermined regarding lending decisions in the next period. To adjust for the different time dimension of repo rates and bank securities holdings and balance sheet data, I average repo rates between the relevant reporting dates.[24]

In principle, term repo rates might be more relevant for banks' lending decisions as they allow the effective funding of short term-loans. I rely on overnight rates because first, term rates are often unavailable as trades occur more infrequently; second, the choice of the term would be ambiguous; and third, overnight rates should already capture the evolution of rates for the specific ISIN. When the ISIN becomes special, the entire yield curve on that security will move downwards, as scarce collateral is also expensive to borrow at longer terms. Hence, overnight rates are a good approximation for the general evolution of rates on the security level, especially for the cross-sectional comparison.

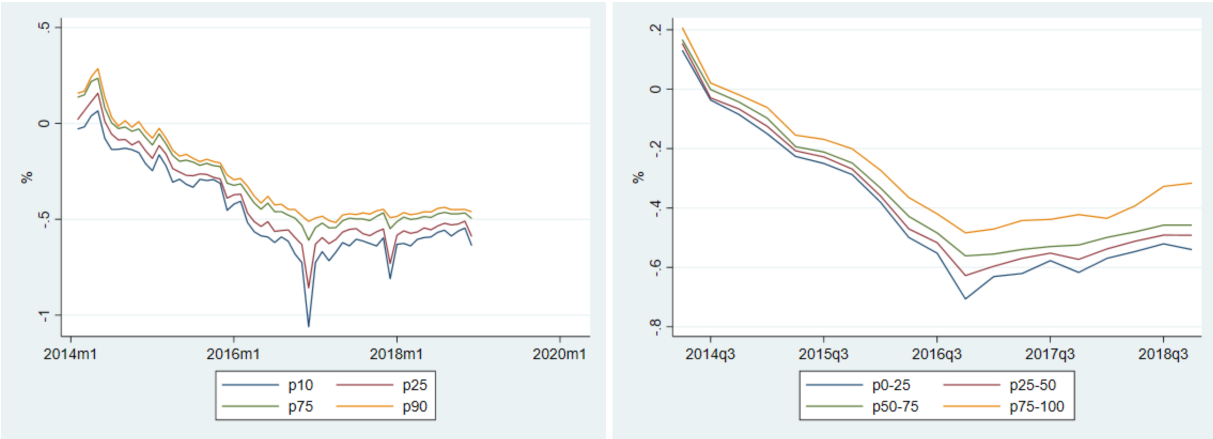
So did heterogeneous bank securities holdings and the asset scarcity shock lead to diverging funding costs for banks? Figure 2 plots the distribution of the Funding Rate from Equation 3 for the sample of German banks and for a sample of 21 large euro area banks. In both samples, the dispersion of the Funding Rate increases over time, with a peak in December 2016. The dispersion stays elevated thereafter, with larger effects in the euro area sample. For example, between November 2014 and November 2016, the difference between the 25th and 75th percentile grew by roughly 50% within German banks. For the euro area sample, the change is even substantially larger, jumping by 140% between the third quarters of 2014 and 2016. Hence, asset scarcity and the corresponding price moves in the repo market had a substantial effect on the heterogeneity of rates at which banks were able to fund themselves.

The Funding Rate also exhibits considerable variation at the bank level. Each year, the transition probability of moving from the lower half of the Funding Rate distribution to the upper half is above 30%. Even though it is more likely to stay in the upper or lower half, over 60% (30%) of banks end up in the lowest quartile (decile) of the distribution at

[23]MMSR data cannot be used as they are only available over a shorter time period (from July 2016).

[24]In practical terms, for the credit supply regressions, end of December securities holdings are matched with next year's average overnight rate.

Figure 2: Distribution of Bank Funding Cost Measure



(a) Germany **(b) euro area sample**

Notes: This graph plots percentiles of the monthly cross-sectional distribution of the funding cost measure from Equation 3. Subplot (a) shows the distribution for German banks, subplot (b) uses data for 21 large euro area banks. DUe to confidentiality reasons, data are averaged across banks within percentiles, using 5p.p. steps in subplot a) and 25p.p steps in subplot b). Sources: SHS, WpInvest, BrokerTec, MTS.

least once.[25] Hence, only a minority of banks has a constantly high or low funding rate. This result is even stronger when only banks that are active in the repo market at some point are considered.

Is it certain that the shock to repo rates really hit banks in a quasi-random fashion? The interpretation of the setting as quasi-random experiment also depends on the question of whether securities holdings were random with respect to subsequent specialness. This means banks must not tend to purchase more of a security that becomes special thereafter and this tendency should not differ between banks according to their Funding Rate.

To test whether this requirement holds, I extract purchases from movements in banks' monthly securities holdings and regress them on their current and future repo rates, to account for a possible future specialness of that security. Furthermore, I interact the market repo rates with the Funding Rate to test whether the tendency to target special securities depends on the exposure to asset scarcity. Note that the funding rate is on the yearly level in order to provide a more static and forward-looking view of banks' scarcity exposure as well as to be in line with the credit supply regressions, which are also conducted on a yearly level.

$$\begin{aligned} \mathrm{I[Purchase]}_{ijt} = \beta_1 \mathrm{RR}_{jt} + \beta_2 \mathrm{RR}_{jt+1} + \beta_3 \mathrm{RR}_{jt+2} + \beta_4 \mathrm{RR}_{jt+3} \\ + \kappa_1 \mathrm{FR}_{iy} + \theta_1 \mathrm{RR}_{jt} * \mathrm{FR}_{iy} + \theta_2 \mathrm{RR}_{jt+1} * \mathrm{FR}_{iy} \\ + \theta_3 \mathrm{RR}_{jt+2} * \mathrm{FR}_{iy} + \theta_4 \mathrm{RR}_{jt+3} * \mathrm{FR}_{iy} + \gamma_{ij} + \delta_{jt} + u_{it} \end{aligned} \tag{4}$$

Here, the dependent variable is a dummy indicating whether security j was bought (=1) or held (=0) by bank i at date t. RR is the repo rate of security j at date t and in the next three consecutive months. FR is the Funding Rate of bank i in the current year

[25] Only 2% of banks are constantly in the lowest decile.

y. I add bank*security and security*time fixed effects, but also estimate regressions with fewer fixed effects. I refrain from including bank*time fixed effects, as these would pick up time-varying differences in purchasing behaviour across banks, which is what the β and θ coefficients are supposed to estimate.

Results can be found in Table 4. The regressions differ according to the fixed effects structure and with respect to the bank sample. Column 1 only includes monthly fixed effects to control for time trends in the funding rate, leaving as much variation to explain as possible. Columns 2 and 3 control for bank*security and security*time fixed effects to test whether market making activities or security-specific events might bias the results. However, across specifications, only one interaction term is marginally significant. Also in the subsample of banks that are active in the repo market, no interaction term is significant (column 3). Columns 4 to 6 repeat the first three regressions but use the average repo market rate in the subsequent year as explanatory variable so as to be even more forward-looking with respect to the scarcity exposure. However here, too, no term is significant, which leads to the conclusion that the distribution of securities across banks is random with respect to the subsequent exposure to asset scarcity.[26] This strengthens the notion of the Funding Rate as a exogenous measure for exposure to asset scarcity, akin to a quasi-random experiment.

5 Repo Funding Costs and Repo Book Profits

5.1 Empirical Strategy

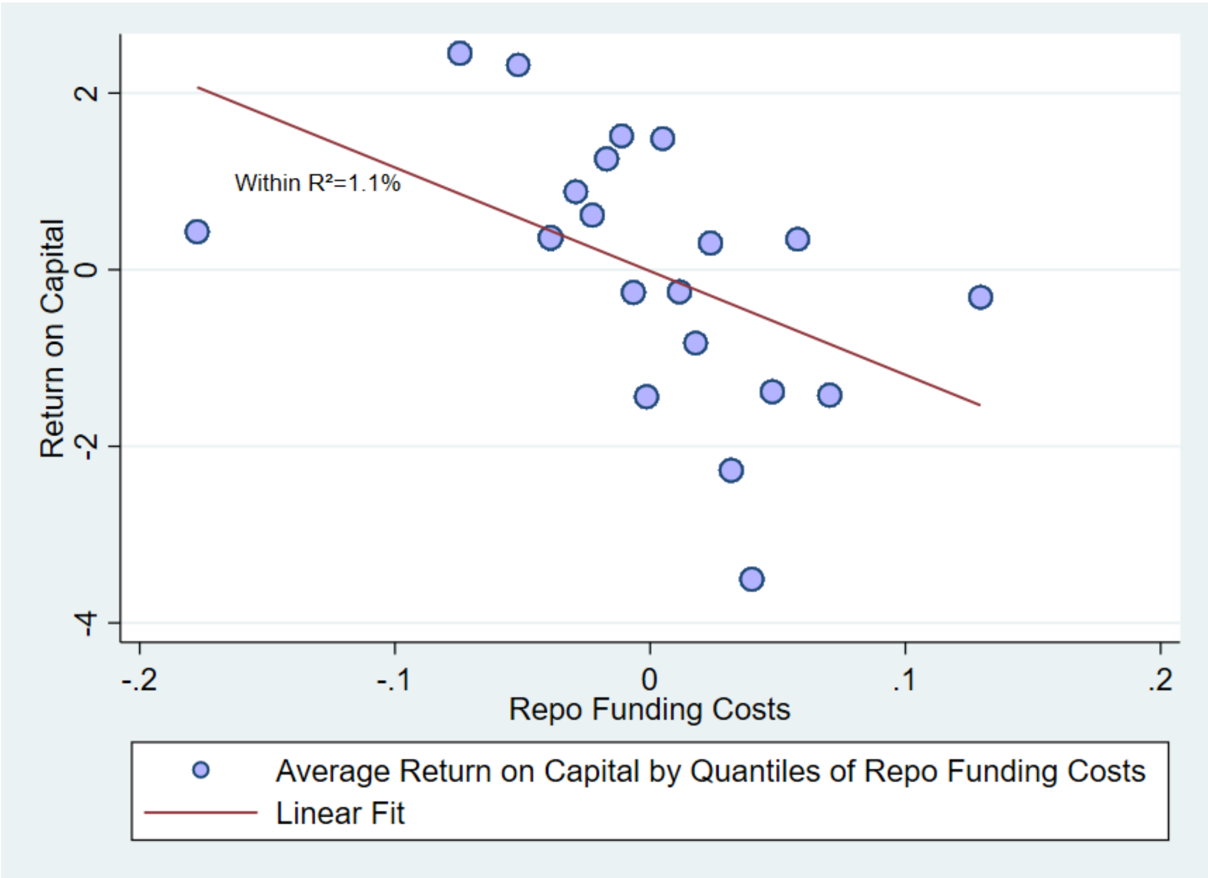
How does the Funding Rate behave? Does it indeed capture repo borrowing costs? Before turning to the effects on credit supply, it should be verified that the Funding Rate is indeed a realistic proxy for the scarcity-induced shock to funding costs. This would be the case when it has explanatory power for actual bank repo borrowing costs, whereas it should not explain income from repo lending. In other words, this chapter asks whether banks with higher scarcity exposure experienced windfall gains on their repo books.

This question serves a dual purpose. First, as a cross-check to the results obtained so far: if securities holdings determine the use of collateral and hence the Funding Rate measures potential repo funding costs, then the Funding Rate should also be able to explain actual repo funding costs. Second, it helps to answer the question of whether one bank's joy is another bank's sorrow: one might argue that some banks experience windfall gains due to lower borrowing costs, whereas other banks incur losses because they have to pay more to borrow expensive collateral. The former statement would imply that a lower funding rate is correlated with higher profits in the repo book due to lower borrowing costs. The latter statement would imply that a higher funding rate is correlated with lower profits in the repo book due to lower lending rates (because banks with a high funding rate that do not own scarce collateral might have to borrow the scarce collateral, resulting in low cash lending rates, which curtails profits).

The raw data already suggest that a connection between repo rates and profitability exists, as evidenced by the significant cross-sectional correlation between the funding cost

[26]Table A.II.4 in the Appendix repeats the analysis with log purchase volumes as the dependent variable with similar results.

Figure 3: Repo Funding Rate and Return on Capital



Notes: This graph plots the distribution of banks' return on capital and the funding rate, together with a linear fit. Both variables are adjusted for time fixed effects so that the correlation uses cross-sectional information. Also, both variables are averaged within the quintiles of the funding rate. The correlation is statistically significant at the 10%-level. Sources: WpInvest, BrokerTec, MTS, GuV.

measure and banks' return on capital in Figure 3. Given the high-level relationship, it should also be found with a more narrow focus on the profits of banks' repo operations.

In order to test the propositions more thoroughly, I again use data on German banks' repo transactions from the MMSR for the period June 2016 to December 2017. I construct the full repo book, i.e. all outstanding repo borrowing and repo lending amounts for each bank. In order to do this, the data have to be cleaned for open repos, i.e. repos without a fixed term ex ante that run until they are terminated by one counterparty. The reason is that open repos have to be reported daily, but often feature a notice period, which is represented in the data by adjusting the maturity date of the repo. Hence, each daily report of an open repo with a notice period can be falsely understood as a single transaction lasting for several days, when in fact it lasts only until the next day, as the notice period only becomes effective after the termination of the repo. Disregarding open repos can lead to huge misrepresentations of the outstanding. For example, an open repo with a notice period of 10 days falsely increases the uncleaned outstanding for this open repo by a factor of up to 10 until the repo is terminated.

Using the outstandings, I calculate the volume-weighted average (annualised) interest rate for borrowing and lending for each bank, which allows me to calculate the profit on the repo book as the difference between the lending and borrowing rate. I match this data with the Funding Rate to estimate the following relationship:

$$\text{Repo Book Profit}_{it} = \beta_1 \text{Funding Rate}_{it} + \kappa X_{it} + \gamma_i + \delta_t + u_{it} \tag{5}$$

Here, Repo Book Profit is the difference between the volume-weighted average rate on outstanding repo lending and borrowing of bank i on day t. Funding Rate is calculated as in Equation 3, but with daily repo rates and monthly snapshots of securities holdings. I include the percentage mismatch between borrowing and lending outstanding volumes and the daily aggregate trading volume of that bank in bond cash markets to control for the impact of non-intermediation activity on repo profits. I further add bank and month, or, in some specifications, day fixed effects.[27] Standard errors are clustered at the bank level.

5.2 Results

Table 5 shows the results for estimating Equation 5. The funding rate has a significant and negative effect on repo book profits, meaning that lower Funding Rates indeed lead to gains on banks' repo portfolios (column 1). The second column introduces the control variables, which do not significantly change the effect of the funding rate. But, interestingly, the coefficient on the cash market trading volume is negative, suggesting that a higher trading volume in the cash market reduces the repo book profit. Note that this is within-bank variation as bank fixed effects are included, so that the effect cannot be driven by differences in trading affinity between banks. This again supports the notion that trading activity in the bond market triggers the need for repo intermediation to source securities or take short positions. This ultimately can reduce repo book profits as

[27] As in Arrata et al. (2017), I leave out the last week of each year where repo rates are very volatile due bank balance sheet constraints at year ends.

those repos are not designed to maximise profits for the repo desk, but for the trading unit.

Columns 3 and 4 add monthly and daily fixed effects, respectively. Again, this rules out the possibility that common shocks such as reporting dates or a common trend in repo rates drive the results. The coefficient gets smaller in size but is still highly significant. In fact, a decrease in the funding rate by 10 b.p. increases annualised profits by 1.2 - 1.5 b.p. in these columns.

To disentangle whether the effect of the Funding Rate on profits stem from windfall gains on the borrowing side or losses on the lending side, columns 5-6 use the volume-weighted average rate on the outstanding repo borrowing (lending), i.e. the actually realised borrowing and lending rates as the dependent variable. For borrowing, even after controlling for bank and time fixed effects, the funding rate has a highly significant positive impact on the borrowing rate. This suggests that the funding rate is indeed indicative of actual borrowing costs, and that windfall gains on collateral increased repo book profits. When looking at repo lending, the funding rate has no explanatory power (see column 6), which asserts that repo profits were driven by changes in repo funding costs, determined by the holdings of securities that became scarce on the repo market. Furthermore, this result suggests that banks that did not possess scarce collateral suffered no systematic disadvantage. Apparently, they had no systematic need to borrow scarce securities such that their lending rates would be affected by these endeavours.[28] This suggests that any positive effects on lending due to lower funding costs might not be counteracted by negative effects on the lending of banks that had to borrow scarce collateral at higher prices.

Taken together, the results in this section support the results and assumptions made earlier: the stock of assets matters for repo borrowing, which, given the dispersion in repo rates, affects bank funding costs (and repo book profits).

6 Funding Costs and Loan Growth

6.1 Empirical Strategy

The ultimate question I attempt to answer in this paper is whether asset scarcity has real effects. Given that we now have an exogenous bank level measure of the exposure to asset scarcity, which is plausibly exogenous, it is possible to tackle this question. To this end, I employ a sample of all German banks with total assets above Eur 1bn between 2013 and 2018, and a second sample of 21 of the largest euro area banks. I first estimate regressions on the bank level and complement these with regressions on the borrower level using the German credit register. The specification is as follows:

$$\frac{\text{Loans}_{it} - \text{Loans}_{it\text{-}1}}{\text{Loans}_{it\text{-}1}} = \beta_1 \text{Funding Rate}_{it} + \kappa X_{it\text{-}1} + \gamma_i + \delta_t + u_{it} \tag{6}$$

[28] This is also in line with the view that banks are intermediaries in the repo market that respond to collateral demand (and supply) from other parts of the financial system.

Here, the dependent variable is the growth rate of loans to non-banks, which is regressed on the Funding Rate, the funding cost measure from Equation 3, bank and time fixed effects and bank balance sheet control variables lagged by one period. Due to the construction of the Funding Rate, time fixed effects control for the general trend in repo rates, as the same rates are used for all banks. In fact, the remaining variation is based on cross-sectional heterogeneity in bond holdings. This is of particular importance as during the estimation period, the central bank policy rate decreased substantially. Lower rates, or more specifically negative monetary policy shocks, usually go hand in hand with increases in bank lending. As repo rates follow the policy rate, a negative effect of the funding rate and loan growth might well be driven by changes in the policy rate, not asset scarcity. The time fixed effects allow the interpretation that for a given year, banks with a lower average funding rate have higher loan growth rates, all other things being equal.

I control for the lagged balance sheet shares of deposits, loans, central bank reserves, provisions and capital to control for main determinants of credit growth. To reduce the impact of short-term variations in repo rates, I construct the variables on a yearly basis. Balance sheet variables and securities holdings are from the end of December and repo rates are averaged over the year, for the period from 2013 to 2018. Standard errors are clustered at the bank-level. To control for outliers, the dependent variable is winsorized at the 1% tails, whereas the funding rate is winsorized at the 1%-tails in each year, owing to the general decline in in money market rates over time.[29]

6.2 Results

Column 1 of Table 6 shows results from a simple OLS regression, where loan growth is regressed only on the funding rate. The coefficient is negative and significant with a value of -0.029, so that a decrease in the funding rate by 10 b.p. would increase the loan growth rate by 0.3 p.p. However, as noted above, this might well be driven by the general trend in repo rates that correlates with central bank policy rates. The coefficient loses significance once controls and bank and year fixed effects are introduced in column 2.

However, this does not mean that asset scarcity has no effect on loan growth. There is an important distinction that has been left out far: a lower Funding Rate can only affect bank funding costs when the bank is actually active in the repo market. Hence, I add an interaction term with a dummy equal to one when a bank was active in the repo market in column 4. The coefficient on the interaction term is now negative and highly significant, whereas the base effect is zero. Hence, the fairly plausible result emerges that repo funding costs have effects only for banks using repo.

In addition, the interaction term helps to shed light on another important question. Jordan and Jordan (1997) showed that collateral on special in the repo market also has a higher price in the cash market. The reason is that the collateral borrower could also purchase the asset in the cash market so that prices in both markets should react to make the borrower indifferent between borrowing and purchasing the asset. Hence, if the repo rate decreases, i.e. borrowing the collateral becomes more expensive, the borrower will buy the bond in the cash market, driving up its price.[30] So an alternative transmission

[29] The results all still hold when log growth rates of credit are used as dependent variable, see columns 1-4 of Table A.II.5 in the Appendix.

[30] A complementary effect is that a bond on special provides a convenience yield to bond investors: by

channel of the low repo rates could be that they drive up security prices, which leads to capital gains at banks and fosters loan growth. Indeed, the lowest funding costs due to bond specialness correspond to the highest capital gains so that the effect of the funding rate on loan growth could be entirely driven by capital gains.[31]

Luckily, the interaction term for repo users serves as a test of these two alternative channels: the capital channel should, in principle, apply to all banks holding special collateral, as all banks holding a bond experience the same price increase, which correlates with bond specialness and hence the Funding Rate. However, the funding cost channel can only apply to banks actually using repo. So an insignificant interaction term would have suggested that the funding rate channel is not relevant for loan growth, while a significant base effect would have been evidence in favour of a capital channel. The results suggest that the funding cost channel is indeed the relevant one.[32]

However, an obvious problem with the interaction term is that the decision to tap the repo market might be endogenous to loan demand: if the bank faces higher loan demand and hence loan growth, it might need additional funding, which it might obtain from the repo market. In order to alleviate this concern and show that the estimated effect is indeed causal, I proceed via three steps. First, in column 5, I interact the funding rate with a dummy for the subset of banks that is constantly active in the repo market throughout the sample period. Due to their continued presence, the value of the dummy itself is independent of loan demand. The coefficient increases in absolute size and remains significant, suggesting that the effect here is even stronger. Second, in column 6, I show that the effect of the funding rate on loan growth is still present within the subsample of constant repo users. Third, I control for loan demand directly by making use of the German credit register (also used, for example, in Abbassi et al., 2016).

The credit register makes it possible to look at loan growth at the borrower level.[33] As Khwaja and Mian (2008) firmly established, borrowers which have multiple bank relationships can be used to control for loan demand by introducing borrower*time fixed effects, which pick up all time-specific borrower-related variation, including loan demand. The estimation procedure is comparable to Equation 6, but with an additional borrower

buying the bond and lending it in the repo market (and investing the cash obtained in repo at the GC rate), the investor receives an extra dividend consisting of the difference between the GC rate and the repo rate for the bond it purchased (Duffie, 1996). This repo dividend is a risk factor priced in bond prices (D'Amico and Pancost, 2018).

[31] Duffie (1996) and Jordan and Jordan (1997) show that the bond price increase depends on the expected time a bond is on special (which affects the total gains from the convenience yield), so the argument above abstracts from the specialness period.

[32] One might argue that the result is driven by banks which faced capital constraints before the PSPP and hence invested in relatively safe bonds. The PSPP then relaxed their capital constraints and they handed out more loans, financed by repo. However, when including the lagged balance sheet share of debt securities and an interaction term with the book share of capital, the result still holds (not reported), suggesting that equity constraints by repo-using banks are not driving the results.

[33] German banks have to report quarterly their outstanding loan amounts to those borrowers with an overall credit exposure above EUR 1 million (before 2015: EUR 1.5 million). Abbassi et al. (2016) report that although lending to small and medium-sized firms are not fully covered, overall the credit register covers nearly 70% of the total credit volume in Germany even with the higher threshold. The dataset includes information on the total outstanding loan amount per bank-borrower relationship as well as defaults, but not on maturities or interest rates of the underlying loans. For more information, see, e.g., https://www.bundesbank.de/resource/blob/759062/c2adfd3c3f582bd95d74d6cca783df6c/mL/dfbs-abgabe-gross-millionenkreditanzeigen-data.pdf (in German).

level j:

$$log(\text{Loans}_{ijt}) - log(\text{Loans}_{ijt-1}) = \beta_1 \text{Funding Rate}_{it} + \kappa X_{it-1} + \gamma_{jt} + \delta_i + u_{ijt} \qquad (7)$$

To ensure consistency with other papers using credit register data, I use log growth rates (see, e.g., Abbassi et al., 2016). Here, the log growth rate of the loan volume granted by bank i to borrower j at time t is regressed on the funding rate of bank i at time t, the same explanatory variables $X_{it\text{-}1}$ as in the previous bank-level regressions and fixed effects on the borrower*time level and the bank level.

Column 1 of Table 7 confirms the main result from Table 6 (column 3): banks active in the repo market have higher loan growth when they are more exposed to the asset scarcity shock, i.e. have lower repo funding costs. Even the coefficient is of comparable size. This holds after controlling for the same set of controls and additionally for borrower*time fixed effects. So loan growth *to the same borrower* is higher for banks with higher exposure to the scarcity shock, expressed as lower repo funding costs. Still, one might argue that the use of a dynamic version of the dummy for active repo users introduces some endogeneity. Therefore, as in Table 6, columns 2 and 3 use a dummy for banks that are constantly active in the repo market, which only varies across i. The result still holds in this setting, which reduces the endogeneity concern further.

Note that the coefficient increases in absolute size when only time fixed effects are used in column 3. This could imply that some borrower-specific heterogeneity affects the coefficient. Consistently, the effect becomes smaller again when borrower heterogeneity is reduced by restricting the sample to non-financial corporations (instead of non-banks) in the robustness Table A.II.6 in the Appendix. Lastly, columns 3 to 6 show that the result also holds when the sample is restricted only to those banks that are constantly active in the repo market. Reassuringly, in these regressions, too, the coefficient is of similar magnitude to the bank-level regressions. Column 6 also introduces bank fixed effects in addition to the borrower*time fixed effects, without materially changing the result. Hence, endogeneity problems do not appear to drive the results in Table 6.

As a final cross-check, I show that also the actual repo funding costs (obtained by combining BrokerTec repo rates with ISINs listed as "pledged as collateral" in the security register)[34] also have a significant and negative effect on loan growth, just like the funding rate. As there is a strong correlation between actual repo borrowing costs and the funding rate, it can also be used as an IV for the actual funding costs, with similar results (see columns 5 and 6 of Table A.II.5 in the appendix). Of course, the actual repo lending rate can be approximated in the same way. It has, however, no explanatory power for loan growth (column 7), which provides further evidence that banks without access to expensive collateral did not decrease their lending, i.e. that the positive effect on loan supply found above is not the better half of a zero sum game.

After having established the relationship between the Funding Rate, the proxy for exposure to asset scarcity, and loan supply, the question remains as to *how* banks increase their lending. In other words, how does the decrease in funding costs lead to higher loan

[34]Note that this is not a perfect measure of repo funding as a) the term is not known (I use overnight rates), b) it is unclear whether it is pledged as collateral in a repo transaction or e.g. as margin and c) collateral baskets might not be properly accounted for.

growth? Usually, lower funding costs allow a bank to charge lower loan rates while keeping the net interest margin unaffected. However, this relationship should be stronger for loans and liabilities of comparable maturity, as banks' asset liability management usually attempts to fund long-term loans with more long-term liabilities. Since we are looking at short-term funding costs, effects on loan rates should be strongest for short-term loans. To test this conjecture, I include banks' average loan rate for short-term loans as dependent variable in the regression.

Table 8 shows that lower funding costs lead to lower loan rates for short-term corporate loans, but not for longer-term loans (columns 1 and 2, 3 and 4). This holds true even after controlling for further measures of bank funding costs such as interest rates for consumer and corporate deposits. Consistent with this result, columns 5 and 6 show that a lower Funding Rate is also correlated with a higher growth rate in those short-term corporate loans. This suggests that asset scarcity led to higher loan growth by lowering bank funding costs, which in turn lowered loan rates.

We saw earlier in Figure 2 that the divergence in Funding Rates was even more pronounced in the smaller sample of 21 euro area banks. So does a similar effect of asset scarcity also arise on the euro area level? Table 9 provides some tentative answers by estimating equation 6 for the 21 euro area banks.

In line with the previous results, columns 1 to 4 again show a significant negative effect of the Funding Rate on loan growth. Column 1 contains no controls, column 2 introduces control variables as in Table 6, column 3 bank fixed effects and column 4 time fixed effects.[35] Due to the inclusion of banks from multiple countries, the regression makes possible to further control for loan demand, at least on the country level. Country*year fixed effects (while removing bank fixed effects due to the low sample size) in column 5 capture diverging time-varying credit demand conditions in different euro area countries. Essentially, the comparison is between the credit growth of banks with different funding rates facing the same credit demand on the national level. Given that the sample consists of the biggest European banks, the approximation of national demand seems reasonable. The coefficient is again negative and significant. Hence, the euro area sample confirms that asset scarcity and the resulting differences in bank funding costs had effects on bank lending.

The results in this chapter are an interesting qualification of the results in Altavilla et al. (2019), who show that a higher cross-sectional dispersion of unsecured money market rates, which they use as time-series measure of funding uncertainty, is associated with an increase in bank lending rates. As I show that repo funding costs also affect lending, the authors' results could be strengthened by using bank-level measures of uncertainty for various funding markets in order to rule out the possibility that their results just capture the fact that banks with higher risk face higher funding costs and increase their loan rates. In fact, Table A.II.7 in the Appendix shows that time series uncertainty measures for rates in the repo market are actually positively correlated with bank lending (columns 1 to 4). Only a bank-level measure of the rate uncertainty for the bank's own securities holdings affects bank lending negatively, but is insignificant and small in size (while the effect of the funding rate remains unaffected). Hence, it might be important to distinguish between bank-level measures of funding costs and time series measures of uncertainty.

[35] The lagged balance sheet share of provisions can not be calculated from the data and is thus not included.

7 Conclusion

Safe asset scarcity is usually associated with declines in economic activity once the economy reaches the lower bound of interest rates. This paper shows that safe asset scarcity can have beneficial effects for the incumbent owners of safe assets. The PSPP of the Eurosystem serves as a laboratory to study this effect. Due to the reduction in asset supply during the PSPP, safe euro area assets became scarce. This became particularly evident in the repo market, where an increasing share of bonds became special. Repo rates declined substantially, while the dispersion of rates increased owing to differences in the level of specialness across securities. The drop in repo rates hit banks heterogeneously: banks hold different securities in their portfolios, which determine the collateral they use in repo borrowing transactions. As a result, the repo market scarcity is akin to a quasi-natural experiment, where banks are hit randomly by a shock to their funding costs.

I make use of this setting and measure the exposure to asset scarcity by weighting market repo rates with banks' predetermined securities holdings. Under the assumptions that both, asset purchases and the initial distribution of securities are exogenous to the subsequent loan demand on the bank level, the measure enables to estimate the causal impact of the drop in funding costs on bank outcomes to be estimated. The measure is indeed reflective of actual repo funding costs: banks with a higher exposure experienced higher declines in funding costs. This led to higher profits in the repo book and an increase in credit supply. The latter can be shown on the bank and the borrower level for German banks and in a panel of euro area banks. The result is in line with the literature on the bank lending channel, which posits that decreases in funding costs should lead to increases in bank lending.

Taken together, the results suggest that safe asset scarcity and, in turn, asset purchases, had positive effects on banks that were incumbent owners of safe assets: Lower repo rates affected bank funding costs, which in turn led to higher bank lending and windfall gains on banks' repo business. Hence, the concern expressed by Cœuré (2018) that asset scarcity might affect monetary policy transmission appears to be justified. However, regarding bank-based transmission, the results in this paper suggest that this is not necessarily a problem for monetary policy, as scarcity provided additional easing when monetary policy was expansionary.

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Tables

Table 1: Securities Holdings, Trading and Repo: Bank-ISIN level

Dependent Variable:	Repo Turnover					Repo Outstanding	
	ln(Borrowing+Lending)$_{ij}$			ln(Lend)$_{ij}$	ln(Borrow)$_{ij}$	ln(Lend)$_{ij}$	ln(Borrow)$_{ij}$
Sample:	Held or Traded, issued		Repoed				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln(Cash Turnover)$_{ij}$	0.151***	0.132***	0.055***	0.141***	0.052	0.162***	0.045
	(0.038)	(0.035)	(0.016)	(0.049)	(0.060)	(0.054)	(0.058)
ln(Initial Holdings)$_{ij}$	0.105***						
	(0.025)						
ln(Banking Book)$_{ij}$		0.083***	0.068***	-0.241***	0.334***	-0.252***	0.388***
		(0.020)	(0.010)	(0.048)	(0.040)	(0.051)	(0.043)
ln(Trading Book)$_{ij}$		0.151***	0.038***	0.019	0.112**	0.007	0.063
		(0.034)	(0.009)	(0.016)	(0.042)	(0.019)	(0.048)
Bank FE	yes	yes	yes	yes	yes	yes	yes
ISIN FE	yes	yes	yes	yes	yes	yes	yes
Observations	393,159	393,083	12,290	12,279	12,286	12,290	12,290
R^2	0.331	0.333	0.584	0.656	0.632	0.648	0.634

Notes: This table shows regressions of Equation 1, i.e. of aggregate repo trading volumes from MMSR of German banks per bank i - ISIN j on their cash market trading volumes and securities holdings. Variables are aggregated for each bank-ISIN combination over the period July 2016-December 2017 (except Holdings, which use values from June 2016). Apart from that, variables are defined as in Table A.II.1. Columns 2-3 use all bonds held or traded by German banks during the observation period that were issued before July 2016. The other columns use only bonds repoed by German banks during the observation period. Standard errors (in parentheses) are double clustered by bank and ISIN. ***, **, * stand for p<0.01, 0.05, 0.1. For further information, please refer to Table A.II.1. Sources: MMSR, CSDB, WpInvest, WpHMV.

Table 2: Securities Holdings, Trading and Repo: Bank-ISIN-Date level

Dependent Variable:	Repo Turnover				Repo Outstanding	
	ln(Borrow+Lend)$_{ijt}$		ln(Lend)$_{ijt}$	ln(Borrow)$_{ijt}$	ln(Lend)$_{ijt}$	ln(Borrow)$_{ijt}$
Sample:	Repoed					
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Cash Turnover)$_{ijt}$	0.047***	0.046***	0.051***	0.020***	0.026***	0.012***
	(0.005)	(0.005)	(0.005)	(0.003)	(0.002)	(0.002)
ln(Holdings)$_{ijm\text{-}1}$	0.307***		0.040***	0.291***	0.018	0.444***
	(0.045)		(0.012)	(0.045)	(0.021)	(0.065)
ln(Banking Book)$_{ijm\text{-}1}$		0.064***				
		(0.013)				
ln(Trading Book)$_{ijm\text{-}1}$		0.050***				
		(0.010)				
Bank*Day FE	yes	yes	yes	yes	yes	yes
Bank*ISIN FE	yes	yes	yes	yes	yes	yes
ISIN*Day FE	yes	yes	yes	yes	yes	yes
Observations	4,881,807	4,881,807	4,881,670	4,881,766	4,881,807	4,881,807
R^2	0.644	0.644	0.555	0.631	0.641	0.663

Notes: This table shows regressions of equation 2, i.e. of daily lending and/or borrowing repo turnover (or outstanding) of German banks per bank i - ISIN j - date t on their daily cash market trading volumes and lagged monthly securities holdings for the period 1 July 2016 - 31 December 2017. Repo Rate is the daily average repo rate traded by bank i in ISIN j on day t. All other variables are as in Table 1, but on the daily or monthly level. The panel is balanced, i.e. includes zeros for days without turnover/outstanding. Only bank-ISIN combinations are included that feature a repo transaction by the bank in that ISIN. Standard errors (in parentheses) are double clustered by bank and ISIN. ***, **, * stand for p<0.01, 0.05, 0.1. Sources: MMSR, CSDB, WpInvest, WpHMV.

Table 3: Securities Holdings, Trading and Repo: Effect of the Repo Rate

Dependent Variable:	Repo Outstanding					
	$\ln(\text{Borrowing})_{ijt}$				$\ln(\text{Lending})_{ijt}$	
Sample:	Repoed			PSPP ISINs	Repoed	PSPP ISINs
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(\text{Cash Turnover})_{ijt}$	-0.011**	-0.010	0.019***	0.021***	0.027***	0.033***
	(0.004)	(0.008)	(0.003)	(0.004)	(0.005)	(0.005)
$\ln(\text{Holdings})_{ijm-1}$	0.263***	0.202***	0.370***	0.514***	0.035*	0.042
	(0.055)	(0.043)	(0.071)	(0.103)	(0.020)	(0.033)
Traded Repo Rate_{ijt}	-0.003**	-0.004*				
	(0.001)	(0.002)				
Market Repo Rate_{jt}			-0.098**	-0.092*	-0.046	-0.015
			(0.043)	(0.052)	(0.033)	(0.036)
Bank*Day FE	yes	yes	yes	yes	yes	yes
Bank*ISIN FE	yes	yes	yes	yes	yes	yes
ISIN*Day FE	yes	no	no	no	no	no
Instrument			PSPP_{jt}	PSPP_{jt}	PSPP_{jt}	PSPP_{jt}
Observations	432,267	986,180	5,480,074	2,497,045	5,480,074	2,497,045
R^2	0.774	0.658	0.408	0.458	0.495	0.535

Notes: This table shows regressions of Equation 2, i.e. of daily lending and/or borrowing repo turnover (or outstanding) of German banks per bank i - ISIN j - date t on their daily cash market trading volumes, lagged monthly securities holdings and on the daily volume-weighted average repo rate repo rate for ISIN j prevailing in the market on day t (Market Repo Rate) or as traded by bank i on day t (Traded Repo Rate) for the period 1 July 2016 - 31 December 2017. The market repo rate in columns 3-6 is instrumented in an IV setting by the daily net purchase volume of ISIN j on day t by the Eurosystem under the PSPP (PSPP_{jt}). All other variables are as in Table 1, but on the daily or monthly level. The panel is balanced, i.e. includes zeros for days without turnover/outstanding, but is reduced on ijt combinations were an actual trade took place in columns 1 and 2. In columns 3-6, the traded repo rates are averaged on the jt level and, if necessary, carried forward, to use as many observations as possible for the IV approach. Columns 3 and 5 use all resulting observations, whereas columns 4 and 6 only include ISINs that were purchased under the PSPP at any date during the sample period. As before, in all columns, only bank-ISIN combinations are included that feature a repo transaction by the bank in that ISIN. Standard errors (in parentheses) are double clustered by bank and ISIN. ***, **, * stand for p<0.01, 0.05, 0.1. Sources: MMSR, CSDB, WpInvest, WpHMV.

Table 4: Random Distribution of Security Purchases with respect to Specialness

Dependent Variable:	I[Purchase]$_{ijt}$					
Sample:	monthly, held ISINs					
Bank Sample:	All Banks		Repo User	All Banks		Repo User
	(1)	(2)	(3)	(4)	(5)	(6)
Market Repo Rate$_{jt}$	-0.022					
	(0.015)					
Market Repo Rate$_{jt+1}$	0.003					
	(0.003)					
Market Repo Rate$_{jt+2}$	-0.001					
	(0.002)					
Market Repo Rate$_{jt+3}$	0.003					
	(0.003)					
Funding Rate$_{iy}$	-0.030	-0.015*	-0.480**			
	(0.038)	(0.009)	(0.226)			
Market Repo Rate$_{jt}$*Funding Rate$_{iy}$	-0.003*	-0.003	-0.211			
	(0.002)	(0.002)	(0.145)			
Market Repo Rate$_{jt+1}$*Funding Rate$_{iy}$	0.000	0.000	-0.082			
	(0.000)	(0.000)	(0.176)			
Market Repo Rate$_{jt+2}$*Funding Rate$_{iy}$	0.000	0.000	0.060			
	(0.000)	(0.000)	(0.239)			
Market Repo Rate$_{jt+3}$*Funding Rate$_{iy}$	-0.001	0.000	-0.084			
	(0.001)	(0.001)	(0.208)			
Market Repo Rate$_{jy+1}$				-0.001		
				(0.005)		
Funding Rate$_{iy+1}$				-0.208	-0.063	-0.285
				(0.145)	(0.145)	(0.371)
Market Repo Rate$_{jy+1}$*Funding Rate$_{iy+1}$				0.003	0.024	-0.137
				(0.012)	(0.240)	(0.797)
Month FE	yes	-	-	yes	-	-
Bank*Month FE	no	no	no	no	no	no
Bank*ISIN FE	no	yes	yes	no	yes	yes
ISIN*Month FE	no	yes	yes	no	yes	yes
Observations	292,937	288,639	104,016	224,527	221,831	91,552
R^2	0.009	0.453	0.443	0.008	0.448	0.433

Notes: This table shows regressions of securities purchase decisions of bank i in security j in month t on current and future levels of security j's market repo rate in month t to $t+3$ from BrokerTec and interactions with the funding rate of bank i in the current year y from January 2014 to September 2018. Funding Rate is the volume-weighted average repo rate (overnight rates averaged over the year) of each bank's securities holdings (as of December of the previous year) as in Equation 3. Funding rate is winsorized yearly at the 1% tails. The dependent variable is a dummy indicator equal to 1 if a bank purchased security j in month t. Note that only securities holdings are included where a repo rate (in t, $t+1$, $t+2$, $t+3$, or $y+1$) is available for that security. Therefore, the number of observations is smaller in columns 3 to 6, which use the market repo rate and the funding rate in the subsequent year $y+1$. Columns 3 and 6 only include banks active in the repo market in that year, whereas the other columns use all banks. Bank*Month FE are not included to measure differences in trading behaviour between banks. Standard errors (in parentheses) are clustered by bank. ***, **, * stand for p<0.01, 0.05, 0.1. Sources: BrokerTec/MTS, CSDB, WpInvest.

Table 5: Repo Funding Costs and Repo Book Profit

Dependent Variable:	Repo Book Profit$_{it}$				Borrowing Rate$_{it}$	Lending Rate$_{it}$
Sample:	June 1, 2016 - December 23, 2017					
	(1)	(2)	(3)	(4)	(5)	(6)
Funding Rate$_{it}$	-25.809***	-24.757***	-15.418***	-12.100**	6.865***	-6.203
	(8.427)	(8.121)	(4.139)	(4.396)	(2.324)	(4.113)
Repo Book Mismatch$_{it}$		-0.017	0.003	0.003		
		(0.050)	(0.042)	(0.042)		
ln(Cash Turnover)$_{it}$		-0.172**	-0.101**	-0.023		
		(0.071)	(0.047)	(0.093)		
Bank FE	yes	yes	yes	yes	yes	yes
Month FE	no	no	yes	no	no	no
Day FE	no	no	no	yes	yes	yes
Observations	7,148	7,148	7,148	7,148	7,148	7,148
R^2	0.753	0.756	0.800	0.821	0.908	0.845

Notes: The table shows regressions of Equation 5. Dependent variable is the Repo Book Profit (difference of daily volume-weighted average rate of outstanding lending and borrowing from MMSR) of bank i on day t in columns 1-4 and the daily volume-weighted average rate on outstanding borrowing in columns 5-6. Funding Rate is the daily volume-weighted average repo refinancing rate of each bank's last month's securities holdings as in Equation 3. Repo Book Mismatch is the daily percentage difference between borrowing and lending outstandings [(max-min)/max] and Cash Turnover is the natural logarithm of the daily gross cash market bond trading volume of each bank. Observations are weighted by the minimum of lending and borrowing outstandings. The last week of each year is excluded. Standard errors (in parentheses) are clustered at the bank level. ***, **, * stand for p<0.01, 0.05, 0.1. Sources: MMSR, BrokerTec/MTS, WpInvest, WpHMV.

Table 6: Repo Funding Costs and Bank Lending: Germany

Dependent Variable:	$(\Delta$Nonbank Lending$_{it})$/Nonbank Lending$_{it\text{-}1}$				
Sample:	Germany 2013-2018				
Bank Sample:	All Banks				Constant Repo User$_i$
	(1)	(2)	(3)	(4)	(5)
Funding Rate$_{it}$	-0.029***	-0.009	0.002	0.003	-0.467*
	(0.011)	(0.020)	(0.018)	(0.018)	(0.237)
Repo User$_{it}$			-0.008		
			(0.023)		
Funding Rate*Repo User$_{it}$			-0.142**		
			(0.069)		
Funding Rate*Constant Repo User$_i$				-0.223**	
				(0.093)	
Constant	0.054***				
	(0.004)				
Controls	no	yes	yes	yes	yes
Bank FE	no	yes	yes	yes	yes
Year FE	no	yes	yes	yes	yes
Observations	3,919	3,919	3,919	3,919	210
R^2	0.002	0.320	0.323	0.325	0.279

Notes: This table shows results from estimating Equation 6. Dependent variable is the yearly growth rate of loans for each German bank i with total assets above Eur 1 bn in year t. Funding Rate is the volume-weighted average repo rate (overnight rates averaged over the year) of each bank's securities holdings (as of December of the previous year) as in Equation 3. Funding rate is winsorized yearly at the 1% tails, whereas the dependent variable is winsorized at the 1%-tails. Repo User is a dummy for banks that are active in the repo market in year t, Constant Repo User is a dummy for banks that are active in the repo market in each year of the sample. Additional controls are the lagged balance sheet shares of deposits, loans, central bank reserves, provisions and capital, respectively. Standard errors (in parentheses) are clustered at the bank level. ***, **, * stand for p<0.01, 0.05, 0.1. Sources: BISTA, BrokerTec/MTS, WpInvest.

Table 7: Repo Funding Costs and Bank Lending: German Credit Register

Dependent Variable:	ΔLog(Loan Volume$_{ijt}$)					
Country and Period:	Germany 2013-2018					
Borrower Sample:	Non-banks					
Bank Sample:	All Banks			Constant Repo User$_i$		
	(1)	(2)	(3)	(4)	(5)	(6)
Funding Rate$_{it}$	-0.029*	-0.032**	-0.016	-0.870***	-0.821*	-0.745**
	(0.016)	(0.016)	(0.017)	(0.314)	(0.421)	(0.317)
Repo User$_{it}$	-0.048*					
	(0.027)					
Funding Rate*Repo User$_{it}$	-0.142**					
	(0.057)					
Constant Repo User$_i$		-0.033	-0.105**			
		(0.034)	(0.048)			
Funding Rate*Constant Repo User$_i$		-0.129*	-0.223***			
		(0.067)	(0.071)			
Controls	yes	yes	yes	no	yes	yes
Year FE	-	-	yes	yes	-	-
Borrower*Year FE	yes	yes	no	no	yes	yes
Bank FE	no	no	no	no	no	yes
Observations	856,236	856,236	856,236	218,481	218,481	218,481
R^2	0.379	0.379	0.018	0.452	0.017	0.454

Notes: This table shows results from estimating Equation 7 on the German credit register. The dependent variable is the yearly log growth rate of the loan volume that borrower j borrows from bank i in year t. Borrowers are restricted to non-bank corporations only. Funding Rate is the volume weighted average repo rate (overnight rates averaged over the year) of each bank's securities holdings (as of December of the previous year) as in Equation 3, winsorized yearly at the 1% tails. Repo User is a dummy for banks that are active in the repo market in year t, Constant Repo User is a dummy for banks that are active in the repo market in each year of the sample. Additional controls are the lagged balance sheet shares of deposits, loans, central bank reserves, provisions and capital, respectively. Standard errors (in parentheses) are clustered at the bank level. ***, **, * stand for p<0.01, 0.05, 0.1. Sources: MiMiK, BrokerTec/MTS, WpInvest.

Table 8: Repo Funding Costs and Bank Lending: Interest Rates

Dependent Variable:	Interest Rate Corporate Loans				$(\Delta \text{Lending}_{it})/\text{Lending}_{it\text{-}1}$	
	$\leq$ 1 year		> 1 year		Corporate $\leq$ 1 year	
Sample:	Germany 2013-2018					
	(1)	(2)	(3)	(4)	(5)	(6)
Funding Rate*Repo User	0.237*	0.276**	-0.041	-0.014	-0.528*	-0.535*
	(0.129)	(0.133)	(0.115)	(0.113)	(0.317)	(0.315)
Funding Rate$_{it}$	-0.081	-0.088	0.014	0.003	-0.082	-0.096
	(0.097)	(0.096)	(0.058)	(0.057)	(0.147)	(0.145)
Repo User$_{it}$	0.033	0.034	-0.001	0.002	0.016	0.028
	(0.086)	(0.086)	(0.069)	(0.068)	(0.109)	(0.110)
Consumer Deposit Rate$_{it}$	-0.059		-0.312**			0.319
	(0.137)		(0.125)			(0.270)
Corporate Deposit Rate$_{it}$	0.302		0.298**			0.318
	(0.215)		(0.141)			(0.343)
Consumer Deposit Rate$_{it\text{-}1}$		-0.122		-0.168*		
		(0.091)		(0.092)		
Corporate Deposit Rate$_{it\text{-}1}$		0.223*		0.290***		
		(0.119)		(0.105)		
Controls	yes	yes	yes	yes	yes	yes
Bank FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Observations	1,012	1,012	1,012	1,012	1,012	1,012
R^2	0.806	0.806	0.886	0.886	0.357	0.360

Notes: This table shows results from estimating Equation 6 with alternative dependent variables. Funding Rate, Repo User and the additional controls are defined as in Table 6. In Columns 1 and 2, the dependent variable is the volume weighted average interest rate on newly issued corporate loans with initial maturity≤1 year. Columns 3 and 4 use newly issued corporate loans with an initial maturity of above 1 year. Column 5 and 6 employ the yearly growth rate of corporate loans with initial maturity≤1 year winsorized at the 1% tails. Note that the number of observations differs between this table and Table 6, as data on rates are only available for a subset of banks. Standard errors (in parentheses) are clustered at the bank level. ***, **, * stand for p¡0.01, 0.05, 0.1. Sources: BISTA, ZISTA, BrokerTec, MTS, WpInvest.

Table 9: Repo Funding Costs and Bank Lending: euro area

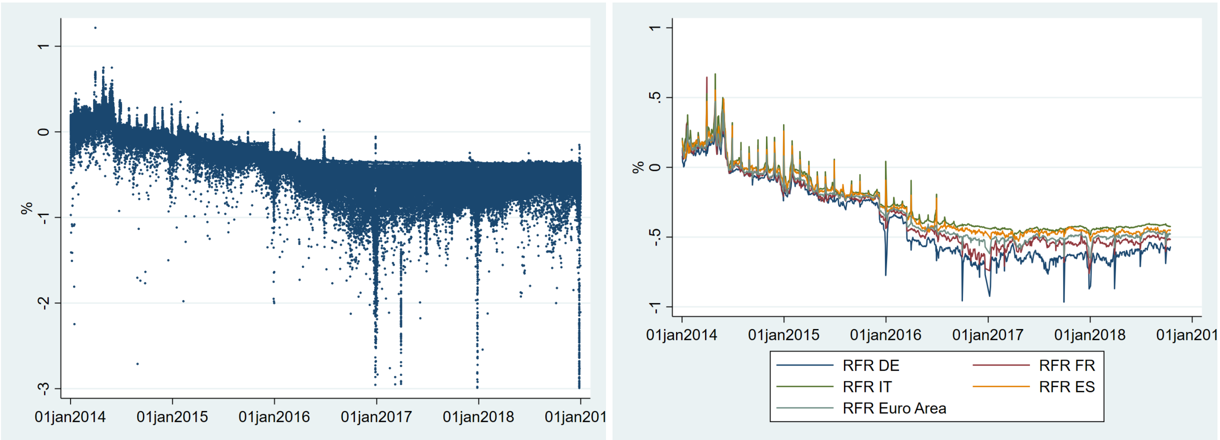
Dependent Variable:	(ΔNonbank Lending$_{it}$)/Nonbank Lending$_{it-1}$				
Sample:	euro area 2014-2018				
	(1)	(2)	(3)	(4)	(5)
Funding Rate$_{it}$	-0.196**	-0.224**	-0.310**	-0.663*	-0.781***
	(0.086)	(0.104)	(0.125)	(0.363)	(0.255)
Constant	-0.056*	0.197**			
	(0.030)	(0.083)			
Controls	no	yes	yes	yes	yes
Bank FE	no	no	yes	yes	no
Year FE	no	no	no	yes	no
Country*Year FE	no	no	no	no	yes
Observations	76	76	76	76	72
R^2	0.053	0.174	0.452	0.502	0.398

Notes: This table shows results from estimating Equation 6. Dependent variable is the yearly growth rate of loans for 21 euro area banks (i) in year t. Funding Rate is the volume-weighted average repo refinancing rate (rates are averaged over the year) of each bank's securities holdings (as of December of the previous year) as in Equation 3. Funding rate is winsorized yearly at the 1% tails, whereas the dependent variable is winsorized at the 1%-tails. Additional controls are the lagged balance sheet shares of deposits, loans, central bank reserves and capital, respectively. Standard errors (in parentheses) are clustered at the bank level. ***, **, * stand for p<0.01, 0.05, 0.1. Sources: IBSI, BrokerTec, MTS, SHS.

A Appendix

A.I Additional Graphs

Figure A.I.1: Euro Repo Rate Dispersion



(a) ISIN-level **(b) Repo funds rates**

Notes: Graph (a) shows daily volume-weighted average overnight (including spot-next and tomorrow-next) repo rates for German, French, Italian, Dutch and Spanish government collateral traded on BrokerTec and MTS. Graph (b) shows the repo funds rates for German, French, Italian, Spanish and euro area government bonds, which are volume-weighted and trimmed averages of trades conducted on BrokerTec and MTS. Sources: BrokerTec, MTS, RepoFundsRate.

A.II Robustness Tables

Table A.II.1: Securities Holdings, Trading and Repo: ISIN-level

Dependent Variable:	$I[\text{repoed}]_j$	Repo Turnover			Repo Outstanding	
		$\ln(\text{Borrowing+Lending})_j$			$\ln(\text{Lending})_j$	$\ln(\text{Borrowing})_j$
Sample:	Holdings		Repoed			
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(\text{Cash Turnover})_j$	0.018***	0.345***	0.066***	0.052***	0.012	0.380***
	(0.000)	(0.005)	(0.006)	(0.006)	(0.018)	(0.017)
$\ln(\text{Initial Holdings})_j$	0.035***	0.721***	0.035***		0.002	0.123***
	(0.001)	(0.014)	(0.004)		(0.012)	(0.011)
$\ln(\text{Initial Holdings Banking Book})_j$				0.025***		
				(0.005)		
$\ln(\text{Initial Holdings Trading Book})_j$				0.023***		
				(0.005)		
$I[\text{Currency Euro}]_j$	0.159***	3.369***	2.814***	2.734***	11.522***	2.916***
	(0.006)	(0.114)	(0.133)	(0.137)	(0.263)	(0.293)
$I[\text{Senior Unsecured Bond}]_j$	-0.040***	-0.765***	-0.230***	-0.265***	-1.449***	0.653**
	(0.005)	(0.098)	(0.089)	(0.091)	(0.318)	(0.279)
$I[\text{Bond with Guarantee}]_j$	0.053***	0.853***	-0.034	-0.017	-1.801***	1.235***
	(0.008)	(0.156)	(0.093)	(0.096)	(0.330)	(0.293)
$I[\text{Bond issued in Germany}]_j$	-0.147***	-2.871***	-0.783***	-0.855***	-2.356***	0.934***
	(0.005)	(0.104)	(0.089)	(0.092)	(0.282)	(0.216)
$I[\text{Corporate Bond}]_j$	0.146***	2.341***	-0.512***	-0.413***	-2.064***	0.108
	(0.012)	(0.212)	(0.085)	(0.088)	(0.307)	(0.270)
$I[\text{Bank Bond}]_j$	-0.042***	-0.827***	-0.006	0.025	-1.091***	0.723***
	(0.008)	(0.147)	(0.083)	(0.085)	(0.277)	(0.245)
$I[\text{Government Bond}]_j$	0.031***	1.068***	2.171***	2.102***	4.353***	2.235***
	(0.009)	(0.184)	(0.109)	(0.114)	(0.322)	(0.286)
Constant	-0.526***	-11.044***	14.666***	14.886***	4.666***	3.510***
	(0.012)	(0.233)	(0.146)	(0.146)	(0.427)	(0.424)
Observations	26,078	26,078	7,963	7,399	7,963	7,963
R^2	0.405	0.422	0.255	0.236	0.213	0.201

Notes: This table shows regressions of aggregate repo trading volumes by German banks on their cash market trading volumes, securities holdings and control variables, all aggregated on the ISIN-level j. More specifically, Repo Turnover (Outstanding) is the natural logarithm of the aggregate lending and/or borrowing turnover (outstanding) for ISIN j of all German banks during the period July 2016 to December 2017. I[repoed] is a dummy equal to one if a security was used as collateral in a repo transaction by German banks in that period. ln(Cash Turnover) is the natural logarithm of the aggregate turnover for each bond in the cash market by all German banks during that period, ln(Initial Holdings) is the log of the aggregate holdings of German banks per ISIN in June 2016, Initial Holdings Banking Book (Trading Book) are the aggregate holdings in the banking book (trading book). I[Currency Euro] equals one when the bond is denominated in euro, I[Bond with Guarantee] equals one for bonds with a government guarantee. Dummies for corporate, bank, government bonds are based on ESA sector classifications of the issuer from CSDB. Columns 1-2 use only securities held by German banks in June 2016, whereas the other columns use only assets repoed by German banks during the observation period. Standard errors (in parentheses) are robust. ***, **, * stand for $p<0.01$, 0.05, 0.1. Sources: MMSR, CSDB, WpInvest, WpHMV.

Table A.II.2: Securities Holdings, Trading and Repo: Bank-ISIN-level - Robustness

Dependent Variable:	Repo Turnover		
	ln(Borrowing+Lending)$_{ij}$		
Sample:	Held	Held, Repoed	Repoed, issued
	(1)	(2)	(3)
ln(Cash Turnover)$_{ij}$	0.066***	0.034***	0.047***
	(0.020)	(0.011)	(0.016)
ln(Initial Holdings)$_{ij}$	0.322***		
	(0.049)		
ln(Initial Holdings Banking Book)$_{ij}$		0.046***	0.073***
		(0.010)	(0.013)
ln(Initial Holdings Trading Book)$_{ij}$		0.004	0.043***
		(0.008)	(0.008)
Bank FE	yes	yes	yes
ISIN FE	yes	yes	yes
Observations	115,714	4,979	8,397
R^2	0.519	0.630	0.572

Notes: This table provides robustness results for Table 1, estimating Equation 1 for different subsamples of the data. Column 1 includes all bonds held by German banks in June 2016. Column 2 includes all bonds held in June 2016 and repoed by German banks between July 2016 and December 2017. Column 3 includes all bonds repoed during the observation period that were issued before July 2016. Variables are as defined in Table 1. Standard errors (in parentheses) are double clustered by bank and ISIN. For further information, please refer to Table 1. ***, **, * stand for p<0.01, 0.05, 0.1. Sources: MMSR, CSDB, WpInvest, WpHMV.

Table A.II.3: Securities Holdings, Trading and Repo: Bank-ISIN-Date-level - Robustness

Dependent Variable:	Repo Turnover			
	ln(Borrowing+Lending)$_{ijt}$			
Sample:	Held	Held, Repoed	Repo Turnover$_{ijt}$ >0	Repo Turnover$_{ijt}$ & Holdings$_{ijm-1}$ >0
	(1)	(2)	(3)	(4)
ln(Cash Turnover)$_{ijt}$	0.046***	0.047***	0.007***	0.009***
	(0.004)	(0.004)	(0.001)	(0.001)
ln(Holdings)$_{ijm-1}$	0.297***	0.321***	0.038**	0.454***
	(0.043)	(0.046)	(0.014)	(0.146)
Bank*Day FE	yes	yes	yes	yes
Bank*ISIN FE	yes	yes	yes	yes
ISIN*Day FE	yes	yes	yes	yes
Observations	1,457,185	1,349,662	432,267	133,341
R^2	0.714	0.712	0.822	0.820

Notes: This table provides robustness results for Table 2, estimating Equation 2 for different subsamples of the data. Column 1 uses all bonds held by German banks in June 2016. Column 2 restricts further to those bonds that were repoed during the observation period. Column 3 only uses observations with a positive repo turnover, whereas column 4 restricts further to observations where also holdings are positive. Variables are as defined in Table 2. Standard errors (in parentheses) are double clustered by bank and ISIN. For further information, please refer to Table 2. ***, **, * stand for p<0.01, 0.05, 0.1. Sources: MMSR, CSDB, WpInvest, WpHMV.

Table A.II.4: Random Distribution of Securities Purchases with respect to Specialness: Robustness

Dependent Variable:	Purchase volume$_{ijt}$					
Sample:	monthly, held ISINs					
Bank Sample:	All Banks		Repo User	All Banks		Repo User
	(1)	(2)	(3)	(4)	(5)	(6)
Market Repo Rate$_{jt}$	-0.349					
	(0.230)					
Market Repo Rate$_{jt+1}$	0.039					
	(0.052)					
Market Repo Rate$_{jt+2}$	-0.012					
	(0.030)					
Market Repo Rate$_{jt+3}$	0.076**					
	(0.036)					
Funding Rate$_{iy}$	-0.442	-0.193	-7.751*			
	(0.570)	(0.125)	(3.923)			
Market Repo Rate$_{jt}$*Funding Rate$_{iy}$	-0.051*	-0.034	-4.527**			
	(0.030)	(0.024)	(2.076)			
Market Repo Rate$_{jt+1}$*Funding Rate$_{iy}$	0.001	0.003	-0.325			
	(0.003)	(0.002)	(2.742)			
Market Repo Rate$_{jt+2}$*Funding Rate$_{iy}$	0.005	0.002	-0.992			
	(0.006)	(0.002)	(3.713)			
Market Repo Rate$_{jt+3}$*Funding Rate$_{iy}$	-0.010	0.005	-0.754			
	(0.017)	(0.006)	(3.248)			
Market Repo Rate$_{jy+1}$				-0.023		
				(0.067)		
Funding Rate$_{iy+1}$				-3.307	-1.869	-6.017
				(2.254)	(2.278)	(5.010)
Market Repo Rate$_{jy+1}$*Funding Rate$_{iy+1}$				-0.029	-0.346	0.079
				(0.157)	(2.952)	(9.417)
Month FE	yes	-	-	yes	-	-
Bank*Month FE	no	no	no	no	no	no
Bank*ISIN FE	no	yes	yes	no	yes	yes
ISIN*Month FE	no	yes	yes	no	yes	yes
Observations	292,937	288,639	104,016	224,527	221,831	91,552
R^2	0.008	0.457	0.451	0.008	0.446	0.436

Notes: This table repeats the regressions from Table 4 with another dependent variable. Purchase volumes of bank i in security j in month t are regressed on current and future levels of security j's market repo rate in month t to $t+3$ from BrokerTec and interactions with the funding rate of bank i in the current year y from January 2014 to September 2018. Funding Rate is the volume-weighted average repo rate (overnight rates averaged over the year) of each bank's securities holdings (as of December of the previous year) as in Equation 3. Funding rate is winsorized yearly at the 1% tails. The dependent variable is the purchase volume of bank i in security j in month t and zero otherwise. Note that only securities holdings are included where a repo rate (in t, $t+1$, $t+2$, $t+3$, or $y+1$) is available for that security. Therefore, the number of observations is smaller in columns 3 to 6, which use the market repo rate and the funding rate in the subsequent year $y+1$. Columns 3 and 6 only include banks active in the repo market in that year, whereas the other columns use all banks. Bank*Month FE are not included to measure differences in trading behaviour between banks. Standard errors (in parentheses) are clustered by bank. ***, **, * stand for p<0.01, 0.05, 0.1. Sources: BrokerTec/MTS, CSDB, WpInvest.

Table A.II.5: Repo Funding Costs and Bank Lending: Germany - Robustness

Dependent Variable:	ΔLog(Nonbank Lending$_{it}$)				$\frac{\Delta \text{Nonbank Lending}_{it}}{\text{Nonbank Lending}_{it-1}}$		
Country and Period:	Germany 2013-2018						
Bank sample:	All Banks			Const. Repo User	Repo User$_{it}$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Funding Rate$_{it}$	-0.030***	0.001	0.002	-0.362**			
	(0.009)	(0.015)	(0.015)	(0.178)			
Repo User$_{it}$		-0.008					
		(0.019)					
Funding Rate*Repo User$_{it}$		-0.106*					
		(0.060)					
Funding Rate*Const. Repo User$_i$			-0.187**				
			(0.079)				
Actual Borrowing Rate$_{it}$					-0.090***	-0.086** (IV)	
					(0.030)	(0.038)	
Actual Lending Rate$_{it}$							0.552
							(0.604)
Constant	0.042***						0.175
	(0.004)						(0.166)
Controls	no	no	no	no	no	no	no
Bank FE	no	yes	yes	yes	yes	yes	yes
Year FE	no	yes	yes	yes	yes	yes	yes
Observations	3,919	3,919	3,919	210	458	458	136
Instrument	-	-	-	-	-	Funding Rate$_{it}$	-
R^2	0.003	0.310	0.313	0.246	0.546	0.546	0.311

Notes: This table shows results from estimating Equation 6. Dependent variable is the yearly growth rate of loans for each German bank i with total assets above Eur 1 bn in year t. Actual Borrowing Rate is the approximated volume weighted average actual repo borrowing rate calculated as in Equation 3 with volume weights from information on ISINs posted as collateral from WpInvest as of each December of the preceding year combined with yearly averaged overnight repo rates from BrokerTec/MTS for the current year, assuming that all collateral posted is overnight repo. Funding Rate is the volume-weighted average repo rate (overnight rates averaged over the year) of each bank's securities holdings (as of December of the previous year) as in Equation 3. Funding rate is winsorized yearly at the 1% tails, whereas the dependent variable is winsorized at the 1%-tails. Repo User is a dummy for banks that are active in the repo market in year t, Constant Repo User is a dummy for banks that are active in the repo market in each year of the sample. Additional controls are the lagged balance sheet shares of deposits, loans, central bank reserves, provisions and capital, respectively. Column 6 estimates an IV regression where the actual borrowing rate is instrumented by the funding rate. In columns 5-7, the number of observations reduces to those repo users, for which information on collateral posted/received and corresponding repo rates are available. Standard errors (in parentheses) are clustered at the bank level. ***, **, * stand for p<0.01, 0.05, 0.1. Sources: BISTA, BrokerTec/MTS, WpInvest.

Table A.II.6: Repo Funding Costs and Bank Lending: German Credit Register - Robustness

Dependent Variable:	ΔLog(Loan Volume$_{ijt}$)					
Country and Period:	Germany 2013-2018					
Borrower Sample:	Non-financial Corporations					
Bank Sample:	All Banks			Constant Repo User$_i$		
	(1)	(2)	(3)	(4)	(5)	(6)
Funding Rate$_{it}$	-0.033*	-0.038*	-0.017	-0.725*	-0.819**	-0.541**
	(0.018)	(0.019)	(0.019)	(0.421)	(0.351)	(0.253)
Repo User$_{it}$	-0.044*					
	(0.027)					
Funding Rate*Repo User$_{it}$	-0.139***					
	(0.052)					
Constant Repo User$_i$		-0.037	-0.092**			
		(0.034)	(0.046)			
Funding Rate*Constant Repo User$_i$		-0.134**	-0.207***			
		(0.060)	(0.061)			
Controls	yes	yes	yes	no	yes	yes
Year FE	-	-	yes	yes	-	-
Borrower#Year FE	yes	yes	no	no	yes	yes
Bank FE	no	no	no	no	no	yes
Observations	722,283	722,283	722,283	198,049	198,049	198,049
R^2	0.390	0.390	0.019	0.018	0.453	0.455

Notes: This table shows results from estimating Equation 7 on the German credit register. The dependent variable is the yearly log growth rate of the loan volume that borrower j borrows from bank i in year t. Borrowers are restricted to non-financial corporations only. Funding Rate is the volume-weighted average repo rate (overnight rates averaged over the year) of each bank's securities holdings (as of December of the previous year) as in Equation 3, winsorized yearly at the 1% tails. Repo User is a dummy for banks that are active in the repo market in year t, Constant Repo User is a dummy for banks that are active in the repo market in each year of the sample. Additional controls are the lagged balance sheet shares of deposits, loans, central bank reserves, provisions and capital, respectively. Standard errors (in parentheses) are clustered at the bank level. ***, **, * stand for p<0.01, 0.05, 0.1. Sources: MiMiK, BrokerTec/MTS, WpInvest.

Table A.II.7: Repo Rate Uncertainty and Bank Lending

Dependent Variable:	(ΔNonbank Lending$_{it}$)/Nonbank Lending$_{it\text{-}1}$					
Sample:	Germany 2013-2018					
	(1)	(2)	(3)	(4)	(5)	(6)
Funding Rate*Repo User$_{it}$	-0.150**	-0.154**	-0.144**	-0.146**	-0.143**	-0.145**
	(0.070)	(0.070)	(0.069)	(0.069)	(0.069)	(0.072)
Funding Rate$_{it}$	0.024	0.010	0.028	0.009	-0.002	-0.002
	(0.018)	(0.017)	(0.017)	(0.017)	(0.019)	(0.018)
Repo User$_{it}$	-0.011	-0.012	-0.009	-0.010	-0.009	-0.008
	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
Repo Vola$_t$	0.093**	0.132**				
	(0.036)	(0.053)				
Repo Max-Min$_t$			0.013***	0.017***		
			(0.003)	(0.004)		
Repo Max-Min$_{it}$					-0.003	-0.002
					(0.002)	(0.002)
Repo Max-Min$_{it}$*Repo User$_{it}$						-0.001
						(0.009)
Eonia$_t$		0.068		0.084*		
		(0.053)		(0.047)		
Controls	yes	yes	yes	yes	yes	yes
Bank FE	yes	yes	yes	yes	yes	yes
Year FE	no	no	no	no	yes	yes
Observations	3,919	3,919	3,919	3,919	3,919	3,919
R^2	0.318	0.319	0.320	0.321	0.323	0.323

Notes: This table shows results from estimating Equation 6 with additional controls for repo rate uncertainty. The dependent variable, Funding Rate, Repo User and the additional controls are defined as in Table 6. Repo Rate Vola is the yearly standard deviation of all ISIN-day level rates for all assets traded on BrokerTec/MTS with a euro cash leg (excluding Greek bonds and days with low trading volume (<50 million)). Repo Max-Min is the average per year and across ISINs (traded on BrokerTec and MTS) of the difference between the daily highest and lowest rate per ISIN. Repo Bank Max-Min constructs the Repo Max-Min indicator on the bank-year level using banks' securities holdings as weights for the yearly average ISIN-level difference between daily highs and lows of the repo rate (variable is winsorized at the 1%-tails). Eonia is the yearly average of EONIA, a euro overnight unsecured money market rate. Standard errors (in parentheses) are clustered at the bank level. ***, **, * stand for p<0.01, 0.05, 0.1. Sources: BISTA, BrokerTec, MTS, WpInvest.