EUROPEAN CENTRAL BANK

EUROSYSTEM

Working Paper Series

Francesca Barbiero, Glenn Schepens,
Jean-David Sigaux

Liquidation value and loan pricing

Revised June 2023

No 2645 / February 2022

Abstract

This paper shows that the liquidation value of collateral depends on the interdependency between borrower and collateral risk. Using transaction-level data on short-term repurchase agreements (repo), we show that borrowers pay a 1.1 to 2.6 basis points premium when their default risk is positively correlated with the risk of the collateral that they pledge. Moreover, we show that borrowers internalize this premium when making their collateral choices. Loan-level credit registry data suggest that the results extend to the corporate loan market as well.

Keywords:Liquidation value; Collateral choice; Money markets
JEL Classification Codes:G21, G12, E43

Non-technical Summary

Collateral is a key component of a wide variety of loan contracts. it decreases the risk for the lender since the collateral can be sold if the borrower defaults. As such, a crucial determinant of the interest rate charged by the lender is the liquidation value of collateral, i.e. what the lender expects the value of the collateral to be in case the borrower defaults. Accordingly, a lender is typically willing to charge a lower interest rate if the liquidation value is higher.

The ability to quickly sell a collateral is seen as an important determinant of the liquidation value (e.g. Shleifer and Vishny (1992), Williamson (1988), Benmelech et al. (2005), Benmelech and Bergman (2009)). In particular, collateral that can be used in many different industries has been shown to have a higher liquidation value than collateral of more narrow uses. Importantly, this characteristic depends only on the collateral provided by the borrower. Not on who the borrower is. Following this logic, one collateral should have a single liquidation value at any point in time.

We show that lenders recognize that a given collateral can have different liquidation values depending on who the borrower is. More precisely, we show that the correlation between borrower default and future collateral value is a crucial component of liquidation value. This correlation is closely related to a concept known in risk management as wrong-way risk (ICMA (2020)).

To do so, we use a dataset that contains all secured money market ("repo") borrowing of 47 major European banks between October 2016 and April 2020. In the secured money market, we exploit the strong positive relation between the default risk of a bank and the default risk of the country where the bank is located. We expect that lenders charge a higher interest rate when the borrower is from the same country as the one that issued the sovereign bond used as collateral. Or, more generally, we expect borrowers to pay higher rates (a 'correlation premium') when there is a higher correlation between borrower default and the risk of the collateral.

We find that borrowers in the repo market pay a 1.1 to 2.6 basis points higher interest rate when they are from the same country as the sovereign that issued the bond used as collateral. As a mean of illustration, our results imply that lenders that receive an Italian collateral are charging a higher rate to an Italian borrower than to an otherwise identical Portuguese borrower. The 2.6 basis points premium is economically large given that the repo market is a market with high volumes and low margins. The average rate in secured money markets during our sample period is minus 60 bps.

Our next set of results helps understanding whether and how the correlation premium affects borrowers' collateral decisions. These results are as follows. First, we provide evidence that borrowers adjust their collateral choices in a way that is consistent with the presence of the correlation premium. A borrower that holds both a domestic- and a non-domestic security is less likely to pledge the domestic security. Second, we show that the fact that borrowers pledge domestic securities does not necessarily contradict with the fact that they internalize the correlation premium. This is because borrowers also internalize another premium, a collateral risk premium, and because some borrowers are constrained: they simply don't have sufficient non-domestic collateral available.

Finally, we generalize our repo market results to corporate collateralized loans. More precisely, we employ data from Anacredit, which is a credit register containing detailed information on individual bank loans in the euro area and exploit the fact that the default risk of construction firms is more positively correlated with the risk of real estate collateral than the default risk of other types of firms. We find that a construction firm that uses a real estate collateral instead of other types of collateral pays a 25 basis points higher interest rate compared to what a non-construction firm pays.

Our results have three main implications. First, lenders monitor the interdependency between borrower and collateral risk. Second, existing empirical proxies for liquidation value miss a key characteristic of the concept of loss given default: for a collateral to be of high quality, it is not sufficient nor necessary for it to have a high unconditional expected value. It has to feature a high expected value conditional on default. By acknowledging that liquidation value varies at the borrower-collateral level, our analysis captures that idea. Finally, banks' home bias in securities holdings has an impact on banks' funding cost. That is, a borrowing bank pays a premium when of the same country as the collateral issuer.

I. Introduction

Collateral is a key component of a wide variety of loan contracts. It reduces financial constraints by increasing the borrower's pledgeable income, as the lender can liquidate the collateral in case of default. As such, a crucial determinant of loan pricing is the liquidation value of collateral, i.e., the expected value of the collateral conditional on borrower default. The higher the liquidation value, the lower the rate charged by the lender.

The driver of liquidation value that receives most attention in the theoretical and empirical literature is collateral redeployability (e.g. Williamson (1988), Benmelech et al. (2005), Benmelech and Bergman (2009)). The higher the collateral redeployability, the more diverse the contexts in which the collateral can be exploited, and hence the higher the liquidation value. Importantly, liquidation value seen through the lens of redeployability is often assumed to be independent from the borrower, such that one collateral pledged by two different borrowers is assigned a single liquidation value at any given point in time.[1]

This paper finds that lenders assign a different liquidation value to a given collateral depending on who is pledging it. To fix ideas as to why this is the case, suppose that two firms with the same probability of default pledge the exact same headquarter as collateral to the same lender. The first borrower operates in the construction sector while the second borrower is active in the food industry. Also suppose that the future value of the collateral is not perfectly known in advance. Arguably, the time when the construction firm defaults on its loan is likely to be a time when the real estate collateral has dropped in value, for example due to a real estate crisis. In contrast, when the food-industry firm defaults, the value of the collateral is less likely to have decreased.

In this example, the lender expects to liquidate the collateral either at a low (construction firm) or at a high (food firm) price upon borrower default. Therefore, the same collateral has either a low or a high liquidation value depending on who is pledg-

[1] One notable exception where liquidation value is not seen as being independent from the borrower is Shleifer and Vishny (1992). In their model, the liquidation value of a given industry-specific collateral varies with the degree of exposure of the borrower to shocks that hit that industry.

ing it. This is driven by the fact that the two borrowers do not have the same default probability conditional on the future value of the collateral, even if their unconditional default probabilities are assumed to be the same. In other words, a crucial determinant of liquidation value, and thus of the price of a loan, is the correlation between the default risk of the borrower and the risk of the collateral.[2]

The euro-area repo market is an ideal market to analyze the pricing impact of the correlation between borrower default risk and collateral risk. Economically, a repo is a short-term collateralized loan, where the collateral is a security. We exploit the fact that European banks typically borrow using sovereign bonds as collateral, including bonds issued by their home country. Given the strong positive relation between the default risk of a bank and that of the country where the bank is located[3], there is variation in the liquidation value of a given collateral depending on whether or not the borrower is from the same country as the collateral issuer. If lenders do recognize that the correlation between borrower and collateral risk matters, we expect them to charge a premium ("correlation premium") when the borrower is from the same country as the collateral issuer.

Our main result is that lenders charge a 1.1 to 2.6 basis points premium when borrowers are from the same country as the sovereign that issued the collateral.[4] As a mean of illustration, our results imply that lenders charge a higher rate when they receive Italian collateral from an Italian borrower than when they receive the same Italian collateral from an otherwise identical Portuguese borrower. Importantly, this correlation premium is on top of any borrower- or collateral-specific premium.

To obtain this result, we rely on a dataset that includes all bilateral repo transactions of 47 major European banks between October 2016 and April 2020. We collect this data from the European Central Bank's (ECB) Money Market Statistical Reporting (MMSR) database. This database includes contract-level information such as the identity of the

[2]Note that this correlation is closely related to a concept known in risk management as wrong-way risk (ICMA (2020)).

[3]This relation is widely documented in the literature on the sovereign-bank nexus; see Dell'Ariccia et al. (2018) for an excellent overview of the literature. We also show the presence of this positive correlation using CDS prices, see Section IV.

[4]We focus on loan prices given that haircuts are equal to zero in the vast majority of the loans in our sample; see Section VI.F for more info.

counterparties, the ISIN code of the collateral, and the rate and volume of the trade.

The richness of the data at hand allows us to perfectly disentangle the correlation premium from any other borrower, collateral or lender-specific premium that might affect loan prices. To do so, we saturate the regressions of our correlation indicator on loan rates with borrower-day, ISIN-day and lender-day fixed effects. The data allow for these fixed effects given that participants in the repo market typically perform multiple trades on the same day, and given that our data include ISIN-level information on the collateral. Borrower-day fixed effects ensure that the estimates of the correlation premium are not contaminated by the impact of borrower risk. Likewise, ISIN-day fixed effects ensure that collateral risk or specific collateral demand is perfectly controlled for. As for the lender-day fixed effects, they ensure that the correlation premium does not capture any lender-specific preferences.

We provide three additional pieces of evidence to confirm that the premium can be attributed to lower liquidation values triggered by borrower-collateral correlation. In a first test, we show that the premium is larger when the lender receives a bond issued by the borrower itself. This collateral has a one-to-one relation with the default risk of the borrower, and hence commands a larger premium. In a second test, we find that the premium disappears when the trade is cleared by a central counterparty clearing platform (CCP). A CCP is an entity on which all legal repayment obligations fall in case of borrower default. As such, borrower-collateral correlation should be of little importance to the lender. In a third test, we show that there is a premium when the collateral is positively correlated with the borrower's default risk, even when the collateral has not been issued by the borrower's home country.

Our next set of results helps understanding whether and how the premium affects borrowers' collateral decisions. These results are as follows. First, we provide evidence that borrowers adjust their collateral choices in a way that is consistent with the presence of the correlation premium. To do so, we gather securities holdings data from the ECB's Securities Holdings Statistics Group (SHSG) database. This database contains quarterly security-level information on the holdings of large European banks. Our results indicate that a borrower that holds both a domestic- and a non-domestic security in the same proportions is less likely to pledge the domestic security.

The fact that borrowers actively try to avoid the correlation premium is an important indication that the estimate of 1.1 to 2.6 basis points is economically sizeable. The average interest rate in our sample is minus 61 basis points. Given that the repo market is a market with high volumes and low margins, the premium is large enough for borrowers to try and adjust their collateral choices accordingly. One should note, however, that the correlation premium is smaller than the premium charged for collateral risk, which we estimate to be 6.5 basis points.

Second, we show that the fact that borrowers pledge domestic securities does not necessarily contradict the fact that they internalize the correlation premium. This is because the correlation premium is not the only premium that matters, and because some borrowers are constrained. More specifically, we find that borrowers internalize another premium, namely the collateral risk premium. This entails a preference for low-risk rather than high-risk collateral. One important implication is that some borrowers face a trade-off between pledging a security that is relatively safe but turns out to be domestic, and pledging a security that is riskier but not domestic. In particular, if a borrower's portfolio of domestic securities is sufficiently safer than her non-domestic securities, she can decrease her cost of debt by pledging domestic collateral. Furthermore, some borrowers simply cannot avoid the correlation premium: 30% of borrowers in our sample have a volume of repo borrowing that is larger than their holdings of non-domestic securities. These borrowers have to use domestic collateral for a sizable share of their repo loans.

Finally, we provide complimentary evidence on European corporate lending markets to ensure the external validity of our results. We employ loan-level data from Anacredit, which is a credit register containing detailed information on individual bank loans in the euro area, harmonised across all euro-area countries. The features of the data lead us to design a test that compares borrowers from the construction sector to borrowers from other sectors of the economy. We exploit the fact that the default risk of construction firms is more positively correlated with the risk of real estate collateral than the default risk of other types of firms. Accordingly, we estimate a premium of 25 basis points charged to construction firms when they pledge real estate collateral instead of another type of collateral, over and beyond the premium paid by non-construction firms.

Our paper contributes to several strands of the literature. First and foremost, our paper contributes to the literature on collateral liquidation value and financial contracting (see, e.g., Williamson (1988), Shleifer and Vishny (1992), Benmelech et al. (2005)). An important implication of Shleifer and Vishny (1992) is that a collateral pledged by a borrower that is prone to idiosyncratic shocks has a higher liquidation value than that of an identical collateral pledged by a borrower that is prone to shocks that hit the collateral's industry. Our findings can be viewed as empirical evidence of that implication. In other words, we provide evidence that liquidation value is state-contingent, and does not solely depend on the redeployability of the collateral.

Finding a proxy for liquidation value that matches the theoretical literature and captures its state-contingent nature is challenging. Existing empirical work typically measures liquidation value at the industry level (Strömberg (2000), Acharya et al. (2007), Kim and Kung (2017)) or at the collateral level, either using zoning restrictions (Benmelech et al. (2005)), the diversity of track gauges in nineteenth-century American railroads (Benmelech (2009)), or the number of other airlines using the same type of airplane (Benmelech and Bergman (2009)).[5] All these measures are asset-specific, and not asset-borrower specific. Put differently, existing work either focusses on asset-specific characteristics that resonate the redeployability concept, or on the number of potential buyers of the collateral.

Importantly, these empirical proxies miss a key characteristic of the concept of loss given default (LGD) which is widely used in the banking industry and for which Shleifer and Vishny (1992) provide a micro-foundation. For a collateral to be of high quality (i.e., low LGD), it is not sufficient nor necessary for it to have a high unconditional expected value. Instead, a high quality collateral has to feature a high expected

[5]A number of other related papers that investigate the impact of laws, creditor rights and institutions on collateralized lending exploit bank estimates of expected liquidation values (E.g. Calomiris et al. (2017), Cerqueiro et al. (2016), Degryse et al. (2020), Liberti and Mian (2010)). While these estimates in theory could be asset-borrower specific, these papers do not investigate this aspect of liquidation value.

value conditional on borrower default.

We differ from previous empirical studies by constructing a proxy of liquidation value that varies at the borrower-collateral level. Our proxy therefore more closely captures the implication featured in Shleifer and Vishny (1992) that collateral quality is conditional on borrower default. We do recognize, however, that our proxy has some potential drawbacks as well. In particular, our proxy is agnostic on whether a collateral has a low liquidation value due to a low liquidity upon default (as in Shleifer and Vishny (1992)), or a low fundamental value upon default (as in the bank-sovereign nexus literature).[6] It is also agnostic on whether the shock is common to the borrower and the collateral, or whether the shock is being transmitted from one to the other.

Our paper also contributes to the literature on repo markets. There is recent evidence on the monitoring of collateral quality in US repo markets (Auh and Landoni (2022)). In our paper, we find that lenders also monitor the correlation between the borrower and the collateral risk. Our results thus imply a form of monitoring of borrower quality. This implication is important because collateral quality is often thought to be a substitute for borrower monitoring. While our results do not invalidate this substitutability, we show that borrower monitoring is not completely absent from markets where borrowers bring one of the safest form of collateral available. The substitutability of monitoring and collateral quality is therefore imperfect.

The repo pricing effects that we report are also important because they could precede credit rationing. One prominent example of rationing is the US interbank market around the time of the Great Financial Crisis (Mancini et al. (2016), Gorton and Metrick (2012), Boissel et al. (2017), Martin et al. (2014)). For example, Gorton and Metrick (2012) report that the interbank rate had increased fivefold by August 2007, whereas the first significant increase in haircuts occurred later in that year. While the haircuts are overwhelmingly null in our sample, a credit rationing based on borrower-collateral correlation is a non-negligible possibility in bad times. In fact, some actors of the CCP segment already have a credit rationing mechanism in place whereby they specify a

[6] In particular, a low liquidity upon default may be caused by fire-sale, see e.g. fire-sale in equity markets in Coval and Stafford (2007), and fire-sale in corporate bond markets in Ellul et al. (2011).

limit in the quantity of same-country assets that borrowers can use as collateral (Eurex Clearing (2020)).

Finally, our paper contributes to the literature on the bank-sovereign nexus. Our paper is the first to show that banks' home bias in security holdings has an impact on banks' funding cost in repo markets. That is, pledging a domestic collateral increases the funding cost of banks via the correlation between bank default and collateral issuer default. This cost has been overlooked by the literature and should be counted against the potential benefits that banks derive from their home bias. Existing literature on the bank-sovereign nexus mainly considered the impact of home bias on banks' market value (Dell'Ariccia et al. (2018)), lending (Popov and van Horen (2014), Altavilla et al. (2017), Gennaioli et al. (2018), De Marco (2019)) and the real economy (Bottero et al. (2020), Acharya et al. (2018)).

The rest of this paper is organized as follows. Section II develops the conceptual framework. Section III describes the institutional setting and the data. Section IV presents the empirical setup for the main analysis. Sections V and VI describe the main results and a set of robustness checks. Section VII shows that our main results also hold in corporate loan markets. Section VIII concludes.

II. Conceptual framework and hypothesis development

In this section, we develop a simple PD-LGD framework to illustrate why loan prices should reflect variation in liquidation value at the collateral-borrower level. Within this framework, we can think about the interest rate charged by a lender as being defined by three factors:

$$R = f(BorrowerRisk, Liquidation_{Col}, Liquidation_{Col-Bor}) \tag{1}$$

where R is the interest rate, $BorrowerRisk$ is a measure of the borrower risk, $Liquidation_{Col}$ is an approximation of the liquidation value based solely on collateral characteristics, $Liquidation_{Col-Bor}$ is a collateral-borrower specific term that comes as a correction to the approximation made, and $f(.)$ a function increasing in $BorrowerRisk$ and decreasing in $Liquidation_{Col}$ and in $Liquidation_{Col-Bor}$.

Why is this a suitable way to think about loan pricing? Let us consider the following PD-LGD model. Let PD (*probability of default*) be the expectation of a random dummy variable D indicative of default. Let L (*loss*) be a random variable capturing the unconditional loss in collateral value. Let LGD (*loss given default*) be the expectation of L conditional on default. Under a series of assumptions[7], the model says that lenders ask for an interest rate that exactly compensates them for expected losses:

$$R = ExpectedLoss = PD * LGD \tag{2}$$

After some rearrangements[8], we can express R as a function of D and L:

$$R = \mathrm{E}[D * L] \tag{3}$$

Finally, we obtain the following relationship between R, PD, D and L[9] :

$$R = PD * \mathrm{E}[L] + \mathbf{COV}(\mathbf{D}, \mathbf{L}) \tag{4}$$

Our interpretation of Equation 4 in light of Equation 1 is that interest rates increase in PD (a measure of $BorrowerRisk$), increase in $E(L)$ (negatively related to $Liquidation_{Col}$) and in $COV(D, L)$ (negatively related to $Liquidation_{Col-Bor}$).[10]

The presence of the third term $COV(D, L)$ stresses the importance of the co-movement between borrower default and the value of the collateral. In other words, it is not en-

[7]Lenders are competitive and risk-neutral. Haircuts are assumed to be zero to match our setting. Alternatively, haircuts can be non-zero as long as they do not perfectly adjust for the covariance between D and L. Finally, D and L are assumed to be jointly distributed with finite second moments.

[8]Using $PD = Prob(D = 1)$, $LGD = E(L|D = 1) = \mathrm{E}[D * L \mid D = 1]$ and adding the null term $Prob(D = 0) * \mathrm{E}[D * L \mid D = 0] = 0$, one finds $PD * LGD = Prob(D = 1) * \mathrm{E}[D * L \mid D = 1] + Prob(D = 0) * \mathrm{E}[D * L \mid D = 0]$. One then uses the law of total expectations.

[9]Using the general result $Cov(X, Y) = \mathrm{E}[XY] - \mathrm{E}[X]\,\mathrm{E}[Y]$ where X and Y are jointly distributed real-valued random variables with finite second moments, and $COV(X, Y)$ is the covariance.

[10]In Online Appendix A, we illustrate the validity of Equation 4 by providing a numerical application.

tirely satisfactory to set the liquidation value of a collateral equal to a component that depends solely on collateral-specific characteristics. When doing so, one makes an error that varies at the collateral-borrower level. Consequently, the collateral value pledged by one borrower will differ from that pledged by another borrower with the exact same collateral. It is the impact of this third term, $COV(D, L)$, on loan rates that we aim to capture in our empirical analysis, while controlling for the impact of borrower risk (PD) and collateral-specific risk ($E(L)$).

III. Institutional setting and data description

A. The repo market in the euro area: Institutional setting

Banks, non-bank financial institutions, as well as non-financial corporations heavily rely on repo markets for their short-term funding and collateral needs. Economically, a repo is very similar to a collateralized loan, as the securities (i.e., collateral) provide credit protection in the event that the seller (i.e., cash borrower) defaults. Technically, a repo is a sale of securities for cash with a commitment to repurchase them at a specified price at a future date. Legally, a repo is seen as a Title Transfer Collateral Arrangement (TTCA) in the European Union's (EU) Financial Collateral Directive (FCD). The lender becomes the legal owner of the collateral and can, in principle, immediately liquidate the collateral in case of borrower default. The Bank Recovery and Resolution Directive (BRRD) can, however, force a short stay of collateral (up to two days) in case the borrower is a bank and goes into resolution (Paech (2017)).[11]

In the bilateral segment of the repo market, borrowers and lenders negotiate the interest rate ("repo rate") and the haircut. Haircuts determine how much the borrower can borrow for each euro of collateral. To the best of our knowledge, there are no explicit rules on haircuts in the bilateral segment of the EU repo market. Our data suggest that haircuts are extremely scarce during our sample period; only 4.5% of the trades backed by government bonds have a haircut. This is in line with the observations

[11]See Article 69-71 of the BRRD.

in Julliard et al. (2022) for UK repo markets, and with survey evidence in BIS (2010). Given the insignificance of haircuts in our sample, we focus the analysis on repo rates.

The majority of euro-area repo trades are concentrated in one-day markets. There are three types of one-day transactions: "overnight", when the repo settles on the trade date T and the bond is repurchased the next business day T+1; "tomorrow next", when the repo settles at T+1 and the bond is repurchased the following business day T+2; and "spot next" when the repo settles at T+2 and the bond is repurchased at T+3. ECB (2019) shows that, taken together, these trades make up more than 90% of the transactions in the euro-area money market.

B. The repo market in the euro area: data description

Our repo market analysis is based on transaction-level bilateral repo data collected within the scope of the Money Market Statistical Reporting (MMSR) framework. The MMSR dataset is a confidential proprietary dataset available at the European Central Bank. It covers all euro-denominated daily borrowing and lending transactions undertaken by a sample of major euro area banks in the secured and unsecured segments of the money market, and booked at European Union and EFTA locations.[12] In this paper, we focus on the secured ("repo") borrowing activity of these banks. Banks that report their transactions under the MMSR framework submit the list of all their repo transactions, including detailed information on quantities, prices and collateral, to their National Central Bank or to the ECB.

We select all bilateral, one-day trades backed by euro-area government bonds that are used in at least 30 transactions in a month.[13] Focussing on trades backed by government bonds is key for our identification strategy (see Section IV below). Government bonds also constitute the main type of collateral used in repo trades. Figure 1 shows that more than 50% of borrowing volumes are backed by government bonds. In addition, almost 60% of the repo borrowing that is secured by government bonds is backed

[12]EFTA is the European Free Trade Association and includes the countries of Iceland, Liechtenstein, Norway and Switzerland.

[13]We exclude borrowing transactions in which the counterparty is a central clearing counterparty (CCP) because, in this case, the lender is insured against borrower risk.

by domestic bonds (Figure 2).

PLACE FIGURE 1 ABOUT HERE

PLACE FIGURE 2 ABOUT HERE

The final repo market sample spans the period from 3 October 2016 until 16 April 2020, covering 828,718 unique transactions between 47 borrowing banks and their counterparties, which can be banks, financial companies or non-financial corporations. All transactions are collateralized by sovereign bonds issued by euro area countries. For the purpose of our analysis, we collect information on the volume, the rate and the haircut of each transaction, the borrower and lender involved, as well as ISIN-level information on the asset that backs the transaction.

To study the collateral choice of the borrowers, we also require information on the banks' securities holdings. We collect this data from the ECB's Securities Holdings Statistics by banking Group (SHSG) database. The SHSG data provides end-of-quarter ISIN-level information on securities holdings and securities encumbrance of individual banking groups. In particular, it includes information about the extent to which a given ISIN is held and pledged in a repo transaction by a given bank at a given time. We have access to the data for the 2018Q4-2020Q2 period.

Descriptive statistics for the trade-level repo sample are reported in the upper panel of Table I, while the lower panel of Table I contains summary statistics for the SHSG variables at the borrower-ISIN-quarter level. The (annualized) average repo rate in the sample is -61 basis points. The variation in repo rates is considerably high, with a standard deviation of 25 basis points. Our main variable of interest is the trade-level *High-correlation dummy*. This dummy variable is equal to 1 if the issuer of the collateral is the home country of the borrower, and equal to 0 otherwise. It has a sample average of 0.44. This implies that the borrower is of the same country as the issuer of the collateral in 44% of the trades in our sample.

PLACE TABLE I ABOUT HERE

IV. Empirical strategy

The main goal of the empirical exercise is to isolate the impact of the collateral-borrower term ($COV(D, L)$) from the borrower risk (PD) and the collateral-level liquidation value ($Liquidation_{Col}$), as presented in equation (4). To do so, we take two key steps. First, we construct a credible proxy for the collateral-borrower term. Second, we develop a regression setup that allows to perfectly disentangle the pricing impact of this proxy from that of the other two relevant factors.

We proxy the correlation between collateral and borrower risk by constructing a *High-correlation dummy* that is equal to 1 if the borrower is of the same country as the collateral issuer, and equal to 0 otherwise. The underlying assumption is that there is a strong positive relation between the default risk of a bank and the default risk of its home country, as widely documented in the literature on the sovereign-bank nexus (see e.g.Dell'Ariccia et al. (2018)).

Then, we exploit the granularity of the MMSR database and estimate the following regression model:

$$Rate_{i,t,c,l} = \alpha + \beta \text{High-correlation dummy}_{c^{country}=i^{country}} + \chi_{i,t} + \psi_{c,t} + \omega_{l,t} + \gamma Volume_{i,t,c,l} + \delta Maturity_{i,c,l} + \nu_{i,t,c,l} \quad (5)$$

where t is the day of the repo trade, i is the borrower, c is the ISIN of the collateral, l is the lender, $i^{country}$ is the country of borrower i, $c^{country}$ is the country of collateral c. $High\text{-}correlation\ dummy_{\{c^{country}=i^{country}\}}$ is the main explanatory variable. $\chi_{i,t}$, $\psi_{c,t}$, $\omega_{l,t}$ correspond to the borrower-, collateral-, and lender-day fixed effects, respectively. $Volume_{i,t,c,l}$ is the log volume of the trade. $Maturity_{i,c,l}$ is a fixed effect capturing the settlement date of the trade, i.e., either overnight, tomorrow next or spot next, which are all one-day loans starting respectively in 0, 1, and 2 days. We cluster standard errors at the borrower-ISIN level, as our main variable of interest varies at this level.[14] In order to

[14] In Table B3 in Online Appendix B, we introduce a double clustering at the borrower-level and at the ISIN-level, instead of a single clustering at the borrower-ISIN level. The results are qualitatively similar

ensure that our results are not biased by strong outliers, we winsorize the repo rate at the 1 percent level.[15]

This specification allows us to study whether lenders require a premium when the borrower is of the same country as the issuer of the collateral. Our main coefficient of interest is β, as it captures this premium. For example, a positive coefficient will imply that an Italian bank borrowing against Italian collateral will pay a higher repo rate than, for instance, an otherwise identical Portuguese bank borrowing against the exact same Italian collateral from the same lender.

The setup ensures that the estimates are not polluted by collateral- or borrower-specific characteristics. Given that the exact same bond (at the ISIN-level) is often pledged by multiple borrowers in the repo market on the exact same day, we can saturate the regressions with ISIN-day fixed effects to control for collateral-specific characteristics. Similarly, the fact that borrowers in repo markets typically engage in multiple trades on a given day allows us to focus on within-borrower-day variations by adding borrower-day fixed effects.

As a result, our empirical strategy highlights the link between loan prices and a proxy for $COV(D, L)$ from equation (4), while perfectly controlling for the two other covariates. Additionally, our most conservative setup includes lender-day fixed effects, which ensures that lender-specific preferences do not affect our estimates.

Before turning to the main empirical evidence, we briefly study the validity of the proxy of $COV(D, L)$. The goal is to show that $COV(D, L)$ is effectively larger in situations where the *High-correlation dummy* $= 1$ compared to when the *High-correlation dummy* $= 0$. To that end, we focus on correlations between the default risk of the borrower and that of the collateral issuer. We proxy bank and sovereign default risk by their Credit Default Swap (CDS) spreads. We collect five-year CDS spreads for 25 banks and 16 sovereigns. For each sovereign-bank pair, we calculate the 60-day rolling CDS correlation ("CDS correlation") between the bank's CDS and the sovereigns CDS. Table II shows that the average correlation is 13.3 percentage points higher when the

to our main results (Table III).

[15]Table B4 in Online Appendix B shows that our main results also hold when we don't winsorize.

bank is not from the same country as the collateral issuer. Table B1 in Online Appendix B shows that this also holds when comparing correlations within the same bank: the CDS correlation between a bank and its home country is on average 15 percentage points higher than the average correlation between that bank and other countries. These results confirm the reliability of our proxy.

PLACE TABLE II ABOUT HERE

V. Results

We start by presenting our main findings, as well as a number of additional tests confirming the existence of a correlation premium in repo markets. We then investigate the link between the correlation premium and collateral choice.

A. Main results

Table III presents our main findings. It shows the results from estimating equation 5. The dependent variable is the repo rate at the transaction level. The independent variable of interest is the *High-correlation dummy*, which is equal to 1 when a bank is of the same country as the issuer of the sovereign bond used as collateral.

The first column of Table III corresponds to a specification with day fixed effects only. We find a large and positive impact of the *High-correlation dummy* of 10.3 basis points ("bps"). In other words, lenders charge a 10.3 bps premium when a borrowing bank is using collateral issued by its home country. While this is fully in line with the idea of a borrower-collateral pricing component, this specification neither takes into account the pricing impact of the collateral-specific component of liquidation values nor the effect of borrower risk. This is taken care of in columns 2 and 3.

PLACE TABLE III ABOUT HERE

In column 2, we add ISIN-day fixed effects to control for time-varying, collateral-level determinants of repo rates. This reduces the premium to 3.9 basis points. The drop in the coefficient indicates that the characteristics of an individual collateral have a significant impact on the premium. Failing to include this type of fixed effects would result in a biased estimate. In column 3, we further saturate the specification with borrower-day fixed effects to control for borrower risk. The correlation premium drops to 2.5 basis points, but remains statistically significant at the 1% level. Overall, these three columns confirm the existence of a correlation premium, even after controlling for the direct impact of borrower and collateral characteristics.[16]

In columns 4 and 5 of Table III, we take into account lender heterogeneity. Some lenders might be more risk-averse than others, or lenders' risk preferences might be changing over time. To ensure that this does not affect our results, we either control for the lender's sector (banking, non-bank financial institutions etc.) by means of lender-sector-day fixed effects (column 4) or, in our most conservative setup, for lender-day fixed effects (column 5). This leads to an estimated correlation premium of 2.6 and 1.1 basis points, respectively.

Column 4 and 5 of Table III also illustrate that there is a trade-off between, on the one hand, identifying the correlation premium as clean as possible (column 5) and, on the other hand, ensuring that we have a sample that is as representative as possible of the bilateral repo market (column 4). When we add lender-day fixed effects, we lose a substantial number of observations (a drop from 792,364 in column 4 to 227,598 in column 5). The reason for this drop in observations is twofold. First, before March 2019, the MMSR data only includes information on the lender's identity if the lender is a bank, or if the borrower voluntarily reports it. From March 2019 onwards, borrowers are obliged to report the identity of the lender. Second, not all lenders lend to multiple borrowers each day, which also leads to fewer observations. While the lender-sector-day fixed effects in column 4 are not as comprehensive as lender-day fixed effects, they allow to analyze a broader sample.

Additionally, a substantial part of the drop in the point estimate between column 4

[16] Note that the sample size slightly varies across the four columns of our main table. This is due to the set of fixed effects, which differs from column to column. In Table B2 in Online Appendix B, we re-run all specifications on the same sample used in column 5 of Table III. The results remain qualitatively and quantitatively similar.

and 5 of Table III is not due to the introduction of lender-day fixed effects, but caused by the change of the sample. To show this, we re-estimate the specification with lender-sector-day fixed effects on the smaller sample from column 5. We then get a point estimate of 1.6 basis points.[17] In other words, the change of the sample accounts for two-thirds of the drop in the point estimate between column 4 and 5 of Table III. This, combined with the described trade-off, leads us to report the range between 1.1 bps (column 5) to 2.6 bps (column 4) as our headline result.

Overall, our estimates imply that borrowers are penalized by a 1.1 to 2.6 basis points higher repo rate when they are from the same country as the collateral that they pledge.

B. Additional evidence of the correlation premium

This section introduces three additional tests that confirm the existence of a correlation premium. We start by studying two extreme settings: one in which the correlation between the default risk of the borrower and the collateral is virtually equal to one, and one in which the correlation is mostly irrelevant. We then introduce a continuous proxy of the borrower-collateral correlation.

In column 1 of Table IV, we study an extreme case in which the borrower is also the issuer of the collateral. In this setting, the correlation between borrower and collateral is virtually equal to 1. The sample comprises trades backed by bonds or equity issued by banks. The main explanatory variable is a dummy (*"Own-collateral dummy"*) equal to 1 if the borrower is also the issuer of the collateral, and 0 otherwise. Our specification includes borrower-day, ISIN-day and lender-day fixed effects. The coefficient for the *Own-collateral dummy* is equal to 0.104 and is significantly different from zero at the 1% level. This implies that borrowers are penalized by a premium of 10.4 basis points when they are the issuer of the collateral that they pledge. This premium is significantly larger than the premium documented in Table III. This is in line with the intuition that a larger correlation implies a larger premium.

PLACE TABLE IV ABOUT HERE

[17] See column 4 of Table B2 in Online Appendix B.

In column 2 of Table IV, we study the case in which lenders are insured against counterparty risk and thus should not care about liquidation values. More precisely, we study the case where a central counterparty clearing platform (CCP) clears the trade. CCPs are regulated financial institutions that take on the counterparty credit risk between parties engaging in a transaction. In these trades, the agreement between the lender and the borrower is replaced by two separate agreements: one between the lender and the CCP, and one between the CCP and the borrower. In other words, there is no direct legal obligation between lenders and borrowers (see, e.g., BIS (2010)). The risk that the borrower defaults thus falls fully on the CCP, and lenders are unlikely to internalize liquidation values. We therefore predict that the correlation risk premium is close to zero in these trades. In column 2, we rerun our main specification, but focus on CCP-cleared trades. As predicted, the coefficient on the *High-correlation dummy* is not statistically distinguishable from zero.

In column 3 of Table IV, we construct a continuous proxy of the correlation between borrower default risk and collateral risk. We use the 60-day rolling correlation between a borrower's and a collateral issuer's respective five-year CDS spreads. We require that both the bank and sovereign CDS price change on at least 90% of the days within the 60-day period. If not, we consider the series as being insufficiently liquid during that period, and we do not calculate a correlation during that window. Column 3 shows that the coefficient associated with the continuous proxy is positive and significantly different from zero. Lenders penalize borrowers with a 1.3 basis points premium when borrower default risk is perfectly correlated with collateral risk, compared to the case where it is uncorrelated.[18]

C. *The correlation premium and collateral choice*

Having established the existence of a correlation premium, we now turn to analyzing whether borrowers internalize this premium and, if so, why they still decide to pledge domestic collateral.

[18]The extreme case of perfect correlation may be underestimated by our linear specification given that some banks in our sample are far from being perfectly correlated with the collateral issuer (see Table II).

As detailed below, our results indicate that borrowers do internalize the correlation premium. However, borrowers also internalize a collateral risk premium. This gives rise to a trade-off for borrowers that hold relatively safe domestic securities and partly explains why we still observe trades backed by correlated collateral. Additionally, we find that around 30% of borrowers have a volume of repo borrowing that is larger than their holdings of non-domestic securities. These borrowers have to make use of domestic collateral to fulfill their repo demand.

C.1. Borrowers avoid pledging correlated collateral

In this section, we show that borrowers try to avoid pledging correlated collateral. Our empirical strategy consists in showing that a given borrower that holds both a domestic- and a non-domestic security in the same proportion is less likely to pledge the domestic security.

As in the main analysis, we focus on banks that borrow in the repo market. We collect information on banks' securities holdings from the ECB's Securities Holdings Statistics by banking Group (SHSG) database. The SHSG data provides end-of-quarter ISIN-level information on securities holdings and securities encumbrance of individual banking groups. In particular, it includes information about the extent to which a given ISIN is held and pledged in a repo transaction by a given bank at a given time. Our sample covers the 2018Q4-2020Q2 period. We restrict the collateral to euro-area sovereign securities. We have information on more than half of the banks covered in our main sample (28 banks).

One notable caveat of the data is that it does not allow us to determine whether a given ISIN is used in a bilateral or, alternatively, in a CCP-cleared repo transaction. Note, however, that this is likely to bias the findings downwards due to the fact that there is no correlation premium in the CCP segment (see column 2 of Table IV).

For each ISIN-borrower-quarter combination, we construct four variables. The *Holdings ratio* captures the weight of a given ISIN in the borrower's portfolio. The *Repo ratio* is equal to the weight of an ISIN in the borrower's pledged collateral. The *Non-null repo ratio dummy* takes a value 1 if the *Repo ratio* is non-null, that is, if the ISIN is pledged at all by the borrower. Finally, the *High-correlation dummy* is equal to 1 if the ISIN held by the borrower is issued by that borrower's home country.

Formally, the first two variables are defined as follows:

$$Holdings\ ratio_{i,c,t} = HoldingsVol_{i,c,t} / \sum_{c=1}^{C} HoldingsVol_{i,c,t} \tag{6}$$

$$Repo\ ratio_{i,c,t} = PledgedVol_{i,c,t} / \sum_{c=1}^{C} PledgedVol_{i,c,t} \tag{7}$$

where i denotes a borrower, c denotes the collateral's ISIN, t denotes the end of a quarter. $HoldingsVol$ and $PledgedVol$ are the holdings volume and the volume of pledged collateral in the repo market, respectively.

We predict a negative β coefficient in the following specification:

$$Repo\ ratio_{i,c,t} = \alpha + \beta High\ Correlation_{c^{country}=i^{country}} + \gamma Holdings\ ratio_{i,c,t} + \chi_{i,t} + \nu_{i,c,t} \tag{8}$$

The above specification allows us to test if a domestic ISIN is less likely to be pledged than a non-domestic ISIN, for the same borrower, in the same quarter. Apart from including borrower-quarter fixed effects ($\chi_{i,t}$) to control for time-varying borrower specificities, we also include the *Holdings ratio* as control variable. Controlling for the *Holdings ratio* is crucial given that portfolio composition is likely to shape collateral usage. Consequently, what matters is the distance between the *Repo ratio* and the *Holdings ratio*. The more negative the distance, the more we can be confident that borrowers avoid pledging correlated collateral, and that they are not simply randomizing their collateral choice. Controlling for the *Holdings ratio* takes care of measuring that distance.

Column 1 of Table V shows a negative and significant impact of the *High-correlation dummy* on the *Repo ratio*. The *Repo ratio* of a domestic ISIN is on average 0.069 percentage points lower than the *Repo ratio* of a non-domestic ISIN, for the same borrower in the same quarter. This is a sizable effect given that, on average, an individual security makes up 0.3% of a borrower's total repo collateral. Column 2 confirms this result when using the *Non-null Repo ratio dummy* as dependent variable. The coefficient of -0.026 implies that a domestic ISIN is 2.6 percentage points less likely to be pledged on the repo market than a non-domestic ISIN, during the same quarter, for the same borrower. This is a sizable effect given that the unconditional probability of a non-zero *Repo ratio* in our sample is 19% (see Table I). Both results imply that borrowers internalize the correlation premium and, subsequently, avoid pledging correlated collateral.

PLACE TABLE V ABOUT HERE

C.2. Why do borrowers pledge correlated collateral?

Given that borrowers internalize the presence of a correlation premium, why do they decide to pledge correlated collateral? We find that they do so for at least two reasons. First, minimizing the correlation premium is not the sole objective of these borrowers, as they also internalize a collateral risk premium. This gives rise to a trade-off for borrowers that hold relatively safe domestic securities. Second, around 30% of borrowers have a volume of repo borrowing that is larger than their holdings of non-domestic securities. These borrowers have to make use of domestic collateral to fulfill part of their repo demand.

In detail, we build on specification 8 above to show that borrowers also internalize a collateral risk premium. We add a *High- and a Low collateral-risk dummy*, equal to 1 when the CDS spread of the country issuing the collateral is in the highest and lowest quartile of the CDS distribution, respectively.

Column 3 of Table V shows a negative and significant impact of the *High collateral risk dummy* on the *Repo ratio*. The latter is on average 0.04 percentage points lower when pledging a high-risk collateral. The negative and significant impact of the*High-correlation dummy* also survives in this specification. The results in column 4 of Table V further confirm that borrowers are both less likely to use domestic and riskier collateral. In particular, the negative and significant coefficient of 0.0515 on the *High collateral risk dummy* implies that the probability that borrowers use high-risk collateral is 5.15 percentage points lower compared to medium-risk collateral (second and third quartile of risk distribution; omitted category in the regression). Conversely, the probability that borrowers use low-risk collateral is 2.97 percentage points higher compared to medium-risk collateral. This is a sizeable effect given that the unconditional probability of a non-zero *Repo ratio* in our sample is 19%.

Taken together, the results in Table V imply that borrowers internalize both the correlation premium and the collateral risk premium. One important consequence is that borrowers that hold relatively safer domestic securities compare the cost of using domestic debt (correlation premium) with the benefits (lower collateral risk premium). The trade-off can tip in favour of domestic collateral when it is sufficiently safer than the non-domestic collateral.

Finally, we show that some borrowers are unable to collateralize the totality of their repo borrowing with non-domestic collateral. We construct a borrower-quarter level ratio that compares the borrower's amount of repo borrowing with the borrower's volume of non-domestic government bond holdings. Accordingly, the following ratio measures the maximum share of a borrower's repo transactions that can be collateralized with non-domestic government bonds:

$$\text{Unconstrained ratio}_{i,t} = \text{Non-domestic holdings}_{i,t} / \text{PledgedVol}_{i,t} \tag{9}$$

where i denotes a borrower, t denotes the end of a quarter. *Non-domestic holdings* is the holdings volume of non-domestic securities, and *PledgedVol* is the volume pledged as collateral in the repo market.

The variable takes its name from the fact that a borrower with an *Unconstrained ratio* of 1 or more is able to collateralize the totality of her repo borrowing with non-domestic securities. She is therefore unconstrained. On the contrary, a borrower is constrained if the ratio is below 1. For example, a borrower with an *Unconstrained ratio* of 0.2 can collateralize a maximum of 20% of its repo volume with non-domestic government bonds. That is, such borrower would have to collateralize a minimum of 80% (100% - 20%) of her repo borrowing with domestic securities.

Figure 3 shows the distribution of the *Unconstrained ratio*. The histogram indicates that the ratio belongs to the $[0,1)$ interval for almost 30% of borrower-quarter observations in our sample. These borrowers borrow an amount that exceeds the volume of their non-domestic holdings. They must use domestic collateral for a portion of their repo borrowing. Constraints therefore play a role in a borrower's decision to pledge domestic collateral.

PLACE FIGURE 3 ABOUT HERE

To conclude, note that ex-post constraints in the use of collateral (as measured by the *Unconstrained ratio*) derive from ex-ante optimal choices of portfolio holdings. Given that borrowers are aware of the correlation premium, it must be that the premium is included in the optimization problem that borrowers solve when deciding on the composition of their holdings. That is, borrowers that choose to hold domestic securities consciously incur the corresponding cost. Home bias in the securities holdings of euro area banks is therefore not only costlier but also more puzzling than previously thought.

VI. Additional evidence and robustness tests

A. The correlation premium versus other determinants of the cost of debt

In this section we compare the correlation premium with other known determinants of the cost of debt, namely collateral and borrower risk. Correlation risk is measured as in our main analysis, that is, by means of a dummy equal to 1 in case the borrower is using domestic sovereign collateral. To obtain comparable measures of collateral and borrower risk, we construct risk dummies based on the distribution of sovereign and borrower CDS spreads. We construct a high collateral (borrower) risk dummy which is equal to 1 in case the CDS spread of the collateral issuer (borrower) is in the highest quartile of the CDS distribution. Similarly, we construct a low collateral (borrower) risk dummy which is equal to 1 in case the CDS spread of the collateral issuer (borrower) is in the lowest quartile of the CDS distribution.

Table VI shows the three premiums separately. In each column, we measure a given premium while perfectly controlling for the other two via fixed effects. All the specifications also include lender-day fixed effects and trade-level controls. In detail, column 1 measures the impact of the *High-correlation dummy*, while featuring ISIN-day and borrower-day fixed effects. It is the same specification as in column 5 of Table III, our most conservative specification. Column 2 shows the collateral risk premium and controls for the other two premiums via high-correlation-day and borrower-day fixed effects. Finally, the borrower risk premium is measured in column 3, in the presence of high-correlation-day and ISIN-day fixed effects. We also add two extra control variables in column 3, given that, apart from borrower riskiness, a number of other borrower characteristics could affect the repo rate. More specifically, we control for borrower size, proxied by the log of the total volume of daily borrowing, and the market share of the borrower, proxied by the ratio of the borrower's borrowing volume over total market volume.

PLACE TABLE VI ABOUT HERE

Column 1 of Table VI recalls that the premium for going from a low to a high correlation is equal to 1.1 bps in our most conservative specification. Column 2 shows that the premium for going from the 25^{th} (*Low collateral risk*) to the 75^{th} (*High collateral risk*) percentile of the distribution of collateral risk is equal to 6.5 bps (2.2 - (-4.3)). Finally, column 3 shows that there is no borrower risk premium. One potential explanation for the absence of a borrower risk premium is that collateralized markets may attract lenders that find it more costly to monitor borrower risk than to simply monitor collateral adequacy (i.e., whether the collateral is of low risk, and whether it is not correlated to the borrower in an obvious fashion).

Overall, the correlation premium appears to be lower than the collateral premium, but more relevant than the borrower premium.

B. *Heterogeneity of the correlation premium*

In this section, we analyse whether the size of the correlation premium changes with borrower and collateral risk. While our setup with borrower-day and ISIN-day fixed effects allows us to separate the correlation premium from the impact of borrower and collateral risk, one might for example still be worried that safe borrowers only post uncorrelated collateral. This would imply that our results only pertain to a group of risky borrowers.

To study the heterogeneity of the correlation premium, we amend our main specification with interaction terms between the *High-correlation dummy* and a set of borrower- and collateral-risk indicators. We construct a high collateral (borrower) risk dummy which is equal to 1 in case the CDS spread of the collateral issuer (borrower) is in the highest quartile of the CDS distribution. Similarly, we construct a low collateral (borrower) risk dummy which is equal to 1 in case the CDS spread of the collateral issuer (borrower) is in the lowest quartile of the CDS distribution.

Column 1 of Table VII shows that the correlation premium for collateral that belongs to the second and third quartile of the risk distribution is significantly different from zero and equals 2.31 basis points. Collateral in the first quartile fetches a premium that is not significantly different; while collateral in the fourth quartile fetches a correlation premium that is 8.83 basis points larger.

PLACE TABLE VII ABOUT HERE

Column 2 shows that the correlation premium for borrowers in the second and third quartile of the risk distribution is significantly different from zero and equals 1.62 basis points. The correlation premium for borrowers in the first quartile is 1.30 basis points smaller, but is still positive. Borrowers in the fourth quartile are charged a premium that is not significantly different from that of the second and third quartiles.

Overall, our results suggest that even safe collateral and safe borrowers can face a correlation premium. As for riskier borrowers and riskier collateral, they are associated with higher correlation premiums.

Finally, do note that the regression specifications in both Column 1 and 2 of Table VII exclude lender-day fixed effects. The reason for the absence of lender-day fixed effects is a lack of variation in the interaction terms once we include lender-day fixed effects.[19] Including lender-day fixed effects would thus imply a severe lack of power and a set of results driven by a very small sub-sample of lenders, which are not necessarily representative for the wider sample.

C. *Securities-lending demand in repo markets*

A cash lender may also be seen as a securities borrower (e.g. a short seller). The main mechanism tested in the repo market analysis not only applies to cash-driven but also to securities-driven transactions. Indeed, a short seller is penalized if the cash borrower defaults precisely at the time when the short-sell is profitable, that is when the collateral has lost value. Accordingly, the short seller should require a higher interest rate on her cash if the cash borrower correlates with the collateral.

However, our main specification in Table III does not control for the possibility that some cash lenders have a particular interest or disinterest in a specific collateral. For example, if a cash lender is highly interested in borrowing a bond issued by country A, she will be willing to receive a lower interest rate on this trade. If this cash lender happens to be more likely to borrow the bond from a bank located in country B than from a bank located in country A, then the *Collateral country A - Borrower country B* pair would feature a lower average interest rate than the *Collateral country A - Borrower country A* pair. Consequently, our estimates of the correlation premium would capture this effect and would be biased upward.

We take care of this possibility by adding fixed effects at the lender-ISIN-day level. The fixed effects allow to compare the rate charged to borrowers that borrow from the same lender while providing the same collateral to that lender on the same day. According to column 3 of Table VII, our main results are qualitatively unchanged.

[19] More specifically, variation in the interaction terms between the *High-correlation dummy* and the *Collateral (Borrower) risk dummy* is non-zero in only 1% (5%) of the 1,906 lender-day groups. For comparison, the within lender-day variation of the *High-correlation dummy* is non-zero for at least 25% of the lender-day groups in our main sample.

D. Relationships in repo markets

Existing work on bank lending points out that repeated interactions between borrowers and lenders could have an impact on lending conditions. For example, the theory in Petersen and Rajan (1995) and Hauswald and Marquez (2003) shows that repeated interactions make it easier for lenders to gather private information about the borrower; thereby reducing uncertainty about the borrower's actual credit quality. In the specific case of money markets, there is recent empirical evidence that relationships matter for loan prices. Among others, Cocco et al. (2009) and Bräuning and Fecht (2017) show that borrowers in interbank markets pay a significantly lower interest rate to their relationship lender than to arm's-length lenders. If relationship lenders are less (or more) likely to accept collateral that is correlated with the borrower, this might introduce an upward (or downward) bias in our main results.

In column 4 of Table VII, we control for the potential impact of borrower-lender relationships on repo prices by including borrower-lender fixed effects. The fixed effects imply that we study trades within a specific borrower-lender pair, which should rule out any impact of relationship between a borrower and a lender. The empirical specification still includes ISIN-day fixed effects to control for time-varying collateral-specific characteristics, as well as loan size and maturity. Our main result is qualitatively unchanged.

E. The convenience yield channel

In the main analysis, we argue that the premium reflects a compensation received by lenders. However, the premium might reflect a convenience yield enjoyed by borrowers from pledging domestic collateral. This borrower's surplus might then be shared with the lender through higher repo rates.

One plausible situation of convenience yield occurs when a bank mainly holds domestic bonds and only few non-domestic bonds, and would want to keep their non-domestic bonds unencumbered. In this case, the bank would have a preference for pledging its abundant domestic holdings as collateral. If lenders have market power, they may extract a premium in exchange for accepting domestic collateral.

In Column 5 of Table VII, we provide the results of a robustness test aimed at removing the impact of a potential convenience yield channel from our main results. To do so, we exclude the borrowers for which the ratio of domestic sovereign bond holdings over non-domestic sovereign bond holdings is at least equal to the 75$^{\text{th}}$ percentile. These borrowers do not hold many non-domestic securities to cover their repo activities, and are therefore likely to enjoy a convenience yield from pledging their domestic collateral. Column 5 of Table VII shows that our main results are qualitatively unchanged after excluding these borrowers.

F. Haircuts in repo markets

Throughout the analysis, we focused on repo rates as the key pricing factor for a repo. We did not focus on haircuts. The main reason for not studying haircuts is that our data suggest that non-null haircuts are very scarce in the euro-area OTC market during our sample period.

Our sample is composed of OTC trades backed by government bonds. 95.5% of the trades in our sample have a zero haircut. Outside of our sample, 94.8% of trades backed by bank bonds feature a zero haircut, while this number is equal to 93.6% and 83% for trades backed by non-bank financials and non-financial companies, respectively.

The observed scarcity of haircuts is in line with recent evidence from other markets. Julliard et al. (2022) study a snapshot of the repo books of six major UK banks at the end of 2012 and document that 78.9% of the overnight OTC trades have a zero haircut. Based on bilateral interviews with a worldwide set of market participants, the BIS (2010) reports that "among prime brokers and major financial institutions, there is no haircut when government bonds are used in repos. Zero haircuts are also applied to local government bond repos in some jurisdictions." Finally, it is also important to note that our sample period is a quiet time, which could also partly explain the scarcity of haircuts.

To fully ensure that haircuts do not affect our main finding, column 6 of Table VII re-estimates our main specification, while adding a dummy equal to 1 in case the trade has a positive haircut, and zero otherwise. Our main result are qualitatively unchanged.

VII. External validity: liquidation value and loan pricing in the corporate loan market

The goal of this section is to provide external validity for our main results by employing loan-level corporate credit data from the Anacredit database. We first describe the data used for this exercise. Next, we discuss the empirical setup. Finally, we present our empirical results.

A. Corporate loans: data

The data on corporate loans is taken from Anacredit, which is a proprietary dataset maintained by the ECB and covering corporate loans granted by all euro-area banks. Anacredit is a harmonised database that builds on –and enhances– the data available at the national credit registers of euro-area countries. If a bank's total credit exposure to a firm equals or exceeds 25,000 EUR, she has to report to Anacredit each loan granted to that firm. The data collection started in September 2018, and is done on a monthly basis.[20]

Anacredit has a granular structure that covers an extensive set of credit instruments such as credit lines, term loans and overdrafts, and reports 94 loan-level attributes at a monthly frequency. These attributes include basic loan characteristics such as the amount, interest rate and maturity, as well as information on the type of collateral used.

We focus on both term loans and credit lines granted by banks to non-financial institutions. We select all collateralized new loans granted between September 2018 and December 2020, and limit the sample to loans that are backed by only one type of collateral. Summary statistics on the corporate loans included in our analysis can

[20]More detailed information on the Anacredit database can be found in Online Appendix C. Detailed information on the regulation that sets out the reporting requirements and defines the reporting population can be found at https://www.ecb.europa.eu/stats/money_credit_banking/anacredit/html/index.en.html.

be found in the upper panel of Table VIII. The average loan in the full sample has an interest rate of 2.40% and a maturity of around 3 years, with an average size of 180,546 euros. The lower panel of Table VIII contains overview of the different collateral categories. In particular, loans backed by one of the three real-estate types of collateral (commercial real estate, residential real estate and offices and commercial premises) make up around 9% of the sample.

PLACE TABLE VIII ABOUT HERE

B. Corporate loans: empirical setup

Our setup aims to check whether there exists a correlation premium for corporate loans. For this, we proceed in two steps. In the first step, we focus on one specific type of collateral: real estate assets. We test whether firms operating in the construction industry (NACE Rev.2 codes 41 and 43) borrow at a premium when using real estate collateral compared to firms operating in other industries. This premium would be warranted by the correlation that exists between the default risk of construction firms and the risk of real estate collateral.

The choice to focus on real estate collateral and construction companies is driven by the availability of the collateral data in the Anacredit database. In Anacredit, there are 14 collateral categories (see the lower panel of Table VIII). Three of these types refer to real estate collateral: Commercial real estate collateral, Offices and commercial premises, and Residential real estate collateral (For brevity, referred as "real estate collateral"). Real estate collateral is the only type of collateral that can be clearly linked to a particular industry. This link is key to identify variation in liquidation value at the borrower-collateral level. In the case of real estate collateral, the time when the construction firm defaults on its loan is likely to also be a time when the real estate collateral has dropped in value, for example due to a real estate crisis.

Specifically, we estimate the following specification:

$$Rate_{b,l,f,t} = \alpha + \beta Construction_{b,l,f,t} + \gamma X_{b,l,f,t} + \chi_{b,r,t} + \psi_m + \epsilon_{b,l,f,t} \quad (10)$$

where $Rate_{b,l,f,t}$ is the lending rate charged by bank b on loan l to firm f in month t. The main variable of interest is $Construction_{b,l,f,t}$, which is a dummy equal to 1 if the correlation between the borrowing firm and the real-estate collateral is high, namely if the borrower operates in the construction sector. We control for the size of the loan (in logs) and the borrower's default probability (both represented as $X_{b,l,f,t}$ in the above equation). In our most conservative setup, we include two types of fixed effects: a bank-region-month fixed effects ($\chi_{b,r,t}$) and a set of maturity-bucket fixed effects (ψ_m). The bank-region-month fixed effect implies that we are comparing firms operating in the same region borrowing from the same bank, ensuring that our findings are not driven by (time-varying) local real estate shocks, nor by differences in banks' risk appetite, among other things. The maturity buckets included are below 1 year, 1 to 2 years, 2 to 3 years, 3 to 5 years, 5 to 10 years, 10 to 15 years and above 15 years.

In the second step, we re-integrate into our sample loans that are not backed by real estate collateral, allowing us to focus on within-firm variations in loan rates. In this way, we address a potential problem with specification 10 where the *Construction* dummy picks up industry-specific characteristics of construction firms. Specifically, we test whether the within-firm rate difference between loans backed by real-estate collateral and loans backed by other types of collateral differs between construction firms and non-construction firms. Given the borrower-collateral correlation, we expect the difference to be more positive for construction firms. That is, we expect construction firms to be charged a premium for using real estate collateral instead of other types of collateral, over and beyond a potential premium charged to other types of firms.

Accordingly, we estimate the following model:

$$Rate_{b,l,f,t} = \alpha + \beta_1 Construction_{b,l,f,t} * REcollateral_{b,l,f,t} + \gamma X_{b,l,f,t} + \chi_{b,r,t} + \mu_{f,t} + \nu_c + \psi_m + \epsilon_{b,l,f,t} \quad (11)$$

where $Rate_{b,l,f,t}$, $Construction_{b,l,f,t}$ and $X_{b,l,f,t}$, $\chi_{b,r,t}$ and ψ_m are defined as in 10. *REcollateral* is a dummy equal to 1 if the loan is backed by real-estate collateral, $\mu_{f,t}$ is a firm-month fixed effect and ν_c a collateral-type fixed effects. The different collateral types are residential and commercial real estate, offices and commercial premises, commercial real estate, securities, gold, currency and deposits, loans, trade receivables, equity, life insurance policies, credit derivatives, and other physical collateral not captured in any of the other categories.

Note that the interaction term between the construction dummy and the real estate collateral dummy mimics the high-correlation dummy in the repo-market setup: they both capture loans in which the default risk of the borrower has a strong, positive correlation with the risk of the collateral. Equation 11 also allows to control for time-varying borrower-specific characteristics by means of firm-time fixed effects.

An important caveat is that capturing the direct impact of collateral characteristics on loan prices is more difficult with the Anacredit data than with the MMSR data. While the collateral-type fixed effects to some extent remove the direct impact of collateral value on loan prices, they are less precise than the ISIN-day fixed effects that we employ in the main analysis. Put differently, the repo market data allows us to compare trades backed by exactly the same collateral, while the Anacredit data allows us to only define a very broad collateral category. Within this category, there could still be some variation left that affects loan prices, and thus biases our estimation.

C. *Corporate loans: results*

Table IX shows the main results for our corporate loan sample. The dependent variable in each column is the loan-level interest rate.

Columns 1 to 3 of Table IX focus on loans backed by real estate collateral and show the results from estimating equation 10, gradually saturating the specification with a set of fixed effects and control variables. The positive and significant coefficient on the *Construction sector* dummy indicates that construction firms pay a premium when using real estate collateral, relative to non-construction firms. Our most conservative specification is displayed in column 3. Our estimate for this specification indicates that a construction firm operating in the same region, borrowing from the same bank and using the same type of collateral (real estate) as another firm operating in a different industry is subject to a 13.5 basis points interest rate premium.

PLACE TABLE IX ABOUT HERE

One potential weakness of the setup in columns 1 to 3 is that the premium may capture unobservable factors specific to the construction sector. For example, construction firms might be deemed riskier than other firms. To the extent that the estimate of borrower default risk used in column 3 does not perfectly capture the true borrower default risk, our estimate of the premium could be biased.

To ensure that our results are not driven by unobservable characteristics specific to construction firms, we next focus on variation in loan rates within firms. To do so, we expand our sample with loans backed by non-real-estate collateral and estimate equation 11. This is done in columns 4 and 5 of Table IX.

The main variable of interest in column 4 is the interaction between the *Real estate collateral* and the *Construction sector* dummy. The positive and significant coefficient implies that the difference in loan rate when using real estate compared to non-real-estate collateral is larger for construction than for non-construction firms.

In detail, for a non-construction firm loans backed by real estate collateral are on average 17.3 basis points more expensive than other loans granted to that firm in the same month. For a construction firm, the difference rises to 36.6 basis points (0.173+0.193). Put differently, a construction firm pays a 19.3 basis points premium for using a real estate collateral compared to another type of collateral, over and above the premium paid by a non-construction firm. This correlation premium increases to 25 basis points in our most stringent specification (column 5), which includes collateral-month fixed effects. Given the average rate of 2.4% in our sample, the premium is also economically meaningful.

VIII. Conclusion

We show that borrowers pay a premium on a loan when their default risk is positively correlated with the risk of the collateral that they pledge. The premium exists because this correlation reduces the liquidation value of the collateral. Borrowers internalize this premium and adjust their collateral choices accordingly.

Our results have three main implications. First, lenders monitor the interdependency between borrower and collateral risk. Second, existing empirical proxies for liquidation value miss a key characteristic of the concept of loss given default: for a collateral to be of high quality, it is not sufficient nor necessary for it to have a high unconditional expected value. It has to feature a high expected value conditional on default. By acknowledging that liquidation value varies at the borrower-collateral level, our analysis captures that idea. Finally, banks' home bias in securities holdings has an impact on banks' funding cost. That is, a borrowing bank pays a premium when of the same country as the collateral issuer.

REFERENCES

Acharya, V. V., Bharath, S. T., and Srinivasan, A. (2007). Does industry-wide distress affect defaulted firms? evidence from creditor recoveries. *Journal of Financial Economics*, 85(3):787–821.

Acharya, V. V., Eisert, T., Eufinger, C., and Hirsch, C. (2018). Real effects of the sovereign debt crisis in europe: Evidence from syndicated loans. *Review of Financial Studies*, 31(8):2855–2896.

Altavilla, C., Pagano, M., and Simonelli, S. (2017). Bank exposures and sovereign stress transmission. *Review of Finance*, 21(6):2103–2139.

Auh, J. K. and Landoni, M. (2022). Loan terms and collateral: Evidence from the bilateral repo market. *Journal of Finance*, 77(6):2997–3036.

Benmelech, E. (2009). Asset salability and debt maturity: Evidence from nineteenth-century american railroads. *The Review of Financial Studies*, 22(4):1545–1584.

Benmelech, E. and Bergman, N. K. (2009). Collateral pricing. *Journal of financial Economics*, 91(3):339–360.

Benmelech, E., Garmaise, M. J., and Moskowitz, T. J. (2005). Do liquidation values affect financial contracts? evidence from commercial loan contracts and zoning regulation. *The Quarterly Journal of Economics*, 120(3):1121–1154.

BIS (2010). The role of margin requirements and haircuts in procyclicality. *CGFS Papers*, (36).

Boissel, C., Derrien, F., Ors, E., and Thesmar, D. (2017). Systemic risk in clearing houses: Evidence from the european repo market. *Journal of Financial Economics*, 125(3):511–536.

Bottero, M., Lenzu, S., and Mezzanotti, F. (2020). Sovereign debt exposure and the bank lending channel: impact on credit supply and the real economy. *Journal of International Economics*, 126(103328).

Bräuning, F. and Fecht, F. (2017). Relationship lending in the interbank market and the price of liquidity. *Review of Finance*, 21(1):33–75.

Calomiris, C. W., Larrain, M., Liberti, J., and Sturgess, J. (2017). How collateral laws shape lending and sectoral activity. *Journal of Financial Economics*, 123(1):163–188.

Cerqueiro, G., Ongena, S., and Roszbach, K. (2016). Collateralization, bank loan rates, and monitoring. *The Journal of Finance*, 71(3):1295–1322.

Cocco, J. F., Gomes, F. J., and Martins, N. C. (2009). Lending relationships in the interbank market. *Journal of Financial Intermediation*, 18(1):24–48.

Coval, J. and Stafford, E. (2007). Asset fire sales (and purchases) in equity markets. *Journal of Financial Economics*, 86(2):479–512.

De Marco, F. (2019). Bank lending and the european sovereign debt crisis. *Journal of Financial and Quantitative Analysis*, 54(1):155–182.

Degryse, H., Ioannidou, V., Liberti, J. M., and Sturgess, J. (2020). How do laws and institutions affect recovery rates for collateral? *Review of Corporate Finance Studies*, 9(1):1–43.

Dell'Ariccia, M. G., Ferreira, C., Jenkinson, N., Laeven, M. L., Martin, A., Minoiu, M. C., and Popov, A. (2018). Managing the sovereign-bank nexus. *ECB Working Paper Series*, (2177).

ECB (2019). Euro money market study 2018. *ECB Report*.

Ellul, A., Jotikasthira, C., and Lundblad, C. T. (2011). Regulatory pressure and fire sales in the corporate bond market. *Journal of Financial Economics*, 101(3):596–620.

Gennaioli, N., Martin, A., and Rossi, S. (2018). Banks, government bonds, and default: What do the data say? *Journal of Monetary Economics*, 98:98–113.

Gorton, G. and Metrick, A. (2012). Securitized banking and the run on repo. *Journal of Financial economics*, 104(3):425–451.

Hauswald, R. and Marquez, R. (2003). Information technology and financial services competition. *Review of Financial Studies*, 16:921–948.

Julliard, C., Pinter, G., Todorov, K., and Yuan, K. (2022). What drives repo haircuts? evidence from the uk market. *Bank of England Working Paper*, (985).

Kim, H. and Kung, H. (2017). The asset redeployability channel: How uncertainty affects corporate investment. *Review of Financial Studies*, 30(1):245–280.

Liberti, J. M. and Mian, A. R. (2010). Collateral spread and financial development. *Journal of Finance*, 65(1):147–177.

Mancini, L., Ranaldo, A., and Wrampelmeyer, J. (2016). The euro interbank repo market. *Review of Financial Studies*, 29(7):1747–1779.

Martin, A., Skeie, D., and Thadden, E.-L. v. (2014). Repo runs. *Review of Financial Studies*, 27(4):957–989.

Paech, P. (2017). Repo and derivatives portfolios. between insolvency law and regulation. *LSE Law, Society and Economy Working Paper Series*, (13).

Petersen, M. A. and Rajan, R. G. (1995). The effect of credit market competition on lending relationships. *Quarterly Journal of Economics*, pages 407–443.

Popov, A. and van Horen, N. (2014). Texporting sovereign stress: Evidence from syndicated bank lending during the euro area sovereign debt crisis. *Review of Finance*, pages 1825–1866.

Shleifer, A. and Vishny, R. W. (1992). Liquidation values and debt capacity: A market equilibrium approach. *Journal of Finance*, 47(4):1343–1366.

Strömberg, P. (2000). Conflicts of interest and market illiquidity in bankruptcy auctions: Theory and tests. *Journal of Finance*, 55(6):2641–2692.

Williamson, O. E. (1988). Corporate finance and corporate governance. *Journal of finance*, 43(3):567–591.

Tables

Table I. Summary statistics

The table shows trade-level summary statistics for our sample of repo trades (upper panel), and borrower-ISIN-quarter level summary statistics for our sample of borrowers' holdings data (lower panel). The sample period for the repo trades is 3 October 2016 until 16 April 2020, for the holdings data the sample period is 2018Q4-2020Q2. *Repo rate (%)* is the annualized trade-level interest rate. In the upper panel, the *High-correlation dummy* is a dummy equal to 1 if the ISIN used as collateral is issued by the borrower's home country. Similarly, in the lower panel, *High-correlation dummy* is a dummy equal to 1 if the ISIN held by the borrower is issued by the borrower's home country. *CDS correlation* is the trade-level correlation between the borrower's CDS and the CDS of the sovereign issuer of the underlying collateral. This correlation is calculated over a 60-day rolling window, where the 60^{th} day of the window is the day before the trade day. *Positive haircut dummy* is a dummy equal to 1 if the trade has a non-null positive haircut. *Repo ratio* is defined as the ratio of the total amount of ISIN i used by borrower b as collateral in the repo market, divided by the total amount of sovereign securities used by borrower b as collateral in the repo. *Holdings ratio* is defined as the ratio of the total amount of ISIN i held by borrower b over the total amount of sovereign securities held by borrower b. *Non-null repo ratio dummy* is a dummy equal to 1 if the *Repo ratio* is above 0, and equal to 0 otherwise. All variables in the upper panel are calculated using data from the Money Market Statistical Reporting (MMSR) database, apart from the CDS variable, which is based on Credit Monitoring Arrangements (CMA) data. All variables in the lower panel are calculated using the ECBs Securities Holding Statistics by Group (SHSG) database.

Trade level								
	N	mean	sd	p1	p5	p50	p95	p99
Repo rate (%)	828,718	-0.61	0.25	-1.65	-1.05	-0.54	-0.40	-0.37
High-correlation dummy	828,718	0.44						
Loan amount (mill. EUR)	828,718	29.91	48.23	0.05	0.23	10.80	111.99	229.38
Overnight trades (share of total)	828,718	0.58						
Spot next trades (share of total)	828,718	0.24						
Tomorrow next trades(share of total)	828,718	0.18						
Own-collateral dummy	701, 619	0.003						
CDS correlation	368,103	0.54	0.39	-0.61	-0.26	0.66	0.95	0.97
Positive haircut dummy	760,307	0.04						
Borrower-ISIN-quarter level								
	N	mean	sd	p1	p5	p50	p95	p99
Repo ratio	49,727	0.00	0.01	0.00	0.00	0.00	0.01	0.08
Holdings ratio	49,727	0.00	0.01	0.00	0.00	0.00	0.02	0.05
Non-null repo ratio dummy	49,727	0.19						
High-correlation dummy	49,727	0.50						

Table II. CDS correlation across the two groups

The table shows the average correlation between the bank's CDS and the sovereign CDS for repo trades secured by non-domestic collateral (*High-correlation dummy* = 0) and for repo trades secured by domestic collateral (*High-correlation dummy*= 1). CDS data is taken from CMA, the high-correlation dummy is calculated using MMSR data.

	High-correlation dummy =0	High-correlation dummy =1	Difference
CDS correlation	0.470	0.603	-0.13***
N	174,036	194,067	

Table III. Borrower-collateral correlation and repo rates

The dependent variable is the trade-level interest rate (annualized, in %). *High-correlation dummy* is a dummy equal to 1 if the country of the collateral is the same as the country of the borrower. Trade-level control variables include the log of the volume of the trade and a set maturity fixed effects. The sample period is 3 October 2016 until 16 April 2020. All data at the trade-level and taken from the Money Market Statistical Reporting (MMSR) database. Robust standard errors (clustered at the borrower-ISIN level) are reported in parentheses.

	Dependent variable = Repo rate				
	(1)	(2)	(3)	(4)	(5)
High-correlation dummy	0.103***	0.0385***	0.0250***	0.0255***	0.0110***
	(0.0129)	(0.00339)	(0.00567)	(0.00574)	(0.00413)
Observations	828,718	795,572	792,735	792,364	227,598
Nr. borrower	47	47	40	40	39
Adjusted R-squared	0.189	0.811	0.846	0.847	0.924
Day FE	Y	N	N	N	N
ISIN-day FE	N	Y	Y	Y	Y
Borrower-day FE	N	N	Y	Y	Y
Lender's sector-day FE	N	N	N	Y	N
Lender-day FE	N	N	N	N	Y
Trade-level controls	Y	Y	Y	Y	Y

Table IV. **Alternative borrower-collateral correlation measures**

The dependent variable is the trade-level interest rate (annualized, in %). *High-correlation dummy* is a dummy equal to 1 if the country of the collateral is the same as the country of the borrower. *Own-collateral dummy* is a dummy equal to 1 for trades backed by bonds or equities issued by the borrower. In column 1, the sample consists of bilateral repo trades backed by securities issued by banks. In column 2, the sample consists of all repo trades between a cash borrower and a Central Clearing Counterparty (CCP), backed by euro-are sovereign bonds. In column 3, the sample consists of all bilateral repo trades backed by euro-area sovereign bonds. All specifications include the log of the volume of the trade and a set maturity fixed effects as trade-level control variables. The sample period is 3 October 2016 until 16 April 2020. All data at the trade-level and taken from the Money Market Statistical Reporting (MMSR) database. Robust standard errors (clustered at the borrower-ISIN level) are reported in parentheses.

	Dependent variable = Repo rate		
	(1)	(2)	(3)
Own-collateral dummy	0.104***		
	(0.0396)		
High-correlation dummy		0.0000167	
		(0.000322)	
CDS correlation			0.0130**
			(0.000656)
Observations	701,619	5,961,508	104,981
Nr. borrowers	27	38	39
Adjusted R-squared	0.849	0.886	0.946
Borrower-day FE	Y	Y	Y
ISIN-day FE	Y	Y	Y
Lender-day FE	Y	N	Y
CCP-day FE	N	Y	N
Trade-level controls	Y	Y	Y
Collateral	Bank-issued	Sovereign	Sovereign

Table V. Collateral choice

The dependent variable in columns 1 and 3 is the *Repo ratio*, defined as the ratio of the total amount of ISIN i used by borrower b as collateral in the repo market, divided by the total amount of sovereign securities used by borrower b as collateral in the repo market. The dependent variable in columns 2 and 4 is the *Non-null repo ratio dummy* which is equal to 1 when the *Repo ratio* is above zero. *High-correlation dummy* is a dummy equal to 1 if ISIN i held by borrower b is issued by bank b's home country. *Holdings ratio* is defined as the ratio of the total amount of ISIN i held by borrower b over the total amount of sovereign securities held by bank b. *Low (high) collateral risk* is a dummy which is equal to 1 in case the CDS spread of the country issuing the security is in the lowest (highest) quartile of the CDS distribution. All data is at the bank-quarter-ISIN level. The sample period is 2018Q4-2020Q2. Data on banks' securities holdings and encumbrance is taken from the ECB's SHSG database. CDS data is taken from CMA. Robust standard errors (clustered at the borrower-ISIN level) are reported in parentheses.

	(1) Repo ratio	(2) $\mathbb{1}(Reporatio > 0)$	(3) Repo ratio	(4) $\mathbb{1}(Reporatio > 0)$
High-correlation dummy	-0.000688***	-0.0259***	-0.000683***	-0.0269***
	(0.000181)	(0.00703)	(0.000181)	(0.00701)
Low collateral risk			7.09e-05	0.0297***
			(0.000178)	(0.00665)
High collateral risk			-0.000403**	-0.0515***
			(0.000197)	(0.00885)
Holdings ratio	0.722***	12.35***	0.723***	12.45***
	(0.0331)	(0.490)	(0.0331)	(0.488)
Observations	49,727	49,727	49,727	49,727
Adjusted R-squared	0.269	0.170	0.269	0.172
Borrower-quarter FE	Y	Y	Y	Y

Table VI. Other rate determinants

The dependent variable is the trade-level interest rate (annualized, in %). *High correlation dummy* is a dummy equal to 1 if the country of the collateral is the same as the country of the borrower. *High (low) collateral risk* is a dummy equal to 1 in case the CDS spread of the country issuing the collateral is in the highest (lowest) quartile of the CDS distribution. Similarly, *High (low) borrower risk* is a dummy which is equal to 1 in case the CDS spread of the borrower is in the highest (lowest) quartile of the CDS distribution. Trade-level control variables include the log of the volume of the trade and a set of maturity fixed effects. In column 3, we additionally control for two borrower-specific characteristics: borrower size, proxied by the log of the total volume of daily borrowing, and the market share of the borrower, proxied by ratio of the borrower's borrowing volume over total market volume. CDS data are taken from CMA. All other data is taken from the Money Market Statistical Reporting (MMSR) database. The sample period is 3 October 2016 until 16 April 2020. Robust standard errors (clustered at the borrower-ISIN level) are reported in parentheses.

	Dependent variable = Repo rate		
	(1)	(2)	(3)
High-correlation dummy	0.0110***		
	(0.00413)		
Low collateral risk		-0.0431***	
		(0.00666)	
High collateral risk		0.0227	
		(0.0139)	
Low borrower risk			0.00434
			(0.00323)
High borrower risk			-0.00705
			(0.00554)
Log(borrower size)			-0.0154*
			(0.00927)
Borrower market share			0.124*
			(0.0740)
Observations	227,598	175,366	175,366
Adjusted R-squared	0.924	0.752	0.950
Isin-day FE	Y	N	Y
Borrower-day FE	Y	Y	N
Lender-day FE	Y	Y	Y
High-correlation FE	N	Y	Y
Trade-level controls	Y	Y	Y

Table VII. Additional robustness checks

The dependent variable is the trade-level repo rate (annualized, in %). *High-correlation dummy* is a dummy equal to 1 if the country of the collateral is the same as the country of the borrower. The *high (low) collateral risk* dummy is equal to 1 if the CDS spread of the country issuing the collateral is in the highest (lowest) quartile of the CDS distribution. Similarly, we construct a *high (low) borrower risk* dummy which is equal to 1 if the CDS spread of the borrower is in the highest (lowest) quartile of the CDS distribution. Each specification includes the log volume of the trade and a set of maturity fixed effects as control variables. The sample period is 3 October 2016 until 16 April 2020. CDS data are taken from CMA. All other data is taken from the Money Market Statistical Reporting (MMSR) database. Robust standard errors (clustered at the borrower-ISIN level) are reported in parentheses.

	Dependent variable = Repo rate					
	(1)	(2)	(3)	(4)	(5)	(6)
High-correlation dummy	0.0231**	0.0162***	0.0151***	0.00501**	0.0105**	0.0109**
	(0.0108)	(0.00573)	(0.00362)	(0.00203)	(0.00409)	(0.00487)
High-correlation dummy x	-0.0116					
Low collateral risk	(0.0112)					
High-correlation dummy x	0.0883**					
High collateral risk	(0.0355)					
High-correlation dummy x		-0.0130*				
Low borrower risk		(0.00693)				
High-correlation dummy x		0.00672				
High borrower risk		(0.00776)				
Positive haircut dummy						0.00321
						(0.00803)
Observations	175,366	175,366	146,007	208,030	196,838	197,409
Adjusted R-squared	0.917	0.917	0.939	0.933	0.933	0.927
Isin-day FE	Y	Y	N	Y	Y	Y
Borrower-day FE	Y	Y	Y	N	Y	Y
Trade-level controls	Y	Y	Y	Y	Y	Y
Lender-day FE	N	N	N	N	Y	Y
Lender-ISIN-day FE	N	N	Y	N	N	N
Borrower-lender-day FE	N	N	N	Y	N	N

Table VIII. Corporate loans - descriptive statistics

The sample consists of collateralized loans granted to euro-area firms between September 2018 and December 2020. *Borrower default probability* is the default probability of the borrower, assigned by the bank granting a loan to that borrower. *Construction sector* is a dummy equal to 1 for loans to construction firms. Construction firms are defined as firms with NACE Rev. 2 code 41 (Construction of buildings) or 43 (Specialised construction activities). *Real estate collateral* is a dummy equal to 1 for loans backed by real estate collateral. Real estate collateral is collateral belonging to one of the following three collateral categories in Anacredit: Commercial real estate, Residential real estate, and Offices and commercial premises. All variables are calculated using data from Anacredit.

Corporate loans - summary statistics						
	N	mean	p50	sd	p1	p99
Rate (%)	139,765	2.405	2.520	1.275	0.000	5.641
Loan amount (EUR)	139,765	180,546	18,992	3,012,289	58.43	1,800,000
Borrower default probability (%)	139,765	0.038	0.013	0.096	0.001	0.569
Real estate collateral dummy	139,765	0.09				
Construction sector dummy	139,765	0.23				
Maturity (days)	139,765	1163.607	720.000	1663.943	23.000	7395.000
Collateral types						
Type	Frequency	Share of loans (%)				
Other physical collateral	107,610	76.99				
Other protection	15,173	10.86				
Commercial real estate	5,888	4.21				
Residential real estate	4,612	3.3				
Trade receivables	1,880	1.35				
Offices and commercial premises	1,683	1.2				
Currency and deposits	1,509	1.08				
Securities	649	0.46				
Equity and investment fund shares	496	0.35				
Life insurance policy	227	0.16				
Credit derivatives	26	0.02				
Loans	12	0.01				

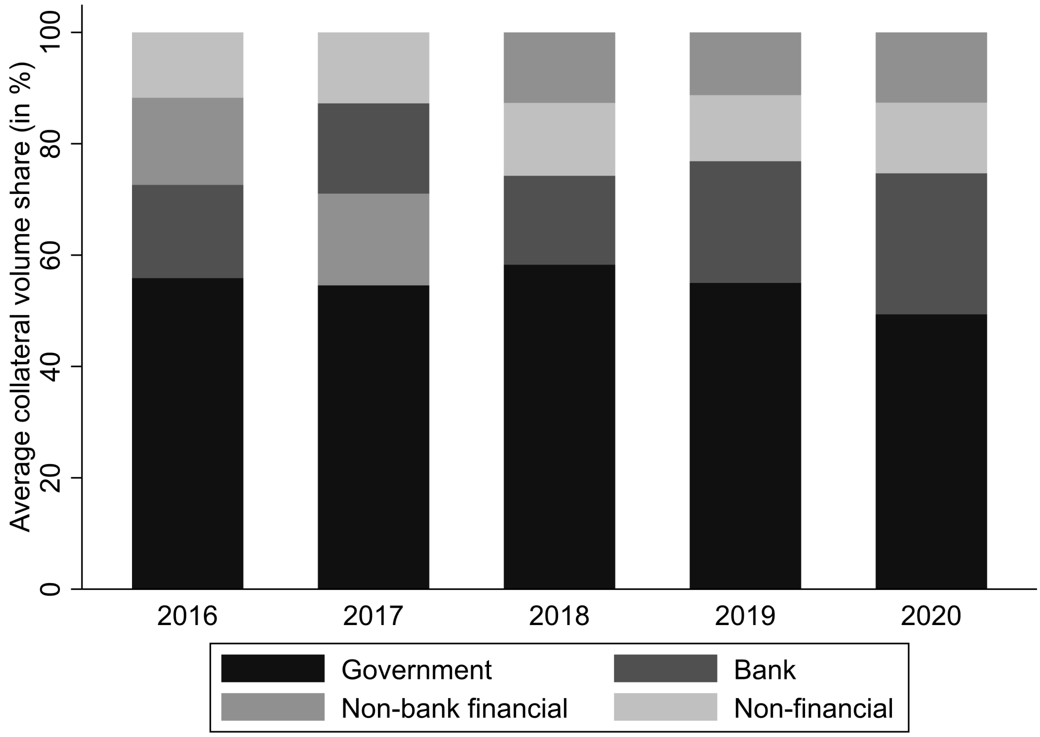
Table IX. Borrower-collateral correlation in the corporate loan market

The sample consists of all collateralized corporate loans backed by real estate collateral (column 1 to 3), or all collateralized corporate loans granted during the sample period (columns 4 and 5). The dependent variable is the loan-level interest rate (annualized, in %). *Construction sector* is a dummy equal to 1 for loans to construction firms. Construction firms are defined as firms in industries with NACE Rev. 2 code 41 (Construction of buildings) or 43 (Specialised construction activities). *Real estate collateral* is a dummy equal to 1 for loans backed by real estate collateral. All specifications include a set of maturity fixed effects, capturing different maturity buckets: below 1 year, 1 to 2 years, 2 to 3 years, 3 to 5 years, 5 to 10 years, 10 to 15 years, and above 15 years. Columns 3 to 5 also include the log volume of the loan and the probability of default of the borrower (assigned by the lender) as control variables. The sample period is September 2018 to December 2020. Data is taken from Anacredit. Robust standard errors (clustered at the industry level (2-digit NACE code) in columns 1 to 3 and at the industry-collateral level in columns 4 and 5) are reported in parentheses.

	Dependent variable = Loan rate				
	Only real estate collateral			All collateral	
	(1)	(2)	(3)	(4)	(5)
Construction sector	0.220***	0.133**	0.135**		
	(0.0734)	(0.0582)	(0.0577)		
Real estate collateral				0.173***	
				(0.0336)	
Real estate collateral x Construction sector				0.193**	0.250***
				(0.0877)	(0.0768)
Ln(loan amount)			-0.0749***	0.00559	0.00556
			(0.0109)	(0.00905)	(0.00909)
Lender estimate of borrower default probability			0.179*	-0.0209	0.0236
			(0.107)	(0.287)	(0.303)
Observations	73,508	65,597	61,896	139,765	139,765
R-squared	0.387	0.589	0.596	0.948	0.948
Maturity FE	Y	Y	Y	Y	Y
Firm-month FE	N	N	N	Y	Y
Collateral-month FE	N	N	N	N	Y
Region-month FE	Y	N	N	N	N
Bank-region-month FE	N	Y	Y	Y	Y

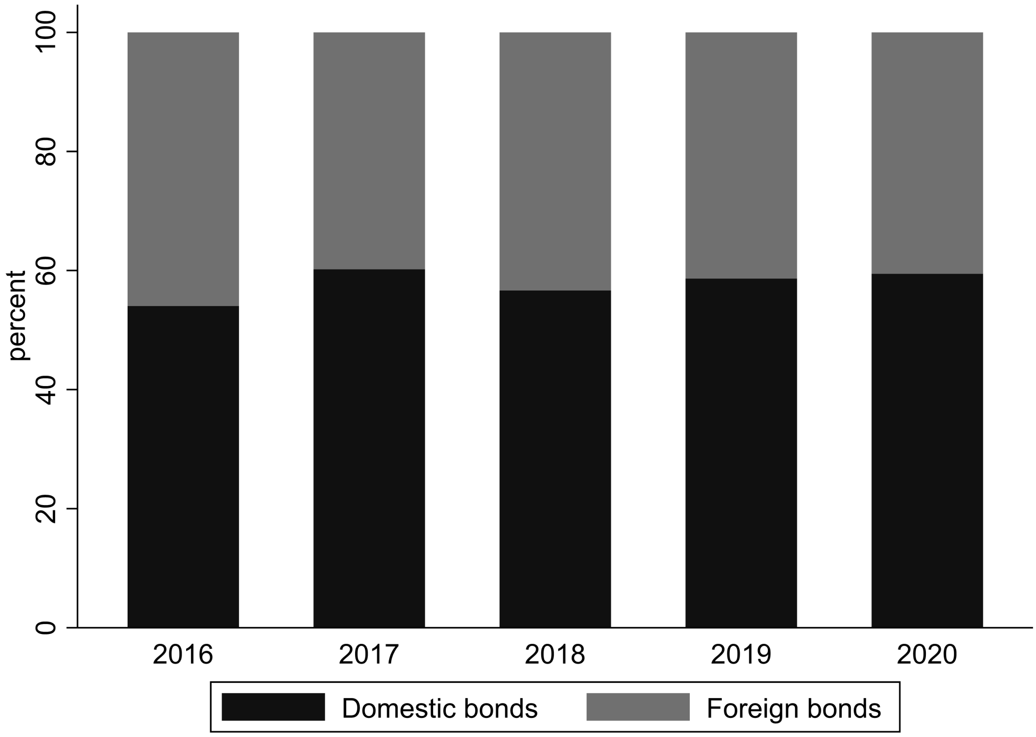
Figures

Figure 1. Collateral types in repo borrowing



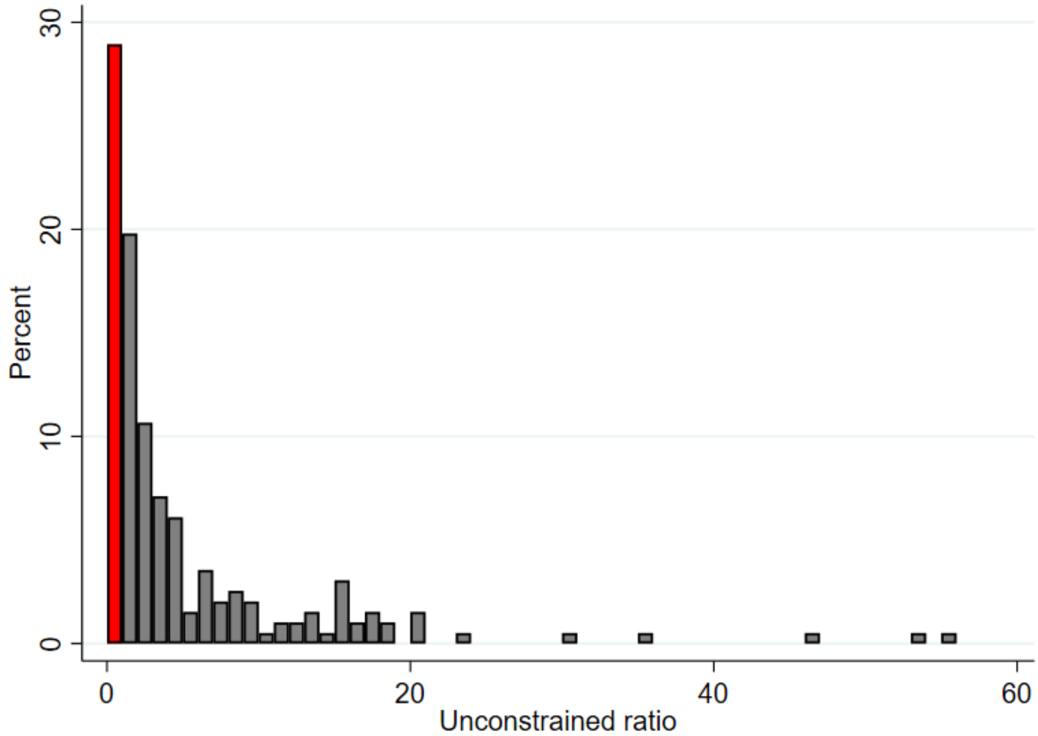
This figure shows the average volume share (by type of collateral) for the bilateral repo trades of the euro-area banks in our sample between 3 October 2016 and 16 April 2020. The collateral categories are government bonds, bank bonds, non-bank financial bonds and non-financial bonds. Volume shares are calculated by averaging quarterly, bank-level volume shares for each collateral category over the year. Own calculations based on Money Market Statistical Reporting (MMSR) data.

Figure 2. Domestic vs. non-domestic collateral



This figure shows the share of repo volume traded backed by domestic or non-domestic government bonds, as a percentage of the total volume traded that is backed by government bonds. Volume shares are calculated by averaging quarterly, bank-level volume shares for each category (domestic and foreign) over the year. The sample covers all bilateral repo trades backed by sovereign collateral of the EU banks in our sample between 3 October 2016 and 16 April 2020. Own calculations based on Money Market Statistical Reporting (MMSR) data.

Figure 3. Distribution of the Unconstrained ratio



This figure shows the distribution of the *Unconstrained ratio*. The ratio is defined as the volume of non-domestic sovereign debt in a bank's securities portfolio divided by the total repo borrowing of the bank that is backed by sovereign collateral. The red bar indicates the observations for which the unconstrained measure belongs to the [0,1) interval.Data is taken from the ECB Securities Holdings Statistics Group (SHSG) dataset, the sample period is 2018Q4 until 2020Q2.

Acknowledgements

We thank Hans Degryse, Darrell Duffie, Jan Erics-son, Jasmin Gider, Florian Heider, Sergio Mayordomo, Steven Ongena, Ali Ozdagli, Alex Popov, Angelo Ranaldo, Philipp Schnabl, Roberto Steri and conference and seminar participants at the MPC taskforce workshop on banking analysis and monetary policy (Central Bank of Ireland), the 2020 IWH FIN FIRE Workshop, the European Finance Assocation 2020 Annual Meeting, the 4th Bristol Banking and Financial Intermediation Workshop, the Bundesbank-FRIC-CEPR conference on Credit Risk over the Business Cy-cle, IBEFA 2022, the Adam Smith Business School Glasgow, De Nederlandsche Bank, and the European Central Bank for their helpful comments and suggestions. All remaining errors are our own.
The views expressed in this paper are those of the authors and do not necessarily reflect those of the European Central Bank or the Eurosystem.

Francesca Barbiero
European Central Bank, Frankfurt am Main, Germany; email: francesca.barbiero@ecb.europa.eu

Glenn Schepens
European Central Bank, Frankfurt am Main, Germany; email: glenn.schepens@ecb.europa.eu

Jean-David Sigaux
European Central Bank, Frankfurt am Main, Germany; email: Jean-David.Sigaux@ecb.europa.eu

Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website www.ecb.europa.eu

This paper can be downloaded without charge from www.ecb.europa.eu, from the Social Science Research Network electronic library or from RePEc: Research Papers in Economics. Information on all of the papers published in the ECB Working Paper Series can be found on the ECB's website.

PDF ISBN 978-92-899-4978-1 ISSN 1725-2806 doi:10.2866/173797 QB-AR-22-010-EN-N