Liquidation value and loan pricing *

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Abstract

We show that the liquidation value of collateral depends on who is pledging it. We employ transaction-level data on overnight repurchase agreements (repo) and loan-level credit registry data on corporate loans. We find that borrowers on the repo market pay a 2.6 basis points rate premium when their default risk is positively correlated with the risk of the collateral that they pledge. The premium in corporate loan markets amounts to 25 basis points. Our results imply that liquidation value contains a component at the borrower-collateral level, and that lenders monitor and price-in the interdependency between borrower and collateral risk.

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1 Introduction

Collateral is a key component of a wide variety of loan contracts. For one, it reduces the borrower's financial constraints by increasing her pledgeable income, as the lender can take hold of the collateral and liquidate it 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 liquidity and, in particular, collateral redeployability (e.g. Shleifer and Vishny (1992), Williamson (1988), Benmelech et al. (2005), Benmelech and Bergman (2009)). The idea behind redeployability is that a collateral that has many alternative uses also has a higher liquidation value. Importantly, redeployability is typically seen as a collateral-specific characteristic, such that one collateral is assigned a single liquidation value at any point in time.

This paper raises the point that a collateral can have several liquidation values, depending on who is pledging it. To fix ideas, 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. Suppose also 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 also a time when the real estate collateral has dropped in value, for example due to a real estate crisis. In constrast, 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 lower or a higher liquidation value depending on who is pledging 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 probability would be the same. More simply put, a crucial component of liquidation value is the *correlation* between the default risk of the borrower and the risk of the collateral. This correlation is closely related to a concept known in risk management as wrong-way risk (ICMA (2020)). One implication of this is that the literature potentially features a mismeasurement error which consists of failing to disregard the value taken by the collateral in the states of the world where borrowers are unlikely to default.

We are the first to show that lenders recognize that a given collateral can have different liquidation values depending on who is pledging it. To do so, we use loan-level data from two different European credit markets: the secured money market ("repo market") and the corporate loan market. The bulk of the analysis is done using the secured money market data, as the characteristics of the trades in this market allow us to precisely estimate the loan pricing impact of the correlation between borrower default risk and collateral risk. To ensure the external validity of our repo-market results, we provide complimentary evidence on corporate lending markets by using loan-level credit register data.

In the European repo market, banks typically borrow using sovereign bonds as collateral. We exploit the strong positive relation that exists between the default risk of a bank and the default risk of the sovereign of the country where the bank is located, as widely documented in the literature on the sovereign-bank nexus.[1] This positive relation implies that the value of the sovereign bond used as collateral is likely to be low upon default of a borrowing bank that comes from the same country as the collateral issuer. This allows us to construct a proxy for liquidation value that varies at the borrower-collateral level. We refer to it as "borrower-collateral specific liquidation value". If this concept matters for loan pricing, we expect that lenders charge a premium when the borrower is from the same country as the collateral issuer. Or, more generally, we expect borrowers to pay higher rates when there is a high correlation between default risk and collateral risk ("collateral-borrower correlation").

Furthermore, the characteristics of the trades in the repo market allow us to pre-

[1]See Dell'Ariccia et al. (2018) for an excellent overview of the mechanisms behind and literature on the sovereign-bank nexus. We also show the presence of this positive correlation using CDS prices, see Section 4.1.

cisely estimate the loan pricing impact of this collateral-borrower correlation. More specifically, participants in this market typically perform multiple trades on the same day, using collateral that is very homogeneous across trades (sovereign bonds). This allows us to perfectly control for the direct impact of borrower risk and collateral risk on loan prices by means of borrower-day and isin-day fixed effects.

Using a trade-level dataset of all bilateral repo trades from 47 major European banks between October 2016 and April 2020, we find that borrowers pay a 2.6 basis points premium when they are from the same country as the sovereign that issued the bond used as collateral. This premium is on top of any borrower- or collateral-specific premium. As a mean of illustration, our results imply that lenders charge a higher rate if the Italian collateral that they receive is coming from an Italian borrower than from 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 basis points.

We argue that this premium exists due to the fact that a positive collateral-borrower correlation decreases the liquidation value of the collateral. We provide further evidence of our mechanism by constructing a continuous alternative proxy for the correlation. More specifically, we measure the correlation between the CDS spread of the borrower and the CDS spread of the collateral. Using this correlation, we show that there is a premium when the borrower brings a collateral correlated with her default risk, even when the collateral has not been issued by the borrower's country.

Next, we generalize our repo market results to collateralized corporate loans. More precisely, 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. We test if a corporate borrower pays a premium when its default risk is positively correlated with the risk of the collateral. To do so, we exploit the fact that the default risk of a construction firm is more positively correlated with the risk of real estate collateral than the default risk of a non-construction firm. Accordingly, we predict that construction firms pay a premium when using real estate collateral.

In a first step, we look at all new loans granted between September 2018 and December 2020 and backed by real estate collateral. We show that construction firms borrowing with real estate collateral pay a 22 basis points premium compared to similar non-construction firms borrowing with a similar collateral. This is an economically relevant premium, given that the average rate in the sample is 2.4 percent. This finding also holds when comparing firms that borrow from the same bank and operate in the same region. This allows us to control for regional real estate factors, thus ensuring that our findings are not driven by bank specialization in a certain sector.

In a second step, we add loans backed by non-real estate collateral to our sample. This allows us to better control for borrowers' default risk by focusing on within-borrower variation. We predict that the difference in loan rate when using real estate compared to non-real-estate collateral is more positive for construction than for non-construction firms. This is indeed the case. We find that a construction firm that uses real estate collateral instead of other types of collateral pays a premium of 25 basis points compared to what a non-construction firm pays. That is, there is a penalty for a construction firm to pledge real estate collateral instead of another type of collateral, over and beyond the penalty paid by a non-construction firm. Taken together, these results indicate that the "collateral-borrower specific liquidation value" also plays a key role in the pricing of corporate loans.

Our paper contributes to several strands of literature. First and foremost, our paper contributes to the literature on collateral liquidation value and financial contracting. We add to this literature by showing that liquidation value depends on who is pledging the collateral, and not only on the redeployability of the collateral. By doing so, we highlight a mismeasurement error potentially present in the literature, which consists of failing to disregard the value taken by the collateral in the states of the world where the borrower is unlikely to default. Additionally, we reconfirm the importance of liquidation value for loan pricing.

In detail, two key theory papers are Williamson (1988) and Shleifer and Vishny (1992). Williamson (1988) identifies asset redeployability as a key determinant of liquidation value. One can see the concept of redeployability as being determined by asset-specific characteristics. Shleifer and Vishny (1992) stress the importance of asset liquidity; that is the ability to sell the asset at its best-use value when the firm defaults. They show that this ability is reduced in times of industry-wide stress, given that the most likely buyers are firms operating in the same industry as the defaulting borrower.

Finding a proxy for liquidation value that closely matches the theoretical literature is challenging. Existing empirical work tried to measure it 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)). A number of other papers that investigate the impact of laws, creditor rights and institutions on collateralized lending are using bank estimates of expected liquidation value (Calomiris et al. (2017), Cerqueiro et al. (2016), Degryse et al. (2020), Liberti and Mian (2010)). All these measures are asset-specific, and not asset-borrower specific. Put differently, existing work either focussed 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 an unconditionally high value. Instead, a high quality collateral has to feature a high value conditional on borrower default. Taken literately, this means that a collateral has a low quality when its unconditional value is solely driven by a high value in the states of the world where the borrower does not default. Conversely, it is possible for a high-quality collateral to have a zero value in the no-default states of the world and, consequently, a rather low unconditional value.

Our proxy more closely captures the implication of the LGD concept and, in particular, the implication featured in Shleifer and Vishny (1992) that collateral quality is conditional on borrower default. More precisely, we differ from previous empirical studies by acknowledging that liquidation value varies at the borrower-collateral level. By doing so, we avoid making a mismeasurement error that could attribute a high quality to a collateral that actually has a low value in states of the world where the borrower defaults. As such, our proxy provides more precise variation in collateral quality than the other proxies. We do recognize, however, that our proxy has some 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). It is also agnostic on whether the shock is common to the borrower and the collateral, or whether the shock is being transmitted between both.

Our paper also contributes to the literature on repo markets. There is recent evidence of monitoring of collateral quality in US repo markets(Auh and Landoni (2016)). 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 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)). Gorton and Metrick (2012) for example 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 in our sample were found to be unaffected by borrower-collateral correlation, 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 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, using 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. (2015), Acharya et al. (2018)).

The rest of this paper is organized as follows. Section 2 develops the conceptual framework. Section 3 presents the data. Section 4 and 5 present the empirical evidence in the repo market and in the corporate loan market, respectively. Section 6 concludes.

2 Conceptual framework and hypothesis development

Our goal is to explore whether loan prices reflect liquidation values, using variation in liquidation value at the collateral-borrower level. In this section we develop a simple PD-LGD framework to illustrate why it should be the case.

The goal of this framework is to show that interest rates on a loan can take the following form:

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

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[2], 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[3], 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[4] :

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

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 $Liquidation_{Col-Bor}$).[5] The presence of the third term $COV(D, L)$ stresses the importance of the comovement between borrower default and the value of the collateral. In other words, it is not entirely 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

[2] 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.

[3] 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

[4] 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.

[5] In appendix A, we illustrate the validity of Equation 4 by providing a numerical application.

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 ($E(L)$).

3 Data and descriptive evidence

3.1 The repo market

Banks, non-bank financial institutions, as well as non-financial corporations heavily rely on repo markets for their short-term funding and collateral needs. Technically, a repo is a sale of securities for cash with a commitment to repurchase them at a specified price at a future date. Economically, this is very similar to a collateralized loan, as the securities (collateral) provide credit protection in the event that the seller (cash borrower) defaults.

Our repo-market analysis is based on transaction-level money market 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 (ECB). It covers all euro-denominated daily borrowing and lending transactions undertaken by a sample of euro area banks in the secured and unsecured segments of the money market. In this paper, we focus on the secured (repo) segment. Banks reporting 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.

For the purpose of our analysis we collect information on the amount and the rate for each transaction, as well as the amount of collateral provided and ISIN-level information on the asset backing each individual transaction, such as the type of collateral, the issuer entity, and the applied haircut. In order to ensure that our results are not biased by strong outliers we winsorize the main variable of interest (i.e. the repo rate) at the 1 percent level. The final data set contains information on several dimensions: borrower (the reporting bank), lender (the counterparty), time (daily), and collateral-level information.

We limit our sample to bilateral, overnight repo trades backed by euro-area government bonds. Focussing on trades backed by government bonds is key for our identification strategy. Government bonds also constitute the main type of collateral used in repo trades.[6] We further exclude borrowing transactions in which the counterparty is a central clearing counterparty (CCP) because, in this case, the lender is insured against borrower risk. We also remove transactions in which the counterparty is a central bank or a government entity, which accounts for a very small share of total secured borrowing.

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 the trade date plus one business day (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. We therefore restrict the sample to secured borrowing transactions with a maturity of one day (see top panel in Table 1 for the distribution of overnight, spot next, and tomorrow next trades as a share of the total in our sample).

The final sample spans the period from 3 October 2016 until 16 April 2020, covering 828,718 unique transactions between 47 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.

Descriptive statistics on our final repo market sample are reported in the first panel of Table 1. The (annualized) average repo rate in the sample is -60 basis points. The variation in repo rates is considerably high, with a standard deviation of 25 basis

[6]Figure B1 shows that more than 50 percent of borrowing volumes are backed by government bonds. In addition, 60 percent of the repo borrowing volume secured by government bonds is backed by domestic bonds (Figure B2), much in line with the holdings of domestic bonds in bank's securities portfolio shown in Figure B3.

points. The variable *high correlation* has a sample average of 0.44. This dummy variable is equal to 1 if the borrower is of the same country as the issuer of the collateral, and equal to 0 otherwise. Hence, in around 44 percent of the trades in our sample the borrower is of the same country as the issuer of the collateral. The variable *CDS correlation* has a sample average of 0.45, with a large variation across the sample. This variable is constructed by gathering information on five-year credit default swaps (CDS) on bank and government debt from Datastream. For each day in our sample, We then compute the 60-day correlation between the CDS of each borrowing bank and the CDS of the sovereign collateral pledged in the repo transaction.

We enrich the MMSR data by adding information from other datasets in order to complement borrower, lender and collateral characteristics. We obtain credit ratings for each reporting bank and for the collateral from the main public rating agencies (S&P, Moody's, Fitch and DBRS), which we harmonise and translate into a numeric scale in order to build a measure of the median credit rating of each bank. We obtain the same information at the ISIN level for the collateral backing the transactions covered by our sample. Finally, we match our sample of banks with proprietary data on the holdings of domestic and non-domestic sovereign bonds. The data comes from the individual balance sheet items (iBSI) dataset and allows us to obtain information on almost all borrowers in our sample.

3.2 The corporate loan market

The data on corporate loans is taken from Anacredit, a proprietary dataset covering loan-level data granted by euro-area financial institutions. 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.

The dataset includes basic loan characteristics such as the loan amount, the interest rate and the maturity, as well as detailed information on the type of collateral backing each loan. An overview of the different collateral categories can be found in Table B4 in Appendix B. Loans backed by one of the three real-estate types of collateral (commercial real estate, residential real estate and offices and commercial premises), which will be of key importance for our identification strategy, together make up around 9 percent of the sample.

Summary statistics on the corporate loans included in our analysis can be found in panel 2 of Table 1. 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.

4 Liquidation value and loan pricing: evidence from repo markets

In this section, we describe the empirical setup of our repo market analysis and present the main results, as well as additional evidence.

4.1 Empirical setup

The granularity of the MMSR database allows us to isolate the collateral-borrower term ($COV(D, L)$) in equation (4) from the borrower risk (PD) and the collateral-level proxy of liquidation value ($Liquidation_{Col}$) by estimating the following regression model:

$$\begin{aligned} Rate_{i,t,c,l} = \alpha + \beta HighCorrelation_{c^{country}=i^{country}} + \chi_{i,t} + \psi_{c,t} + \omega_{l^{sector},t} \\ + \gamma Volume_{i,t,c,l} + Maturity_{i,c,l} + \nu_{i,t,c,l} \quad (5) \end{aligned}$$

where t is the day of the repo trade, i is the borrower, c is the collateral's ISIN, l is the lender, $i^{country}$ is the country of borrower i, $c^{country}$ is the country of collateral c, l^{sector} is lender l's sector (Bank, non-bank financial company, or non-financial company). $HighCorrelation_{\{c^{country}=i^{country}\}}$ is the main explanatory variable which is equal to 1 if the borrower is of the same country as the issuer of the collateral, and 0 otherwise. $\chi_{i,t}, \psi_{c,t}, \omega_{l^{sector},t}$ correspond to the borrower-, collateral-, and lender-sector-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 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 ($HighCorrelation_{\{c^{country}=i^{country}\}}$) varies at this level.

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

Our setup allows us to overcome a number of empirical difficulties. First, it is challenging to obtain a reliable source of variation in liquidation value. Relying on variation in key collateral characteristics (such as collateral prices or liquidity) introduces measurement error because characteristics that are unconditional on default may differ from conditional characteristics. For example, a collateral may have a low value conditional on default despite having a high unconditional value. Analysing repo trades offers the opportunity to get variation in liquidation value by using variation in collateral-borrower default correlations. This correlation does not suffer from the above-mentioned measurement error because it is inherently a conditional characteristic.

Second, we want to ensure that our estimated impact of liquidation value on loan prices at the collateral-borrower level is not polluted by collateral-specific characteristics. Given that the exact same bond (ISIN-level) is often used by multiple borrowers as collateral in the repo market at the exact same day, we can rule this out completely by saturating our regressions with ISIN-day fixed effects.

Third, borrower-specific characteristics (e.g. borrower riskiness) likely have an impact on loan prices. One could be concerned that these borrower-specific characteristics are correlated with collateral liquidation values. For example, riskier borrowers might be required to pledge collateral with a higher expected liquidation value. The fact that borrowers in repo markets typically engage in multiple trades on the same day allows us to focus on within-borrower-day variation in loan prices, which entirely removes this concern.

As a consequence, our empirical strategy highlights the link between actual loan rates and a proxy for $COV(D, L)$ from equation (4), while perfectly controlling for the two other covariates PD (borrower risk) and $E(L)$ (collateral-specific component of liquidation value).

Before turning to the main empirical evidence, we briefly study the validity of our proxy of $COV(D, L)$. The goal is to show that $COV(D, L)$ is effectively larger in situations where $HighCorrelation = 1$ than when $HighCorrelation = 0$. To that end, we focus on correlations between the default risk of the borrower and of the collateral issuer. We proxy bank and sovereign default risk by their CDS spreads. We collect five-year CDS spreads for the banks and for the sovereigns issuing government bonds that are used as collateral in our sample. We obtain CDS spreads for 31 banks and 38 sovereigns. For each sovereign-bank pair, we calculate the correlation between the bank's CDS and the sovereigns CDS (CDS correlation, henceforth).

Table 2 reports average CDS correlation for three definitions of the CDS correlation variable. The first measure is the CDS correlation between the bank and the sovereign in a given month, the second and third measures are the 30 and 60-day rolling CDS correlation, respectively. The average CDS correlation between the bank and the sovereign issuer ranges from 0.30 to 0.33 when the borrower is not from the same country as the issuer. The correlation ranges from 0.47 to 0.51 when both are from the same country. The difference ranges from 0.16 to 0.18 and is statistically different from zero for each of the measures. In Appendix B, Table B1 shows that this also holds when comparing correlations within the same bank: the CDS correlation between a bank and it's home country is on average 10 % higher than the average correlation between that bank and other countries of which the same bank uses the issued sovereign bonds as collateral. These results confirm the reliability of our proxy measure.

4.2 Main results

Table 3 presents our main repo market findings. It shows the results from estimating equation 5. The dependent variable is the repo rate at the transaction level, the 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. In all specifications we control for the size and the maturity (O/N, S/N, T/N) of the transaction. Standard errors are clustered at the borrower-isin level, as this is the level of variation of our main variable of interest.[7]

The first column of Table 3 shows the results from a specification with day fixed effects only. We find a large and positive impact for 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 does not take into account the direct impact of the collateral component of liquidation value neither the effect of borrower risk on loan prices. This is taken care of in columns 2 to 4.

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. In columns 3 and 4 we further saturate the specification with borrower-day and lender-sector fixed effects, in order to control for borrower risk and for lenders' preferences respectively. In our most stringent specification in column 4, the coefficient associated with the *High-correlation dummy* variable implies a 2.6 basis points premium and continues to be significant at the 1% level.[8] This means that borrowers are penalized by a 2.6 basis points higher repo rate when they are from the same country as the collateral that they provide in the repo transaction. For example, it implies that lenders charge a higher rate to an Italian bank for borrowing against an Italian collateral than a Por-

[7]In Table B3 in 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 there are qualitatively similar to those displayed in Table 3).

[8]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 Appendix B we rerun all specifications on the same sample used in column 4 of 3. The results remain qualitatively and quantitatively similar.

tuguese bank with exactly the same Italian collateral, after eliminating the unobserved differences between the borrowers and lenders.

Overall, the results in Table 3 illustrate that loan prices reflect liquidation values at the collateral-borrower level. Throughout the results section, we refer to this premium as the high-correlation premium. The high-correlation premium is economically significant in several dimensions. First, 2.6 basis points is large given that the average repo rate in our sample is minus 60 basis points. Second, the premium is likely to affect a large number of borrowing banks, given the large proportion of repo loans that are secured by domestic sovereign bonds.

Next, we take the analysis a step further, and construct a continuous proxy for the correlation between a borrower's default risk and collateral value. Given that a substantial part of borrowers and collateral issuers in our sample have CDS contracts running on their debt, we can use the correlation between CDS spreads as a time-varying proxy for default risk correlation.

Table 4 reports the result of a specification where the main explanatory variable is the CDS correlation between the borrower and the collateral underlying the repo transaction. We use the 60-day rolling correlation between the borrower's five-year CDS spread and the collateral issuer's five-year CDS spread. Column 1 estimates a specification with day fixed effects, column 2 adds borrower-day fixed effects, column 3 further adds ISIN-day fixed effects, and column 4 saturates the model with borrower-day, ISIN-day and lender-sector-day fixed effects. The coefficient associated with the CDS correlation variable is positive and significantly different from zero. Based on the most conservative specification displayed in column 4, we find that lenders penalize borrowers with a 1.5 bps premium when the borrower risk is perfectly correlated (CDS correlation equal to 1) with collateral risk compared to the case where it is uncorrelated (CDS correlation equal to 0).[9]

[9]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 2).

4.3 Additional evidence

This section introduces a number of additional tests that confirm the existence of a borrower-collateral specific premium in repo markets. We study 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 close to zero.

In columns 1 to 4 of Table 5 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 therefore virtually equal to 1. The sample comprises trades backed by bonds or equity issued by the borrowing banks. The main explanatory variable is a dummy equal to one if the borrower is also the issuer of the collateral, and zero otherwise. We progressively saturate the model with we include day fixed effects (column 1), borrower-day fixed effects (column 2), and borrower- and ISIN-day fixed effects (column 3).

Our most stringent specification includes borrower-day, ISIN-day and lender-sector-day fixed effects (column 4). The coefficient for the *Own-collateral dummy* is equal to 0.211 and is significantly different from zero at the 1% level. This implies that borrowers are penalized by a premium of around 21 basis points for being the issuer of the collateral that they pledge. This premium is eight times larger than the premium documented in Table 3. This is in line with our intuition that a larger default correlation implies that lenders charge a larger premium.

In column 5 of Table 5 we study the alternative case in which lenders are insured against counterparty risk and thus should not care about liquidation value. More precisely, we study trades cleared by a central counterparty clearing platform (CCP). CCPs are regulated financial institutions that take on the counterparty credit risk between parties engaging in a transaction and provide clearing and settlement. When trading on such platforms, lenders are unlikely to internalize the liquidation value of the collateral backing the trades because of the insurance provided by the CCP. In this test, the main explanatory variable is the *High-correlation dummy*. The specification in column 5 includes borrower- and ISIN-day fixed effects. The coefficient is not statistically distinguishable from zero. This confirms our intuition: given that in the lenders are protected in case of borrower default, the high-correlation premium disappears.

5 Liquidation value and loan pricing: evidence from the corporate loan market

In this section we provide evidence based on the corporate loan market, using loan-level data from Anacredit. Our goal is to generalise the previous result to the market of collateralised corporate loans, thus providing evidence on the external validity of our mechanism and results.

5.1 Empirical setup

Our test on the corporate loan market aims at confirming the existence of an interest rate premium for loans in which the risk of the borrower is correlated with the risk of the collateral pledged. We proceed in two steps.

First, we focus on one specific type of collateral: real estate assets. We test whether firms operating in the construction industry borrow at a premium when using real estate collateral compared to firms operating in other industries. This premium would be warranted by the default-risk correlation that exists between construction firms and real estate collateral. Specifically, we estimate the following specification:

$$Rate_{b,l,f,t} = \alpha + \beta Construction_{b,l,f,t} + \gamma X_{b,l,f,t} + \chi_{b,r,t} + \psi_m + \epsilon_{b,l,f,t} \quad (6)$$

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, among other things ensuring that our findings are not driven by (time-varying) local real estate shocks, nor by differences in banks' risk appetite. 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.

Second, we add loans that are not backed by real-estate collateral to our sample and focus on within-firm variation in loan rates. This allows to address a potential problem with specification 6 where the *Construction* dummy could pick up industry-specific characteristics of construction firms that affect the loan rate. 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. We expect the difference to be more positive for construction firms, as the default risk of the construction firm is more positively correlated to the riskiness of the real-estate collateral.

Accordingly, we estimate the following model:

$$Rate_{b,l,f,t} = \alpha + \beta_1 Construction_{b,l,f,t} * REcollateral_{b,l,f,t} + \gamma X_{b,l,f,t} + \chi_{b,r,t} + \mu_{f,t} + \nu_c + \psi_m + \epsilon_{b,l,f,t} \quad (7)$$

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 6. $REcollateral_{b,l,f,t}$ is a dummy equal to one 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 between which we can distinguish 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.

This setup comes closest to our repo-market setup. 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 7 also allows to control for time-varying borrower-specific characteristics by means of firm-time fixed effects. In addition, the collateral-type fixed effects remove to a large extent the direct impact of collateral value on loan prices. While not as precise as the ISIN-day fixed effects employed in our repo setup, these are the best we can do given the available data.

5.2 Empirical results

Table 6 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 6 focus on loans backed by real estate collateral and show the results from estimating equation 6, 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 basis points interest rate premium.

One potential weakness of the setup in columns 1 to 3 is that the premium potentially captures unobservable factors specific to the construction sector. For example, construction firms might be deemed on average 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 6. This is done in columns 4 and 5 of Table 6.

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 more positive for construction than for non-construction firms. For a non-construction firm, loans backed by real estate collateral are on average 17 basis points more expensive than other loans granted to that same non-construction firm in the same month. For a construction firm this difference rises to 36 basis points (0.17+0.19). Put differently, after controlling for the average difference in rates between loans backed by real estate and other collateral, we find that a construction firm pays a 19 basis points premium when using real estate collateral compared to the rate paid on other collateralized loans granted to that same firm in the same month. In our most stringent specification (column 5), we add collateral-month fixed effects. In this specification, the premium is 25 basis points. Given the average rate of 2.4 percent in our sample, the premium is economically meaningful.

6 Robustness

In this part, we perform a series of tests to reject alternative mechanisms that could explain our main findings and to further highlight the robustness of our results.

6.1 Direct impact of collateral and borrower risk on loan prices

In this section, we test how the level of collateral and borrower default risk affects the borrower-collateral specific premium in repo markets. The impact of the collateral-borrower correlation should be larger if the collateral and/or the borrower is riskier. Indeed, situations in which the collateral does not offer sufficient (unconditional) protection or in which the borrower is likely to default should be those in which the lenders suffer the most from the additional risk brought forth by the collateral-borrower correlation. We study how the high-correlation premium varies with the riskiness of the collateral or of the borrower.

We measure borrower and collateral risk via the 5-year CDS for the borrower and the issuer of the collateral. We standardize both variables, such that coefficients can be interpreted as the impact of a standard deviation change in these CDS spreads.

First of all, colum n1 of Table 7 shows tthat collateral and borrower risk are indeed priced by the market . The premium for a one standard deviation increase in collateral (borrower) risk is found to be equal to 3 basis points (1.7 basis points). This result is not surprising and in line with intuition: riskier borrowers pay a premium in the repo market; the same holds true for borrowers using riskier collateral.

Next, we introduce interaction terms between our high-correlation dummy and collateral and borrower risk proxied by the respective 5-year CDS, This allows us to assess how the high-correlation premium varies with the riskiness of the collateral and the borrower. Column 2 shows that a one standard deviation increase in collateral risk increases the impact of the collateral-borrower component of liquidation value by 10 basis points. Similarly, in column 3 we interact the high-correlation dummy with the variable measuring borrower risk and find that the premium increases (0.7 basis points).

6.2 Securities-lending demand in repo markets

The main mechanism tested in the repo market analysis applies not only to cash-driven but also to securities-driven transactions. Indeed, a securities borrower (i.e. a short-seller) is penalized if the cash borrower defaults precisely at the time where the short-sell is profitable, that is when the collateral has lost value. Our main specification in Table 3, however, does not control for the possibility that some cash-lenders have a particular interest or disinterest in a specific collateral. This would influence the *High-correlation* dummy if domestic borrowers are more likely to supply the collateral for which there is a particularly high or low demand. For example, if a cash-lender is highly interested in a bond issued by country A, he will be willing to pay a higher price (i.e. receive a lower interest rate) on this trade. If this lender happens to be less likely to borrow this bond from a bank in country A, our *High Correlation dummy* might be biased. We take care of this possibility in column 1 of Table 8 by adding fixed effects at the lender's sector-ISIN-day level. We find that our coefficient of interest is still significant and is equal to 2.0 bps.

6.3 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. Petersen and Rajan (1995) and Hauswald and Marquez (2003) for example theoretically show that repeated interactions make it easier for lenders to monitor borrowers, as the former are able to gather private information about the latter and should, among others, reduce uncertainty about the borrower's actual credit quality.

The topic of relationship lending is widely investigated empirically for lending to non-financial firms; see, e.g. Berger and Udell (1995), Petersen and Rajan (2002), Degryse and Ongena (2005). For the specific case of money markets, there is recent empirical evidence that relationships matter for loan prices. Cocco et al. (2009) and Bräuning and Fecht (2017) for example show that borrowers in interbank markets pay a significantly lower interest rate to their relationship lender as compared 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 2 of Table 8 we control for the potential impact of borrower-lender relationships on repo prices by including a borrower-lender's sector-day fixed effect. This implies that we are now looking at trades within a specific borrower-lender sector pair, which should rule out any impact of relations between a borrower and a lender sector.[10] The empirical specification still includes ISIN-day fixed effects to control for time-varying collateral-specific characteristics, as well as loan size and maturity which vary at the transaction level. Our main result still survives: the coefficient on the *High Correlation dummy* is equal to 1.8 significant at the 1%-level and implies a 1.8 basis points premium.

[10]for the majority of trades in our sample, we don't know the exact identity of the lender, but only the sector in which it is active. As such, we can look at relations at the lender-sector level, but not at the lender level.

6.4 The convenience yield channel

In the paper, we argue that the premium reflects a compensation received by lenders. However, in the repo market the premium might reflect a convenience yield enjoyed by borrowers when using 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 rather keep the non-domestic bonds on its balance sheet for diversification purposes or to use them in other operations. In this case, the bank would have a preference for using its abundant domestic holdings as collateral in repo trades. If lenders have market power, they may extract a premium in exchange for accepting domestic collateral.[11]

In Column 3 of Table 8 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 obtain data on banks' holdings of sovereign bonds for the majority of the borrowers in our sample. We exclude borrowers for which the proportion of domestic versus non-domestic bond holding belongs to the 75th percentile or higher. These borrowers are the ones more likely to enjoy a convenience yield for using their domestic collateral. Column 3 of Table 8 shows that our main results are qualitatively unchanged even when we exclude borrowers holding a large fraction of domestic bonds.

6.5 Generality of our results across countries

In columns 4 to 6 of Table 8 we mitigate the concern that the entire effect may be driven by trades operated by banks belonging to a few countries. We drop pairs of countries one by one. The header of each of the columns include the name of two countries. For these countries, we exclude from the sample the trades where the borrowers of these countries used as collateral sovereign bonds issued by the same country. In each of the three columns, our main result survives. Similar results are obtained when dropping

[11]This channel crucially relies on lenders' market power. In previous robustness tests, we have controlled for lenders' market power by adding borrower-lender-time fixed effects. However, these fixed effects are not enough to completely rule out the possibility that a lender's market power varies across collateral types.

countries one-by-one.

7 Conclusion

This paper is the first to show that the liquidation value of collateral depends on who is pledging it. We employ transaction-level data on overnight repurchase agreements (repo) and loan-level credit registry data on corporate loans. We find that borrowers on the repo market pay a 2.6 basis points rate premium when their default risk is positively correlated with the risk of the collateral that they pledge. The premium is 25 basis points for corporate loans.

Our results have three main implications. First, lenders in repo markets and in corporate loan markets 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 (i.e. to have a low loss given default), it is not sufficient nor necessary for it to have a high unconditional expected value. It has to feature a high value upon default. Our proxy more closely captures the idea that collateral quality is a concept that is conditional on borrower default by acknowledging that liquidation value varies at the borrower-collateral level. Finally, banks' home bias in security holdings has an impact on banks' funding cost, as our repo market results indicate that banks pay a premium when they are of the same country as the collateral issuer.

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Tables

Table 1: Summary statistics

	N	mean	p50	sd	p1	p99
Repo trades						
Rate (%)	828,718	-0.606	-0.540	0.253	-1.650	-0.369
High-correlation dummy	828,718	0.442				
Ln(loan amount)	828,718	15.931	16.195	1.966	10.491	19.251
5-year sovereign CDS	828,716	37.166	21.020	38.755	5.070	138.410
5-year Bank CDS	778,446	69.640	64.810	36.921	20.263	189.785
CDS correlation	756,165	0.454	0.532	0.399	-0.620	0.967
Overnight trades (share of total)	828,718	0.579				
Spot next trades (share of total)	828,718	0.238				
Tommorow next trades (share of total)	828,718	0.183				
Corporate loans						
	N	mean	p50	sd	p1	p99
Rate (%)	139,765	2.405	2.520	1.275	0.000	5.641
Loan amount	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
High Correlation dummy	139,765	0.006	0.000	0.077	0.000	0.000
Maturity (days)	139,765	1163.607	720.000	1663.943	23.000	7395.000

This table shows summary statistics for our sample of repo trades (first panel) and corporate loans (second panel). The sample period for the repo trades is 3 October 2016 until 16 April 2020, for the corporate loans 1 September 2018 until 31 December 2019.

Table 2: CDS correlation across the two groups

	HighCor =0	HighCor =1	Difference
month-by-month corr.	0.30	0.47	-0.16***
30-day rolling window corr.	0.30	0.47	-0.16***
60-day rolling window corr.	0.33	0.51	-0.18***

This table reports the average correlation between the bank's CDS and the sovereign CDS for loans secured by foreign collateral (*High-correlation dummy* = 0) and for loans secured by same-country collateral (*High-correlation dummy*= 1). The correlation is computed in three different ways: (i) CDS correlation in a given month; (ii) 30-day rolling CDS correlation; (iii) 60-day rolling CDS correlation.

Table 3: Impact of same-country collateral on repo rates

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

The sample consists of all repurchase agreements (trade level) backed by euro-area sovereign bonds where the cash borrower is a European bank reporting to the Money Market Statistical Reporting (MMSR) database. The sample period is 3 October 2016 until 16 April 2020. The dependent variable is the trade-level interest rate (annualized). *High-correlation dummy* is a dummy equal to one if the country of the collateral is the same as the country of the borrower. Control variables include the log volume of the trade and a set maturity fixed effects. Column 1 includes day fixed effects. Column 2 includes ISIN-day fixed effects (ISIN of the collateral). Column 3 adds borrower-day fixed effects, Column 4 additionally includes lender's sector-day fixed effects. A lender's sectors is either the banking sector, the non-bank financial sector, or the non-financial sector. Robust standard errors (clustered at the borrower-ISIN level) are reported in parentheses.

Table 4: Borrower-collateral CDS correlation and repo rates

	Dependent variable =Interest rate			
	(1)	(2)	(3)	(4)
Borrower-collateral CDS correlation	0.0981***	0.0166***	0.0153**	0.0148*
	(0.0106)	(0.00481)	(0.00775)	(0.00805)
Observations	756,165	718,019	716,231	715,859
Adjusted R-squared	0.211	0.846	0.870	0.871
Day FE	Y	N	N	N
Borrower-day FE	N	N	Y	Y
ISIN-day FE	N	Y	Y	Y
Lender's sector-day FE	N	N	N	Y
Trade-level controls	Y	Y	Y	Y

The sample consists of all repurchase agreements (trade level) backed by sovereign bonds for which we are able to find borrower and sovereign CDS spreads. Non-domestic in this context implies that the collateral country is different from the borrower country. The cash borrower is a European bank reporting to the Money Market Statistical Reporting (MMSR) database. The sample period is 3 October 2016 until 16 April 2020. The dependent variable is the trade-level interest rate (annualized). *Borrower-collateral CDS correlation* measures the correlation between the borrower's CDS and the collateral issuer's CDS during a 60-day rolling window. Control variables include the log volume of the trade and a set maturity fixed effects. Column 1 includes day fixed effects. Column 2 includes ISIN-day fixed effects (ISIN of the collateral). Column 3 adds borrower-day fixed effects, column 4 additionally includes lender's sector-day fixed effects. A lender's sectors is either the banking sector, the non-bank financial sector, or the non-financial sector. Robust standard errors (clustered at the borrower-ISIN level) are reported in parentheses.

Table 5: Own collateral, CCP and repo rates

	Dependent variable = Interest rate				
	Own collateral				CCP trades
	(1)	(2)	(3)	(4)	(5)
Own-collateral dummy	0.0817	0.141	0.210***	0.211***	
	(0.110)	(0.0890)	(0.0756)	(0.0758)	
High-correlation dummy					0.0000163
					(0.000322)
Observations	871,608	842,228	840,539	839,943	5,968,297
Nr. borrowers	30	30	27	27	38
Adjusted R-squared	0.019	0.762	0.805	0.807	0.885
Day FE	Y	N	N	N	N
Borrower-day FE	N	N	Y	Y	Y
ISIN-day FE	N	Y	Y	Y	Y
Lender's sector-day FE	N	N	N	Y	N
Trade-level controls	Y	Y	Y	Y	Y
Sample	Bank-issued	Bank-issued	Bank-issued	Bank-issued	Sovereign

In column 1 to 4 the sample consists of all bilateral repurchase agreements (trade level) backed by securities issued by banks. In column 5 the sample consists of all repurchase agreements between a cash borrower and a CPP, backed by government bonds. The cash borrower is a European bank reporting to the Money Market Statistical Reporting (MMSR) database. The sample period is 3 October 2016 until 16 April 2020. The dependent variable is the trade-level interest rate (annualized). *Own-collateral dummy* is a dummy equal to one for trades backed by bonds or equities issued by the cash borrower. *High-correlation dummy* is a dummy equal to one if the country of the collateral is the same as the country of the borrower. All specifications include the log volume of the trade and a set maturity fixed effects as control variables. Column 1 includes day fixed effects. Column 2 includes ISIN-day fixed effects (ISIN of the collateral). Column 3 adds borrower-day fixed effects, column 4 additionally includes lender's sector-day fixed effects. A lender's sectors is either the banking sector, the non-bank financial sector, or the non-financial sector. Column 5 includes borrower-day and ISIN-day fixed effects. Robust standard errors (clustered at the borrower-ISIN level) are reported in parentheses.

Table 6: The impact of collateral-borrower correlation on loan pricing in corporate loan markets

	Dependent variable = Interest 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

This table analyses a set of corporate loans granted to euro area firms between September 2018 and December 2020. 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). Data is taken from the Anacredit credit registry. The dependent variable is the loan-level interest rate. *Construction sector* is a dummy equal to one for loans to construction firms. *Real estate collateral* is a dummy equal to one for loans backed by real estate collateral. All specifications include a set 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. Column 1 also includes region-month fixed effects. Columns 2 to 5 include bank-region-month fixed effects. Columns 4 adds firm-month fixed effects, column 5 further adds collateral-month fixed effects. The latter capture the different collateral types in our sample. Collateral types include 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 physical collateral not captured in any of the other categories. 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. 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.

Table 7: Interaction of the high-correlation premium with collateral and borrower risk

	Dependent variable = Interest rate		
	(1)	(2)	(3)
Collateral risk	0.0302***	0.0352***	
	(0.00590)	(0.00547)	
Borrower risk	0.0171***		-0.00770***
	(0.00637)		(0.00271)
High-correlation dummy		0.0873***	0.0354***
		(0.0177)	(0.00426)
High-correlation dummy x Collateral risk		0.108***	
		(0.0208)	
High-correlation dummy x Borrower risk			0.00770**
			(0.00333)
Observations	778,115	826,011	740,126
Nr. borrowers	32	40	32
Adjusted R-squared	0.216	0.395	0.845
Borrower-day FE	N	Y	N
ISIN-day FE	N	N	Y
Lender's sector-day FE	Y	Y	Y
Trade-level controls	Y	Y	Y

The sample consists of all repurchase agreements (trade level) backed by EMU sovereign bonds where the cash borrower is a European bank reporting to the Money Market Statistical Reporting (MMSR) database. The sample period is 3 October 2016 until 16 April 2020.The dependent variable is the trade-level interest rate (annualized). *High-correlation dummy* is a dummy equal to one if the country of the collateral is the same as the country of the borrower. *Borrower risk* (*Collateral risk*) captures the riskiness of the borrower (collateral issuer) and is equal to the standardized borrower's (collateral issuer's) five-year CDS premium. Control variables include the log volume of the trade and a set of maturity fixed effects. Robust standard errors (clustered at the borrower-ISIN level) are reported in parentheses.

Table 8: Additional robustness checks

	(1) Sector-specific demand	(2) Relationships	(3) Excl. concentrated	(4) No DE, NL	(5) No FR, BE	(6) No IT, ES
High-correlation dummy	0.0204***	0.0178***	0.0146***	0.0441***	0.0171**	0.0235***
	(0.00478)	(0.00504)	(0.00461)	(0.0117)	(0.00821)	(0.00573)
Observations	736,890	789,375	613,467	704,647	720,552	577,881
Nr. borrowers	40	40	28	40	40	38
Adjusted R-squared	0.873	0.862	0.848	0.849	0.860	0.824
Borrower-day FE	Y	N	Y	Y	Y	Y
ISIN-day FE	N	Y	Y	Y	Y	Y
Lender's sector-day FE	N	N	Y	Y	Y	Y
Lender's sector-ISIN-day FE	Y	N	N	N	N	N
Borrower-lender's sector-day FE	N	Y	N	N	N	N
Trade-level controls	Y	Y	Y	Y	Y	Y

The sample consists of all repurchase agreements (trade level) backed by EMU sovereign bonds where the cash borrower is a European bank reporting to the Money Market Statistical Reporting (MMSR) database. The sample period is 3 October 2016 until 16 April 2020. The dependent variable is the trade-level interest rate (annualized). *High-correlation dummy* is a dummy equal to one if the country of the collateral is the same as the country of the borrower. Each specification includes the log volume of the trade and a set of maturity fixed effects as control variables. The first columns includes lender-ISIN fixed effects to control for the potential impact of the lender's demand for borrowing a specific security. The second column includes borrower-lender fixed effects to control for the potential impact of borrower-lender relationships. The third column controls for the convenience yield channel. It excludes the borrowers for which the ratio of domestic sovereign bond holdings over non-domestic sovereign bond holdings is at least equal to the 75^{th} percentile. In columns 4 to 6 we exclude high-correlation trades for a subset of countries. In column 4, we exclude trades by German and Dutch borrowers in which they respectively use German or Dutch collateral. In columns 5 and 6 we follow a similar approach, but for France and Belgium (column 5) and for Italy and Spain (column 6). Robust standard errors (clustered at the borrower-ISIN level) are reported in parentheses.

APPENDIX A

Numerical application

To illustrate the validity of Equation 4 in the paper, we provide a numerical application and show that failing to consider the covariance term in Equation 4 can result in mismeasuring the liquidation value if the sample average of the covariance term is not null. In our example, there are two possible states of collateral value, and a positive covariance between D and L. For ease of exposition, suppose that lenders first learn about the collateral value, and they subsequently learn about default.

Let there be a *high* and a *low* state of collateral value, each with probability 0.5 denoted P_H and P_L respectively. In the high state, the collateral value increases by 10% compared to the initial value (hence, L is 0%) and the borrower defaults with a 1% probability (D= 1%). In the low state, the collateral value decreases by 10% (hence, L is 10%) and the borrower defaults with a 5% probability (D= 5%). One can see that L and D are (perfectly) positively correlated.

We compute the interest rate as given by the typical *PD-LGD* in Equation 2. We first note that, conditional on default, the outcome of 10% loss is five times more likely that the outcome of 0% loss. Therefore:

$$LGD = (1/6) * L_H + (5/6) * L_L = (1/6) * 0\% + (5/6) * 10\% = 8.33\% \tag{8}$$

The average probability of default being 3%, we now obtain:

$$R = PD * LGD = 3\% * 8.33\% = \mathbf{0.25}\% \tag{9}$$

We then compute an approximation of the liquidation value, i.e. the first term of Equation 4. This approximation uses the unconditional expected loss (L) instead of the conditional expected loss (LGD):

$$\begin{aligned} R_{approx} = PD * \mathrm{E}[L] &= (P_H * PD_H + P_L * PD_L) * (P_H * L_H + P_L * L_L) \\ &= (0.5 * 1\% + 0.5 * 5\%) * (0.5 * 0\% + 0.5 * 10\%) \\ &= 3\% * 5\% = \mathbf{0.15}\% \end{aligned} \tag{10}$$

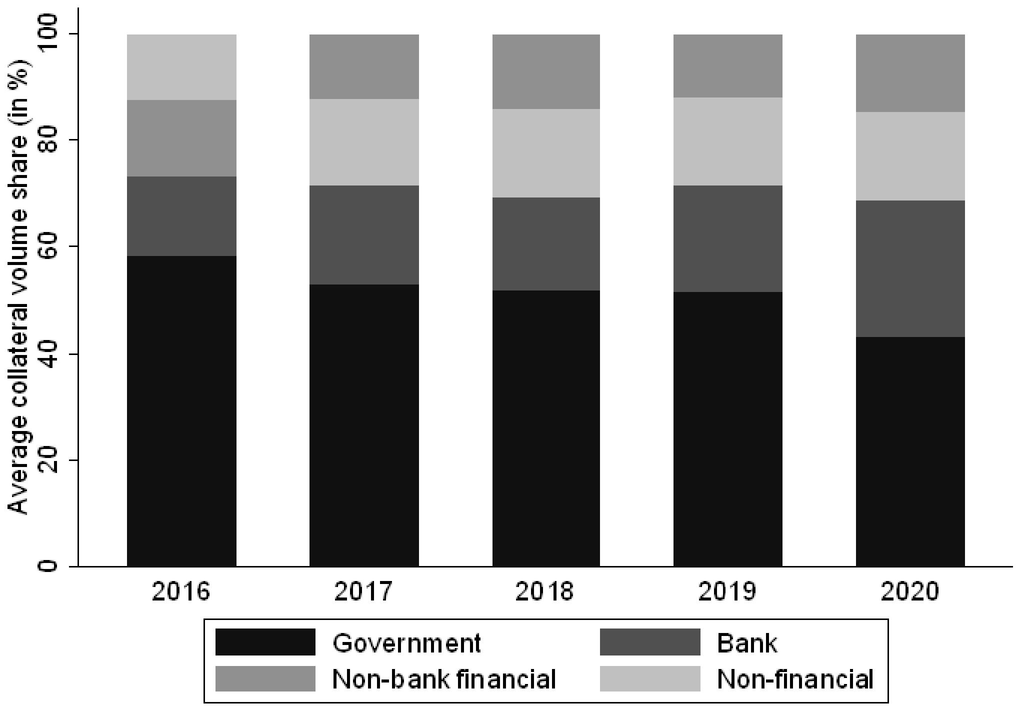
Finally, we compute the correction term, i.e. the second term of Equation 4. We find that, added to R_{approx}, the correction term allows to reconcile R_{approx} with R:

$$\begin{aligned} COV(D, L) &= P_H * (D_H - PD)(L_H - E(L)) + P_L * (D_L - PD)(L_L - E(L)) \\ &= 0.5 * (1\% - 2.5\%)(0\% - 5\%) + 0.5 * (5\% - 2.5\%)(10\% - 5\%)) \\ &= \mathbf{0.10}\% = \mathbf{R} - \mathbf{R_{approx}} \end{aligned} \tag{11}$$

APPENDIX B

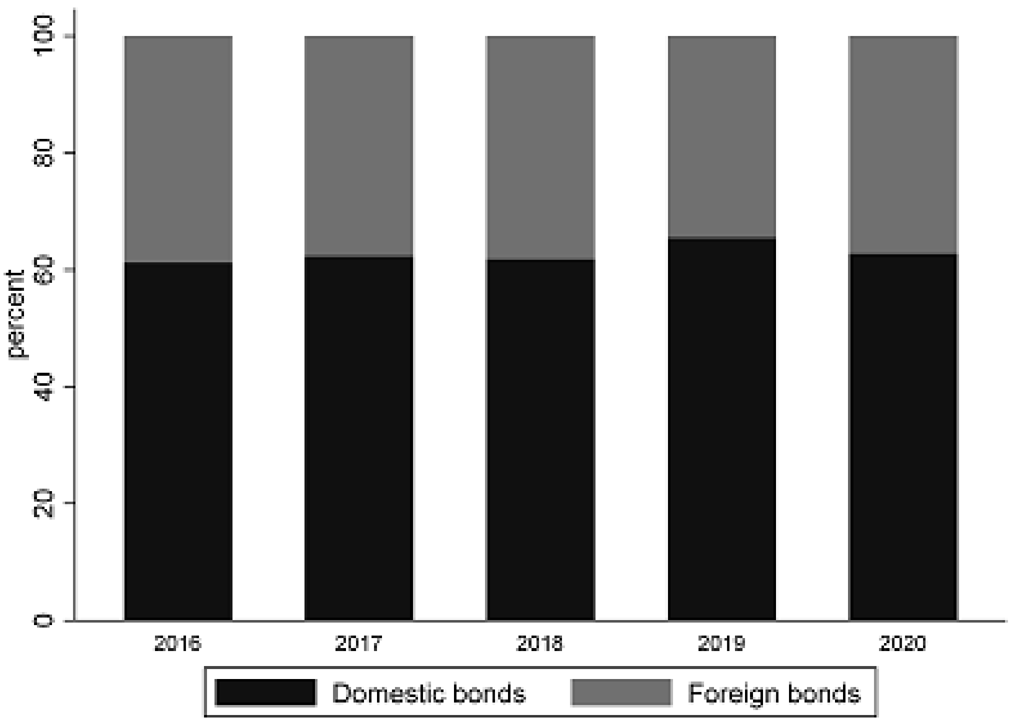
Supplementary figures and tables

Figure B1: Collateral types in repo borrowing



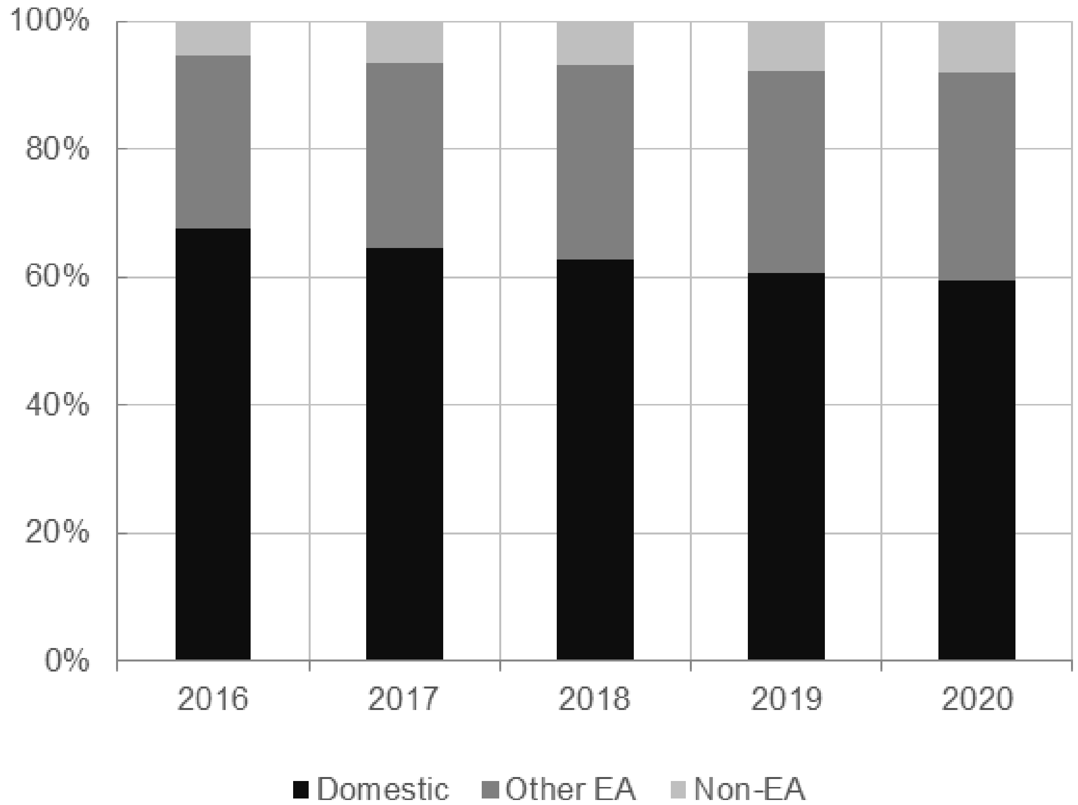
This figure shows the average volume share of repo trades backed by different types of collateral. The collateral categories are government bonds, bank bonds, non-bank financial bonds and non-financial bonds. Volume shares are calculated by averaging quarterly, bank-level volume shares for each collateral category over the year. Sample: all trades made by the banks in our sample in the CCP and bilateral secured segments of money markets. Own calculations based on MMSR data.

Figure B2: Government bond collateral in repo borrowing - Domestic/foreign split



This figure shows share of repo volume traded backed by domestic or foreign government bonds, as a percent 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. Sample: all trades made by the banks in our sample in the CCP and bilateral secured segments of money markets. Own calculations based on MMSR data.

Figure B3: Government bond holdings by banks - Domestic/foreign split



This figure shows the share of domestic and foreign government bonds, as a percent of the total volume of government bonds in a bank's securities portfolio. Volume shares are calculated by averaging monthly, bank-level volume shares for each category (domestic, other euro area, and non-euro area government bonds) over the year. Sample: portfolio of the banks in our sample. Own calculations based on monthly, MFI level data from the ECB's iBSI dataset.

Table B1: The relation between home bias and the default correlation between banks and sovereigns

	(1) Correlation, EA sovereigns
High-correlation dummy	0.0933***
	(0.0252)
Observations	400,084
Adjusted R-squared	0.248
Bank-day FE	Y
Cluster	bank-collateral country

The dependent variable is the correlation between a bank's CDS spread and the CDS spread on a sovereign bond that the bank uses as collateral in the repo market. More specifically, for each day t during our sample period we calculate the correlation between the CDS spread of each bank b trading in the repo at t, and the CDS spread of every sovereign collateral issuer from which bank b uses securities to back these repo trades on day t. Correlations are measured over a 60-day rolling window period ($t-60$ to t). *High-correlation dummy* is a dummy equal to one if the country of the collateral is the same as the country of the borrower. The sample period is 3 October 2016 until 16 April 2020.

Table B2: Main results with constant sample

	Dependent variable = Interest rate			
	(1)	(2)	(3)	(4)
High-correlation dummy	0.102***	0.0378***	0.0250***	0.0255***
	(0.0133)	(0.00334)	(0.00568)	(0.00574)
Observations	792,364	792,364	792,364	792,364
Nr. borrower	40	40	40	40
Adjusted R-squared	0.193	0.813	0.846	0.847
Day FE	Y	N	N	N
ISIN-day FE	N	Y	Y	Y
Borrower-day FE	N	N	Y	Y
Lender's sector-day FE	N	N	N	Y
Trade-level controls	Y	Y	Y	Y

The sample consists of all repurchase agreements (trade level) backed by EMU sovereign bonds where the cash borrower is a European bank reporting to the Money Market Statistical Reporting (MMSR) database. The sample period is 3 October 2016 until 16 April 2020. The sample is kept constant across the four columns. The dependent variable is the trade-level interest rate (annualized). *High-correlation dummy* is a dummy equal to one if the country of the collateral is the same as the country of the borrower. Control variables include the log volume of the trade and a set maturity fixed effects. Column 1 includes day fixed effects. Column 2 includes ISIN-day fixed effects (ISIN of the collateral). Column 3 adds borrower-day fixed effects, Column 4 additionally includes lender's sector-day fixed effects. A lender's sectors is either the banking sector, the non-bank financial sector, or the non-financial sector. Robust standard errors (clustered at the borrower-ISIN level) are reported in parentheses.

Table B3: Main results with double clustering

	Dependent variable = Interest rate			
	(1)	(2)	(3)	(4)
High-correlation dummy	0.103**	0.0385***	0.0250**	0.0255**
	(0.0440)	(0.00886)	(0.00973)	(0.0108)
Observations	828,718	795,572	792,735	792,364
Nr. borrower	47	47	40	40
Adjusted R-squared	0.189	0.811	0.845	0.847
Day FE	Y	N	N	N
ISIN-day FE	N	Y	Y	Y
Borrower-day FE	N	N	Y	Y
Lender's sector-day FE	N	N	N	Y
Trade-level controls	Y	Y	Y	Y

The sample consists of all repurchase agreements (trade level) backed by EMU sovereign bonds where the cash borrower is a European bank reporting to the Money Market Statistical Reporting (MMSR) database. The sample period is from 3 October 2016 until 16 April 2020. The dependent variable is the trade-level interest rate (annualized). *High-correlation dummy* is a dummy equal to one if the country of the collateral is the same as the country of the borrower. Control variables include the log volume of the trade and a set maturity fixed effects. Column 1 includes day fixed effects. Column 2 includes ISIN-day fixed effects (ISIN of the collateral). Column 3 adds borrower-day fixed effects, Column 4 additionally includes lender's sector-day fixed effects. A lender's sectors is either the banking sector, the non-bank financial sector, or the non-financial sector. Robust standard errors, double clustered at both the borrower-level and the ISIN-level, are reported in parentheses.

Table B4: Collateral types in corporate loan sample

Type	Frequency	Percent
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

This table lists the different types of collateral in our corporate loans sample.